Human Health and Ecological Risk Assessment for the Use of Wildlife Damage Management Methods

by APHIS-Wildlife Services

Chapter XXVIII

THE USE OF NONCHEMICAL DETERRENTS IN WILDLIFE DAMAGE MANAGEMENT

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EXECUTIVE SUMMARY

Nonchemical deterrents are devices or tools (e.g., vehicles, remote control vehicles, effigies, scarecrows, predator models, light devices, propane cannons) United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) uses for wildlife dispersal in damage management projects. Wildlife dispersed by WS using nonchemical deterrents during the analysis period (Federal fiscal years 2016-2020) involved birds (99% of the wildlife dispersed) and mammals and reptiles (1%). Most of the projects conducted by WS were to prevent wildlife hazards at airports and to protect natural resources (including threatened and endangered species), agricultural crops, and livestock. WS uses several nonchemical deterrents to disperse wildlife through physical, visual, or auditory means. These devices include rubber ammunition, remote-controlled vehicles, light devices, effigies, predator models, scarecrows, mylar and non-mylar flagging, propane cannons, and electronic harassment. Propane cannons and vehicles were the most used nonchemical deterrents, accounting for 80% of all wildlife dispersed.

APHIS evaluated the potential human health and environmental risks from WS's proposed use of nonchemical deterrents and determined that the risks to human health and the environment are negligible. Risks to workers are low because WS personnel are trained in the proper use and setup of nonchemical deterrents. Risks to the general population are negligible because site selection and timing of activities minimize exposure to the public. Nonchemical deterrents would not contaminate water or result in the bioaccumulation of chemicals or other hazardous materials. Environmental hazards associated with nonchemical deterrents are generally limited to unintentional disturbances of nontarget animals that may be near a targeted animal.

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1 INTRODUCTION

Nonchemical deterrents use animal behavior modification to deter or repel damaging animals, thereby reducing damage to the protected resource. The U.S.Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) uses nonchemical wildlife damage management (WDM) methods. These types of methods are used as part of an integrated wildlife damage management program to deter or disperse animals that cause damage to agricultural and natural resources and property and pose hazards to human health and safety (e.g., airports). Deterrent techniques can be a crucial component of wildlife hazard management plans because the deterred target species will return as long as the attractant is accessible. Consistent use of nonchemical deterrents, especially by combining methods, can result in more successful deterrence. Successful deterrence is defined as when the animal chooses not to return to the site or perform the behavior even when the deterrent is not being applied. Target species in nonchemical deterrent WDM include avian species, such as vultures, gulls, geese, and blackbirds, and mammal species, such as deer, black bears, coyotes, and wolves.

WS uses nonchemical deterrents that are designed to make the area or resource unattractive to wildlife or create uncomfortable or fearful conditions for wildlife. Nonchemical deterrents can be physical, visual, or auditory devices. During fiscal years[1] (FY)16-20, these devices included anti-perching devices, fencing, netting, overhead wires, rubber ammunition, paintballs, vehicles, remote-controlled vehicles, lights, effigies, predator models, scarecrows, mylar and non-mylar flagging, propane cannons (gas exploders), pyrotechnics, and electronic harassment. Propane cannons and vehicles were the primary nonchemical deterrents, accounting for 80% of all wildlife dispersed. Wildlife damage management activities occurred at airports for the protection of human health and safety, in agricultural settings for the protection of crops such as sunflowers and apples, and livestock such as backyard flocks of chickens and turkeys, calves, goats, and sheep, and for the protection of natural resources including endangered species such as salmon, and property such as backyard gardens and landscaping. Birds were the primary target of nonchemical deterrents, resulting in 99% of the wildlife dispersed. Mammals were also involved in dispersal projects, consisting of 1% of all wildlife dispersed.

This human health and ecological risk assessment provides a qualitative evaluation of the potential risks and hazards to human health, wildlife, and the environment due to using nonchemical deterrents to deter wildlife in targeted areas. The methods used in this risk assessment follow standard regulatory guidance and methodologies and generally conform to other Federal agencies such as the US Environmental Protection Agency (EPA) (National Research Council 1983, USEPA 2022).

1.1 Nonchemical Deterrents

Nonchemical deterrents can include many deterrents used in wildlife damage management. Nonchemical deterrents may be used alone or in combination depending upon the species targeted and its habits. Effective nonchemical deterrents must affect some aspect of the intended target animals' physical receptors or psychological perception. The primary physical receptors in target species are physical, visual, and auditory (Seamans et al. 2013). Some nonchemical deterrents have been discussed in other APHIS WS risk assessments as described in Table 1 and the risks associated with them will not be discussed in this risk assessment.

[1] FY16 equals the federal Fiscal Year 2016, which is October 1, 2015–September 30, 2016 (the year is denoted by FY16, FY17, and so on)

Table 1. Nonchemical deterrent methods with risks assessed in other APHIS WS Risk Assessments.

Nonchemical Deterrent Method	Risk Assessment	Reference
Firearms for hazing wildlife	The Use of Firearms in WDM	(USDA Wildlife Services 2019)
Rubber Ammunition	The Use of Firearms in WDM	(USDA Wildlife Services 2019)
Paintballs	The Use of Firearms in WDM	(USDA Wildlife Services 2019)
Dogs used for hazing wildlife	The Use of Dogs and Other Animals in WDM	(USDA Wildlife Services 2021)
Pyrotechincs[1]	The Use of Explosive Materials in WDM	(USDA Wildlife Services 2023b)
Fencing/Fladry	The Use of Exclusion in WDM	(USDA Wildlife Services 2023a)
Netting	The Use of Exclusion in WDM	(USDA Wildlife Services 2023a)
Overhead Wires	The Use of Exclusion in WDM	(USDA Wildlife Services 2023a)
Anti-perching devices[2]	The Use of Exclusion in WDM	(USDA Wildlife Services 2023a)
Lasers	The Use of Lasers in WDM	(USDA Wildlife Services 2024)
UAVs	The Use of Unmanned Aerial Vehicles in WDM	FY25[3]

[1]Explosive pest control devices "screamers," "bangers," "shell crackers," "CAPA3 cartridges", and "screamer banger rockets."
[2] Porcupine wire (e.g., Nixilite®, Bird-Flite®, Cat-claw®), floppy wire (e.g., Daddi Long Legs™, Bird Barrier Coil®), spring-tensioned wires, and shock strips
[3]Expected to be completed in Fiscal Year 25.

1.1.1 Physical

Physical deterrents may include barriers (e.g., spikes or wires) and projectiles (e.g., rubber bullets, paintballs). These devices create painful or uncomfortable stimuli to repel the target animal (Seamans et al. 2013) by causing physical pain, discomfort, or hazing via continuous harassment using a scare tactic (Preusser et al. 2008). Risks associated with these deterrents are covered in other risk assessments (Table 1).

1.1.2 Visual

Visual deterrents include motorized vehicles, remote control vehicles, vulture and human effigies, scarecrows, predator models, eye-spot balloons, flags, and mylar reflecting tapes. These types of deterrents have shown only short-term effectiveness and are inappropriate as long-term solutions to wildlife damage. Most short-term success achieved with these devices is likely attributable to "new object reaction" rather than any actual repellent effect they produced (Cleary and Dolbeer 2005). A disadvantage is that animals often quickly become accustomed to these devices, known as habituation, and, in time, ignore them. When combined with other methods, the effectiveness of visual deterrents can be prolonged. Visual deterrents also have more success if they are moved to different locations periodically. This section provides some examples of visual

deterrents that WS may use. The risk associated with these deterrents will be covered in this Risk Assessment.

Motorized Vehicles- Vehicles can be an effective hazing tool. Vehicles are more effective in rural rather than urban areas because urban animals exhibit less fear and aversion to humans than rural animals (Proppe et al. 2017). As with any deterrent tool, animals can behave unpredictably, and hazing may cause them to move where they could create the same or different hazards. WS can use vehicles to haze wildlife on airfields. For example, vehicles may be used to scare wildlife loafing on runways prior to an aircraft taking flight or landing or during an oil spill (Chilvers 2024). Vehicles can include trucks, cars, boats, all-terrain vehicles (ATVs), electric bikes, and motorcycles. WS, for the most part, uses trucks, boats, and ATVs. The main deterrent stimulus of vehicles is the visual aspect. However, noise from the engine or car horn adds an auditory feature as well.

Remote Controlled Vehicles- Animals can be dispersed from areas where they cause damage or threats by being pursued with remote control vehicles (e.g., boats and cars). Remote control vehicles are often used with physical human harassment (e.g., people pursuing animals on foot, clapping their hands, or shouting) and non-motorized or motorized boats. Consistent use of deterrents can result in keeping animals away from an area. Curtis et al. (2016) found the combined use of remote-controlled vehicles with pyrotechnics effective for hazing Canada geese out of city parks. Additionally, Breck et al. (2023) found that combining a remote controlled vehicle with a commercially available predator deterrent (Foxlights Australia, PTY LTD; https://www.foxlightsaustralia.com.au/about-foxlights/) doubled the efficacy of the predator deterrent alone on a colony of captive coyotes.

Flashing Lights- Devices with a light component can be deployed to deter animals from using certain areas. LED lights in the device flash irregularly, replicating human presence to increase an animal's sense of perceived risk. WS uses flashing lights primarily to deter predators from attacking susceptible livestock. These devices were initially developed to protect livestock from foxes in Australia (Foxlights Australia, PTY LTD; https://www.foxlightsaustralia.com.au/about-foxlights/). Flashing lights have been adopted in the United States to protect sheep from predators at night by simulating human activity (Stone et al. 2017).

Effigies, Predator Models, Scarecrows- Effigies, scarecrows, or representations of target species, such as vultures and predators such as eagles and coyotes, are effective components of integrated management strategies (Avery et al. 2002, Tillman et al. 2002, Seamans 2004, Avery et al. 2008). Target species effigies include carcasses, taxidermied mounts, and artificial models used to represent dead animals. For example, hanging effigies of vultures in the "death pose" from structures such as towers, bridges, and other structures tend to disperse vultures quickly from loafing and roosting sites (Figure 1). Bird effigies are typically displayed in a prominent location so birds using the roost will notice them. The effigy is hung upside down by its feet, far enough from branches or other contact points to prevent entanglement. Using the feathers of the target species in the effigy seems to be important in their success. A permit is required to possess and use a dead or preserved bird or its feathers. A taxidermied effigy is most effective for roosts of the same species of birds, but dispersal may also be effective for other flocking birds. Vulture and crow effigies have been shown to effectively resolve various problems associated with roosting vultures and crows, including property damage at communication towers, depredation of crops and livestock, and aircraft safety (Avery et al. 2008).

Figure 1. Example of effigies, vulture (Left) and gull (Right) to disperse birds from loafing and roosting sites.

Predator models, shaped as human, coyote, and eagle, are typically located where birds enter a field and may be placed up to the center of the field or in other areas to prevent target bird use. Predator effigies should be frequently moved so birds do not habituate to them.

Tape/Flags- Reflective ribbons, such as mylar and non-mylar tape and flags, are sometimes used to deter birds. The reflecting tape evaluated most often in field tests is approximately 1.0 cm wide and 0.25 mm thick. The tape is usually twisted and suspended between erect poles in parallel lines above the crop. Its mylar coating (commonly silver on one side, red on the other as in Figure 2) reflects sunlight, which produces a flashing effect. Twisting the tape enhances the reflecting effect and creates an illusion of motion (Figure 2). In windy conditions, vibrations made by the tape produce a humming or roaring noise, which may contribute to its deterrent effect (Bruggers et al. 1986, Dolbeer et al. 1986, Tobin et al. 1988). The effectiveness of mylar ribbon is variable. Mylar ribbon protected corn, millet, sunflower, and sorghum fields from bird damage (Bruggers et al. 1986, Dolbeer et al. 1986). However, mylar ribbon did not deter birds in a blueberry field (Tobin et al. 1988).

Figure 2. Mylar tape strung across a field to deter depredating birds.

