U.S. Department of Agriculture
Animal & Plant Health Inspection Service
Wildlife Services
August 2016

Wildlife Damage Management Technical Series

Geese, Ducks and Coots

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Figure 1. Canada geese (*Branta candensis).*

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Human-Wildlife Conflicts

Landscapes

Canada geese, snow geese, ducks, and American coots all have been implicated in agricultural crop and turf damage.

Canada geese and snow geese that graze on winter wheat and rye crops can reduce subsequent grain and vegetative yields. Canada geese also cause serious damage to sprouting soybeans in spring and to standing cornfields in the autumn. The most common damage to agricultural resources associated with geese results from consumption of crops. Other impacts involve unacceptable accumulations of feces in pastures, trampling of emerging crops, and increased erosion and runoff from fields where the cover crop has been grazed. Canada geese graze on a variety of crops, including alfalfa, barley, beans, corn, soybeans, wheat, rye, oats, spinach, and peanuts, sometimes resulting in significant reductions in yields.

Since the dramatic increase in snow goose populations, there has been extensive damage to their breeding habitat in the

Figure 2. Snow goose (*Chen caerulescens*).

in the Arctic and tremendous grazing pressure on exposed crops and vegetation during the early spring migration. Most damage results from grubbing, trampling, and uprooting and occurs along the migration route on the eastern coastal areas, and in the mid-western and southern states. In addition, agricultural producers are concerned that geese spread noxious seeds to crop and pasture lands and reduce livestock forage.

During the fall, winter, and early spring, large flocks of ducks and American coots migrate into California where they damage small grains and alfalfa. Most damage is from grazing on alfalfa or sprouting grain. In the fall, large flocks of ducks and American coots alighting in un-harvested rice fields trample and consume the crop.

Prior to the 1990s, ducks and geese had been reported to cause as much as $6 million to $10 million in damages to grains that are swathed and laid on the ground before harvesting. Most of this damage occurred in the Canadian Provinces and Dakotas. However, changes in harvesting techniques in the 1990s from swathing to straight- or stripper-cutting have greatly resolved the problem.

Migratory Canada geese, ducks, and American coots on their winter range have become acclimated to urban environments where they graze on domesticated grasses in parks, golf courses, highway rights-of-way, sport fields, and similar locations. Damage and economic costs at these locations varies by species, numbers, and concentrations, but can be substantial. For example, damage to putting greens by geese, ducks, or coots can cost thousands of dollars to repair or replace.

Human Health and Safety

Overabundant geese, ducks, and coots also can present human health and safety issues. A single Canada goose can defecate every 20 minutes, resulting in up to 1.5 pounds of feces per bird each day. This problem is magnified when one considers that populations of resident geese have increased dramatically to about 3.75 million in 2012. The accumulation of bird feces in reservoirs, at parks, on golf courses, or where people gather can present a health risk. Four hundred samples of feces collected over a 2-year period from Canada geese and ring-billed gulls (*Larus delawarensis*) contained significant numbers of fecal coliform bacteria (FC) per gram. The impact on the microbiological quality of the water is multiplied where hundreds or thousands of birds roost on the water surface, especially near intakes to aqueducts.

Geese, ducks, and coots present hazards to aircraft depending on the location, time of year, and habitat on or near airfields. In 1995 Canada geese caused one of the worst military bird strikes ever recorded when a E-3 AWACS aircraft struck a flock of geese on take-off at Elmendorf Air Force Base in Alaska, resulting in total destruction of the aircraft and the loss of all 24 crew members. In 2009, US Airways Flight 1549 taking off from John F. Kennedy International Airport ingested Canada geese at 3,000 feet above ground level, destroying both engines. Fortunately, the crew safely landed the airplane in the Hudson River and evacuated all passengers.

On November 8, 2000, a Saab 340 Turbo-prop plane landing at Aberdeen, South Dakota, flew through a flock of 200 snow geese at 600 feet above ground level. One goose hit the windscreen and dislodged the wiper arm, which then hit the propeller. The propeller then threw the wiper arm parts into the fuselage at three locations, causing more serious damage. One piece of the wiper arm came through the fuselage and embedded in the thigh of a passenger.

Damage Identification

Generally, goose, duck, and American coot damage to crops, vegetation and aircraft can be difficult to identify. Usually the damage to crops or vegetation shows signs of being clipped, torn, or stripped (Figures 3,4). Tracks, feces, or feathers found neat the damage can be used to help identify the species. Damage to aircraft is obvious if the bird is recovered, but if not, and only bird parts are recovered, a scientific analysis is required.

Figure 4. Damage to newly planted wheat by Canada geese.

Management Methods

Auditory Frightening Devices

Gas-Operated Cannons

Gas-operated cannons, generally referred to as propane cannons, are commonly used to disperse geese, waterfowl, and coots from a number of locations, including agricultural crops, wastewater ponds, and airfields (Figure 5). These devices produce loud (120-decibel [dB]), intermittent explosions at 1- to 30-minute intervals, and are effective on areas up to 120 acres. New versions emit up to three explosions in rapid succession and in various directions.

Figure 3. Goose, duck and coot damage to crops or vegetation typically involves plants being clipped, pulled and trampled. Feces left behind can carry noxious weed seeds.

Some units allow for remote activation. Although more expensive, these units reduce habituation because they are activated remotely by people only when birds are present. Propane cannons used to disperse waterbirds at Naval Air Station North Island and Naval Outlying Landing Field Imperial Beach, California, have worked when the cannons were moved every 2 to 3 days and supplemented with other hazing tools. The effectiveness of propane cannons to deter molting sea ducks, mostly long-tailed ducks (*Clangula hyemalis*), was tested in the Beaufort Sea. The cannon was mounted on a raft anchored in the center of an experimental plot and operated at a volume of approximately 120 dB, and at a firing interval of approximately 5 minutes. On the first day of operation, the scaring radius for sitting birds was 3,000 feet. The number of birds remaining within 3,000 feet of the cannon was less than 10% of the original number present. That scaring radius decreased to 1,800 feet by the second day and the density of birds increased. By the third day, the number of birds in the general area increased to a level higher than the average numbers present during control periods, indicating the effectiveness of the cannon significantly decreased.

In another study in coastal areas near Vancouver, British Columbia, a propane cannon was anchored on a raft in an intertidal zone, and another in a drifting boat in open water habitat. The propane cannons were usually set for one

Figure 5. Gas-operated cannons, generally referred to as propane cannons, are commonly used to disperse geese, waterfowl, and coots.

explosion every 20 to 25 minutes. The firing interval was decreased to one every 5 minutes. Explosions were approximately 125 dB at 600 feet from the source over water under optimum conditions. The raft-mounted propane cannon kept all waterfowl away up to a 600-foot radius. It was especially effective on mallards, pintails, teal, and widgeon.

The propane cannon also effectively dispersed waterfowl feeding at night, and it appeared that the effective range was at least the same at night as in daylight. The response distance to the propane cannon for the 31 species of waterbirds recorded varied from 30 to 750 feet. Habituation was observed in most of the major groups of waterbirds tested. Some bird species, such as the northern shoveler (*Anas clypeata*) and teal (*Anas spp.*) became tolerant to blasts after 4 hours of continuous firing. The estimated cost of a typical propane cannon such as the Zon Standard, single-fire propane cannon, is $240. The Zon Electra, a multiple-fire propane cannon, is $650.

