Human Health and Ecological Risk Assessment for the Use of Wildlife Damage Management Methods by USDA-APHIS-Wildlife Services

Chapter V

THE USE OF AIRCRAFT IN WILDLIFE DAMAGE MANAGEMENT

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EXECUTIVE SUMMARY

Aircraft are used by the USDA-APHIS-Wildlife Services (WS) Program for specific wildlife damage management (WDM) projects such as shooting, tranquilizing, hazing, or surveying wildlife that are causing damage to property, agriculture, and natural resources or protecting human health and safety. Additionally, WS uses aircraft to deliver vaccines and baits where appropriate. WS use aircraft annually about 14,000 hours. Most WS activities that involve the use of aircraft are for coyotes and feral swine damage management operations (~70%).

Potential human health and environmental risks from the proposed use of aircraft by WS has been evaluated by APHIS and determined that the risks to human health and the environment are minimal, well within the norms of associated risks. Issues pertaining to the use of aircraft are discussed in the following risk assessment. WS pilots and crewmembers are trained and certified in low level flight safety to ensure operations are conducted as safely as possible. To ensure safety, WS established an Aviation Training and Operations Center to help train agency and contract pilots as well as the crewmembers in a variety of measures to reduce accidents and other problems associated with flying. These measures have been in place for several years and increased safety of the WS aviation personnel.

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1 INTRODUCTION

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) Program uses aircraft, both fixed-wing and rotary-wing (helicopters), in several wildlife damage management (WDM) activities including hunting, surveying, monitoring (e.g., radio telemetry), harassment (dispersing), capturing (e.g., tranquilizing with dart guns, capturing with net guns, or round-ups usually by herding into large corral traps), and bait drops.

WS aerial operations are conducted with agency-owned aircraft crewed by WS employees and with private aircraft/crew hired under contract by WS. WS has owned an average of 34 fixed-wing and 12 rotary winged aircraft and contracted the use of 19 fixed-wing and 10 rotary-winged aircraft for FY11[1] through FY15. The most frequent aircraft used in aerial shooting and harassment are the fixed-wing aircraft Piper PA-18 Super Cub and CubCrafters CC-18 Top Cub and rotary-wing Hughes MD500 and Bell 206. Capturing usually involves only the MD500 and Bell 206 helicopters. Surveying and monitoring are done with the same aircraft, but also may include the Cessna 172 Skyhawk. Bait drops, thus far, have been completed with the Beechcraft King Air C-90.

1.1 Use Pattern

WS aircraft use increased in 2011 to assist with a National Feral Swine Program initiated to reduce feral swine damage throughout the United States. On average, WS annually flew aircraft 14,328 hours for FY11 to FY15; aerial shooting, tranquilizing, and bait drops accounted for the most time annually averaging 11,149 hours, followed by ferrying at 1,705 hours, surveying at 997 hours, training at 331 hours, maintenance flights at 91 hours, radio telemetry at 22 hours, emergency response, search and rescue, and accident investigations at 16 hours, and hazing at 7 hours (Table 1). WS annually averaged 16,843 work tasks[2] for all activities (Table 1). Of these, 10,037 were associated with aerial activities where an animal was taken, captured, or hazed. This included the lethal removal of 41,747 animals from aerial shooting, the capture and radio collaring of an average of one animal, the dispersal of 540 animals, and the surveying/monitoring 2,877 animals (Table 2)[3]. No nontarget animals were taken from FY11 to FY15. Additionally, WS used aircraft to aerially drop an annual average of 3.55 million rabies vaccine baits and 7,655 acetaminophen baits.

Aerial shooting (*i.e.*, shooting a firearm from an aircraft) is the most common use of aircraft in the WS program. From FY11 to FY15, WS annually averaged the take of 41,747 animals during 7,066 work tasks associated with aerial shooting (Table 2). Aerial shooting is typically used to remove coyotes[4], feral swine, gray wolves, red fox, and bobcats. WS used aerial shooting for FY11 through FY15 to primarily take coyotes (65% of lethal take) and feral swine (34%). Additionally 7 other predators and 5 other hoofed mammals were taken; these additional species may be removed when requested by the property owner or manager and after coordination with the appropriate state or federal wildlife management agency. The primary use of aerial shooting is to control livestock losses from coyotes and to prevent damage to agricultural property and natural

[1] FY11 equals the federal Fiscal Year 201 which is October 1, 2010-September 30, 2011 (the year is denoted by FY11, FY12, and so on and is the federal Fiscal Year for 2011, 2012, and so on.

[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 taken into account and, thus, a Work Task could be 10 minutes to 10 hours in duration.

[3] Table 1 and Table 2 have different numbers of work tasks. Table 1 includes work tasks without an animal taken, but were actively searching for unknown target animals whereas Table 2 only includes work tasks where an animal was taken and the target was known. The MIS cannot differentiate by target species unless an animal was taken.

[4] See the Risk Assessment Introduction (Chapter 1) for scientific names of animals. These will only be given if they are not used in that Chapter.

resources from feral swine. It can be especially effective in removing coyotes, feral swine, and other animals that have become "*bait-shy*" to trap sets or animals not susceptible to calling, dispersal shooting, or other WDM methods. Cain *et al*. (1972) rated aerial shooting as "*very good*" in effectiveness for problem solving, safety, and lack of adverse environmental impacts. Connolly and O'Gara (1987) documented the efficacy of aerial shooting in taking confirmed sheep-killing coyotes. Wagner and Conover (1999) reported that aerial shooting reduced sheep losses to coyotes. Gantz and Knowlton (2005) determined that the removal of coyotes from high elevation areas was an effective method of reducing sheep losses for the following summer because territorial pairs were more likely to be taken, which are the coyotes that would be more apt to be involved in killing sheep. Aerial shooting is one of the preferred damage management methods for reducing feral swine damage as well, in that local swine populations can be removed quickly when weather and habitat conditions are favorable (Saunders 1993, Steen 2006). Nonnative species eradication programs such as the removal of feral swine (Parkes et al. 2010), goats (Campbell and Donlan 2005, Cruz et al. 2009, Beauchamp et al. 2011), and donkeys (*Equus asinus*) (Carrion et al. 2007) using aerial shooting as the primary method of removal, especially from islands, have been ecologically beneficial and relatively inexpensive (Carrion et al. 2011). WS has used fixed- and rotary-wing aircraft for aerial shooting for over sixty years with no known significant adverse impacts on any native wildlife populations. WS conducts aerial activities over areas with signed Work Initiation Documents for Wildlife Damage Management (WS Form 12A) or where a Work Plan (e.g., U.S. Forest Service (USFS) and Bureau of Land Management lands) is in place and concentrates efforts during certain times of the year and to specific areas. WS flies very little over any one property in any given year.

Table 1. The average annual hours flown by aircraft and its various categories. Included are the work tasks for the various activities as well.