For goose management, a more cost-effective flag made of white or black plastic can be effective. Flags are made of white garbage bags (30 x 60 in; 77 x 154 cm) stapled widthwise to a four-foot (1.2 m) length wooden lath and placed at a density of one flag per acre. White or black flags offered significant protection from snow goose grazing in agricultural fields (Mason et al. 1993, Mason and Clark 1994).

Fladry- Fladry is a barrier device explicitly used for predators, such as coyotes and wolves. Fladry may alleviate livestock predation by taking advantage of wolf and coyote fear of unfamiliar items on the landscape (Young et al. 2019, Windell et al. 2021). Fladry consists of a continuous rope strand with strips of red or orange flagging (20 x 4 in; 50 x 10 cm) sewn or tied at 20 in (50 cm) intervals and strung 20 in (50 cm) from the ground for wolves (Musiani et al. 2003) (Figure 3). Closer spacing of fladry has been shown to be more effective with coyotes (11 in, 28 cm) (Young et al. 2019). Turbo fladry is modified from typical fladry by carrying an electric charge along the rope. Recent testing conducted by WS using turbo fladry to protect crops from feral swine damage has shown positive results (Unpublished data 2022). Fladry can protect prairie dog colonies, black-footed ferrets, and livestock, especially during critical seasons (e.g., calving) (Windell et al. 2021).

Figure 3. Fladry installed on cow pasture fence to alleviate predation by coyotes.

Figure 4. Eye spot balloon used to disperse flocking birds (e.g., geese, gulls).

Balloons- Weatherproof, vinyl, inflatable balloons with large eyes or "eye spots" can be used to deter pest birds. Holographic eyes are especially helpful in creating an illusion that the eyes follow the birds like a predator ready to attack. The "eye" movement combined with the balloon's natural movement in the wind reduces the likelihood that birds will become accustomed to the product (Figure 4). Balloons can be suspended from poles so that they swing freely in the wind, or they can be inflated with helium and tethered to float above the area to be protected. Some efficacy has been shown in reducing blackbird numbers at roosts (Mott 1985) using helium-filled balloons of various colors. Helium balloons are used for roosts and floated up and over the roosting trees; fishing lines with a swivel attached to the balloon are effective for letting balloons out and retrieving them so they can be used for multiple days. They have also been used for geese at a density of 3 to 5 balloons per acre. Balloons must be installed before birds acclimate to the site (French and Parkhurst 2009). Although effective in the short term, the efficacy of balloons or eye spots decreases over time as the birds habituate to them (McLennan et al. 1995).

Inflatable Deterrents- Inflatable scarecrow or human shaped deterrents are sold under trade names such as “Scary Man”, “Air Dancer”, or “Scare Dancer” (Figure 5). These devices rapidly inflate and move unpredictably. They can be used to deter birds, including pigeons and starlings, from ledges, railings, and other roosting or loafing surfaces in fruit crops (Steensma et al. 2016), or in hazardous places (Snow et al. 2021). WS has used these devices to disperse starlings at refineries and ethanol plants.

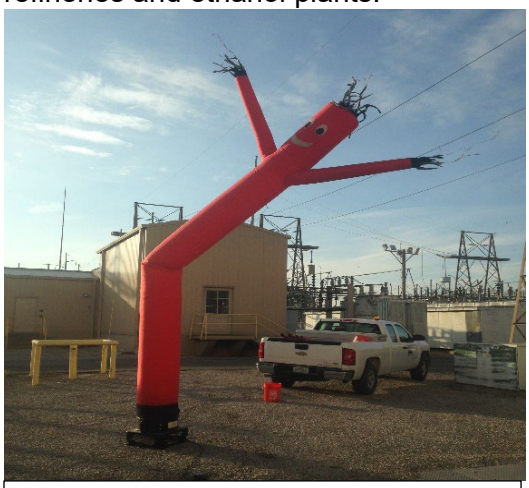

Figure 5. Air dancer installed at a facility to deter flocking birds.

1.1.3 Auditory

Auditory deterrents, such as pyrotechnics, propane cannons, and various electronic distress devices, alter the behavior of birds and mammals using sound. These devices produce sounds similar to shotguns, distress calls of birds, or other noises that are perceived by animals as dangerous. They are often used in conjunction with visual deterrents. This section provides some examples of auditory deterrents that WS may use. The risks associated with pyrotechnics are covered in The Use of Explosives in Wildlife Damage Management (USDA Wildlife Services 2023b).

Propane Cannons- Propane cannons generate a shotgun-sounding blast. Propane cannons are commonly used to disperse blackbirds, waterfowl, and other birds from agricultural crops, wastewater ponds, and airfields (Figure 6). These devices produce loud (120-decibel [dB]) intermittent explosions at 1- to 30-minute intervals and are effective in areas up to 120 acres with a recommendation of one cannon per 4-6 acres (Cummings et al. 1986, Avery and Werner 2017). Recent research suggests placing one cannon every 1,000 ft (300 m) for maximum effectiveness with red-winged blackbirds and brown-headed cowbirds (Duttenhefner and Klug 2024) Newer versions emit up to three explosions in rapid succession and various directions. Birds quickly habituate to cannons that detonate at systematic or random intervals throughout the day. Thus, it is best to use cannons sparingly and only when target birds are in the damage prevention area to ensure they remain effective. Additionally, as with other devices, frequently moving them enhances the duration of their effectiveness. Reinforcement by occasional lethal removal with a shotgun might also enhance effectiveness (under appropriate permits) (Baxter and Allan 2008).

Figure 6. Propane cannon installed on an airport greenbelt to deter birds.

The advantages of propane cannons are that they do not require a constant human presence, are relatively portable, effective day or night, and are inexpensive to operate. Disadvantages are that they must be moved every 2 to 3 days to prevent habituation, regular maintenance is required, and the noise may be a nuisance to nearby residents (Klug et al. 2023).

Electronic Distress Signals- Auditory electronic deterrents are marketed as either ultrasonic, sonic, or bioacoustic calls (Seamans et al. 2013). Examples of sonic calls are human-made sounds that are thought to frighten birds by relying on their perception of danger. Sonic call units may include devices such as Bird B Gone Bird Chase Super Sonic Sound Deterrent or Bird X Electronic Bird Repeller. Ultrasonic calls are those above 20 kilohertz and cannot be heard by humans or birds (Jenni-Eiermann et al. 2014). Recent testing of directional sonic calls has been shown to disrupt starling foraging. The disruption occurs by overlapping the frequency with which starlings communicate (Mahjoub et al. 2015). Birds can habituate to and ignore recorded distress calls (bioacoustic calls) and other noises produced by electronic auditory devices. Distress calls are more effective when there are actual threats in the environment. Some research has shown that conspecific distress calls are effective with reduced habituation compared to sonic calls (Spanier 1980, Lecker et al. 2015). Such devices can be helpful if used as part of an integrated program of bird dispersal (Cleary and Dolbeer 2005).

Recorded distress calls are available for common birds at airports, such as gulls, crows, and starlings. Conspecific calls broadcast from speakers mounted on a vehicle will often initially draw the birds toward the sound source to investigate the threat. The birds can then be dispersed using pyrotechnics or a shotgun to remove an occasional bird. As with propane cannons, distress calls routinely broadcast from stationary speakers, with no associated follow-up stimuli that provide additional fear or stress, have little utility (Klug et al. 2023). Reinforcement by occasional lethal removal with a shotgun generally enhances their effectiveness (under appropriate permits).

Scare Radios- A new type of electronic deterrent device being utilized by WS are scare radios. The units are programmed to play FM radio (e.g., local talk shows) during designated times, typically from dusk to dawn, to deter predators from livestock. Local talk shows are selected due to the variability of content (e.g., commercials, music, human talking) to avoid habituation. The scare radios are powered by a 12-volt deep cycle battery connected to a solar panel to minimize battery loss. Scare radios are typically positioned where predator disturbance has been recorded

or is expected. The device can be mounted to trees or as a mobile unit allowing it to be moved whenever cattle are relocated (Figure 7). One mobile unit is typically used per 40-acre pasture. The audio deterrent can be used with Foxlights (see Section 1.1.2) or other visual deterrents. Preliminary results have shown that these devices alone or in combination with other deterrents may be effective at predator deterrence for 1-3 weeks.

Figure 7. Mobile scare radio electronic deterrent device for wolf damage management.

1.2 Use Pattern of Nonchemical Deterrents

WS annually averaged 32,693 work tasks[2] associated with nonchemical deterrents from FY16-20. Of these work tasks, 93% were for visual deterrents (vehicles, effigies, lights, mylar tape, and flagging), and 7% for auditory deterrents (propane cannons and electronic harassment). It should be noted that all birds, mammals, and reptiles dispersed may not necessarily be documented and may not be estimated if WS staff were not present at the time of dispersal.

1.2.1 Visual

WS used visual deterrents, including vehicles, remote control vehicles, effigies, lights, and flags, to disperse an annual average of 1.6 million target birds, mammals, and reptiles (Tables 2-5). WS used remote control vehicles and motorized vehicles to disperse wildlife from airfields, landfills and other locations.

Table 2. The annual average number of target mammals and birds hazed with vehicles by WS in wildlife damage management activities from FY16-20 throughout the United States. Species that averaged less than 100 hazed annually are included in “other" categories.

Species	Dispersed
European Starling	189,045
Yellow-headed Blackbird	482
Red-winged Blackbird	15,286
Tricolored Blackbird	1,431
Brown-headed Cowbird	14,797

Species	Dispersed
Brewer’s Blackbird	2,810
Common Grackle	5,078
Boat-tailed Grackle	724
Great-tailed Grackle	4,202
Mixed Blackbirds	5,575

[2] A Work Task is defined as a visit to a property, or a portion of it, where a WS employee conducts field work. However, duration is not considered and, thus, a Work Task could be 10 minutes to 10 hours in duration.

Species	Dispersed
Rock Dove*	41,575
Island Collared-Dove*	1,895
Eurasian Collared-Dove*	1,112
Spotted Dove*	20,019
Zebra Dove*	49,711
White-winged Dove	1,883
Mourning Dove	65,998
Other Dove (2 sp.) [1]	65
Red-legged Kittiwake	17,082
Bonaparte's Gull	463
Laughing Gull	4,886
Franklin's Gull	3,056
Short-billed Gull	309
Ring-billed Gull	9,402
Western Gull	482
California Gull	5,296
Herring Gull	27,572
Glaucous-winged Gull	4,040
Great Black-backed Gull	1,086
Caspian Tern	858
Whiskered Tern	348
Forster's Tern	202
Other Larid (17 sp.) [1]	392
Black-bellied Whistling Duck	256
Snow Goose	28,915
Greater White-fronted Goose	4,685
Brant	2,855
Cackling Goose	37,267
Canada Goose	203,538
Hawaiian Goose T&E	4,083
Mute Swan*	141
Tundra Swan	150
Wood Duck	462
Blue-winged Teal	1,715
Cinnamon Teal	448
Northern Shoveler	9,128
Gadwall	1,310
American Wigeon	5,060
Hawaiian Duck T&E	527
Mallard (incl. domestic*)	25,636
American Black Duck	454
Northern Pintail	3,071
Green-winged Teal	2,588
Canvasback	400
Redhead	509
Ring-necked Duck	433
Greater Scaup	1,257
Lesser Scaup	1,074
Bufflehead	2,974
Common Goldeneye	718
Barrow's Goldeneye	597
Hooded Merganser	1,145