The advantages of propane cannons are that they are portable, effective day or night, are inexpensive to operate, and are especially effective in deterring dabbling ducks and geese. Disadvantages are that they must be moved every 2 to 3 days to prevent habituation, regular maintenance is required, they have limited effectiveness on American coots, and the explosions may be a nuisance to nearby residents.

Pyrotechnics

Pyrotechnics include various devices fired from shotguns, starter pistols, and flare pistols, or specialized launchers (Figure 6). Pyrotechnics include banger/whistler cartridges, shell crackers, flares, firecrackers, cartouche anti peril aviaire (CAPA) cartridges, and rockets, that produce a loud blast or scream accompanied by smoke and a flash of light. The most common pyrotechnics used for bird dispersal are 15-millimeter (mm) bangers, 15-mm whistlers, 12-gauge shell crackers, and 18-mm CAPA cartridges. Pyrotechnics travel 75 to 900 feet before emitting a blast, flash, or bright light. Some emit a screaming or whistling sound during flight. The 15-mm bangers and whistlers have a range of approximately 150 to 200 feet. The 12-gauge shell crackers have a range of approximately 200 to 300 feet. The 18-mm CAPA cartridge has the greatest range, shooting an exploding rocket to a distance of 1,000 feet with a report of approximately 150 dB. Operators should wear eye and ear protection at all times. Pyrotechnics can be very useful in hazing birds in a variety of situations, when used in combination with other hazing techniques.

For safety reasons, only trained personnel should fire pyrotechnics. The launching device should be an open-choked, single-shot, 12-gauge shotgun (for shell crackers) or a pyrotechnics pistol (for bangers and whistlers) that

Figure 6. a) 15mm pistol, banger (red) and whistler (yellow) cartridges, (b) 18mm CAPA pistol and cartridge, (c) shotgun used to launch 12-guage shell crackers, (d) firing a pyrotechnic device.

allow for easy inspection of the barrel. Other safety precautions that should be taken in any program using pyrotechnics include the following:

- operators should wear eye and ear protection at all times
- check gun barrels for obstructions after each firing as shell crackers may misfire
- clean guns each day after use, as shell crackers are corrosive
- pyrotechnics must be fired from pyrotechnics pistols only
- take necessary fire precautions, as pyrotechnics can be a fire hazard
- do not fire pyrotechnics from inside a vehicle

If used correctly, pyrotechnics provide one of the most effective methods to disperse geese, waterfowl, and American coots from crops and open water. Pyrotechnics can effectively haze waterfowl at distances up to 3,000 feet. They are effective day or night and are relatively inexpensive. The disadvantages of pyrotechnics are they can be labor intensive, geese, waterfowl, or American coots may habituate to them, especially if they are used improperly (used too frequently). There is some degree of fire hazard associate with these devices when used during dry conditions, and they may be a nuisance to people living nearby.

Visual Frightening Devices

Visual dispersal techniques include hawk kites, hawk silhouettes, lights, eyespot balloons, flags, Mylar® reflective tape, effigies, scarecrows (human or predator), and lasers. Most of these devices are effective for a short period before birds become habituated to them because they learn that the devices pose no danger. Geese and waterfowl seem to respond to some of these devices more than others, especially during hunting seasons.

Flagging

White flags and black flags made from 30-inch x 60-inch garbage bags have been shown to significantly and effectively deter snow geese from agricultural fields. Flags are typically placed on 4-foot stakes at one flag per acre. Cost of each flag and stake is about $0.30.

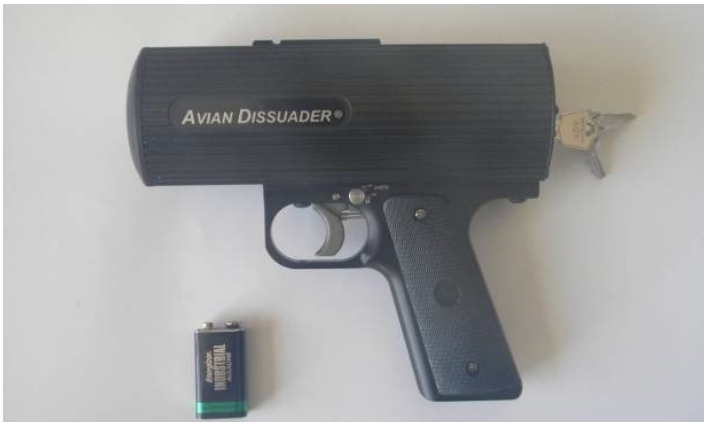

Figure 7. Avian Dissuader laser for dispersing birds.

Lasers

Lasers have shown promise for dispersing some waterfowl, geese, cormorants, and other waterbird species (Figure 7). Lasers are most effective before dawn or after dusk, when red or green beams are clearly visible. Bright sunlight will wash out a laser beam, rendering it ineffective, but the green beam is most visible in brighter situations. Although bird vision differs from that of humans, a laser beam is visible to some species and results in the birds dispersing. The effectiveness of low-powered lasers varies with the bird species and the context of the application, likely due to differences in eye structure among bird species.

The US Food and Drug Administration (FDA) regulates laser devices because of safety concerns due to radiation emissions and potential tissue damage. The FDA standard for unregulated lasers is generally less than 5.0 milliwatts (mW) of power. Lasers using more than 5.0 mW of power require a variance (permit) from FDA.

Canada goose numbers were successfully reduced by 85% at sites used consistently for foraging, loafing, and roosting. The reduction followed a 5-day treatment period where geese at each site were hazed for a 30-minute period each night. The Avian Dissuader red laser was used at night to disperse waterfowl (*Anatidae spp.*), herons

Figure 8. Coyote models or decoys are used to deter geese and other waterfowl.

(*Ardeidae spp.*), and egrets (*Ardeidae spp.*) from wetlands. Roosting flocks of waterfowl, herons, and egrets were dispersed to other areas after repeated hazing for less than 30 minutes. Monitoring on following nights indicated that none of the hazed species returned to their original roosting areas. The estimated cost of the Avian Dissuader is $1,400-$2,000 per unit. Advantages of the laser is that it can be used to disperse birds from long distances (effective up to 2,600 feet), is effective on most bird species, (especially waterfowl), is easy to operate, requires minimal training, and is considered safe when used properly. The disadvantages are that it is only effective at night and dusk, and not effective on all bird species.

Avian Systems Corporation (ASC) 7500 Rotating Laser System

The Avian Systems Corporation (ASC) 7500 Rotating Laser System is a stationary device that can be mounted on a stand on land or in water. The relatively compact unit can be transported easily to different locations. The unit has a drive system for a low-intensity laser beam that can be programmed to scan 360 degrees and also up or down, as needed. The laser beam also can be programmed to stop or reverse field, or be used in a random mode. The laser beam is either red or green, and approximately 3 inches in diameter. The operational distance for the beam is up to 1,500 feet. The unit can be set to operate at designated times, or a radar system can be integrated with the system, activating the laser when bird activity is detected. The system is powered by a 12-volt gel battery, but can be converted to solar power or a marine battery. The battery life depends on use; a marine battery operating at 12 hours per day could keep the system functioning for 4 to 5 days. The laser is considered non-harmful to humans.