ANNUAL AVERAGE AIRCRAFT USE FOR VARIOUS ACTIVITIES BY WS FOR FY11-FY15		
Activity	**Aircraft Hours**	**Work Tasks**
Wildlife Management Activities		
Aerial Shooting/Tranquilizing/Bait Drops	11,149	10,865
Wildlife Surveys	997	364
Radio Telemetry	22	10
Wildlife Hazing	7	3
Other Activities		
Ferry	1,705	5,458
Training	331	21
Maintenance	91	52
Emergency Response & Search/Rescue	16	70
TOTAL	**14,328**	**16,843**

Aerial shooting is a species-selective method with only a minimal potential for misidentification, and can be used for immediate response to reduce livestock and natural resource losses, and protect and human health and safety. WS uses shotguns for aerial shooting, but rifles may be used selectively in the future as well for certain target species, primarily from helicopters. Aerial shooting success may be affected by a number of variables such as weather, terrain, snow cover, and vegetative cover (Mason et al. 2002). Fixed-wing aircraft are most frequently used in flat and gently rolling terrain whereas helicopters, with better maneuverability, have greater utility and are safer over rugged terrain and brushy or timbered areas. In broken timber or deciduous cover, aerial shooting is more effective in winter when leaves have fallen and snow cover improves visibility. WS Aviation and Safety and Operations Directive (WS Directive 2.620) and guidance within the WS Aviation Operations and Safety Manual prescribes the minimum safety and operations standards for WS aerial operations. Pilots and aircraft must be certified under established WS program procedures and only certified WS employees are approved as crewmembers. WS Policy requires that all WDM aerial operations are conducted in conjunction with a ground crew or responsible WS point of contact. Ground crews are used with aerial operations for safety reasons and to assist locating and recovering target animals, as necessary. Ground crews can improve the effectiveness of aerial shooting by locating target animal (e.g., howling for coyotes and listening for a response) and safety such as assisting in watching for people, obstructions, and other environmental conditions (Mason et al. 2002).

WS also uses aircraft, primarily helicopters, to capture animals either by using tranquilizer dart or net guns, or herding them into corrals or other enclosures (herd traps). WS has not been involved in the use of herd traps recently, but could if there is a need in the future. The use of these other methods, namely tranquilizer and net guns, and corral traps, is covered in the Immobilization and Euthanasia Drug and Cage Trap Risk Assessments, but the hazards associated with flying are discussed here. For FY11 through FY15, WS only used tranquilizer dart guns from helicopters for an annual average of 1 work task capturing and radio-collaring 1 wolf (Table 2).

Aerial harassment through low-level flights is used to frighten wildlife from an area and prevent damage to agriculture and natural resources. WS has used aerial harassment infrequently with an annual average of 2 work tasks associated with its use to disperse elk for FY11 through FY15 (Table 2).

Aerial surveying is a commonly used tool for evaluating and monitoring damage, establishing wildlife population estimates, aerial photography, and determining locations of various species of wildlife or their sign. Aircraft play an important role in the management of various wildlife species for many agencies. Resource management agencies rely on low flying aircraft to monitor the status of many animal populations, including large mammals (Lancia et al. 2000), birds of prey (Fuller and Mosher 1987), waterfowl (Bellrose 1976), and colonial waterbirds (Speich 1986). Many flights to survey animals are conducted in preselected routes. Aerial surveying also includes the use of radio telemetry, a technology used in research projects to study the movements of various wildlife species (Gilmer et al. 1981, Millspaugh et al. 2012). Biologists will frequently place radio-transmitting collars on selected individuals of a species and then monitor their movements over a specified period. Whenever possible, the biologist attempts to locate the research subject using a hand-held antennae and radio receiver on the ground, but occasionally animals will travel long distances or into rugged terrain that prevent biologists from locating the animal from the ground. In these situations, WS can use either fixed wing aircraft or helicopters to conduct telemetry and locate the specific animal. WS also uses radio telemetry in conjunction with the "Judas Technique" (McIlroy and Gifford 1997) which involves use of radio collared feral swine sows to lead WS' personnel to additional animals. WS and contract aircraft are then used to locate and euthanize these animals.

WS used aerial surveying between FY11 and FY15, including radio-telemetry, to monitor wildlife populations or their damage for feral swine, coyotes, wolves, grizzly bear, mule deer, white-tailed deer, beaver, greater sage-grouse, and double-crested cormorants. As with aerial shooting, the WS Directive 2.620 on aircraft-use helps ensure that aerial surveys are conducted in a safe and environmentally sound manner, in accordance with Federal and State laws. Pilots and aircraft must also be certified under established WS program procedures and policies. From FY11 to FY15, WS conducted an annual average of 364 work tasks associated with aerial surveying (Table 2). Additionally, WS is investigating the potential use of drones for feral swine surveying. A private company in New Mexico is offering drone services which are being used occasionally by other state and federal agencies. WS could possibly work with the company and other agencies to use drones to survey for species such as feral swine, especially in areas where they are believed to be eradicated and the area needs to be monitored for their presence. The use of drones could minimize human injury or death risk by reducing the number of hours WS personnel spend in aircraft. Additionally, drones are less expensive than turbine helicopters and have the advantage of using forward-looking infrared, night vision, and other technology.

Table 2. The annual average number of animals taken by aerial shooting or tranquilizer darts, dispersed or surveyed with aircraft, and baits dropped by WS between FY11 and FY15.

Species	Ave. Annual Number	Ave. Work Tasks/FY**	Percent of Work Tasks	Ave Hours Flown	Percent of Hours Flown
Aerial Shooting (killed)					
Bobcat	61	44	0.6%	83.9	0.7%
Mountain Lion	0.2	0.2	<0.0%	0.2	<0.0%
Coyote	27,124	6,301	84.0%	8,491.8	72.3%
Gray Wolf	84	64	0.9%	150.8	1.3%
Red Fox	79	62	0.8%	83.2	0.7%
Gray Fox	5	3	<0.0%	7.5	0.1%
Black Bear	0.2	0.2	<0.0%	0.2	<0.0%
Raccoon	0.4	0.2	<0.0%	0.8	<0.0%
Feral Swine*	14,372	589	7.8%	1,203.2	10.2%
Moose	0.4	0.2	<0.0%	1.0	<0.0%
Mule Deer	6	0.6	<0.0%	2.6	<0.0%
White-tailed Deer	1	0.8	<0.0%	1.8	<0.0%
Feral Goat*	8	0.2	<0.0%	1.0	<0.0%
Bighorn Sheep	6	0.4	<0.0%	1.5	<0.0%
Total	**41,747**	**7,066**	**94%**	**10,029.5**	**85%**
Aerial Capture with Tranquilizer Gun (captured, collared, & released)					
Gray Wolf	1	1	<0.0%	2.3	<0.0%
Total	**1**	**1**	**0%**	**2.3**	**0%**
Aerially Dispersed from Damage Site (hazed)					
Elk	540	3	<0.0%	4.3	<0.0%
Total	**540**	**3**	**0%**	**4.3**	**0%**
Aerial Survey including Wildlife Counts, Radio Telemetry (surveyed)					
Coyotes	14	0.6	<0.0%	0.9	<0.0%
Gray Wolf	56	33	0.4%	44.3	0.4%
Grizzly Bear	0.2	0.2	<0.0%	0.4	<0.0%
Feral Swine*^	254	254	3.4%	817.3	7.0%
Mule Deer	412	1	<0.0%	7.3	0.1%
White-tailed Deer	78	1	<0.0%	2.2	<0.0%
Beaver	367	22	0.3%	68.2	0.6%
Greater Sage-Grouse	234	51	0.7%	49.6	0.4%
Double-crested Cormorant	1,462	1	<0.0%	7.0	0.1%
Total	**2,877**	**364**	**5%**	**997.2**	**8%**
Aerial Drop (disease management, bait distribution)					
Bait Type	**Baits Dropped**	**Work Tasks**	**% of WTs**	**Hours**	**% of Hours**
Rabies Vaccine Baits	3,550,607	63	0.8%	711.0	6.0%
Acetaminophen Baits	7,655	7	0.1%	9.4	0.1%
Total	**N/A**	**70**	**1%**	**720.4**	**6%**
GRAND TOTAL	**N/A**	**7,504**	**100%**	**11,752.7**	**100%**

* Introduced species

** Work tasks/species were summarized from take, surveys, and bait drops (annual average of 7,006) when identified; the WS MIS does not identify what species is targeted when no animal is taken and, thus, work tasks for aircraft where no animal is identified in take could not be used.