Species	Dispersed
Common Merganser	678
Ruddy Duck	750
Other Waterfowl (13 sp.) [1]	411
Black-billed Magpie	1,092
American Crow	21,676
Fish Crow	629
Common Raven	26,525
Other Corvid (6 sp.) [1]	112
Black Vulture	933
Turkey Vulture	3,195
Osprey	992
White-tailed Kite	226
Northern Harrier	1,910
Cooper's Hawk	220
Bald Eagle	4,817
Mississippi Kite	232
Red-shouldered Hawk	132
Swainson's Hawk	552
Red-tailed Hawk	9,481
Rough-legged Hawk	178
Ferruginous Hawk	195
Barn Owl	306
Short-eared Owl	493
Crested Caracara	153
American Kestrel	5,096
Peregrine Falcon	114
Other Raptor (21 sp.) [1]	510
Laysan Albatross	1,334
Double-crested Cormorant	26,152
American White Pelican	5,611
Brown Pelican	520
Other Waterbird (16 sp.) [1]	207
American Coot	3,244
Sandhill Crane	1,741
Yellow Bittern	2,523
Great Blue Heron	2,929
Great Egret	2,069
Snowy Egret	2,036
Little Blue Heron	142
Western Cattle Egret^	27,462
Black-crowned Night-Heron	664
White Ibis	834
Glossy Ibis	311
White-faced Ibis	991
Other Wading Bird (10 sp.) [1]	130
Black-necked Stilt	916
- Hawaiian Black-necked Stilt	771
American Avocet	241
Black-bellied Plover	1,233
American Golden Plover	222
Pacific Golden Plover	112,112
Killdeer	14,426

Species	Dispersed
Semipalmated Plover	1,223
Upland Sandpiper	517
Whimbrel	612
Long-billed Curlew	1,623
Ruddy Turnstone	7,067
Sanderling	799
Dunlin	4,367
Least Sandpiper	6,328
Semipalmated Sandpiper	109
Western Sandpiper	1,703
Long-billed Dowitcher	142
Wilson's Snipe	188
Lesser Yellowlegs	184
Willet	389
Greater Yellowlegs	207
Wood Sandpiper	104
Other Shorebird (22 sp.)[1]	489
California Quail^	234
Wild Turkey	2,445
Sharp-tailed Grouse	637
Ring-necked Pheasant*	757
Gray Francolin*	4,663
Black Francolin*	2,282
Feral Domestic Chicken*	2,725
Erckel's Francolin*	176
Other Gallinaceous (10 sp.)[1]	161
Bank Swallow	2,065
Tree Swallow	2,312
Purple Martin	212
Barn Swallow	14,230
Cliff Swallow	6,583
Cave Swallow	1,435
Other Aerialists (6 sp.)[1]	189
Northern Flicker	170
Rose-ringed Parakeet*	1,511
Other Non-Passerines (8 sp.)[1]	105
Western Kingbird	1,736
Eastern Kingbird	298
Scissor-tailed Flycatcher	952
American Pipit	1,131
Horned Lark	17,333
Lapland Longspur	360
Snow Bunting	950
Lark Sparrow	183
Lark Bunting	466
Field Sparrow	179
Fox Sparrow	187
Dark-eyed Junco	272
White-crowned Sparrow	100
Savannah Sparrow	2,329
Song Sparrow	179

Species	Dispersed
Eastern Meadowlark	21,635
Western Meadowlark^	14,165
Other Grassland Pass.(13 sp.)[1]	382
Bohemian Wawing	696
Northern Mockingbird	1,966
Eastern Bluebird	126
Mountain Bluebird	376
American Robin	4,783
House Finch^	28,304
Pine Siskin	149
American Goldfinc	326
Northern Cardinal^	1,208
Other Forest Passerine (19 sp.)[1]	306
Black Drongo*	194
Eurasian Skylark*	17,297
Red-vented Bulbul*	3,259
Common Myna*	89,522
African Silverbill*	888
Java Sparrow*	3,674
Scaly-breasted Munia*	34,173
Chestnut Munia*	53,413
Red Avadavat*	2,172
Common Waxbill*	6,509
House Sparrow*	9,939
Eurasian Tree Sparrow*	836
Red-crested Cardinal*	8,641
Saffron Finch*	1,044
Other Invasive Passer.(2 sp.)[1]	40
TOTAL BIRDS (341 sp.)	**1,530,615**
Coyote^	719
Red Fox^	408
Feral/Free-roaming Cat*	267
Black Bear	100
Other Predator (17 sp.)[1]	307
Black-tailed Jackrabbit	322
Desert Cottontail	294
Eastern Cottontail^	272
California Ground Squirrel	219
Other Rabbit/ Rodent (16 sp.)[1]	199
White-tailed Deer^	1,003
Mule Deer	120
Axis Deer*	646
Moose	233
Other Mammal (9 sp.)[1]	158
TOTAL MAMMALS (54 sp.)	**5,267**
Reptile (4 sp.)[1]	11
TOTAL REPTILE (4 sp.)	**11**

[1]Other species are listed in Appendix 1.
*Introduced species
^ Introduced populations exist

WS used remote control vehicles to haze birds along with a few mammals (Table 3). Remote control boats are often used to haze waterfowl off ponds. Remote control vehicles were used mostly to disperse waterbird species (98.5%), primarily Canada geese (93%) from FY16-FY20.

Table 3. The annual average number of remote-controlled vehicles (e.g., boats, trucks) used and number of associated work tasks to haze target species by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	Number Used	Number Work Tasks	Number Dispersed
Canada Goose	656	627	14,780
Mallard	8	8	270
Hawaiian Goose[T&E]	5	5	29
American Wigeon	4	4	210
Other Waterbird (11 sp.)[1]	15	11	444
Passerine (2 sp.)[1]	1	1	206
Raptor (2 sp.)[1]	0.6	2	20
Mammal (2 sp.)[2]	0.6	0.6	9
TOTAL	**690**	**659**	**15,968**

[1,2]Other species are listed in Appendix 1.

Effigies were used by WS for the protection of livestock (e.g., vulture dispersal) and human health and safety (e.g., gull dispersal). Species dispersed using coyote, crow, eagle, gull, human, and vulture effigies are described in Table 4.

In some cases, WS may provide supplies or materials of limited availability for use by private entities. Effigies were loaned to cooperators to disperse Canada geese, gull species, and vultures (Table 4).

Table 4. The annual average number of effigies used to haze target species or loaned to cooperators and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Effigy Type	Species	Number Used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Coyote	White-tailed deer	0	0	-	0.2	0.2
Coyote	Feral/Free-ranging Cat	0.2	0.2	-	0	0
Coyote	Double-crested Cormorant	0.6	0.6	-	0	0
Coyote	Canada Goose	4	2	-	9	6
Coyote	Ring-billed Gull	0.8	0.6	-	0	0
Coyote	Wild Turkey	0	0	-	1	1
Coyote	**TOTAL**	**6**	**3**	-	**10**	**7**
Crow	American Crow	19	8	800	0	0
Crow	Common Raven	8	5	-	0	0
Crow	Ring-billed Gull	0.6	0.4	-	0	0
Crow	Black-billed Magpie	0.2	0.2	-	0	0
Crow	Rock Pigeon*	0.6	0.2	-	0	0
Crow	**TOTAL**	**28**	**14**	**800**	**0**	**0**
Eagle	Canada Goose	4	4	-	43	42
Eagle	Rock Pigeon*	2	4	-	0.1	0.2
Eagle	Double-crested Cormorant	6	3	-	0	0

Effigy Type	Species	Number Used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Eagle	Other Bird (6 sp.)[1]	4	7	-	0.8	1
Eagle	**TOTAL**	**16**	**18**	**-**	**44**	**43**
Gull	Glaucous-winged Gull	168	43	1,074	0	0
Gull	Herring Gull	8	5	153	0	0
Gull	Ring-billed Gull	8	5	271	0	0
Gull	Laughing Gull	4	3	60	0	0
Gull	Other Bird (8 sp.)[1]	13	5	8	0	0
Gull	**TOTAL**	**201**	**61**	**1,566**	**0**	**0**
Human	Coyote	7	7	-	0	0
Human	Other Mammal (3 sp.)[2]	2	3	-	0.2	0.2
Human	Herring Gull	7	12	1	0.1	0.2
Human	Ring-billed Gull	6	12	-	0.1	0.2
Human	Double-crested Cormorant	10	5	-	0	0
Human	Other Bird (11 sp.)[1]	12	14	12	0.4	0.2
Human	**TOTAL**	**44**	**53**	**13**	**0.8**	**0.8**
Vulture	Black Vulture	**600**	381	2,176	17	13
Vulture	Turkey Vulture	215	194	867	6	6
Vulture	Other Bird (4 sp.) [1]	5	3	-	0.5	0.4
Vulture	**TOTAL**	**820**	**578**	**3,043**	**24**	**19**

[1,2]Other species are listed in Appendix 1.

Different types of lights, including floodlights, strobe lights, or revolving lighting units, were used by WS to reduce conflicts with coyotes, wolves, and flocking bird species (e.g., European starlings and American crows) (Table 5). A small number of work tasks (38.6 annual average) involved using mylar or non-mylar flags, mylar tape, and balloons (Tables A1-A4 in Appendix 1).

Table 5. The annual average number of light devices used to haze target mammals and birds and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed
Gray Wolf	128	22	0
Coyote	54	22	0
Feral/Free-roaming Dog	5	4	0
Red Fox	5	4	0.2
Mexican Gray Wolf	4	0.6	0
Black-tailed Jackrabbit	3	3	11
Other Mammals (9 sp.)[1]	10	8	8
TOTAL Mammals	**209**	**64**	**19**
European Starling	82	86	24,101
Mourning Dove	93	107	3,721
American Crow	24	38	4,825
Common Raven	5	4	0
Barn Swallow	11	20	218
Cliff Swallow	6	10	150
Scissor-tailed Flycatcher	13	26	70

Species	Number used	Number Work Tasks	Number Dispersed
Savannah Sparrow	10	15	176
Northern Cardinal	4	6	9
Northern Mockingbird	1	3	10
Other Passerine (10 sp.)[2]	11	14	184
Cooper's Hawk	4	7	6
Crested Caracara	2	4	6
Red-tailed Hawk	3	4	7
Other Raptor (10 sp.)[2]	7	12	16
Black-bellied Whistling Duck	4	7	28
Canada Goose	3	3	32
Other Waterbird (3 sp.)[2]	2	2	10
Great Egret	5	9	12
Snowy Egret	2	4	5
Cattle Egret	3	4	148
Yellow-crowned Night Heron	2	3	5
Killdeer	14	18	215
White Ibis	2	3	34
Herring Gull	2	2	27
Other Bird (12 sp.)[2]	4	8	31
TOTAL Birds	**319**	**418**	**34,046**

[1,2]Other species are listed in Appendix 1.

1.2.1 Auditory

WS used auditory deterrents, including propane cannons and electronic harassment devices, to disperse an annual average of 1,286,180 target birds and 43 target mammals (Tables 6a,b-7a,b). WS used propane cannons to protect human health and safety (e.g., airports), aquaculture, and agriculture (e.g., sunflower, corn). The main species dispersed with propane cannons were European starlings and blackbird species (e.g., red-winged blackbirds and brown-headed cowbirds). WS used electronic harassment devices for the protection of human health and safety (e.g., airports, disease risk), and agriculture. Electronic harassment devices for birds included programmable speakers that play distress calls or predator calls. Electronic harassment devices for mammals included programmable devices that emit startling high-pitched sounds in combination with a flashing light.

In some cases, WS may provide supplies or materials of limited availability for use by private entities. Propane cannons were loaned to cooperators to disperse bird and mammal species (Tables 6a,b). An annual average of 70.4 electronic harassment devices were loaned to disperse black bears in 62.8 work tasks. In addition, an annual average of 2.8 electronic harassment devices were loaned to disperse white-tailed deer and bird species, such as wild turkeys and woodpecker species, in 3.4 work tasks.