The effectiveness of the ASC 7500 was tested on Canada geese at several nighttime roosting sites near small golf course water impoundments, using an on-off test design (ASC personal communication). After one night of laser operation, geese dispersed to other locations. After the unit was removed, geese reestablished within 48 hours. The unit was effective over a multiple-week test period. No habituation to the laser unit was observed. In another study conducted under a controlled situation in large pens, a motion-detection device activated the laser unit when geese entered the treated area. The unit reduced Canada goose use of a treated roosting area by 83% to 92% during 20 nights of operation.

The ASC 7500 was evaluated on a 320-acre pond. The system was effective in flushing and moving dabbling ducks at approximately 1,000 feet, but had no effect at longer distances. There was no effect on diving ducks, such as coots, at ranges over 100 feet (J. Cummings, unpublished data).

The estimated cost of the ASC 7500 system without radar is $5,000-$7,000 per unit. This system uses low power, rotates, and can disperse birds at long distances. It uses either red or green lasers, which increases its effectiveness, especially on waterfowl. The beam is 3 inches in diameter. The disadvantages are that the system is expensive and effective only at night. It is not effective on all birds, such as diving ducks, and there could be power issues when operating for prolonged periods.

Coyote Predator Models

Coyote models (Figure 8) have successfully deterred geese, waterfowl, and coots from using agriculture crops and areas on airfields. The more realistic the coyote predator model, the more effective it is in dispersing birds. As for any device, habitation can occur, so moving the

coyote predator model will extend its effectiveness. These devices are relatively inexpensive, about $100 per model, and associated labor costs are low. Coyote models sometimes attract rather than repel birds, a potential issue especially on airfields.

Auditory-Visual Frightening Devices

Radio-Controlled Model Aircraft, Helicopters and Boats

Radio-controlled model aircraft, helicopters, and boats provide both visual and auditory cues, and have shown varying degrees of success. The effectiveness of radio-controlled devices depends on the level of operator experience.

Radio-controlled boats combine two key features for hazing birds: a visual and auditory (engine noise) stimulus. Radio-controlled boats require little experience to operate and can cover the area within 1,000 feet of the operator, or about 35 acres. These boats have been shown to successfully haze waterfowl from ponds and lakes.

Gas-powered, radio-controlled helicopters were used successfully at the Reno Airport to move Canada geese. Geese did not habituate to the helicopter, and in most cases, dispersed upon the start of the engine. Operators of these devices should ensure that the radio frequencies are compatible with other electronics in the area. The estimated cost is about $1,000 per unit, including peripherals.

When properly equipped, these devices are an inexpensive way to disperse a wide range of species at long distances with precision. They can be used during the day or night. Some skill is required to operate and maintain the devices.

Dogs

Using dogs to harass geese from an area has become a popular and successful method. Highly trained border collies generally are used but just about any athletic, medium-large dog capable of obeying commands can be effective in hazing geese, waterfowl, and coots. Control of the dog is vital because dogs used in this manner are legally considered an extension of your hand and must not be allowed to catch, injure, or kill Canada geese, waterfowl, or coots.

Typically, a handler and a dog will enter an area occupied by unwanted geese, waterfowl, or coots. On command, the dog is allowed to chase after the birds. Generally, birds will seek refuge from the dog in a nearby body of water. If this is the case, let the dog enter the water. To make this method more effective, use a boat or pyrotechnics to further harass the birds. Harassment should continue and be repeated until the birds leave the area permanently.

Consult with the U.S. Fish and Wildlife Service (USFWS), state, and local agencies regarding authorization and permits for use of dogs to haze geese, waterfowl and coots.

Repellents

Anthraquinone and methyl anthranilate are two chemical compounds registered as bird repellents with the U.S. Environmental Protection Agency (EPA). These compounds are sold under several product names for use in various agriculture, airfield, and urban situations.

Anthraquinone (AQ) is a naturally-occurring compound found in many plant species, and was first patented in 1944 as a bird repellent. The mechanism of repellency for AQ is not well understood. Ingestion of AQ-treated food by birds can produce vomiting, presumably through irritation of the gut lining.

Two AQ products, Flight Control Plus® and Avipel® are registered with EPA. Flight Control Plus can be used in all states except California. It is generally applied on turf or grass areas used by geese, specifically Canada geese. It cannot be used on food crops. Avipel has two product labels, one for use as a goose repellent similar to Flight Control Plus® and the other as a product designed to protect newly-planted seed from birds.

Methyl anthranilate is a compound derived from concord grapes, approved for human consumption by the FDA, and has been found to be offensive to birds. It produces a negative response in most birds by affecting the trigeminal receptors in the mouth.

Several methyl anthranilate products are registered with EPA as bird repellents for geese, waterfowl, and coots. Products include Rejex-it Migrate®, Rejex-it Fog Force® (TP -40), Liquid Fence Goose Repellent®, and Bird Shield®. The mode of action is similar among products, but formulations, concentrations, and application rates vary.

Repellents can be costly, due to the large quantities needed to be effective, and the need to reapply after periods of precipitation. Frequent reapplication on crops and/or turf-grass areas is necessary to ensure adequate coverage during the growing season, especially in turf areas where the turf is mowed. Cost for Rejex-it Migrate is approximately $600 per acre, Flight Control Plus is approximately $200 per acre, and Avipel is approximately $10 per acre of treated seed.

Nest Removal and Treatment

Nest removal and treatment of eggs generally is authorized by USFWS for resident or non-migratory Canada geese through a permit. Consult with the USFWS regarding authorization and permits for special situations concerning migratory geese, waterfowl, and coots.

Nest treatment usually involves manipulating eggs so they do not develop. Methods include addling (shaking), oiling with corn oil (Figure 9), puncturing, chilling, and replacing eggs. Returning treated eggs to the nest encourages adult birds to remain on the nest beyond the expected hatching date, which reduces or prevents the potential for re-nesting.

Fertility Control

None is available.

Toxicants

None are available.

Trapping and Relocation

Trapping and relocation generally is authorized by permit from the USFWS for resident or non-migratory Canada geese, waterfowl, and coots. Consult with the USFWS regarding authorization and permits for special situation concerning migratory geese, waterfowl and coots.

Shooting

Hunting is the primary method for managing Canada goose, waterfowl, and coot populations. Hunting can have an area-deterrent effect on these species, but hunters are restricted to established bag limits. Shooting permits outside of regulated hunting seasons may often be obtained by USFWS for migratory, resident or non-migratory Canada geese, waterfowl, and coots. This method can solve very localized problems.

Habitat Modification

Ponds, lakes and sloughs adjacent to agricultural areas and airfields can attract large numbers of geese, waterfowl, and coots for foraging, nesting, loafing, and resting. Changing the adjacent habitat at these sites can help to reduce bird use. However, these species are very adaptable and habitat changes in a rural setting can be environmentally challenging. Federal and state laws govern draining or channelizing wetlands, ponds, or lakes and introducing less attractive vegetation might not be compatible with current water and farming practices or airfield maintenance.