^ The National Feral Swine Program had many hours of flights monitoring for feral swine and their damage that was not entered into the MIS, but tracked by the WS National Aviation Training and Operations Center. An estimate was added (253 flights and 816 hours)

Bait drops are another use of aircraft by WS, but vary from other aircraft uses because many operations can be done at higher levels above the ground and are conducted in pre-planned grid patterns. . These drops require some type of conveyer belt or other delivery system to drop the appropriate density of baits. Bait drops are currently conducted for a rabies vaccination program for the eastern raccoon, gray fox, and coyote rabies strains and dropping acetaminophen baits to control the invasive brown tree snake on Guam[5]. For FY11-FY15, WS conducted an annual average of 63 flights dropping almost 3.6 million rabies vaccine baits. The current rabies drop bait program is striving to contain raccoon rabies in the eastern United States and gray fox/coyote rabies in Texas from spreading westward and northward, respectively (Table 2). The Guam program dropped 7,700 baits (a neonatal mouse with an acetaminophen bait (less than a child's dose) glued to a tube that opens and hangs from a parachute, which by design get entangled in the canopy, the target drop site) in an annual average of 7 flights (Table 2); these were associated with research on the effectiveness of the technique[4]. This program was deemed effective in reducing brown tree snake densities and is going to be transitioned into a fully operational approach.

2 HAZARDS

2.1 Human Health and Safety

Human health and safety hazards associated with the use of aircraft in WS programs are mostly related to accidents that can be caused by pilot error, mechanical failure, wildlife strikes (most bird strikes occur under 500 feet), and environmental conditions such as striking a tree or a power line, or the rapid onset of inclement weather like excessive cross-winds. Additionally, specifically related to aerial shooting and aerial capture, the use of firearms in aircraft has inherent dangers of accidental discharge in the aircraft causing damage to the aircraft and potentially airworthiness, or injuring the crew. The use of firearms in the aircraft could also cause a bruise to the shoulder or face of the crewmember from firearm recoil during discharge. The hulls or other debris from ammunition shot or ejected from the firearm[6] could cause eye or facial injury. Loss of hearing is another hazard from exposure to aircraft and shooting noise. Finally, exhaust from engines could be harmful to WS personnel.

Hazards associated with people on the ground could be associated with a crash and shooting from the aircraft. Additionally, concern has arisen by certain members of the public that WS aircraft could be stolen and jeopardize people in a terrorist attack. Recreationists in remote areas may believe that their "wilderness" experience could be ruined by frequent aircraft noise. Finally, WS has conducted bait drops with Oral Rabies Vaccine (ORV) sachets and small blocks of edible meal which could potentially hit people when dropped from an aircraft. Similarly, acetaminophen baits, if the parachute does not deploy correctly, could hit people on the ground. The ecological and human health risks associated with the rabies vaccines and acetaminophen baits is evaluated in a separate risk assessment, but the bait drops from aircraft are considered here.

On the other hand, several wildlife damage management programs reduce the potential for human exposure to problem wildlife and diseases. Though mildly venomous, a reduction in brown tree snakes could reduce the incidence of bites. The removal of large carnivores that have been deemed a public safety threat could reduce potential attacks. A reduction in human cases of rabies from raccoon and gray fox/coyote populations has occurred from vaccinating these species through the vaccine bait drop program. Thus, public safety can be increased by having this method available.

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[5] Starting in 2013, two 55-hectare (136 acres) forest plots on Guam were aerially treated with acetaminophen mouse baits and will be compared to an untreated 55-hectare reference site over a 16-month period. WS-National Wildlife Research Center scientists monitored snake and rodent abundance before, during, and after the drops to evaluate the overall effectiveness and environmental impact of the baiting operation. Thus far, the bait drops have shown a statistical drop in snake activity, but has not eradicated them from the area. As far as nontarget take, only a monitor lizard was found dead from extensive monitoring efforts, but its mortality cause has not been determined.

[6] WS strictly uses shotguns for lethally taking animals from aircraft. However, rifles have been tested for use from helicopters to take wolves and will likely be used operationally, but only for large animals; rifles may be used operationally to enable taking a target animal at longer distance which helps not to scare the remaining animals. No matter the firearm used, training will be completed for the crewmember using them prior to use in the air.

2.2 Environmental

Environmental hazards associated with aircraft and shooting from aircraft to wildlife include the take of nontarget species, primarily species that look similar to target species, and the harassment of wildlife from aircraft overflights. Other environmental hazards include the potential for an aircraft crash to cause a ground or forest fire, or a hazardous waste spill from aviation fuels or oil from the aircraft. Several other areas of concern have been identified, but will be covered in other risk assessments. For example, the use of lead is a concern, but is covered in a Lead Risk Assessment. Other areas include emissions from aircraft (Climate Change and Emissions Section in Risk Assessment Introductory Chapter), ammunition hulls and casings that fall to the ground from aircraft (Firearms Risk Assessment), and tranquilizer darts on the ground that miss their mark (Immobilization and Euthanasia Risk Assessment). Finally, bait drops have lessened animals succumbing to the rabies virus and outbreaks. Preliminary monitoring on Guam has found that snake activity is significantly reduced using acetaminophen bait drops which is beneficial to native fauna and the drops have not had significant problems associated with nontarget species impacts.

3 RISKS

3.1 Human Health and Safety

Aerial shooting combines the use of aircraft and firearms. Risks related to aviation accidents include harm to the public and crewmembers and loss of aircraft. WS use of aircraft is quite different from general aviation (GAV) use. The environment where WS conducts aerial shooting is inherently a higher risk environment than that for GAV. Low-level flights introduce hazards such as power lines and trees, and the safety margin for error during maneuvers is diminished compared to high-level flights. In 1998, WS commissioned an independent review of its aerial shooting operations as a result of several accidents. The panel made several recommendations to WS regarding enhanced aerial safety. WS implemented most all of these recommendations by 2001. WS has implemented an Aviation Safety Program to support aerial activities and recognized that an aggressive overall safety and training program was the best way to prevent accidents. As a result of a fatal aircraft accident in 2007, the WS Deputy Director requested that the Interagency Committee for Aviation Policy to provide a technical review of WS aerial activities, as the committee is well-recognized as experts in aviation safety. The review found that the WS Aviation Safety Program was doing a good job and that safety came first among the pilots in WS. The committee did make the suggestion that WS should have better communication devices in the aircraft. WS recognizes that crew training and communication is critical to the safe aerial operations. Another review was conducted in 2010. This review again found that implementation of the Aviation Safety Program had been mostly a success, but made suggestions for the restructuring of aviation personnel, which was subsequently accomplished by the WS National Aviation Training and Operations Center (ATOC). One additional suggestion was that an annual review be conducted of the Aviation Safety Program. Another program review was conducted in 2017 following an accident and involved personnel from WS, Federal Aviation Administration (FAA), DOI Office of Aviation Services, U.S. Forest Service (USFS), and Utah Division of Wildlife Resources. The focus was on mitigating hazards to aircraft 1) as related to airspeed, stalls, and spins; 2) by increasing overall attentiveness of WS pilots to human factors[7] and pilot error often involved in accidents; and 3) by increasing management's knowledge of aviation related subject matter and human factors associated with accidents. Recommendations from the review focused on flight crew and management training, technological safety enhancements for aircraft, adjustment

[7] Human factors are the study of the relationships between people and their activities through the systematic application of the human sciences, integrated within the framework of engineering. Within the context of aviation, this includes interactions among aviation personnel, their environments, and equipment such as fatigues and crew resource management.

in WS WDM flight profile and mission philosophy, and flight crew compositions. Deficiencies were noted within the WS helicopter program with regards to standardization and an aging aircraft fleet. Current needs include increasing training center assets such as a helicopter and helicopter simulator and updating the agency helicopter fleet. Recommendations from earlier reviews have been completed and the results have been positive. While the goal of the aviation program is to have no accidents, they may still occur, especially those involving mechanical failure.