Table 6a. The annual average number of propane cannons used to haze target bird species or distributed/loaned to cooperators and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
European Starling	469	272	758,139	3	1
American Crow	199	167	1,855	1	1
Great-tailed Grackle	54	52	1,527	0	0
Common Grackle	24	23	2,141	390	64
Blackbirds (Mixed Species)	19	18	10,827	1	0.8
Brown-headed Cowbird	33	12	8,779	4	8
Red-winged Blackbirds	20	10	15,849	341	205
Eastern Meadowlark	224	124	5,932	0	0
Mourning Dove	161	120	3,687	0	0
Rock Pigeon*	107	86	3,105	1	0.6
Barn Swallow	85	69	9,314	0	0
Other Passerine (19 sp.)[1]	53	34	1,302	97	92
Western Kingbird	28	27	238	0	0
Horned Lark	28	26	299	0	0
Island Collared Dove	15	23	-	0	0
Scissor-tailed Flycatcher	26	21	140	0	0
Eurasian Tree Sparrow	13	20	-	0	0
Cliff Swallow	23	20	9,872	0	0
House Sparrow	11	11	288	0.6	0.6
Eurasian Collared Dove*	8	15	35	0	0
Turkey Vulture	554	555	5,245	0.5	1
Red-tailed Hawk	362	274	426	0	0
Bald Eagle	173	149	155	0.2	0.2
American Kestrel	150	75	152	0	0
Northern Harrier	116	65	96	0	0
Osprey	46	46	64	0	0
Mississippi Kite	32	34	109	0	0
Red-shouldered Hawk	35	32	40	0	0
Cooper's Hawk	18	18	20	0	0
Swainson's Hawk	15	15	78	0	0
Black Vulture	29	15	310	1	1
Other Raptor (8 sp.)[1]	8	8	12	0	0
Ring-billed gull	127	97	116,552	0	0
Red-legged Kittiwake	109	26	-	0	0
Herring Gull	45	24	598	0	0
Franklin's Gull	11	11	2,519	0	0
Great Blue Heron	213	175	609	0.1	0.4
Mallard	151	137	2,574	1	0.4
Canada Goose	119	108	5,255	109	67
Other Waterbird (53 sp.)[1]	116	96	8,307	16	18
Double-crested Cormorant	61	61	3,090	0.4	0.4
American Coot	61	60	17,347	0	0
Ruddy Duck	54	55	23,564	0	0

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Ring-necked Duck	48	48	2,361	0	0
Northern Shoveler	41	41	3,585	0	0
Bufflehead	40	40	746	0	0
Wood Duck	18	18	151	0	0
Hooded Merganser	13	13	167	0	0
Redhead	11	11	143	0	0
Blue-winged Teal	11	10	204	0.8	1
Great Egret	118	77	726	3	7
Cattle Egret	82	31	2,119	0	0
Killdeer	101	65	574	0	0
Yellow Bittern	13	21	2	0	0
Golden Pacific Plover	12	17	21	0	0
Upland Sandpiper	19	14	651	0	0
Black Francolin	8	14	-	0	0
Other terrestrial non-passerine (6 sp.)[1]	11	10	26	2	3
Unidentifiable bird spp.[1]	15	15	2,003	0	0
TOTAL	**4,766**	**3,731**	**1,033,930**	**973**	**472**

[1]Other species are listed in Appendix 1.

Table 6b. The annual average number of propane cannons used to haze target mammal species or distributed/loaned to cooperators and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Northern Raccoon	2	9	-	0	0
Feral Swine	11	7	-	1	0.6
Coyote	17	6	5	0.2	0.2
White-tailed deer	6	3	11	5	3
Eastern Gray Squirrel	0.7	3	0.4	0	0
Woodchuck	1	2	-	0	0
Feral/Free-roaming Dog	1	1	1	0	0
Red fox	2	1	0.8	0	0
Other Mammal (12 sp.)[1]	12	4	0.8	4	4
TOTAL	**53**	**36**	**19**	**10**	**8**

[1]Other species are listed in Appendix 1.

Table 7a. The annual average number of electronic harassment devices used to haze target bird species and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed
European Starling	227	227	192,926
Great-tailed Grackle	4	4	584
Brown-headed Cowbird	4	4	1,045

Blackbirds (Mixed Species)	3	3	42,290
Eastern Meadowlark	9	5	169
American Crow	12	12	429
Mourning Dove	14	14	604
Rock Pigeon	10	10	340
Other Passerine sp.[1]	10	10	586
Canada Goose	24	22	672
Ring-billed Gull	27	27	3,967
Laughing Gull	15	15	4,516
Killdeer	15	14	142
Herring Gull	9	9	1,709
Great Blue Heron	9	9	32
Other Waterbird sp.[1]	26	25	1,973
Wild Turkey	2	2	7
Bald Eagle	19	18	28
Red-tailed Hawk	12	7	11
Turkey Vulture	11	11	105
American Kestrel	11	6	25
Northern Harrier	7	2	3
Osprey	6	6	14
Black Vulture	3	3	61
Other Raptor sp.[1]	5	5	12
Unidentified Mixed Mammal and Bird sp.	9	9	-
TOTAL	**503**	**479**	**252,250**

[1]Other species are listed in Appendix 1.

Table 7b. The annual average number of electronic harassment devices used to haze target mammal species and the associated number of work tasks by WS in Wildlife Damage Management activities from FY16-20 throughout the United States.

Species	**Number used**	**Number Work Tasks**	**Number Dispersed**
Gray Wolf	30	22	-
White-tailed Deer	4	4	22
Louisiana Black Bear [T&E1]	3	3	0.2
Coyote	2	2	0.6
Other Mammal sp.[2]	2	2	0.8
Black Bear	0.4	0.4	0.8
Coyote and Wolf	0.4	0.2	-
Red Fox	0.4	0.4	-
Feral/Free-ranging Cat	0.2	0.4	-
Striped Skunk	0.2	0.4	-
Steller Sea Lion	0.4	0.4	-
TOTAL	**43**	**33**	**24**

[1]T&E = Federally listed threatened and endangered species – the Louisiana black bear is no longer federally listed but included.

[2]Other species are listed in Appendix 1.

2 HAZARDS

2.1 Human Health and Safety Hazards

The use of nonchemical deterrents may affect human health and safety. The auditory disturbances related to the various deterrent devices or their installation in targeted damage areas has a potential to affect human health and safety. However, WS personnel are trained or instructed to use nonchemical deterrents in WDM so that human health and safety are prioritized. For example, training and instruction on installing nonchemical deterrents and proper use of appropriate personal protective equipment (PPE) are provided. Appropriate PPE includes hearing protection and eye protection as appropriate, which decrease the risks associated with the use of nonchemical deterrents.

2.1.1 Visual

Visual deterrents have little potential to affect human health and safety. Visual deterrents include passive harassment methods like flags, effigies, inflatable deterrents, and lights. Staff preparation of effigies from bird carcasses poses a safety risk. In addition to the use of sharps for preparation of the effigy, there is a potential for exposure to infectious diseases. WS personnel may get injuries from using sharps during effigy preparation, including cuts, abrasions, or punctures. It is possible for an employee to accidentally poke or cut themselves, which could expose them to an infectious zoonotic disease, similar to risks faced by health care professionals. All WS personnel that use sharps, in collaboration with the APHIS Biosafety Officer, are required to watch the “Safe Handling and Disposal of Sharps Training Video” and adhere to Standard Operating Procedure HS/WS 001.00 “Safe Handling and Disposal of Sharps in Laboratory and Field Settings within Wildlife Services.”

WS personnel should carry a medical alert card, so medical personnel know that diseases from animal exposure are a potential source of sickness. Animal bites and scratches must be reported (federal forms CA-1 or -2 and the APHIS Online First Report). Personnel who handle or are exposed to diseased wildlife are trained using disease-specific training manuals. Training manuals include instructions for collecting samples specific to that disease, sample storage, and sample shipping for testing. There are also in-person training courses, including Necropsy Lab and Wildlife Disease Preparedness Training, available for all WS employees through the WS National Training Academy.

Other potential hazards include cuts or abrasions from loose wires, snags, or sharp edges on the equipment and possible strain from labor and maneuvering of materials. Most injuries occur while setting or maintaining fencing for flagging or installing lights or effigies due to the installation of t-posts or other structural supports. Remote-controlled vehicles are triggered by attending personnel at a distance from the dispersed wildlife, reducing any hazard from the action to personnel or the public.

Driving vehicles for surveys and transportation among field sites carries the typical hazards that any driver of a vehicle may be subject to. The APHIS Job Hazard Analysis identifies “physical trauma from various impacts” as a potential hazard for driving automobiles/box trucks in urban, suburban, and rural areas. However, when using vehicles for wildlife patrols and runway sweeps at airports, drivers must maintain awareness of aircraft movements and other airport vehicles in addition to monitoring for wildlife and attempting vehicle harassment. Vehicles used to survey wildlife in agricultural fields and off paved roads add additional hazards.

2.1.2 Auditory

The use of auditory deterrents has some potential to affect human health and safety due to the potential for repeated exposure to decibels higher than the Occupational Safety and Health Administration (OSHA) recommends. OSHA regards noise levels over 85 decibels (dB) averaged over 8 hours, or an 8-hour time-weighted average, as potentially damaging. Propane cannons produce 120-dB intermittent sounds (measured within 1 m of the deterrent). A recent study measured the sound attenuation of propane cannons and found that at 340 m (1,115 ft) the sound intensity of the propane cannon no longer exceeded ambient noise (Duttenhefner and Klug 2024). Electronic distress signals and other electronic high-pitched sounds may also present a hazard to personnel or the public. Sound source noise emission levels for nonchemical deterrents range from 45-140 dBA (Table 8). Adverse effects of noise can include hearing loss, communication interference, sleep interference, physiologic responses, and annoyance (USEPA 1974). Use of appropriate PPE including hearing protection devices (HPD) can reduce exposure to noise levels over 85 decibels. Hearing protection devices could include formable foam earplugs or pre-molded earplugs in addition to passive earmuffs which are typically worn over the ear.

Table 8. Sound source noise emission levels for nonchemical deterrents and other reference sources.

Equipment	**Maximum Sound Level (dBA[1] Lmax) – 50 feet from Source**	**Reference**
All-Terrain Vehicle (ATV)	75	(Berger et al. 2015)
Air Horn / Deterrent Device	83	(FHWA 2006;2008)
Birds – Crows	45	(Berger et al. 2015)
Birds – Woodpeckers	50	(Berger et al. 2015)
Dog Barking	60	(Berger et al. 2015)
Pick-up Truck	55	(FHWA 2006;2008)
Propane Cannon	120	(Silva et al. 2021)
12 Gauge Shotgun	140	(Berger et al. 2015)

[1]dBA – A-weighted decibel

2.2 Environmental Hazards

The primary environmental hazard that may result from nonchemical deterrents is a disturbance to nontarget animals due to nonchemical deterrent use. Nontarget animals may be affected by loss or inaccessibility to food sources or other habitat components and, potentially, masking effects of noise on communication (Parris and Schneider 2008). A study evaluated the physiological stress response of California spotted owls (*Strix occidentalis occientalis*) to low intensity chainsaw sounds and found no change in fecal corticosteroid levels. This suggests that short term noises may not have an effect on wildlife species. Chronic and higher intensity sounds were not evaluated (Tempel and Gutierrez 2003). There is also a fire risk from propane cannons, particularly in grassy areas during dry periods. The area around propane cannons should be kept clear of fire hazards such as tall grass or shrubs, and the barrel should not be aimed at the fuel tank or in the direction of users (Greer and O'Connor 1994). Using elevated platforms in grassy areas can reduce the chance of fire. Routine maintenance of physical deterrent devices can help prevent mechanical failures. The use of vehicles may lead to erosion problems or injuries to nontarget animals, and improper or inappropriate use of any of the harassment techniques may result in disturbances to nesting animals. No component of nonchemical deterrents would contaminate water or result in the bioaccumulation of chemicals or other hazardous materials.

3 RISKS

3.1 Human Health and Safety Risks

Nonchemical methods available to alleviate or prevent damage associated with birds, mammals, and reptiles pose minimal risks to human safety. Although some safety risks would likely occur, those risks would be minimal when methods are used appropriately and in consideration of human safety.

WS employees are well-trained in safely and properly using nonchemical deterrents, including vehicles. Activities are generally conducted in areas with minimal human activity (e.g., in areas closed to the public), substantially limiting risks to the public. Short-term human disturbance may result from using auditory nonchemical deterrents. Visual deterrents have negligible human health or safety risk.

During FY16-FY20, WS employees had an annual average of 0.6 injuries directly related to nonchemical deterrent deployment. Two employees injured digits (scalpel slip, barbed wire fence puncture), and one employee injured an eye while repairing a propane cannon. Other injuries, such as slips and falls, strains, and sprains, may occur while performing dispersal activities or deploying nonchemical deterrents but are not particular to any nonchemical deterrent activity. These injuries are discussed in the “Introduction to Risk Assessments for Methods Used in WDM” (USDA Wildlife Services 2017).