Habitat modification is better suited for suburban and urban areas such as parks, golf courses, residential areas, and airports. Consider the following when modifying habitat for geese, waterfowl, and coots.

- Install vertical, sight-limiting components, such as trees, shrubs, or aquatic vegetation (cattails). This can disrupt an unobstructed line of sight and help deter them from grazing or walking readily from the water source.
- Limit and reduce the palatability of adjacent habitat by avoiding planting preferred foods such as succulent grasses.
- Maintain grass height at 8 or more inches.
- Plant water lilies or other non-invasive emergent

aquatic vegetation to prevent waterfowl movement and use on the pond or lakes.

- In colder climates, turn off water aerators in ponds, and allow the water to freeze.
- In some cases, plant a lure crop to attract birds away from where they are not wanted.
- Remove and modify nest sites such as platforms, structures, and other waterfowl nest supports.

Cultural Control

Waterfowl damage to agricultural crops typically occurs during spring planting and fall harvest. A small number of geese, waterfowl, or coots can cause damage during post-planting periods to a variety of crops, such as corn, soybeans, and small grains. In rice crops, laser-leveled fields require less water height for planting, making fields less attractive. Delaying planting until after most migratory birds have departed the area can reduce damage. Historically, geese and waterfowl have caused severe damage to swath grains, although advances in breeding programs for cereal crops now allow most grain crops to be straight-combined, alleviating swathing. Where swathing and migratory waterfowl overlap, birds will cause damage through direct consumption, contamination by feces, and trampling swaths. Waterfowl trample as much as five times more grain than they consume. One Canadian researcher estimated Canadian prairie-wide losses of $6 to $10 million annually, mainly from waterfowl.

Figure 9. Oiling goose eggs with corn oil prevents them from developing and reduces the potential for re-nesting.

Diversionary feeding with lure or decoy crops has proven successful for controlling crop depredations. Two approaches can be used: (1) grow or purchase lure crops where geese, waterfowl, or coots can feed unmolested and away from other commercial crops, or (2) use bait stations or field baiting for the same purpose. These programs have been used on and near wildlife refuges and waterfowl management areas that provide protection, food, water, and cover; and help to keep birds onsite while crops are susceptible to damage.

Currently, one of the most common methods to reduce use of airfields by geese, waterfowl, and coots is to maintain vegetation height at 7 to 14 inches. Long grass restricts the line of sight for birds, making them vulnerable and nervous about unseen predators. In some cases, however, long-grass management attracts other granivorous birds that may move onto runways. An alternative approach is to establish less preferred vegetation that is unpalatable to geese, waterfowl, and coots and has minimal seed production. In addition to requiring little maintenance, the vegetation also should be relatively non-flammable, drought resistant, unattractive to invertebrates and rodents, and exclude the establishment of other plants.

Structural Modification

Discourage geese, waterfowl, and coots from using existing ponds by straightening the banks vertically up to 30 inches. Placing large boulders or rip-rap along the edge of a pond makes it more difficult, but not impossible for these birds to enter and exit the water.

Exclusion

Fencing

Barrier and energized fencing can help keep geese, waterfowl, and coots out of agriculture crops and areas on airfields where they have walking access, especially during the molting season. Construct barrier fences from woven wire, poultry wire, plastic snow fence, chain link, netting, pickets, or strands of wires. To be effective in these situations, barrier fences should be at least 30 inches high and made of durable material with openings no larger than 2 to 3 inches.

Energized fences with triple-strand wires strung 3, 10, and 15 inches above the ground with minimal amperage will exclude birds without harming them. Components of an energized triple-strand fence are (1) an energizer, either battery powered or 120 volts (low impedance energizers which deliver a short electrical pulse of at least 4,000 volts once every second are safe and effective); (2) either ½-inch wide polyethylene fibers interwoven with conductive wires, or 17-gauge electric fence conductive wire; and (3) a grounding system composed of a series of 6-foot galvanized-steel rods driven into the earth at 12-foot intervals for the length of the protected area. The rods are connected in series with the wire, which is connected to the ground terminal on the energizer.

Geese, waterfowl, or coots that touch an energized fence receive an uncomfortable but harmless shock that they learn to avoid.

Nets

Nets are not economical for most agricultural crops where geese, waterfowl, or coots are involved, but can be used to cover ponds on airfields.

Netting is available in a variety of materials (nylon, polyethylene, polypropylene), mesh sizes (0.5-inch to 10-inch), and dimensions. Nets should be resistant to ultraviolet (UV) light or coated to make them UV-resistant. With all factors being equal, nylon is the strongest material, followed by polyethylene and polypropylene.

Netting is ideal for covering small ponds (e.g., 150 feet by 200 feet) but also can be used on larger areas if the support structure and weather conditions allow. The type of external structure needed depends on the netting material; mesh size; twine size; geographic location; and wind, ice, and snow loads. Steel anchor poles for the netting around a pond perimeter must be at least 5 feet high so netting will not sag into the pond. Support cables also help alleviate net sag. Inspect netting periodically for rips, tears, or evidence of contact with the pond, especially after heavy precipitation events.

In areas with high wind or ice and snow loading, small-diameter twine and large mesh size netting reduces accumulation of ice and snow. Depending on the wildlife species present, lightweight polypropylene-knitted netting can be used successfully in arid regions. The estimated cost of the material is approximately $0.06 to $0.16 per square foot depending on the type, mesh size, and twine size.

If netting is properly installed, it provides 100% exclusion. With a proper support system, netting can cover a large area. It is lightweight and durable for up to 10 years. However, it is expensive, labor-intensive to install, vulnerable to high winds, and birds can become tangled in netting that is not properly maintained.

Wire Grid System

These systems (Figure 10) are composed of multiple parallel lines of steel, Kevlar, or stainless-steel wire

Figure 10. Wire grid systems are composed of multiple parallel lines of wire stretched above the surface of the water to prevent birds from landing.

stretched 1 to 2 feet above the surface of the water to prevent birds from landing. Wire grid systems do not present an actual physical barrier, but are designed to interfere with birds' flight patterns.

UV-resistant lines, ranging in thickness from 10-to 28-gauge, and constructed as a grid with 10-foot spacing, will deter most birds. Generally, large birds are more challenged by wire grid systems than small birds. If access to the pond is needed, the grid can be elevated to accommodate vehicles or boats. Kevlar wire has several advantages over steel, galvanized-steel, or stainless-steel wires. Kevlar is stronger at smaller diameters, will not sag over long distances, and is lightweight. Monofilament line is not as durable or resistant to UV radiation, is more prone to sagging, and requires constant maintenance.

Floating Membrane Covers

Floating membrane covers set on the surface of the water and rise and fall with changing water levels. Covers are made of high-density polyethylene (HDPE) combined with baffle floats and anchored to the perimeter of impoundments. Floating membrane covers are considered semi-permanent, creating limited access unless the cover is removed. The covers also reduce evaporation by 95%. Estimated cost of materials is approximately $1.75 per square foot, with an installation charge of $1.10 per square foot. It has similar advantages and disadvantages as netting.