WS agency pilots and contractors are highly skilled, hold commercial pilot ratings and must pass proficiency tests annually in the flight environment encountered by WS. WS pilots, crewmembers, and ground crews are trained in hazard recognition and shooting is only conducted in safe environments. Federal aviation regulations (FAR Part 91 section 119, as well as WS Aircraft-use Policy) require pilots to fly a minimum distance of 500 feet from people, vessels, vehicles, or structures. Because of the remote locations in which WS conducts aerial operations, the risk to the public from aviation operations or accidents is minimal. The regulations state that aircraft in congested areas such as over a city, town, or settlement or over any open air assembly must maintain an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft. For places other than congested areas, an altitude of 500 feet above the surface must be maintained, except over open water or sparsely populated areas. From 2000 to 2016, WS had an average fleet of 48 fixed wing aircraft and 24 rotary-winged aircraft.

Seventeen accidents occurred from 2000 to 2016 (17 years) by WS and contract pilots, or 7.2 accidents per 100,000 hours of flying, just minimally over the national general aviation accident rate of 6.7 per 100,000 hours (National Transportation Safety Board (NTSB) 2013, 2017) which includes low- and high-level flying (Table 3). A series of accidents in the late 1990s stimulated an aviation safety audit in 1998 which resulted in the establishment of WS ATOC in 2003. ATOC is responsible for training and certifying pilots, both WS personnel and contract pilots, and WS crewmembers involved in WS aerial operations. WS Aviation Safety Services provides aviation policy for aviation safety management, and aircraft mishap prevention oversight to the organization in the direct support of all WS aviation activities. The core goal is to ensure the safety of aviation activities and prevent all WS aviation accidents. The strategic direction of Aviation Safety Services is to ensure the stability and continuity, and where appropriate elevate, aviation safety standards, increase efficiency, and promote a risk-managed operation of aviation activities for internal and external customers. WS aerial operations embrace high standards of ethics, integrity, safety, and accountability, and accomplishes its objectives through oversight and training. Objectives under this goal define WS Aerial Operations commitment to address safety challenges and to ensure exceptionally safe operations.

In order to promote this culture of safety, WS follows the principles of the Four Pillars of the Safety Management Systems (SMS) approach. These “four pillars” consist of Promotion, Risk Management, Assurance and Policy. SMS can be used as a means of providing a formal process and structure to control the risk associated with the vast array of aviation missions.

WS Aviation Training Services provide aviation policy for aviation training management and personnel training oversight to the organization in the direct support of all WS aviation fleet activities and Commercial Aviation Service operations. WS aerial operations will continue to train, retrain, and develop a high-performing workforce. Furthermore, WS aerial operations will examine its process to determine the optimal mix of classroom, web-based, and practical training to demonstrate commitment to training. ATOC is fully committed to continually assess and improve upon WS aviation training requirements and methods

Table 3. WS and contract pilots hours flown, accidents, and general aviation (GAV) hours and accidents (NTSB 2013) for 2000-2016. The accident rates are standardized for 100,000 hours of flying. The National Aviation Training Center became operational in 2003 and most pilots had undergone required training by 2006. Thus a comparison is made for the accident rate after ATOC became fully operational (2007-2016).

WS Aerial Shooting Hours						
Year	**FW Hours**	**FW Accidents***	**RW Hours**	**RW Accidents***	**GAV Hours (NTSB 2013, 2016)**	**GAV Accidents**
2000	10,884	1P (2I) 1M (2I)	2,671	1U (2F)	27,838,000	1,837
2001	12,123	0	2,328	1P	25,431,000	1,727
2002	12,536	1P	3,247	0	25,545,000	1,716
2003	5,571	2P (3I)	2,088	1M (2I)	25,998,000	1,741
2004	13,618	2P (3I)	3,511	0	24,888,000	1,619
2005	12,966	0	2562	0	23,168,000	1,671
2006	12,467	1P (2I)	3,412	0	23,963,000	1,523
2007	11,670	1P (2F) 1P	2725	0	23,819,000	1,654
2008	12,201	0	2826	0	22,805,000	1,568
2009	11,839	0	2650	0	20,862,000	1,480
2010	11,236	0	2133	0	21,688,000	1,440
2011	10,418	1U	1889	0	21,488,000*	1,471
2012	10,391	0	2563	0	21,697,000	1,473
2013	10,314	0	2687	0	19,492,000	1,224
2014	8,697	0	3031	1M (2I)	19,617,000	1,223
2015	9,128	1U (2F)	3465	0	20,576,000	1,209
2016	9,886	1U(1F 1I)	4795	0	N/A	N/A
Total	**185,945**	**13 (5F 13I)**	**48,583**	**4 (2F 4I)**	**368,875,000**	**24,576**
2000-16	WS FW Accident Rate	7.0 per 100,000	WS RW Accident Rate	8.2 per 100,000	GAV Accident Rate	6.7 per 100,000
FW +RW	**WS Accident Rate**	**234,528 hours 17 accidents**		**7.2 per 100,000**	**6.7 per 100,000**	
Year	**FW Hours**	**FW Accidents**	**RW Hours**	**Accidents**	**GAV Hours**	**GAV Accidents**
Total	**105,780**	**5**	**28,764**	**1**	**81,382,000**	**5,129**
2007-16	WS FW Accident Rate	4.7 per 100,000	WS RW Accident Rate	3.5 per 100,000	GAV Accident Rate	6.3 per 100,000
FW+RW	**WS Accident Rate**	**134,544 hours 6 accidents**		**4.5 per 100,000**	**6.3 per 100,000**	

FW = Fixed-wing RW = Rotary-wing GAV = General Aviation
* P = Pilot Error M = Mechanical U = Unknown Cause F = Fatality I = Injury

The training center has a flight simulator which prepares pilots for low-level flying risks. Additionally, the safety audit identified that WS should use turbine engines in helicopters rather than piston engines because, out of the twelve accidents between 1996 and 2001 just prior to the safety audit, 6 involved piston helicopters.

Some of WS accidents involved pilot error while others were directly related to mechanical failure. Of the accidents between 2000 and 2016, 10 were due to pilot error, 3 were due to mechanical failure, and 4 due to unknown causes. Of the 6 accidents between 2007 and 2016, 2 were due to pilot error, 1 due to mechanical failure, and 3 due to unknown causes. Pilot error accidents have dropped, but ATOC is committed to reducing these to zero. Four of the aircraft accidents that occurred between 2000 and 2016 resulted in 7 crewmember fatalities. This is similar to, but slightly higher than, general aviation fatalities (1.2 GAV vs 1.70 WS fatal accidents/100,000 hours). Nine of the accidents involved injuries to 17 crewmembers.

For comparison, the U.S. Department of Interior (DOI 2017) tracks accidents for all their agencies in DOI. DOI flew an annual average of about 62,000 hours annually with an average of 3 accidents from FY07 to FY16. This provided an accident rate of 4.8 per 100,000 hours, a fairly low accident rate. This accident rate is similar to the WS accident rate from 2007 to 2016 of 4.5 per 100,000. Comparatively, USFS (2013) conducts frequent low-level flying fighting fires and has a low accident rate. Their 10 year average from 2004 to 2013 was 3.9

accidents per 100,000 hours, another low accident rate considering their mission. The low accident rate for USFS can likely be attributed to the rigorous training their pilots receive at the Interagency Fire Training Center in Boise, Idaho. These figures are well within the norms for general aviation and shows the commitment federal agencies have had to increase safety in aviation programs.