During FY16-FY20, WS employees had an annual average of 11 vehicle incidents that occurred on airports, or other facilities or on farmland. No personnel injuries occurred during any incidents. Examples of incidents include sliding off narrow or muddy roads or hitting unseen objects (e.g., gates, fence posts, tree stumps) in tall grass or berms.

Overall, risks to workers are low based on WS personnel being trained in the proper use of vehicles and the use and set up of nonchemical deterrents in accordance with WS Directive 2.635. Risks to the general population are negligible because site selection and activity timing minimize public exposure.

3.1.1 Visual

The use of motorized vehicles for wildlife harassment is the primary risk to human health and safety. WS employees may not be driving on paved roads, or roads at all. Risks may include potential rollovers, fires, and crashes. However, incidents that occurred during FY16-20 were minor and resulted in no injuries to WS employees or the public.

Many visual nonchemical methods are passive devices or only activated when triggered by attending personnel (e.g., lights, effigies, flags, fladry). Potential injury may occur when installing fencing for flags or fladry, or when preparing effigies. Risks to human health and safety have been minimized for WS employees who are well-trained to use sharps in preparation of effigies properly. As required by WS Directive 2.635, "Zoonotic Diseases and Personal Protective Equipment," all WS personnel who handle or are exposed to wildlife will be provided with biological sampling, disease exposure safety training, and PPE training. Use of PPE such as examination gloves, cut-resistant gloves, splash-proof aprons, protective eyewear, face masks, and Tyvek® coveralls and shoe covers while handling wildlife can significantly minimize exposure to zoonotic diseases. Injuries to WS personnel from tools used to prepare effigies are anticipated to be minimal during any given year.

3.1.2 Auditory

Some risk of fire, bodily harm, hearing loss, and other noise related effects exist from using propane cannons. WS proper use and application of these devices and attention to the potential risks of these methods can help prevent risk. In addition, noise levels over 70 dB may be controlled by local regulations. For example, Hawaii requires a permit to allow activities that may exceed maximum permissible levels and durations (Silva et al. 2021).

Propane cannons are generally inappropriate for urban/suburban areas due to the repeated loud noises, which many people would consider a serious and unacceptable nuisance and potential health threat (e.g., hearing damage). In addition, propane cannons are more effective for migratory and hunted species that associate danger with loud noises, and less effective for resident species that are well established in an area (e.g., resident geese in urban/suburban areas) (Marsh et al. 1991).

3.2 Environmental Risks

Like the use of visual and physical dispersal methods, the intent with the use of auditory dispersal methods, such as electronic hazing devices and propane cannons, is to elicit a flight response in target bird and mammal species by mimicking distress calls or producing a novel or adverse noise. Of concern are the possible negative physiological and/or behavioral effects that negative stimuli of any dispersal method could cause, which could reduce the fitness of nontarget animals, especially if the exposure to the stressor was chronic. The stress from dispersal methods could negatively affect an animal's health, interfere with the raising of young, and/or increase energy needs (Bowles 1995). However, for effects to occur, nontarget animals would have to be within hearing distance when WS personnel used an auditory method, and the resulting noise stimuli would have to elicit a negative response. Like other non-lethal methods, WS personnel would not use those methods over large geographical areas or at such an intensity level that essential resources (e.g., food sources, habitat) would be unavailable for extended durations or over such a wide geographical scope that long-term adverse effects would occur to a species' population. WS uses protective measures to minimize any such hazards to nontarget wildlife by applying all methods, including these nonchemical deterrent methods, in locations with the highest likelihood of (purposefully) affecting target animals, while minimizing any impacts to nontarget animals. Target animals are also susceptible to the negative physiological and/or behavioral effects of dispersal techniques. In some cases, the target birds are being dispersed from hazardous areas which could also have a negative impact, for example, oil spills or airports.

Environmental risks are limited to unintentional disturbances of nontarget animals that may be in the area of a targeted animal. However, the risks are minimal because the deterrents are nonchemical. WS understands the potential disturbances that may result from these deterrents and considers them when targeting animals. WS is especially aware of nesting animals that are sensitive to disturbances caused by nonchemical deterrents. APHIS does not recommend practices or knowingly conduct activities that adversely affect federally threatened or endangered species.

There is a small chance of fire due to propane cannon use. Regular maintenance of propane cannons helps to reduce the chance of mechanical failure. Only one incident of fire associated with a propane cannon was reported between 2015 and 2022 (the period for which injury and accident data were available). A small grass fire (1-1.5 acres) occurred, likely due to a propane cannon during dispersal activities. The fire was put out without further damage or injury to personnel or wildlife.

4 UNCERTAINTIES AND CUMULATIVE EFFECTS

Uncertainty in this risk assessment is minimal because WS has several decades of experience and associated data of using the selected methods as nonchemical deterrents. The knowledge gained from this experience has helped reduce risks associated with nonchemical deterrents, especially regarding human health and safety risks due to auditory deterrents that may create disturbances, such as propane cannons.

Cumulative impacts could potentially occur to target and nontarget animals. However, cumulative impacts are addressed in National Environmental Policy Act documents and to date have been found not to be significant to any native population. Additionally, the "Introduction to WS Methods Risk Assessments" (USDA Wildlife Services 2017) assesses all species taken by WS from FY11 to FY15 and shows no significant impacts from a population standpoint. From a human health perspective, using nonchemical deterrents in WDM will not have any known cumulative impacts.

5 SUMMARY

Nonchemical deterrents are used in integrated WDM to reduce the impacts of damage caused by wildlife, such as deer and avian species, but the effectiveness of deterrents varies. An animal's visual and auditory senses affect how it will respond to any given stimulus, and habituation to the stimulus is common in the long-term. Nonchemical deterrents include vehicles, propane cannons, distress recordings/signals, fladry, mylar/reflective tape, balloons, and flashing lights. These deterrents all aid in reducing a target animal's impact on human and natural resources by utilizing the animals' physical, auditory, or visual cues to deter them from the area of damage or threat.

Because these types of deterrents are nonchemical, the hazards and risks associated with their use are relatively low. Disturbances from auditory and visual deterrents, such as propane cannons and vehicles, are the main risks regarding human health, safety, and the environment. The noise from propane cannons can cause disturbance to humans and nontarget animals depending on their proximity to the device. WS personnel are trained to avoid nontarget species and human activity when using nonchemical deterrents, which decreases any potential hazards and risks. Operation of vehicles carries inherent risk but use as a visual deterrent can add to this risk due to the environments vehicles are driven (e.g., airports, agricultural fields).

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7 PREPARERS

7.1 APHIS WS Methods Risk Assessment Committee

Writers for "Use of Nonchemical Deterrents in Wildlife Damage Management Risk Assessment":

Primary Writer: Shelagh DeLiberto
Position: USDA-APHIS-Wildlife Services (WS), Operational Support Staff, Environmental Coordinator, Fort Collins, CO
Education: BA Biology and Environmental Science – Ithaca College; MS Wildlife Biology – Colorado State University
Experience: Twenty years of service in APHIS conducting wildlife research. Two years of experience preparing categorical exclusions and environmental analyses in compliance with the National Environmental Policy Act.

Writer/Editor: Thomas C. Hall
Position: USDA-APHIS-WS, Operational Support Staff, Staff Wildlife Biologist, Fort Collins, CO
Education: BS Biology (Natural History) and BA. Psychology – Fort Lewis College; MS Wildlife Ecology – Oklahoma State University
Experience: Special expertise in wildlife biology, identification, ecology, and damage management. Thirty-two years of service in APHIS Wildlife Services including operations and research in CO for research and OR, GU, CA, OK, and NV for operations conducting a wide variety of programs including bird damage research and management, livestock protection (predators and birds), invasive species management, wildlife hazard management at airports, property and natural resource protection including waterfowl, brown tree snake, feral swine, rodent, and beaver damage management. Expert in preparing environmental documents for WS programs to comply with the National Environmental Policy Act and the Endangered Species Act. For quick-kill traps specifically, used all types of quick-kill traps in WDM and supervised employees that used them in their duties.

Editors/Contributors for "The Use of Nonchemical Deterrents in Wildlife Damage Management Risk Assessment":

Editor: Todd Felix
Position: Wildlife Biologist (Environmental Coordinator)
Education: B.S., M.S., Biology
Experience: 24 years as a Wildlife Biologist for APHIS Wildlife Services.

Editor: Chris Croson
Position: USDA-APHIS-WS, Operational Support Staff, Staff Wildlife Biologist, Mooresville, NC
Education: BS Wildlife Biology, Virginia Tech; Masters of Strategic Studies, U.S. Army War College
Experience: Twenty-three years of service in APHIS Wildlife Services, including operations and operational support. Supervised WDM operations in PA and WV for a variety of operations, including rabies management, livestock protection, wildlife hazard management at airports, deer damage management, and several other urban WDM programs. Special expertise in preparing environmental documents for WS programs to comply with the NEPA and Endangered Species Act.

Data Contributor: Joey Millison
Position: USDA-APHIS-WS Information and Technology (IT), Junior Applications Developer

Education: Information and Technology coursework from various sources
Experience: Eleven years of experience in APHIS, WS Management Information System (MIS.) Group. Retrieves WS field data from the MIS for writers, reviewers, and editors.

7.2 Internal Reviewers

USDA APHIS Wildlife Services

Reviewer: David Allaben
Position: State Director
Education: BS in Wildlife and Fisheries Management and Natural Resources
Experience: 28-years wildlife damage management with APHIS Wildlife Services-SC, VA, NH, VT. Expertise in agricultural crop damage, aviation safety, urban wildlife conflicts and natural resource protection.

Reviewer: Scott Beckerman
Position: USDA APHIS Wildlife Services, State Director/ Supervisory Wildlife Biologist, Springfield, IL
Education: BS and MS in Fisheries and Wildlife Management, University of Missouri-Columbia
Experience: Expertise in wildlife damage management and wildlife biology. Thirty one years of service in APHIS Wildlife Services operational programs in MO, IA, WI, CA, and IL. Experience in mitigating conflicts caused by a wide variety of wild animals including, ungulates, migratory birds/waterfowl, predators, rodents, and invasive species including feral swine.

Reviewer: Matt Cleland
Position: USDA APHIS Wildlife Services, State Director/ Supervisory Wildlife Biologist, Port Allen, LA
Education: BS in Wildlife Management, Washington State University
Experience: Expertise in wildlife damage management and wildlife biology. Twenty-four years of service in APHIS Wildlife Services operational programs in WA, CA, TN, KY and LA. Experience in mitigating conflicts caused by a wide variety of wild animals including ungulates, migratory birds/waterfowl, predators, rodents, reptiles and invasive species including feral swine and nutria.

Reviewer: Aaron Guikema
Position: USDA APHIS WS, State Director, Pittstown, NJ
Education: B.S. in Fisheries and Wildlife Management, Lake Superior State University
Experience: Twenty-three year of wildlife damage management with APHIS Wildlife Services.

Reviewer: Nokota Harpster
Position: USDA-APHIS-WS Staff Wildlife Biologist for Pennsylvania WS
Education: Bachelor of Science-Wildlife Conservation from Juniata College.
Experience: 8 years working for WS.

Reviewer: Daniel Hirchert
Position: USDA-APHIS-WS, State Director, Sun Prairie, WI
Education: BS in Field Biology, University of Wisconsin
Experience: Twenty-eight years of service in wildlife damage management with APHIS Wildlife Services and Wisconsin Department of Natural Resources. Expertise in agricultural crop damage, aviation safety, urban wildlife conflicts and natural resource protection.