Plastic Balls or Spheres

Plastic balls or spheres approximately 4 inches in diameter can be placed in water impoundments to fully cover the water surface. It is believed that birds do not recognize the sphere-covered area as a water body. The density of the balls also prevents access to the water surface. The spheres are effective for water impoundments with fluctuating levels (e.g., from rain or snow) because they rise and fall with the water level. A sufficient quantity of spheres must be used to cover the water impoundment, taking into account any increase in surface area from rising water levels. This method is expensive, but is easy to install and virtually maintenance free. For areas with winds greater than 45 mph, heavier water-filled floating balls have proven effective. The estimated cost is $2.45 per square foot for unweighted balls and $3.45 per square foot for weighted balls. The balls automatically adjust to fluctuating water levels and reduce evaporation.

Economics

Migratory Canada geese, snow geese, waterfowl, and American coots are responsible for significant damage to agricultural crops and aircraft.

Crop Damage

While damage to crops by geese, waterfowl, and coots has been difficult to quantify, surveys of agricultural producers indicate that it may be severe in some areas, resulting in substantial economic losses. One study reported $6 to 10 million in annual damage to swath grains by ducks and geese in Canadian provinces. Damage probably is similar in the northern Great Plains, but the economic impact has not been well documented. Goose damage to sprouting soybeans and corn represented less than 2% and 3% of the damage reported by farmers on a questionnaire in Indiana. In another case, damage by Canada geese to commercial crops surrounding Horicon National Wildlife

Refuge in Wisconsin over an 8-year period during the 1950s averaged $10,000 annually. When waterfowl populations in California were at peak numbers in the 1960s, damage to rice was estimated at $1 million annually. South Dakota Game, Fish and Parks instituted a program in 1996 to reduce crop damage (mainly soybeans) caused by Canada geese. More recent economic loss figures for geese, waterfowl and coots to agriculture crops are not available mainly because of the logistics involved to collecting the data. However, in 2012, farmers in California and Louisiana rice-producing areas reported 80 to 100% loss in some newly planted fields due to waterfowl and coots.

In Oregon's Willamette Valley, wintering Canada geese cause extensive damage to winter wheat and rye grass. An Oregon State University study showed that goose damage reduced yields by 25%, and a survey of Oregon Farm Bureau members in 2010 described goose damage totaling $1.5 million. Individual crop seed producers report losses of $171,000. In addition, the Oregon Department of Fish and Wildlife distributed over $212,000 in 2011 to 2012 to producers to allow goose hunting on their farms.

Breeding snow geese cause extensive destruction of Arctic habitat. Large numbers of migrating snow geese exert tremendous grazing pressure on exposed agricultural crops in early spring, contributing significantly to economic losses.

Aviation Hazards

Canada geese, snow geese, waterfowl, and American coots have been implicated in 4,338 strikes with aircraft between 1990 and 2013, resulting in millions of dollars in damage, loss of life, down plane time, and delayed flights.

Ducks have caused over $100 million in damage to aircraft. Northern mallard strikes alone accounted for over $5 million in damage and 528 strikes during 1990-2009.

Species Overview

Identification

The Canada goose (*Branta canadensis*, Figure 1), family Anatidae, has a black head and neck, white patches on the face, and a brownish-gray body. It exhibits marked morphological variation, perhaps the most extreme intraspecific variation in body size among birds, with some subspecies among the largest and other subspecies among the smallest of all geese.

The snow goose (*Chen caerulescens*, Figure 2), family Anatidae, has two color plumage morphs, white ("snows") and gray/blue ("blues"). Growing populations of blues in midcontinent breeding and wintering populations have adversely affected their own habitat, that of other wildlife species, the economic interests of agriculture producers, and human safety.

Ducks is a general term used for several species within the family Anatidae (Figure 11). They sometimes cause localized damage to agricultural crops. These include mallards (*Anas platyrhynchos*), northern pintails (*A. acuta*), and black-bellied whistling duck (*Dendrocygna*

Figure 11. Mallard (*Anas platyrhnchos).*

Figure 12. American coot (*Fulica americana*).

autumnalis]). Commercial aquaculture interests, such clam beds, are impacted by surf scoter (*Melanitta perspicillata*), while urban parks and golf courses are damaged by American wigeon (*A. americana*).

The American coot (*Fulica americana,* Figure 12) has a slate-colored body, blackish head and neck, a small reddish-brown forehead shield, and a whitish bill with dark band near the tip. It is commonly mistaken to be a duck, but is classified in a distinct family, Rallidae. They are mainly responsible for damage to water-grown crops, such as rice, but also can cause significant damage to grass at parks and golf courses.

Physical Description

Canada goose size varies considerably among subspecies, from the largest goose (*Branta canadensis maxima*) in the South, to one of the smallest (*B. c. minima*) in the North. Body measurements include: mass 9 to 20 pounds, overall length 21 to 43 inches, folded wing 13 to 21 inches, and bill length 1 to 2 inches. Plumage coloration between subspecies varies with palest birds in the East, to darkest birds in the West. Sexes are alike, although males are slightly larger. There is no seasonal variation in size or plumage.

Snow geese are divided into two subspecies based on size and geography. The smaller subspecies, the lesser snow goose (*Chen c. caerulescens*) lives from central northern Canada to the Bering Straits. The lesser snow goose stands 25 to 31 inches tall and weighs 4.5 to 6.0 pounds. The larger subspecies, the greater snow goose (*Chen c. atlanticus*), nests in northeastern Canada. It averages about 7.1 pounds and 31 inches, but can weigh up to 9.9 pounds. The wingspan for both subspecies ranges from 53 to 65 inches. Blue-morph birds are rare among the greater snow geese, and among eastern populations of the lesser snow geese. The adult white morph is completely white except for gray primary-coverts and black primaries. Occasionally rusty-orange staining on head and upper neck is associated with feeding in mud containing iron oxides. Feet and legs are dark pink; the bill is rose-pink with a pale pink or white nail.

A North America bird identification guide will contain descriptions of mallards, northern pintails, American widgeons, black-bellied whistling ducks, black and surf scoters, and other ducks that are implicated in damage.

The American coot measures 13–17 inches in length and has a wing-span of 23–28 inches. Adults have a short, thick, white bill and white frontal shield, which usually has a reddish-brown spot near the top of the bill between the eyes. Males and females look alike, but females are smaller. Body mass of females ranges from 1 to 1.4 pounds and males from 1.3 to 1.9 pounds. Juvenile birds have olive-brown crowns and a gray body. They become adult-colored around 4 months of age.

Range

Canada geese breed in pairs or in localized groups over a wide range of habitats throughout north temperate, subarctic, and arctic regions of North America. Breeding was originally thought to be restricted to areas north of 35°N and south of about 70°N, but because of introductions and translocations, Canada geese now nest in every Canadian province and all 48 continental states in the U.S. Winter range extends from southeast Alaska to Mexico and from California to Florida. Winter distribution has shifted northward in the past several decades in about

half of North America's management populations. These shifts have been attributed to availability of waste grains during late fall and winter, hunting pressure, social ties, and weather. For example in the Central Flyway, Canada geese, which once wintered in the thousands in southern Colorado, now spend their winters primarily in northern Colorado's agricultural areas.