As a result of the accidents and the fact that WS is the only agency that does the predominance of its work in a low-level environment which has unique flight requirements, WS created a WS Mishap Review Panel (MRP) for the purpose of reviewing accidents/incidents to determine probable cause(s) and contributing factors. The MRP consists typically of 4 members from the prior MRP panel that was convened and a 5th member selected from other WS aviation personnel and, if appropriate, crewmembers. The panel membership can vary depending on the nature of incident under investigation. Once an accident/incident occurs, it is investigated by a WS investigation team normally including the WS National Aviation Safety Manager, the ATOC Manager, the WS Airworthiness Safety Inspector, and, others as appropriate. NTSB investigates accidents too. The information is gathered and sorted and given to the MRP which convenes about 30 to 45 days post incident/accident. They review the accident/incident information, determine the problems associated with the flight accident/incident, and make recommendations regarding remedies or solutions to implement as a means to prevent its reoccurrence. These recommendations are distributed to the WS Deputy Administrator, the ATOC Manager, the appropriate WS State Director, and the pilot and/or crewmember (initiate retraining as appropriate). NTSB receives a copy of the recommendations as well.

An MRP goal is to provide solutions to make low-level flying better in a forum where a person can be open and honest without fear of punitive reprisal. Notably, as a result of WS accidents, WS has been responsible for notifying the Federal Aviation Administration of 3 discrepancies (identified aircraft problems), one involving turbine engines used in helicopters which was issued to the public in an Airworthiness Directive and two involving manufacturing problems with aircraft that resulted in the issuance of two Service Bulletins to the manufacturers of these aircraft. The directive and bulletins were issued by the Federal Aviation Administration, the agency responsible for insuring flight safety. The MRP has been effective in providing solutions so that problems do not reoccur which inherently lowers the risk of accidents and incidents.

Training and certification programs for WS personnel have reduced risks associated with aircraft use in the WS program. Thus, with the minimal number of accidents and a dropping accident rate well below general aviation, primarily as a result of the additional training pilots receive at ATOC, WS believes the risk of accidents is minimal and at least in the norms of general aviation.

The use of firearms in aerial shooting has inherent dangers. WS requires training and certification for employees to use firearms (WS Directive 2.615). WS personnel have had accidents with all uses of firearms which include aerial shooting accidents as well as ground shooting accidents with most personnel injured from accidental discharge. For FY13-FY15, WS personnel nationally averaged 2.4 injuries annually from firearms both from aircraft and on the ground. Injuries associated with shooting from an aircraft included shoulder and spine compression injuries from shooting from aircraft repetitively (0.7 or 2 in 3 years). Other injuries associated with firearms on the ground included repetitive strain injuries – trigger finger (0.7), hearing trauma (0.3), burned eye from shot blast (0.3), and a foot shot with an air rifle (0.3). This is a minimal risk considering the number of firearms used by WS in WDM. The Firearms Risk Assessment has more detailed information on these injuries.

In addition to accidents that injured employees, WS also tracks other accidents such as a firearm accidentally discharged in a vehicle/aircraft or missing target and hitting something unintended (mostly firearm user error) and incidents such as ammo or gun misfire or damage to firearm (mostly mechanical malfunction)[8]. From FY11 to FY15, WS had an annual average of 3.0 accidents[9] and 8.4 incidents with firearms. Of the accidents, none was associated with aircraft, though incidents have occurred such as a crewmember accidentally shooting the strut or, most notably, steel shot ricocheting off rocks and hitting the aircraft; these are found on inspection of the aircraft and usually are not noticed as they happen. Most accidents, of the few that occur, result from complacency on the part of the employee and can be avoided, but some accidents and most incidents, those that involved mechanical failure of the firearm or ammunition, would not likely be avoided. WS requires stringent firearm training of employees which has likely resulted in fewer accidents (data is unavailable for comparison). However, considering the number of firearms used by WS and the number of rounds fired (in the millions annually), few accidents and incidents occurred and the risk of injury is relatively minor. Four injuries (0.8/year) occurred for FY11 to FY15; two were accidental discharge of a firearms resulting in foot and leg injuries and two were defective ammunition that resulted in powder burns to the eye and face. For further information and a more detailed analysis of firearm accidents and incidents, see the Firearm Use Risk Assessment. It is possible that accidents could occur, but these are minimal and few involved injuries. Thus, the risk is believed to be minimal.

Injuries to hearing from firearm usage have been reported but no recent documented injuries were to aircraft personnel. These primarily occur over time from shooting in general, but can occur as a result of a mechanical failure,such as a faulty shell that creates an exceptional amount of noise near the ear. In addition to firearm noise, pilots and crewmembers also have noise from the aircraft. As a result of the frequent, high-decibel noise levels, WS initiated a Hearing Conservation Program to minimize hearing loss and monitor employees subjected to frequent noise. Pilots and crewmembers receive routine audiometric testing at ATOC prior to and during their time as a WS employee. To protect against hearing loss, all aircraft crewmembers that fly below 500 feet must wear a Federal Aviation Administration-approved helmet with noise attenuation capabilities that meet or exceed military SPH-4 helmet specifications. In addition, all aircraft crewmembers are issued earplugs that can be used in addition to the flight helmet. Thus, with personal protective equipment (PPE) in use, hearing loss is anticipated to be minimal. In addition, other PPE worn by aircraft crewmembers that fly below 500 feet include fire resistant clothing and safety glasses or visor. PPE worn by WS personnel has undoubtedly reduced the potential for some types of injuries.

Exhaust fumes from aircraft could cause health problems if consistently inhaled. However, the fixed-wing aircraft most commonly used by WS such as the Piper PA-18 Super Cubs, have exhaust systems under the cowling directed away from the aircraft and carried away by the slip stream from the propellers. Turbine-powered helicopters have exhaust systems in the rear where the rotor blast and engine thrust carry it away from the helicopter. Thus, WS personnel would have minimal exposure to exhaust fumes.

WS aerial operations have never injured a person on the ground from a crash or with shooting. If an aircraft were to injure someone on the ground, it would likely be an accident that occurred close to the airport where people are encountered most frequently. WS aerial activities including shooting mostly occur in remote, open areas, and thus, it is unlikely that a crash would occur where people would be encountered. Few incidents have occurred where people were somewhat close to shooting (these have been found to be more than the required minimum distance, but conditions made the people on the ground feel that the aircraft was actually closer than it was). Federal Aviation Administration rules require pilots to stay at least 500 feet from people

[8] A firearm accident is defined by policy as an event that results in an injury or property damage whereas in an incident neither occurs.

[9] An aircraft accident, for the purposes of this risk assessment is viewed as an unplanned, undesired event that leads to personal injury or significant property damage whereas an incident is an unplanned, undesired event that thwarts the completion of a task with possibly minor property damage and had the possibility of becoming an accident.

or buildings. It is feasible that someone may not be seen, but the pilot and crewmembers as well as the ground crew are always watching for people to avoid them. Most areas where WS conducts aerial shooting are open with minimal cover and, thus, people are likely to be seen. The lack of incidents and accidents occurring to people on the ground supports a conclusion of minimal risk to people from WS aircraft operations including aerial shooting.

Concern has arisen that aircraft used by WS could be stolen and used to threaten human safety. WS addresses physical security in Directive 1650.2 (2128/06), the APHIS Aviation Security Program. This directive requires WS personnel to follow security procedures for aircraft, personnel, and facilities for each mission. Additional security oversight is provided by APHIS-Marketing and Regulatory Business Services, the Employee Services Division which conducts security reviews and issues security policy. Helicopters that are used for aerial activity projects are owned by WS or its private contractors. All private contractors, their pilots, and their facilities are subject to a Moderate Background Investigation[10] by WS or to ensure safe use and storage of the aircraft. Thus, WS believes with the security measures and training in place, the risk of theft or illicit activities is minimal.