Reviewer: Page Klug
Position: USDA-APHIS-WS-NWRC, Supervisory Research Wildlife Biologist, Fargo, ND
Education: PhD Biology – Kansas State University; MS Biology – University of Nebraska at Omaha; BS Environmental Science and Policy – Drake University
Experience: Expertise in wildlife biology and wildlife damage management research. Tenure of eight years as North Dakota Field Station leader for USDA-APHIS-WS-NWRC focusing on bird damage to agriculture, including the use of frightening devices, wildlife repellents, and evading strategies. Experience in wildlife damage management includes invasive and native birds (e.g., blackbirds, starlings, and parakeets) and invasive reptiles (e.g., brown treesnakes and tegus). Optimization of methods takes into account avian biology at multiple biological levels and incorporates the influence of landscape ecology at various scales.

Reviewer: Dustin Ranglack
Position: USDA-APHIS-WS-NWRC, Supervisory Research Wildlife Biologist, Millville, UT
Education: PhD Ecology – Utah State University; BS Wildlife Science – Utah State University
Experience: Expertise in wildlife biology and wildlife damage management research. Tenure of 1.5 years as Utah Field Station leader and Predator Project leader for USDA-APHIS-WS-NWRC focusing on predator damage to livestock, including the use of frightening devices, wildlife repellents, and non-lethal strategies. Spent 6.5 years teaching wildlife management, including wildlife damage management, at the University of Nebraska – Kearney. Experience in wildlife damage management includes mammalian predators (coyotes, wolves, mountain lions, bears) and ungulates (elk, deer, bison, pronghorn). Wildlife damage research focuses on evaluating the efficacy of both non-lethal and lethal techniques to reduce human-predator conflict.

Reviewer: Jeff Rumbaugh
Position: USDA-APHIS-Wildlife Services, Staff Wildlife Biologist, Moseley, VA
Education: BS in Wildlife and Fisheries Resources, West Virginia University
Experience: Twenty-six years of service with WS in the SC and VA programs; expertise with a wide variety of damage management techniques for many species of migratory birds and mammals.

7.3 Peer Review

The Office of Management and Budget requires agencies to have peer review guidelines for scientific documents. The APHIS guidelines were followed to have "Minimum Risk Pesticides" peer reviewed. WS worked with the Association of Fish and Wildlife Agencies to have experts review the documents.

7.3.1 Peer Reviewers Selected by the Association of Fish and Wildlife Agencies

Michigan Department of Natural Resources
North Carolina Wildlife Resources Commission
Ohio Division of Wildlife

7.3.2 Comments

1. **Comment:** Section 1-Introduction – It would be beneficial to note the various scenarios where non-chemical deterrents were used (ex. oil spills, landfills, airfields, etc.) in some chart form. The chart only needs to be a simplistic location-type and #. (page 1).

Response: Although this type of data is tracked by WS state offices, the data is not available in a searchable format nationwide. We are unable to provide a quantitative analysis of the sites where these types of deterrents are utilized.

2. **Comment:** Section 1.1.1-Physical – Seems an omission of chasing on foot (ex. geese) is missing from the list of tactics. I would imagine some chasing in this form was utilized by staff. While it may not be a tracked item by USDA, should be noted. (page 2).
   Response: "Chasing" of wildlife on foot is not a WS approved method for deterring wildlife. Physical presence of WS personnel and herding of animals (e.g., geese) could be considered a "physical action" utilized by WS to deter or alter the direction of wildlife. Most often another deterrent method is used in addition to the presence of WS personnel. The physical presence of WS personnel is analyzed along with the deterrent methods described in this risk assessment.

3. **Comment:** Section 1.1.1-Physical:Anti-perching devices and section2.2-Environmental Hazards – Birds becoming entangled in monofilament and or wires or injured by hitting wires should be mentioned. (pages 2 and 8).
   Response: Anti-perching devices are mentioned as examples of physical deterrents, but the risk of use of monofilament wires and other overhead wire designs is discussed in the Use of Exclusion in Wildlife Damage Management (USDA WS 2023b). We have removed the detailed description of anti-perching devices and added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found.

4. **Comment:** Section 1.1.2-Visual-Flashing lights – Seems like lasers are missing from this section. Also, not sure if other "light" devices such as Away With Geese are used and should be noted. (page 3).
   Response: The Use of Lasers in WDM is covered in another risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1). All devices used by WS operational staff may not be mentioned in the risk assessment; the risks associated with these types of devices are assessed irrespective of the branded products.

5. **Comment:** Section 1.1.2-Tape/Flags – it is noted the use of "red" mylar, is that the only color used? I know yellow is also a common color produced and there are other mylar options out there. (page 4).
   Response: The most common type of mylar tape used in WS is red on one side and silver on the other. Other colors may be used by WS also, but they are not tracked separately and the specific color would not change the risk of utilizing this tool. We edited the text in this section to make this more clear.

6. **Comment:** Section 1.1.3-Auditory – The last sentence in the first paragraph notes under "propane cannons" it states "Reinforcement by occasional lethal removal with a shotgun might also enhance effectiveness (under appropriate permits)." In the least I feel this should be in the intro section for auditory or maybe also noted in the introduction of section 1. (page 5).
   Response: The risks associated with the use of firearms as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

7. **Comment:** Section 1.1.3-Auditory – The use of "pyrotechnics" (ex. bangers, screamers, shellcrackers, CAPA) seems to be omitted from this document. (page 6).
   Response: The risks associated with the use of pyrotechnics as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

8. **Comment:** Section 2.1.2-Auditory – The use of pyrotechnics and the safety associated with their use seems to be missing from this section. There should also be some mention of training for staff related to their safe use. (page 8).
   Response: The risks associated with the use of pyrotechnics as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

9. **Comment:** Section 2.1.2-Auditory – Use of firearms and the safety related to their use seems to be omitted from this section (page 8).
   Response: The risks associated with the use of firearms as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

10. **Comment:** Section 2.1.2-Auditory-With the use of auditory devices (especially pyrotechnics) there is a potential for disturbance to people, pets, and livestock due to the noise associated with their use. While this is certainly an issue the closer to urban centers they are used, they still represent a valid "hazard" to their use in rural areas as well. (page 8).
    Response: The risks associated with the use of pyrotechnics as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1). We agree that auditory devices could pose hazards to people and pets if placed near residences in rural areas. However, placement of propane cannons and use of pyrotechnics in rural areas is not typically near residences. We have cited Duttenhoffer et al. 2024 and the attenuation of propane cannon sound at varying distances. The potential hazard posed to livestock by the use of propane cannons is addressed in Section 2.2 (livestock would be considered nontargets).

11. **Comment:** Section 2.2-Environmental Hazards – Note that staff conduct routine maintenance on physical techniques (barriers, wires, etc.) to ensure to minimize environmental hazards, such as bird entanglements and injuries, should be noted. (page 8).
    Response: The risks associated with use of monofilament wires and other overhead wire designs is discussed in the Use of Exclusion in Wildlife Damage Management (USDA WS 2023b). We have added a table to identify the different Risk Assessment chapters where some of the nonchemical deterrent methods used by WS can be found. We have included text in this risk assessment about routine maintenance on propane cannons and other deterrent devices in Sections 2.2 and 3.2.

12. **Comment:** Section 2.2-Environmental Hazards – Seems like there is no mention of potential injury to animals from some techniques such as beanbag rounds and rubber ammunition. (page 8).
    Response: The risks associated with the use of rubber ammunition as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1). Beanbag rounds and rubber ammunition have been removed from the risk assessment.

13. **Comment:** Section 3.1.2-Auditory – Seems like the last paragraph in Section 3.1.1 (" Overall, risks to workers…") should also be noted in this section or moved to the intro in 3.1. (page 9)
    Response: We have made this suggested change to the text.

14. **Comment:** Physical – Anti Perching Devices and Overhead Wires- would it be worth mentioning that some avian species (swallows) will still nest in these types of devices? Mentioning the negative aspect of this deterrent.
    Response: The risks associated with the use of anti-perching devices and overhead wires as nonchemical deterrent devices are covered in the Use of Exclusion in WDM Risk Assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

15. **Comment:** Section 1.1.1: Does this include fencing? If not, why not?
    Response: The risks associated with the use of fencing in wildlife damage management are discussed in the Use of Exclusion in Wildlife Damage Management (USDA WS 2023b). We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

16. **Comment:** Visual- Flashing lights section- would this be a spot to include more information on the use of laser use and associated risks?
    Response: The risks associated with the use of lasers as a nonchemical deterrent device are covered in a separate risk assessment. We have included a table to identify the different Risk Assessment chapters where some of the nonchemical deterrent methods used by WS can be found (Table 1).

17. **Comment:** Auditory- I think it would be worth including a small sub-section on use of pyrotechnics. There are variety of pyrotechnics used by WS, especially in airport tasks and I expected more detail regarding use pattern than the use of propane cannons. I understand there is a separate risks document related to explosives, but if more data is available on pyrotechnics use that would be interesting to include in this document.
    Response: The risks associated with the use of pyrotechnics as a nonchemical deterrent device are covered in a separate risk assessment. We have added a table to identify the different Risk Assessment chapters where other nonchemical deterrent methods used by WS can be found (Table 1).

18. **Comment:** Wondering if a section on the cost vs. longevity of deterrents would be worthwhile? I am not sure how detailed the authors want to get for readers.
    Response: The risk assessments identify and assess the potential risks to humans, target and non-target wildlife and the environment. They are not an assessment of the cost benefit or longevity of each deterrent method. Some descriptive information is provided

to help characterize each method and publications are cited wherever possible that describe scientific studies which may include costs vs. longevity of deterrents.

19. **Comment:** Another point to potentially make is why these nonlethal methods are important to public perception of wildlife management. Research has shown the US public is developing a more mutualistic value toward wildlife, which emphasizes a need to provide a more integrated approach to management.
    Response: The risk assessments identify and assess the potential risks to humans, target and non-target wildlife and the environment. They are not an assessment of public perception of the methods used by WS.

20. **Comment:** Introduction: This sentence and the one above sound better geared to the results and summary, rather than intro. I suggest keeping this section focused on a general definition of deterrents and why they are used
    Response: The Risk assessment does not have traditional sections like “Results” and “Summary”. These sentences introduce the nonchemical deterrents that were used by WS in FY16-20 and identify which methods will be discussed in the risk characterization.

21. **Comment:** May want to write “1% of all wildlife dispersed” for full clarity.
    Response: We have edited this sentence for clarity.

22. **Comment:** Section 1.1: This sentence would be beneficial in the introduction. The sentence in the intro is focused on examples, rather than this general explanation.
    Response: We have added this sentence in the introduction to provide a general explanation of nonchemical deterrents.

23. **Comment:** Consider mentioning examples of what species beanbags/rubber ammunition are used/effective for. Or a threshold of animal size or other metric that users could consider.
    Response: We have removed rubber ammunition and beanbags from Section 1.1. We have added a table to identify the different Risk Assessment chapters where these and other nonchemical deterrent methods used by WS can be found (Table 1).

24. **Comment:** Section 1.1.2: This last sentence is good. As a reader, I know to some extent why there is a not a laundry list of deterrents. May help to explain why these were chosen as examples though (e.g., most commonly used?)
    Response: These deterrents were chosen for inclusion in the risk assessment because they were used during the reporting period FY16-20 by WS and their use is reported in Section 1.2 Use Pattern of Nonchemical deterrents.

25. **Comment:** Section 1.1.2 Motorized Vehicles. Not quite sure what this means. Possibly that urban animals tend to be more predictable due to habituation? Also, research has suggested game species in rural areas may be more leery of people due to hunting.
    Response: We have edited this section for clarity and included a citation.

26. **Comment:** I've noticed some examples have citations to substantiate efficacy (remote controlled vehicles) and some do not (e.g., motorized vehicles). Something to consider for consistency.
    Response: We have added a citation for efficacy in the motorized vehicle section.

27. **Comment:** Detailed description of how to implement an effigy goes beyond what is written for previous examples of deterrents. Consider using the same approach across examples for consistency.
    Response: Effigies are a unique deterrent tool in that they are often not commercially purchased with instructions on how to use them. We have removed some of the extra information describing the installation of effigies to be more consistent with other sections.