Snow geese are divided into three populations (western, mid-continent, and eastern) that breed in colonies of various sizes north of the tree line from north Alaska east along the arctic coast and islands of arctic Canada to northeast Ellesmere Island, Nunavut Territory, and south to Southampton Island and along both coasts of Hudson Bay to mid-James Bay. Winter range for most populations is south of an east/west line across the U.S., with mega-populations wintering in Texas and Louisiana. The northward shift of snow geese wintering areas is attributed to factors similar to those for Canada geese.

The primary North American breeding ground for ducks is the Prairie Pothole Region of Alberta, Saskatchewan, Manitoba, Montana, North and South Dakota, and Minnesota. The Prairie Pothole Region is the core of what was once the largest expanse of grassland in the world, the Great Plains of North America. The potholes are rich in plant and aquatic life, and support globally significant populations of breeding waterfowl. Most ducks spend the winter south of east/west line across the U.S., with concentrations in the Missouri, Arkansas, Louisiana and southern California.

American coots breed over a wide range, from southern Quebec to the Pacific coast and south into northern South America. They often are year-round residents where water remains open in the winter. The number of birds that remain year-round near the northern limit of the species' range seems to be increasing. *(See Appendix 2 for range maps)*

Sign

Web-footed birds such as geese and ducks generally leave only a web and three-toe print in soft surfaces. Geese tracks vary in size from 3 to 5 inches long, whereas duck and coot tracks are usually from 1 to 3 inches long. All tracks have a fan shape when viewed on a mud surface. Coots do not have webbed feet like those of ducks. Instead, each one of the coot's long toes has broad lobes of skin that help it kick through the water (Figure 13). The broad lobes fold back each time the bird lifts its foot, so they do not impede walking on dry land, although they support the bird's weight on mucky ground. Feces from geese, ducks, and coots ranges from 1 to 3 inches long, are straight and slightly curved, and vary in color from dark brown to light green.

Figure 13. American coot's long toes have broad lobes of skin that help it kick through the water.

Voice and Sounds

The repertoire of Canada geese calls includes honking, "hucka," snore, and cackle. Canada geese are noted for honking in flight.

Snow geese probably are the noisiest of all waterfowl. Primary vocalization is a loud nasal monosyllabic "whouk" or "kouk" uttered by both sexes from about 1 year of age.

Most duck species quack, however they make a variety of other sounds. Northern pintails make wheezy mewing notes. Black-bellied whistling ducks make a high-pitched, soft wheezy whistle of 4 to 6 notes, accented on second or third syllable. American wigeons make a high whistle that resembles a squeaky toy. Black scoters make a whistling noise with their wings during flight. Males give clear whistle in courtship. Females give a grating "kraaa."

American coots make a variety of grunting, croaking, and squawking noises; the most common is a short single-noted “krrp” or “prik.”

Reproduction

Canada geese are monogamous, with life-long pair bonds usually formed during the second year. Depending on the location, eggs are laid in ground nests from March to June. Renesting occurs at lower latitudes in the event of nest/clutch loss. Clutch size varies by subspecies, location, and year. A clutch usually has 2 to 8 eggs, with each egg laid at 30- to 40-hour intervals. Only the female incubates the eggs, and it ranges from 25 to 27 days after the last egg is laid. Eggs hatch at about the same time (relatively synchronously). Goslings are precocial and leave the nest site within 24 hours, by which time they can walk, swim, feed, and dive. Offspring remain with their parents throughout the first year of life, traveling together in large flocks of family groups.

Snow geese are monogamous. Individuals in mixed populations of snows and blues breed by choosing mates according to the color morph of the family in which they were raised. Snow geese nest on the ground. Egg laying starts on the breeding grounds soon after the snow melts, generally in May to June. Incubation is by the female only. The clutch of 2 to 6 eggs hatches within an average of 23 days. Goslings are precocial and have an exceptionally high growth rate. At 35 days of age, a few days before they can fly, the average weight is 2.9 pounds (1.3 kg) for males and 2.6 pounds (1.2 kg) for females, which is about 60-65% of their adult weight. Young accompany parents throughout the first winter. Families break up upon returning to the breeding area.

Ducks are monogamous. Depending on the location and species, most nest on the ground in upland habitat from April to July. Clutch size is from 2 to 8 eggs, and incubation from 23 to 31 days. Females provide parental care for varying lengths of time depending on the species. For example, mallard family groups stay together for about 60 days, whereas black scoter chicks are on their own after 21 days.

American coots are monogamous. Nests almost always are built on floating platforms over water, and almost always are associated with dense stands of living or dead vegetation such as reeds (*Poaceae spp.*), cattails (*Typhaceae spp.*), bulrushes (*Typhaceae spp.*), sedges (*Cyperaceae spp.*), and grasses (*Poaceae spp.*). Nesting is usually during March to June depending on location. Early season nests contain an average of 9 eggs per clutch while late clutches contain an average of 6.4 eggs per clutch. American coots are persistent re-nesters that will replace lost clutches within 2 days of clutch-loss during deposition. One study showed that 68% of destroyed clutches were eventually replaced. Replacement clutches typically are 1 to 2 eggs smaller than original clutches. Both sexes incubate eggs, which take about 21 days to hatch. Chicks are precocial and independent within 60 days.

Mortality

Canada goose annual survival rates for adults vary from 46% for *B. c. moffitti* to as high as 90% for *B. c. hutchinsii*. Pre-fledging is a high mortality period, estimated 28-49%. In environments with few predators, gosling survival was 82% and 76% in Connecticut. Hunting followed by predation were the main causes of mortality.

The annual survival rate for adult snow geese during 1970 and 1987 was 78 to 88%; in the 1990s was 94%, and during 2003-2006 was 96% for the midcontinent population. Natural mortality of the midcontinent population was estimated at 5 to 10% annually. Hunter-kill was 15% annually in 1970, but declined to 3-5% in the 1990s. Survival of goslings to 1 year is about 40%. Most mortality was attributed to hunting. Red and arctic foxes (*Vulpes vulpes* and *V. lagopus*) were main predator on breeding grounds.

Mortality rates for adult female dabbling ducks during the breeding season are often as high as 40%. This probably is a major cause of different sex ratios common among duck species. Clutch mortality rates for most ducks were generally greater than 50% and, in some major waterfowl-producing areas, commonly average greater than 80%. Estimated mortality rates for ducks is over 50%. Most mortality occurred during the first 2 weeks after hatching.