Potential risk exists for Oral Rabies Vaccine (ORV) baits that are distributed via aircraft to strike people, pets, or property on the ground. However, ORV baits are distributed at densities of 75 to 150 baits/km^2 (194 to 388 baits/mi^2). These densities are sparse enough to predict that the chance of a person being struck and harmed by a falling bait to be extremely remote. For example, if 100 people were standing outdoors in a square mile of area in which ORV baits were being dropped, and each person occupies about 2 square feet of space at the time that baits were dropped, the chance of being struck would be 1 in 139,000 (200 ft^2 total space occupied by persons divided by 27.8 million ft^2/mi^2) (WS 2010). The negligible risk of being struck is further supported by the fact that out of more than 118 million baits distributed in the United States by WS during other ORV programs between 1995 and 2010, only 11 incidents have been reported in which a person claimed to have been struck by a falling bait (0.000009% chance of being struck by a bait or 1 strike per 10.7 million baits dropped) (WS 2013). None of the reports since WS' ORV program inception have resulted in any injury or harm to the individuals involved. The last reported strike, though unconfirmed, was in 2007 where a roofer apparently reported being struck on the head. If a person were struck with the fishmeal polymer bait it could be painful, but the new coated sachet baits are fairly light and would not likely cause injury. In addition, trained aircrews avoid dropping baits into cities, towns, and other areas with human dwellings, or if humans are

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[10] **4.4 Background Investigations:** APHIS policy for Federal employees and contractors working under the classification or occupation of Pilot is stated as follows:

4.4.1 180 days or MORE: (1) Federal Employees who are expected to work under appointments for a cumulative ***180 days or MORE*** during a service year must be able to obtain and maintain a Minimum Background Investigation (MBI) under the Moderate Risk, Public Trust designation (PSC-5). This investigation is conducted through OPM's secure online e-QIP portal where the employee will be required to complete an electronic SF-85P Questionnaire. (2) Non-Federal Employees who provide a service to the Government on a contracted period of performance for a cumulative ***180 days or MORE*** must be able to obtain and maintain an MBI under the Moderate Risk, Public Trust designation (PSC-5). This investigation is conducted through OPM's secure online e-QIP portal where the non-Federal employee will be required to complete an electronic SF-85P Questionnaire. A Special Agency/Agreement Check (SAC) may be submitted prior to or during the MBI investigation process in order to acquire a pre-clearance investigation. This prescreening SAC must be completed before work under the Federal contract commences, while the MBI is in process.

4.4.2 LESS than 180 days: (1) Federal Employees who are expected to work under appointments for ***LESS than 180 days*** during a service year are subject to a pre-employment SAC. This prescreening SAC must be completed before employment commences. (2) Non-Federal Employees who are expected to work under contract for ***LESS than 180 days*** during a period of performance are subject to a pre-employment SAC. This prescreening SAC must be completed before the work under the Federal contract commences.

NOTE: ***Employee.*** *A Federal employee as defined by Title 5 U.S.C. 2105, Employee with APHIS; or an individual employed by, detailed to, or assigned to APHIS.* ***Non-Federal Employee.*** *Any individual doing work for the government either as a contractor, affiliate, consultant, cooperator, volunteer, or any other designation other than an appointed Federal employee. This includes those who provide a service to the Government under a contract for aerial services.*

observed below. In areas with higher human density, ground placement of baits is normally used. Acetaminophen baits deploy a parachute which minimizes potential impacts to people.

On the other hand, WS' use of ORV baits, including aerial bait drops, has resulted in several notable accomplishments including the elimination of canine rabies from sources in Mexico that had spread to coyotes in south Texas, the successful control of gray fox rabies virus variant in western Texas, and the prevention of any appreciable spread of raccoon rabies in the eastern United States. However, occasional incidents of rabies positive cases have been noted within or just outside of established ORV zones, but when these events do occur, they are addressed through ORV Contingency Actions (WS 2010, 2012) to reduce threats to human and animal health.

As far as the risk of ruining a "wilderness" experience, WS again tries to avoid people. It would be a rare occasion that WS flies over or shoots animals on public lands and someone is in the immediate vicinity of the activity. The amount of time spent over any property is minimal. This has been analyzed in several Environmental Assessments including aerial activities conducted in Colorado (WS 2018), Utah (WS 2019), Nevada (WS 2011), and New Mexico (WS 2006). WS averaged flying over less than 20% of the public lands in these states and flew less than 20 minutes/mi^2 land/year. Colorado had the highest amount of time spent on USFS lands at 16 min/mi^2/year. Other times for federal, state, other public lands in Colorado, Nevada, and New Mexico were less than this (Colorado WS flew Bureau of Land Management lands at about 4 min/mi^2/year). Utah and New Mexico had the overall lowest times (Utah flew 3.5 minutes/mi^2 with fixed winged aircraft and 1.0 minute/mi^2 with rotary wing aircraft. Nevada had the highest amount of time on private lands at 46 min/mi^2/year, but recreationists would not be on these lands without permission from the landowner. Thus, it is likely that few recreationists would be encountered when flying and the maximum amount of time spent in any one area would be minimal.

3.2 Environmental

Several concerns arose in the late 1990s and the 2000s from people that thought that the aircraft that are used by WS aerial shooting operations could unintentionally cause wildlife to disperse from aircraft overflights; among these were that birds may abandon nests and wild horses would stampede causing undue stress and mares to abort fetuses. Additionally it was thought that catastrophic ground fires or pollution from oil or petroleum spills could occur.

3.2.1 Potential Impacts to Wildlife from Low-level Overflights and Sound

Nontarget wildlife may be disturbed by low-level aircraft maneuvers and associated noise. The National Park Service (1995) reviewed studies on the effects of aircraft overflights on wildlife. Pepper et al. (2003) conducted a meta-analysis of articles published between 1968 and 2001 related to the impact of flight noise on wildlife. Francis and Barber (2013) used published information to present a framework of how noise exposure to wildlife can impact fitness at the individual animal level by changing behavior such as changes to the frequency, loudness or timing of vocalization and moving away from the noise. Shannon et al. (2015) synthesized journal articles from 1990 to 2013 regarding the effects of noise on both terrestrial and aquatic wildlife species, recognizing that there has been a rapid increase in the volume of published peer-reviewed literature since 2010. These four publications cited numerous studies that will not be cited here, but were analyzed sufficiently to provide ample discussion of the issue.

Sound and Its Relationship to Noise

Sound energy travels in waves and is measured by the frequency (the number of the wave troughs and peaks occurring in a second), and amplitude (the height of the peaks as measured from the troughs, which measures how "forceful" a wave is). The higher the frequency, the higher pitch the sound has. Amplitude is measured in decibels of sound pressure (dB), roughly corresponding to loudness. The softest sound that a person can hear is 0 dB, which provides the baseline for comparing the dB of sound created from different activities and sources. Normal human speech is approximately 65 dB. Sounds that are at or above 85 dB can permanently damage human hearing, and the more sound pressure a sound has, the less time it takes to cause permanent damage (Oregon Museum of Science and Industry 2017).

Estimates of natural sound levels for the coterminous United States ranges from a median of 24 to 40 dB in the summer during the daytime (sound is perceived to be "noisier" at night). Since decibels are measured logarithmically, an increase in 10 dB actually doubles the perceived loudness of a sound. A decibel level of 55 dB is recommended to protect human health and welfare and above 65 dB is considered the level at which sound becomes noise. Noise is defined as the exposure of people and animals to levels of sound that are annoying, stressful, or damaging to the ears.

Shannon et al. (2015) graphed sound levels documented to induce annoyance responses in humans and terrestrial wildlife and found that they were similar, ranging from approximately 40 to 100 dB sound pressure level (SPL), which is the deviation from the ambient atmospheric pressure caused by a sound wave (Figure 1 – copied from Shannon et al. 2015).