28. **Comment:** These examples seem more like scarecrows than effigies, but maybe not. Defining the difference between an effigy and scarecrow, for example, earlier in the document may be worthwhile.
    Response: We have edited this section to identify effigies, scarecrows, and predator models as types of deterrents used in similar ways. Using all three terms (effigy, predator model, and scarecrow) more accurately describes this group of deterrents.

29. **Comment:** "Reinforcement by occasional lethal removal with a shotgun might also enhance effectiveness (under appropriate permits)". Possibly a citation to back this statement? It may help to provide an explanation of why this is effective.
    Response: We have added a citation for this statement. (Baxter, A.T., and Allan, J.R. 2008. Use of lethal control to reduce habituation to blank rounds by scavenging birds. Journal of Wildlife Management 72: 1653-1657.)

30. **Comment:** Briefly describing advantages and disadvantages of the method is good information for readers. May consider doing this across methods in this publication.
    Response: We agree that describing advantages and disadvantages of methods is valuable, however not all methods have published sources for this information. We have provided advantages and disadvantages or effectiveness of methods when available.

31. **Comment:** Can an estimate of number of target animals be included for other use tables, as for vehicles above?
    Response: All tables provide estimates of numbers of target animals if they were estimated in the MIS data. It is often difficult to determine the numbers of target animals hazed by nonchemical deterrent methods. We have included numbers of work tasks to give an idea of usage for different target species.

32. **Comment:** Does WS record the number of nontarget species hazed as a by product of target species efforts? This can be important to consider for developing or improving BMPs across deterrent methods
    Response: WS does not record the number of nontarget species hazed as a by-product of target species efforts in nonchemical deterrent applications. WS is trained to identify target species and avoids the use of nonchemical deterrent methods when nontarget species are present.

33. **Comment:** Would it be possible to show the data by internal WS use AND cooperator use? This would be helpful to assess how effective loaning equipment is. With common staff and budget cuts at federal and state levels, understanding the effectiveness of cooperators could provide important information for conducting operations in the future.
    Response: Although WS tracks numbers of nonchemical deterrent items loaned we do not track numbers of animals hazed by cooperators.

34. **Comment:** Content in this section (Section 3) seem to heavily overlap that in the Hazards section. Could these be combined for succinctness?

Response: The format for risk assessments is typically to have a Hazard section that describes all of the potential hazards that may occur from a method. The Risk section then identifies the way in which (in this case) WS uses the method and the risk of those hazards occurring by our use pattern. It is better to keep these sections distinct for this reason.

35. **Comment:** There is recent research on sound impacts on wildlife. May consider providing a citation or two here.
    Response: We have added citations in Sections 2.2 and 3.2 on impacts of sounds on wildlife.

36. **Comment:** Maybe knowingly conduct. It is possible some T&E species could be affected without staff knowing. Seems fair to be upfront about this.
    Response: We have updated this text to include the qualifier “knowingly”. WS does make every effort to reduce or eliminate exposures of nonchemical deterrents to T&E species.

37. **Comment:** ...and also data to backup much of the efficacy and associated risks.
    Response: We have added this statement that WS has also tracked the data related to efficacy and associated risks of nonchemical deterrents.

38. **Comment:** What about a paragraph or even section talking about development of new nonchemical deterrents? I am interested to know more about the rigor and standards WS puts into BMPs, including new methods. This may further drive home the message that these methods are thoroughly vetted before, during, and even after use.
    Response: We appreciate the interest in both WS’s and the National Wildlife Research Center’s (the research arm of WS) development of new nonchemical deterrents. Any new developments are published by our state program staff or research staff. There is generally a lag between development and adoption by WS employees nationwide precluding the ability to assess risk in this risk assessment. This Risk Assessment only analyzes the hazards and risks associated with methods currently in use by WS personnel because we can characterize the use patterns, which is critical to the assessment of risk.

39. **Comment:** Would it be worthwhile to mention that an integrated approach is typically best?
    Response: We began this section by indicating that nonchemical deterrents are part of an integrated approach to wildlife damage management.

40. **Comment:** Check format of citations. For example, citation here and below have an extra space between the colon and page numbers. Otherwise, the citations look great.
    Response: We have updated the format of citations to make them more uniform.

41. **Comment:** Consider using a photo where the deterrent is more clearly visible. Here the porcupine wire appears to blend in with the turf in the background, making it hard to see what the photo is trying to illustrate.
    Response: We have replaced the photo for Figure 1 with one that shows the anti-perching device better.

42. **Comment:** Section 1.1.2: Is this *a* disadvantage or the main disadvantage? If the main disadvantage, it might be good to say that directly.
    Response: The risk assessment does not fully evaluate the efficacy of these devices. This is a disadvantage and there could be others associated with these devices.

43. **Comment:** What kind of predator deterrent? Can you provide more context here or rephrase to help readers understand the main takeaway of this sentence?
Response: The authors of the research paper used a Foxlight (Foxlights Australia, PTY LTD; https://www.foxlightsaustralia.com.au/about-foxlights/). We have added this information in Section 1.1.2.

44. **Comment:** Can you simply say "lights" here instead of "lighting devices"?
Response: There is a distinction between “lights” and “lighting devices”. Lights can imply that the device is a lamp or flashlight. These are devices that have a light that flashes, or strobes, or activates in some way.

45. **Comment:** Do the effigies need to be placed where the birds have a habit of loafing? Is one sufficient or are multiple effigies usually necessary to be effective?
Response: The risk assessment is not a manual on how to use these devices. The risk assessment provides a description of the device to provide readers with a basic understanding of the types of devices and the potential hazards and risks associated with them.

46. **Comment:** Define “conspecific” or use simpler terminology.
Response: We have edited this sentence for clarity.

47. **Comment:** What does "up to the center" mean?
Response: We have revised this sentence for clarity.

48. **Comment:** Does specifying non-mylar tape here add value to this sentence?
Response: WS tracks the use of mylar and non-mylar types of tape deterrents.

49. **Comment:** Does this flashing effect happen when the tape is still or only when it is in motion? Does it create an illusion of motion or is the flashing effect a result of actual physical movement of the tape? Give more examples to illustrate this point.
Response: The flashing effect with mylar tape may occur when the tape is still (due to the presence or absence of sunlight (e.g. cloud cover). The flashing effect may also occur due to movement of the tape itself. We have added a reference to a study testing mylar tape in a blueberry field that was unsuccessful (Tobin et al. 1988. Reflecting Tape Fails to Protect Ripening Blueberries from Bird Damage. Wildlife Society Bulletin 16:300-303).

50. **Comment:** Do the garbage bag flags need to be able to move in the wind to be effective? A photo here would be useful.
Response: The research papers cited do not indicate if wind is needed to be effective and did not record weather during the field trials. The papers do indicate that if the flags were damaged or stripped, they were replaced indicating that there was wind during the study period. Unfortunately, no photographs of this deterrent method could be located.

51. **Comment:** Can you provide one or two examples of a sonic call?
Response: Sonic call units may include devices such as Bird B Gone Bird Chase Super Sonic Sound Deterrent or Bird X Electronic Bird Repeller. This information has been added to the text of the document.

52. **Comment:** It hasn't been made clear in the text how a "conspecific distress call" is different from a "sonic call."

Response: We have added examples of devices that produce sonic calls and added an explanation that they are human produced sounds. Conspecific distress calls are distress calls of the same species as the target bird; this information has been added to the text of the document.

53. **Comment:** Consider adding an explanation of why this is effective. Is playing music as effective or does it need to be the sound of humans talking?
    Response: The general idea behind using FM talk radio is that the programming includes commercials, music, and human voices spaced at random intervals. It may help to reduce habituation to the devices to have the variety of sound types. We have included some clarifying text in this section.

54. **Comment:** Provide a reference for what page information about "foxlights" can be found.
    Response: We have added a reference to Section 1.1.2 (Visual Deterrents) where information about foxlights can be found.

55. **Comment:** May be helpful to rewrite to "remote control and manned vehicles" for clarity.
    Response: We have revised this sentence for clarity.

56. **Comment:** Consider revising column headers of Tables 2-7 for improved clarity.
    Response: We have added additional information to the table captions to help improve clarity.

57. **Comment:** Why place use data for mylar or non-mylar flags, mylar tape, and balloons in the appendix?
    Response: We placed this information in an appendix because it involves a small number of work tasks that would take up a large number of pages breaking up the flow of the text.

58. **Comment:** Section 2.1.2: the previous section listed ways that WS personnel are protected from visual hazards. How are they protected from auditory hazards?
    Response: We have added information in this section on potential hearing protection devices.

59. **Comment:** Are there any ways WS minimizes hazards to nontarget animals?
    Response: WS may affect nontarget species that are in the vicinity of target animals as described in Section 3.2. Effects would be of limited duration and over a small geographic area. WS uses protective measures to minimize any such hazards to nontarget wildlife by applying all methods, including these nonchemical deterrent methods, in locations with the highest likelihood of (purposefully) affecting target animals, while minimizing any impacts to nontarget animals. This information has been added to the document.

Comments received not requiring a response.

1. **Comment:** Excellent evaluation of WDM tactics and associated consequences with each deterrent.
2. **Comment:** Section 4 2nd paragraph: This is a nice strong statement that is placed well.
3. **Comment:** We received several editorial comments that helped improve the readability of the risk assessment.

APPENDIX 1. "Other Species" Included in Tables

Table 2

Other dove = common ground-dove, zenaida dove

Other larid = pomarine jaeger, parasitic jaeger, long-tailed jaeger, black-legged kittiwake, black-headed gull, Heermann's gull, Iceland gull, glaucous gull, white tern, least tern, gull-billed tern, black tern, common tern, arctic tern, royal tern, black skimmer,

Other waterfowl = Ross's goose, feral domestic graylag goose*, trumpeter swan, mottled duck, spectacled eider[T&E], king eider, common eider, harlequin duck, surf scoter, white-winged scoter, black scoter, long-tailed duck, red-breasted merganser

Other corvid = Canada jay, Steller's jay, blue jay, California scrub-jay, Woodhouse's scrub-jay, yellow-billed magpie

Other raptor = swallow-tailed kite, golden eagle, sharp-shinned hawk, American goshawk, common black hawk, Harris's hawk, broad-winged hawk, Hawaiian hawk[T&E], eastern screech-owl, great horned owl, snowy owl, northern hawk owl, northern pygmy-owl, burrowing owl, barred owl, great gray owl, boreal owl, merlin, gyrfalcon, prairie falcon

Other waterbird = pied-billed grebe, horned grebe, red-necked grebe, eared grebe, western grebe, red-throated loon, Pacific loon, common loon, black-footed albatross, fork-tailed storm-petrel, wedge-tailed shearwater, Newell's shearwater[T&E], great frigatebird, brown booby, anhinga, pelagic cormorant

Other wading bird = common gallinule, whooping crane[T&E], wood stork[T&E], American bittern, least bittern, tricolored heron, reddish egret, green heron, yellow-crowned night-heron, roseate spoonbill

Other shorebird = American oystercatcher, black oystercatcher, Wilson's plover, mountain plover, bristle-thighed curlew, Hudsonian godwit, marbled godwit, black turnstone, red knot[T&E], sharp-tailed sandpiper, stilt sandpiper, rock sandpiper, white-rumped sandpiper, buff-breasted sandpiper, pectoral sandpiper, short-billed dowitcher, American woodcock, spotted sandpiper, solitary sandpiper, wandering tattler, Wilson's phalarope, red-necked phalarope

Other gallinaceous birds = northern bobwhite, Gambel's quail, ruffed grouse, spruce grouse, willow ptarmigan, rock ptarmigan, gray partridge, Indian peafowl

Other aerialists = lesser nighthawk, common nighthawk, white-throated swift, chimney swift, violet-green swallow, northern rough-winged swallow

Other non-passerine birds = smooth-billed ani, greater roadrunner, belted kingfisher, Lewis's woodpecker, red-headed woodpecker, pileated woodpecker, budgerigar, monk parakeet

Other grassland passerines = gray kingbird, black phoebe, eastern phoebe, Say's phoebe, Loggerhead shrike, northern shrike, grasshopper sparrow, chipping sparrow, American tree sparrow, vesper sparrow, Lincoln's sparrow, dicksissel, bobolink

Other forest passerine = black-capped chickadee, cedar waxwing, red-breasted nuthatch, gray catbird, brown thrasher, western bluebird, Townsend's solitaire, Swainson's thrush, hermit thrush, varied thrush, common redpoll, white-winged crossbill, lesser goldfinch, yellow warbler, yellow-rumped warbler, Townsend's warbler, Wilson's warbler, western tanager, indigo bunting

Invasive Passerines = red-whiskered bulbul, warbling white-eye

Other predator = Arctic fox, badger, bobcat, brown bear (grizzly), feral/free-roaming dog, gray fox, lynx, mink, northern raccoon, northern sea otter, gray wolf, river otter, short-tailed weasel, small Indian mongoose, striped skunk, swift fox, Virginia opossum

Other rabbit/rodent = American beaver, Belding's ground squirrel, common muskrat, eastern fox squirrel, eastern gray squirrel, feral domestic European rabbit, North American porcupine,

nutria, red squirrel, Richardson’s ground squirrel, snowshoe hare, swamp rabbit, white-tailed antelope squirrel, white-tailed jackrabbit, woodchuck, yellow-bellied marmot.