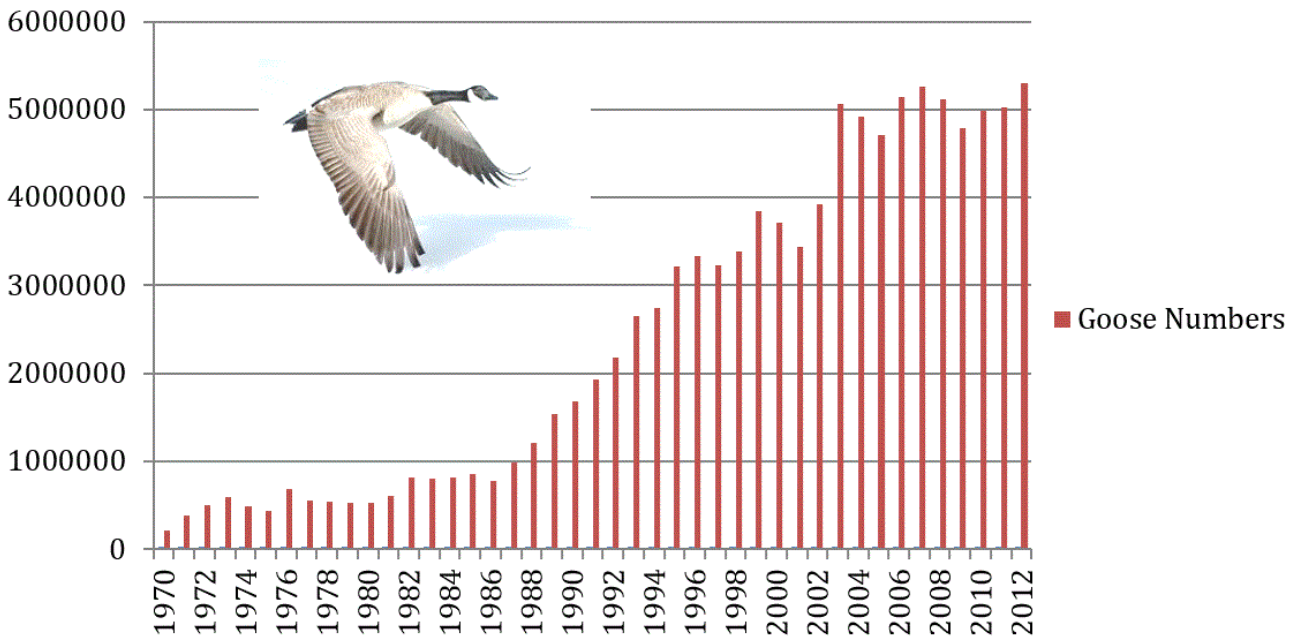

Figure 14. Canada goose population estimates from 1970-2012.

Duck mortalities were attributed mainly to ground predators.

The mortality rate for American coot adults was 51% annually, 56% for juveniles, and 55% overall. Avian predators such as great horned owls (*Bubo virginianus*), bald eagles (*Haliaeetus leucocephalus*), and northern harriers (*Circus cyaneus*) prey on adults and juveniles. American crows (*Corvus brachyrhynchos*) and black-billed magpies (*Pica hudsonia*) prey on eggs.

Population Status

In the early 1900s, Canada geese were nearly eliminated in most parts of their range by unrestricted harvesting of eggs, commercial hunting, and drainage of wetlands. Through management efforts, goose populations have rebounded to record numbers (Fig. 14) and are now frequently implicated in habitat destruction, crop depredation, bird-aircraft collisions, water contamination, and nuisance problems.

Breeding populations of most temperate-nesting Canada geese were at or near record highs in 2012. Winter counts for 15 goose populations also increased, from 5.38 million in 2002 to 5.64 million in 2012. The overall population is increasing, mostly because of a 15.6-fold increase in the population of resident geese (from 0.25 to 3.85 million), especially during the 1990s, when the population increased at a mean annual rate of 12.7%. From 2000 to 2012, the resident population stabilized, fluctuating between 3.36 and 3.85 million birds.

Winter populations of snow geese increased from 3.43 million birds in 2002 to 5.23 million birds in 2012. The midcontinent population showed the greatest growth (65%) during this period.

The breeding populations of 10 species of duck increased from 31.1 million in 2002 to 48.5 million in 2012. The populations of individual species fluctuated during this period.

Habitat

Canada geese use a broad range of habitats during breeding, including treeless and forested areas, prairies and parklands, flats, featureless arctic coastal plains and high mountain meadows, a variety of managed refuges, and areas of human habitation. Nests are usually in areas with a clear view in all directions and nearby permanent

water. Brood and molting habitat includes ponds, rivers, lakes, and sloughs where forage is abundant. Spring, migration, and winter habitats are similar to those above, but include agriculture areas for foraging.

Snow geese are similar to Canada geese but breed in colonies in subarctic and arctic tundra. Spring, migration, and winter habitat use is similar to Canada geese, and also includes agriculture areas for foraging.

The most important breeding habitat for ducks is the Prairie Pothole Region of the U.S. and Canada. Dotted with millions of shallow wetlands, the area encompasses more than 250,000 square miles, and supports more than 50% of the continent's ducks in most years. In some portions of the region, potholes and their associated prairie uplands support over 100 breeding pairs of ducks per square mile. Post-breeding ducks depend on open water sources for foraging, loafing and roosting. Most dabbling ducks forage in agriculture areas during winter and spring migration.

American coots breed in a wide variety of freshwater wetlands. Two features generally characterize all bodies of water where coots breed: a heavy stand of emergent aquatic vegetation along at least some portion of the shoreline, and at least some standing water within the vegetation. In some locations, wintering American coots make extensive use of parks, golf courses, and agriculture fields, especially if these areas are flooded or are adjacent to wetlands. Most American coots migrate from breeding areas to large lakes to molt. In wintering areas, coots use a variety of wetlands.

Behavior

Canada geese, snow geese, ducks, and American coots are well adapted to both terrestrial and aquatic habitats. All are considered herbivores, but also consume aquatic organisms, insects, and agriculture grains. All are most active during daylight hours, but activity varies with seasonal changes. During migration, geese and ducks forage, loaf and roost in open agriculture fields throughout the day and night. American coots generally migrate at night and forage during the day.

During breeding, all except ducks are highly territorial and very aggressive toward intruders such as avian and ground predators and humans. Ducks rely on cryptic coloring and seclusion to elude predators. Outside the breeding period, all tend to avoid predators and humans, especially during hunting seasons.

Food Habits

The diets of Canada geese, snow geese, and ducks consist of a wide variety of plant species and plant parts, including sprouting agricultural crops such as wheat, corn, and rice. Depending on the season and location, diets can be exclusive to native plants, whereas during migration and on wintering areas, agricultural grains represent a high percentage of the diet.

American coots forage mainly on aquatic vegetation and organisms. In one study, plant material comprised 89% of the stomach contents of 777 adult and 15 juvenile American coots.

Legal Status

Canada geese, snow geese, ducks, and American coots are federally protected by the Migratory Bird Treaty Act (MBTA), which stipulates that, unless permitted by regulation, it is unlawful to “pursue, hunt, take, capture, kill, possess, sell, barter, purchase, ship, export, or import any migratory birds alive or dead, or any part, nests, eggs, or products thereof.” Penalties may include fines up to $15,000 per person or organization, and up to 6 months imprisonment. The MBTA does not have an "incidental take" provision.

A migratory bird nest is defined as any readily identifiable structure built, maintained, or occupied for incubating and rearing of offspring for protected species. Only active nests that contain eggs or young are protected.