Chainsaw noise is approximately 120 dB; noise from a power lawn mower, farm tractor, and garbage truck is approximately 90 to 100 dB; noise from a DC8 aircraft at one nautical mile and a Bell J-2A helicopter at 100 feet is approximately 90 to 100 dB; noise from a garbage disposal and food blender is approximately 84 to 88 dB; noise from a commercial propeller plane at 1,000 feet is approximately 88 dB; and noise from a passenger car going 65 mph at 25 feet away or a freeway at 50 feet from the edge of the pavement, as well as from a vacuum cleaner, is approximately 70 to 77 dB. Aircraft are noisier when taking off, landing, and flying at low altitudes. A Cub type aircraft, the type of aircraft which is typically used in WDM is approximately 72 dB at takeoff and 78 dB at landing. Low-level flying, typical of aircraft use by WS, would approximate this range of sound. Helicopters (rotary blade aircraft) emit low-frequency impulses from the blades, which tend to elicit more of a response from wildlife than the drone of fixed-wing aircraft (Pepper et al. 2001).

Framework for Understanding the Effects of Sound on Wildlife

Wild animals often use sound to avoid predators, obtain food, find mates, and communicate. Animals exposed to human-generated noise may interpret that noise, especially sudden and intermittent noise, as something to be afraid of or to avoid, and typically respond through fleeing or hiding. They may adapt or even habituate to more long-term chronic noise. Adaptation or habituation, however, does not mean that the animal's fitness for survival and thriving is not adversely impacted, and the animal may exhibit physiological signs of stress. Human-generated noise may also mask sounds or distract the animals from sounds that animals need to hear regarding important environmental cues, such as presence of predators, conspecifics, prey, and mates.

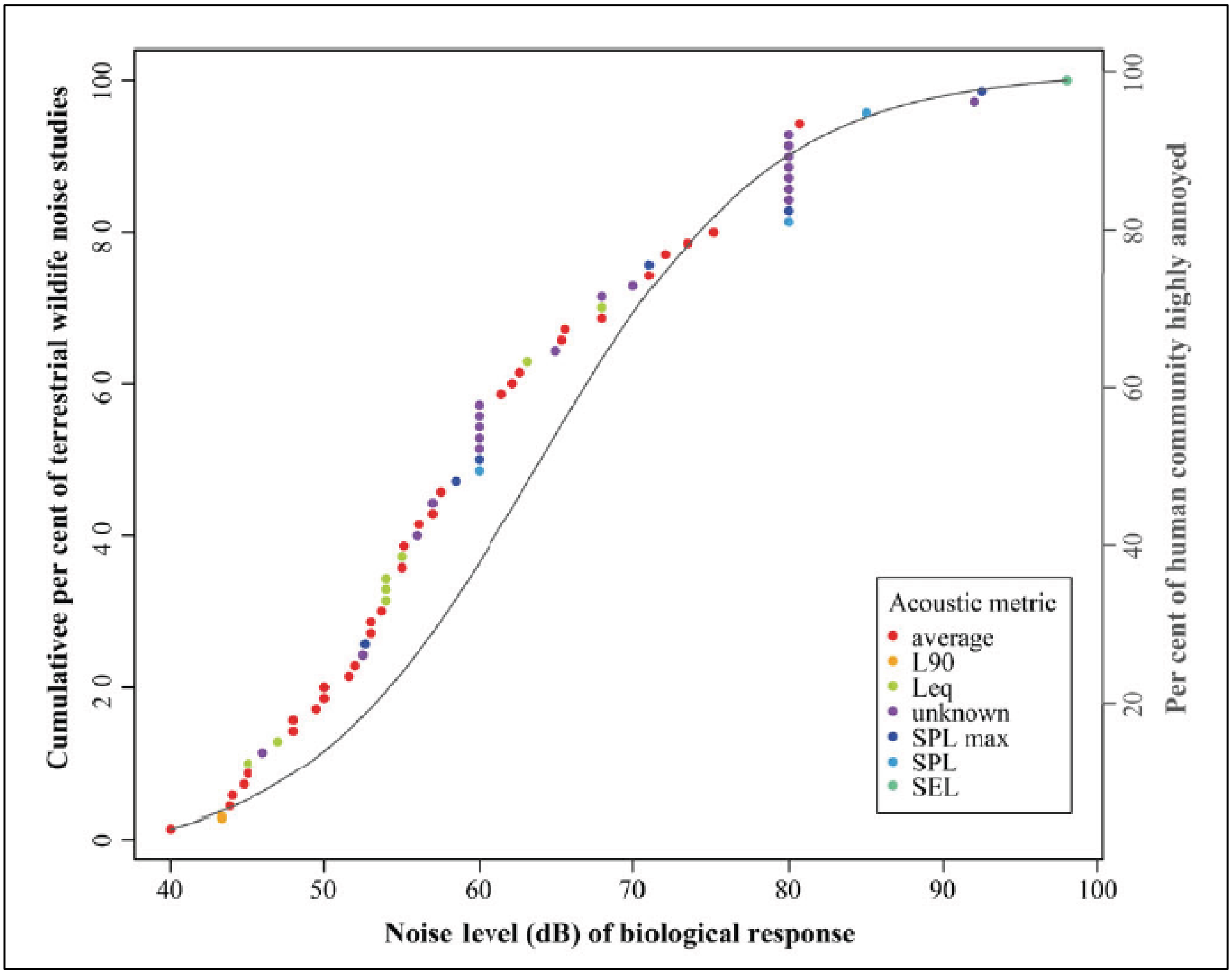

Figure 1. The comparative noise levels resulting in a response from wildlife and humans, indicating similar levels of responses (from Shannon et al. 2015).

The potential for sound to become annoying, frightening, distracting, or physiologically damaging to wild animals, as well as to mask important environmental clues, may be dependent on the following factors and can be highly variable. These factors may also create challenges in conducting research and interpreting the results. Many studies reviewed during meta-analyses do not provide the acoustic metrics and measurements involved, have relatively small sample sizes, and weak correlations, further challenging comparison and interpretation of study results. The factors include:

- Sensitivity to noise varies among taxa, as well as context of the noise, sex of the animal, life history phase, presence of young, and physiological hearing range (can the animal physiologically hear the noise?).

- The impact of noise is rarely isolated from other forms of environmental disturbance, such as the impacts of habitat alteration, presence of predators, human activity, and visual disturbance, confounding the ability of researchers to accurately interpret responses.

- Noise may induce animals to undertake one or more behavioral responses, such as moving away or fleeing the noise source, changing the loudness and pitch of their vocalizations, ceasing to feed, exhibiting more vigilance and alertness, reducing defense of territory boundaries, and/or changing their daily patterns of activities.

- The characteristics of the noise sound itself must be clearly determined and disclosed as part of the research protocols and discussions, such as duration (chronic versus intermittent, expected or unanticipated), inherent pitch (a particular sound may be composed of multiple sounds), and intensity (sound pressure and amplitude or loudness).

- Animals may be more sensitive to noise in open habitats with less cover than in vegetated habitats.

- Previously exposed animals and populations may exhibit a higher level of habituation than naïve animals and populations.

- Presence or absence of an animal within a noisy area cannot necessarily be interpreted as an indication that it is or is not being impacted, because many potential physiological, reproductive, ecological, and population level costs have not been studied, such as survival, reproductive fitness, predator-prey interactions, and ecosystem services, there may not be alternate areas for dispersal, mating success and/or fecundity may be negatively impacts.

- Conducting large-scale, long-duration studies at the landscape level have inherent logistical and experimental challenges, especially when attempting to isolate the effects of noise from other sources of disturbance to avoid confounding results.

- Few studies have been conducted on the impact of sound as it increases in intensity (such as loudness, pitch, or duration).