Other mammal = caribou, collared peccary, feral swine, free-roaming cattle, free-roaming sheep, gemsbok, nine-banded armadillo, pronghorn, unidentified bat (9 sp.)

Other reptile = American alligator, black and white tegu, green iguana, river cooter

Table 3

Other waterbird = American coot, Double-crested cormorant, bufflehead, redhead, ruddy duck, lesser scaup, Northern shoveler, Atlantic brant goose, greater white-fronted goose, ring-billed gull, mute swan*
Other passerine bird = rock pigeon*, European starling*
Other raptor = Black vulture, turkey vulture
Other mammal = white-tailed deer, woodchuck

Table 4

Eagle Effigy

Other waterbird = Cackling goose, mallard, ring-billed gull
Other passerine bird = European starling*, house sparrow*
Other terrestrial non-passerine bird = wild turkey

Gull Effigy

Other waterbird = Canada goose, great blue heron, California gull, western gull, great black-backed gull,
Other passerine bird = American crow, rock pigeon* European starling*

Human Effigy

Other mammal = Feral/free-ranging dog, red fox, white-tailed deer
Other waterbird = neotropic (olivaceous) cormorant, Canada goose, mallard, cattle egret, American white pelican
Other passerine bird = American crow, common raven, European starling*
Other raptor = Bald eagle, black vulture, turkey vulture

Vulture Effigy

Other waterbird = Great blue heron
Other passerine bird = Common raven
Other raptor = Bald eagle, northern crested caracara

Table 5

Other mammal = Eastern cottontail rabbit, raccoon, black bear, fox squirrel, American beaver, white-tailed deer, feral swine, Virginia opossum, striped skunk
Other passerine bird = common grackle, great-tailed grackle, red-winged blackbird, white-winged dove, rock pigeon*, blue jay, loggerhead shrike, eastern meadowlark, house finch, eastern bluebird
Other raptor = Turkey vulture, osprey, American kestrel, broad-winged hawk, northern harrier, red-shouldered hawk, Swainson's hawk, black vulture, barn owl, great horned owl
Other waterbird = Double-crested cormorant, mottled duck, American coot,
Other bird = Great blue heron, little blue heron, white ibis, roseate spoonbill, semipalmated plover, upland sandpiper, Forster's tern, laughing gull, ring-billed gull, common nighthawk, belted kingfisher, pileated woodpecker

Table 6a

Other passerine bird = Common raven, fish crow, black drongo, American robin, Eastern kingbird, tree swallow, bank swallow, Northern rough-winged swallow, purple martin, chimney swift, house finch, western meadowlark, savannah sparrow, boat-tailed grackle, yellow-headed blackbird, Brewer's blackbird, American pipit, Northern mockingbird, black-billed magpie

Other raptor = Sharp-shinned hawk, peregrine falcon, broad-winged hawk, Northern crested caracara, merlin, great horned owl, burrowing owl

Other waterbirds = Laughing gull, great black-backed gull, lesser black-backed gull, glaucus-winged gull, Bonaparte's gull, long-tailed jaeger, whiskered tern, common tern, black tern, gull-billed tern, Caspian tern, green heron, little blue heron, American bittern, tri-colored heron, lesser scaup, gadwall, canvasback, mottled duck, green-winged teal, black-bellied whistling duck, cinnamon teal, American wigeon, American black duck, Northern pintail, Fulvous whistling duck, feral duck*, anhinga, lesser snow goose, greater white-fronted goose, greater snow goose, trumpeter swan, tundra swan, ruddy turnstone, willet, white ibis, glossy ibis, least sandpiper, sanderling, whimbrel, dunlin, wood sandpiper, black-bellied plover, greater yellowlegs, lesser yellowlegs, semipalmated plover, American avocet, Wilson's snipe, snowy egret, black-crowned night heron pied-billed grebe, American white pelican, brown pelican

Other terrestrial non-passerine bird = Common nighthawk, nighthawk spp., wild turkey, sandhill crane, Northern flicker, California Quail

Table 6b

Other mammal = Caribou, elk, pronghorn, striped skunk, white-tailed jackrabbit, black-tailed jackrabbit, bobcat, feral/free-ranging cat, black bear, gray wolf, arctic fox, gray fox

Table 7a

Other waterbirds = American coot, double-crested cormorant, mallard, ruddy duck, Northern shoveler, green-winged teal, American wigeon, Hawaiian goose (T&E), great black-backed gull, California gull, Caspian tern, Forster's tern, cattle egret, great egret, snowy egret, long-billed curlew, sanderling, willet, greater yellowlegs, lesser yellowlegs, upland sandpiper

Other passerine birds = red-winged blackbird, boat-tailed grackle, common grackle, western meadowlark, Eurasian collared dove*, white-winged dove, scissor-tailed flycatcher, American robin, horned lark, barn swallow, cliff swallow, chimney swift

Other raptor = Crested caracara, merlin, peregrine, red-shouldered hawk, sharp-shinned hawk, Swainson's hawk, barn owl

Table 7b

Other mammal = Black bear, red fox, feral/free-ranging cat, striped skunk, Steller sea lion

Table A1. The annual average number of flags (mylar or non-mylar) used to haze target bird species or distributed to cooperators by WS in WDM activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Distributed	Number Work Tasks
American Crow	1	0.2	-	-	-
Common Raven	0.2	0.2	-	-	-

Species	Number used	Number Work Tasks	Number Dispersed	Number Distributed	Number Work Tasks
Sandhill Crane	-	-	-	0.2	0.2
Mallard	0.05	0.2	-	-	-
Northern Shoveler	0.05	0.2	-	-	-
Common Merganser	-	-	-	0.2	0.2
Double Crested Cormorant	8	0.6	-	-	-
Canada Goose	42	9	11	81	16
Cackling Goose	25	0.2	-	-	-
Lesser Snow Goose	2	0.2	-	-	-
Greater Snow Goose	-	-	-	1	0.2
Bald Eagle	1	0.2	-	-	-
Red-tailed Hawk	1	0.4	-	1	1
Red-shouldered Hawk	-	-	-	0.2	0.2
Barred Owl	-	-	-	0.2	0.2
Black Vultures	1	0.2	-	-	-
Turkey Vultures	1	0.2	-	-	-
Rock Pigeons*	0.1	0.2	-	0.4	0.2
Northern Mockingbird	-	-	-	0.4	0.2
American Robin	-	-	-	0.4	0.4
European Starling	1	0.2	-	0.9	0.4
Common Grackles	-	-	-	0.2	0.2
House Sparrow*	-	-	-	0.4	0.2
Wild Turkey	0.2	0.2	-	4	0.8
Downy Woodpecker	-	-	-	1	0.8
Hairy Woodpecker	-	-	-	1	1
Pileated Woodpecker	-	-	-	0.4	0.4
Red-headed Woodpecker	0.2	0.2	-	0.2	0.2
Total	**84**	**13**	**11**	**93**	**23**

Table A2. The annual average number of rolls of mylar tape used to haze target species or distributed to cooperators by WS in WDM activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
American Crow	-	-	-	0.6	0.4
Common Raven	-	-	-	0.4	0.2
Red-winged Blackbird	0.2	0.2	-	-	-
Blackbirds (Mixed Species)	-	-	-	1	0.6
Common Grackles	-	-	-	0.2	0.2
Mourning Dove	0.02	0.2	-	-	-
Rock Pigeon	0.02	0.2	-	0.2	0.2
House Sparrow	0.02	0.2	-	0.2	0.2
European Starling	13	2	-	0.4	0.2
Northern Cardinal	-	-	-	0.4	0.4
American Robin	-	-	-	0.6	0.6
Barn Swallow	-	-	-	0.2	0.2

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Bald Eagle	-	-	-	0.4	0.2
American Kestrel	0.5	0.4	-	-	-
Broad-winged Hawk	-	-	-	0.4	0.4
Cooper's Hawk	-	-	-	0.6	0.4
Northern Goshawk	-	-	-	0.2	0.2
Red-shouldered Hawk	-	-	-	0.2	0.2
Red-tailed Hawk	0.2	0.2	-	2.6	2
Osprey	-	-	-	0.8	0.2
Barred Owl	-	-	-	0.4	0.2
Black Vulture	0.2	0.2	-	-	-
Mallard	0.8	0.2	-	0.2	0.2
Canada Goose	21	8	49	13.2	7
Lesser Snow Goose	0.2	0.2	-	0.4	0.2
Franklin's Gull	-	-	-	0.1	0.2
Glaucous-winged Gull	0.4	0.8	-	-	-
Ring-billed Gull	0.02	0.2	-	0.1	0.2
Wild Turkey	0.6	0.6	-	5.6	5
Northern Flicker	0.2	0.2	-	0.2	0.2
Downy Woodpecker	-	-	-	3.5	3
Hairy Woodpecker	-	-	-	5.3	2
Pileated Woodpecker	-	-	-	0.6	0.6
Red-bellied Woodpecker	-	-	-	0.6	0.6
Yellow-bellied Sapsucker	-	-	-	0.4	0.4
Total	**37**	**14**	**49**	**39**	**27**

Table A3. The annual average number of flags/tape used as fladry to haze target mammal species or distributed to cooperators by WS in WDM activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Black Bear	0.2	0.2	-	1	0.6
Coyote	7	2	-	0.4	0.6
Gray Wolf	43	4	-	6	3
Red Fox	1	0.2	-	-	-
Moose	10	0.2	-	-	-
White-tailed Deer	-	-	-	12	1
Total	**61**	**7**	**-**	**19**	**5**

Table A4. The annual average number of target birds hazed with balloons by WS in WDM activities from FY16-20 throughout the United States.

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Double Crested Cormorant	10	0.6	-	-	-

Species	Number used	Number Work Tasks	Number Dispersed	Number Loaned	Number Work Tasks
Mallard	0.2	0.2	20	-	-
Canada Goose	0.6	0.2	-	9	5
Nene T&E	0.4	0.4	5	-	-
Great Black-Backed Gull	1	1	-	-	-
Herring Gull	1	1	-	-	-
Laughing Gull	1	1	-	-	-
Ring-billed Gull	2	1	-	-	-
Broad-winged Hawk	-	-	-	0.8	0.4
Red-tailed Hawk	-	-	-	1	0.8
Osprey	-	-	-	2	0.2
Rock Pigeon*	-	-	-	0.2	0.2
House Sparrow	-	-	-	0.2	0.2
Eastern Gray Squirrel	-	-	-	0.3	0.2
Wild Turkey	-	-	-	4	2
Vole	-	-	-	0.3	0.2
Downy Woodpecker	-	-	-	1	1
Hairy Woodpecker	-	-	-	0.8	0.4
Pileated Woodpecker	-	-	-	1	0.8
Red-bellied Woodpecker	-	-	-	0.2	0.2
Yellow-bellied Sapsucker	-	-	-	0.4	0.4
Sandhill Crane	-	-	-	0.3	0.2
Total	**16**	**5**	**25**	**22**	**12**