Generally, geese, ducks, and coots can be hazed without a federal permit in order to prevent damage to agriculture crops and property with a variety of scare techniques. In most cases, live ammunition cannot be used.

A migratory bird depredation permit to take migratory birds causing crop damage, and/or safety and health concerns can be obtained from the USFWS. When depredation problems occur, check with federal, state, and local government agencies for current laws and regulations concerning depredating federally protected birds, and local ordinances for the discharge of hazing devices. The USFWS has issued a number of federal migratory bird depredation permits for taking geese, ducks and coots in different situations.

Acknowledgements

Figure 1. Photo by U.S. Fish and Wildlife Service
Figure 2. Photo by Dave Menke, U.S. Fish and Wildlife Service
Figure 3. Photo by John Cummings, USDA-APHIS-WS
Figure 4. Photo by John Cummings, USDA-APHIS-WS
Figure 5. Photo by John Cummings, USDA-APHIS-WS
Figure 6. Photos by Paul Gorenzel, University of California-Davis
Figure 7. Photo by John Cummings, USDA-APHIS-WS
Figure 8. Photo by National Institutes of Health
Figure 9. Photo by USDA-APHIS
Figure 10. Photo by Tom Seamans, USDA-APHIS-WS
Figure 11. Photo by Cameron Rognan, The Cornell Lab of Ornithology website
Figure 12. Photo by Greg Bishop, The Cornell Lab of Ornithology website
Figures 13. Photo by Ohio Department of Natural Resources website
Figures 14. Graphic by Richard Dolbeer, USDA-APHIS-WS

Glossary

Granivorous: Seed-eating

Molt: To shed old feathers to make way for new growth; molting renders waterfowl flightless until new feathers grow in

Pyrotechnics: Flares or cartridges fired from a gun or launcher that produce a loud blast or scream accompanied by smoke and a flash of light.

Key Words

American coot, bird aircraft strikes, Canada goose, control techniques, crops, damage, economic damage, mallard, management, rice, rye grass, snow goose, soybeans, wigeon, and winter wheat.

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.

Mention of any products, trademarks, or brand names does not constitute endorsement, nor does omission constitute criticism.

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Appendix 1

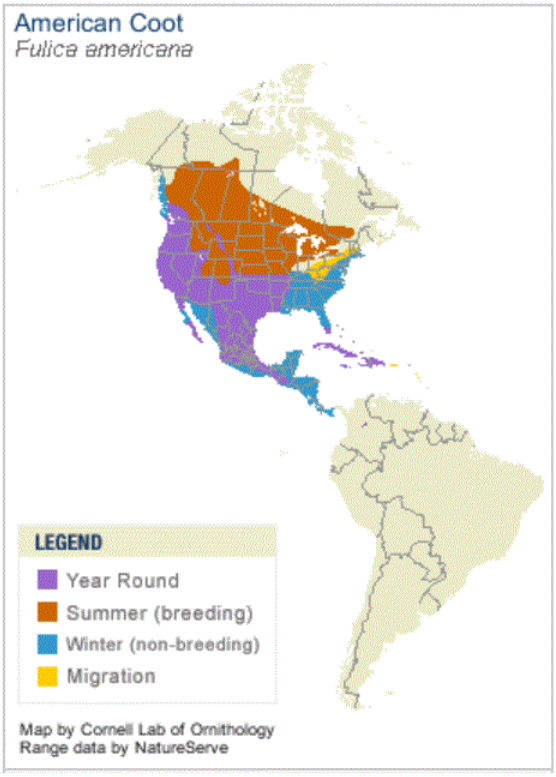
Damage Management Methods for Geese, Ducks and Coots

Type of Control	Available Management Options
Exclusion	• Fences • Netting • Wire grids • Floating membrane covers, and plastic balls or spheres
Fertility Control	None registered
Frightening Devices	• Propane cannons • Pyrotechnics • Flagging • Lasers • Radio-controlled aircraft; helicopters and boats • Trained dogs
Habitat Modification	• Change pond configurations, water depth, bank slope, and /or pond vegetation • Limit or reduce availability or palatability of food in adjacent habitat • Increase visual barriers around ponds • Plant lure crops or vegetation, adjust planting time, or manage vegetation heights
Repellents	• Anthraquinone (Flight Control® PLUS and Avipel®) • Methyl anthranilate (Rejex-it® Migrate™, rejex-it Fog Force™, Liquid Fence Goose Repellent, and Bird Shield®)
Shooting	During the hunting season or for resident or non-migratory Canada geese, waterfowl, and coots at other times of the year
Toxicants	None registered
Trapping	U.S. Fish and Wildlife Service permit required to trap resident Canada geese, waterfowl, and coots

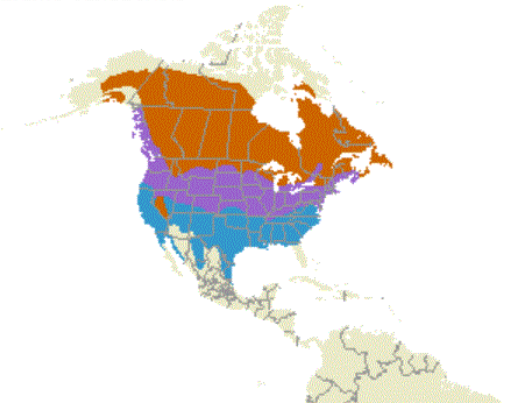
Appendix 2

Range Maps for Common Waterfowl. *Map by Cornell Lab of Ornithology. Data by NatureServe.*

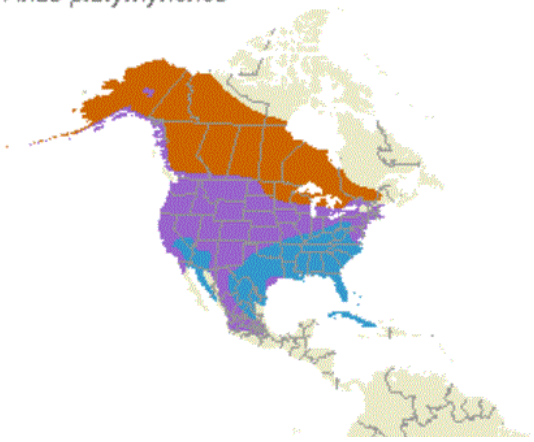
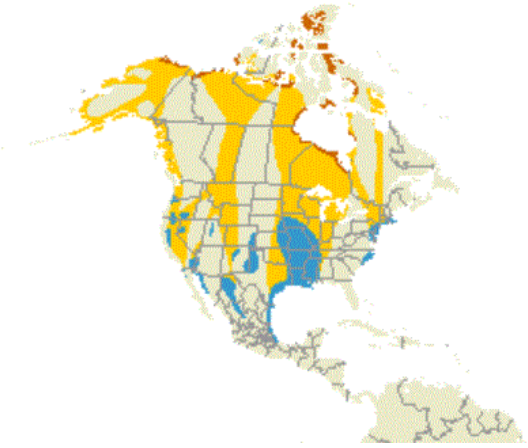
American Coot
Fulica americana



Canada Goose
Branta canadensis



Mallard
Anas platyrhynchos



Snow Goose
Chen caerulescens