Impact of Aircraft Sound on Wildlife

Most terrestrial studies reviewed involved either simulated sounds, such as the sound of chainsaws, human voices, or loud alarms, or ongoing chronic sound such as general construction activities, mixed traffic, individual vehicles, commercial and military airtraffic, military gunfire, explosions, and sonar. These sounds are all relatively loud and intense noises, whether chronic or intermittent, compared to a small two-passenger plane occasionally flying over a small area for several hours a day or two at a time.

The distance of a sound source from an animal also reduces the level of noise and, therefore, the expected level of response. The sight of an occasional and unexpected plane in open country flying unpredictably at low altitude may elicit more of a fright response than the sound of the plane. WS use of aircraft and aerial shooting activities occur in relatively remote rangeland areas where tree cover is sparse or mostly scattered or deciduous woodlands where leaves have fallen from the canopy layer to allow for visibility and clear identification of target animals from the air. Most large mammalian terrestrial species will respond to stimulus from overhead, which is not a typical direction for predators, by a fright response, either fleeing or attempting to hide. If the plane approaches closely, a hidden animal may flush from cover to flee.

The Shannon et al. (2015) meta-analysis suggests that terrestrial wildlife responses begin at noise levels of approximately 40 dB and 20% of the papers document responses below 50 dB. Two-thirds of the studies reviewed in Shannon et al. (2015) involved songbirds and marine mammals, both of which depend on vocalization for communication. None of the studies reviewed involved low-level flights of small two-passenger aircraft, and few involved terrestrial species that do not depend on vocalization. The meta-analysis conducted by Francis and Barber (2013) focused mainly on aquatic and songbird species, with only one paper evaluating aircraft noise, in this case the effects of low-level flights of large military aircraft on seaducks (Goudie 2006). The author suggested that these flights caused multiple behavioral responses by seaducks during 30-minute observation periods.

The National Park Service (1995) reviewed studies on the effects of aircraft overflights on wildlife. The report revealed that a number of studies documented responses by certain wildlife species suggesting adverse impacts could occur. Few, if any studies, have proven that aircraft overflights cause significant long-term adverse impacts on wildlife populations, although the report stated it is possible to draw the conclusion that impacts to populations are occurring. It appears that some species will frequently or, at least occasionally, show adverse responses to even minor overflight occurrences. In general, it appears that the more serious potential impacts occur when overflights are frequent such as hourly and over long periods of time which represents "chronic exposure." Chronic exposure situations generally involve areas near commercial airports and military flight training facilities. WS, on the other hand, spends relatively little time over any one area and noise associated with aircraft use is relatively minor.

Several examples of wildlife species that have been studied with regard to low-level flights are available in the literature. Low-level overflights of 2-3 minutes in duration by a fixed-wing airplane and a helicopter produced no "drastic" disturbance of tree-nesting colonial waterbirds, and, in 90% of the observations, the individual birds either showed no reaction or merely looked up (Kushlan 1979). Conomy et al. (1998) quantified behavioral responses of wintering American black ducks, American wigeon, gadwall, and American green-winged teal (*Anas crecca carolinensis*) exposed to low-level flying military aircraft in North Carolina and found that only a small percentage (2%) of the birds reacted to the disturbance. They concluded that such disturbance was not adversely affecting the time-activity budgets of these species. Mexican spotted owls (*Strix occidentalis lucida*) (Delaney et al. 1999) did not flush when chain saws and helicopters were greater than 110 yards away; owls flushed to these disturbances at closer distances and were more prone to flush from chain saws. Owls returned to their predisturbance behavior 10-15 minutes following the event and researchers observed no differences in nest or nestling success (Delaney et al. 1999). Delaney et al. (1999) found that chain saws at similar distances were more disturbing to the owls than aircraft overflights. Similarly, the USFS (2002) found that Mexican spotted owls showed only minor behavioral changes to F-16 fly-bys during training runs, but less behavioral changes than to natural and other man-made occurrences. Andersen et al. (1989) conducted low-level helicopter overflights specifically directed at 35 red-tailed hawk nests and concluded their observations supported the hypothesis that red-tailed hawks habituate to low-level flights during the nesting period; results showed similar nesting success between hawks subjected to such overflights and those that were not. White and Thurow (1985) did not evaluate the effects of aircraft overflights, but found that ferruginous hawks are sensitive to certain types of ground-based human disturbance to the point that reproductive success may be adversely affected. However, military jets that flew low over the study area during training exercises did not appear to bother the hawks, and nor did the hawks get alarmed when the researchers flew within 100 feet in a small fixed-wing aircraft (White and Thurow 1985). White and Sherrod (1973) suggested that disturbance of raptors by aerial surveys with helicopters may be less than that caused by approaching nests on foot. Ellis (1981) reported that five species of hawks, two falcons, and golden eagles were "incredibly tolerant" of overflights by military fighter jets, and observed that, although birds frequently exhibited alarm, negative responses were brief and the overflights never limited productivity. Grubb et al. (2010) evaluated golden eagle response to civilian and military (Apache AH-64) helicopter flights in northern Utah. Study results indicated that golden eagles were not adversely affected when exposed to flights ranging from 100 to 800 meters along, towards and from behind occupied cliff nests. Eagle courtship, nesting and fledging were not adversely affected, indicating that no special management restrictions were required in the study location.

Krausman et al. (1986) reported that only 3 of 70 observed responses of mule deer to small fixed-wing aircraft overflights at 150 to 500 feet above ground resulted in the deer changing habitats. They believed that the deer may have been accustomed to overflights because the study area was near an interstate highway that was frequently followed by aircraft. VerCauteren and Hygnstrom (2002) noted that when studying the efficacy of hunting to manage deer populations, that when deer were flown over during their censuses, they typically just stood up from their beds, but did not flush. In addition, WS personnel involved in aerial shooting frequently observe deer and antelope standing apparently undisturbed beneath or just off to one side of aircraft. Krausman and Hervert (1983) reported that, in 32 observations of the response of bighorn sheep to low-level flights by small fixed-wing aircraft, 60% resulted in no disturbance, 21% in “slight” disturbance, and 19% in “great” disturbance. Another study (Krausman et al. 1998) found that 14% of bighorn sheep had elevated heart rates that lasted up to 2 minutes after an F-16 flew over at an elevation of 400 feet, but it did alter the behavior of penned bighorns. Weisenberger et al. (1996) found that desert bighorn sheep (*Ovis canadensis nelsoni*) and mule deer had elevated heart rates for 1 to 3 minutes and became alert for up to 6 minutes following exposure to jet aircraft. Fancy (1982) reported that only 2 of 59 bison groups showed any visible reaction to small fixed-wing aircraft flying at 200-500 feet above ground. These studies indicate that ungulates are relatively tolerant of aircraft overflights, even those that involve noise at high decibels. Impacts to livestock from low level flights are expected to similar to what has been observred in the field studies on impacts to wildlife species from low level flights.

WS has actively used fixed- and rotary-wing aircraft for aerial WDM activities in areas inhabited by wildlife for years. The fixed-wing aircraft used by WS are relatively quiet whereas the helicopter is somewhat noisier. WS conducts aerial WDM activities on areas only under agreement and concentrates efforts during certain times of the year to specific areas such as lambing grounds. WS (2005, 2006, 2011, and 2016) looked at the issue of aerial shooting overflights on wildlife and found that WS had annually flown less than 20 min/mi^2 on properties under agreement; basically WS flies very little over any one property under agreement in any given year. As a result, no known problems to date have occurred with WS aerial shooting overflights on wildlife nor are they anticipated in the future. WS avoids nontarget wildlife when seen such as wild horses and grizzly bears. Based on the above information and analysis, it is reasonable to conclude that WS aerial low-level flights should not cause any adverse impacts to nontarget species, including livestock and those that are listed as threatened and endangered.

3.2.2 Fires and Spills

As a result of concerns from environmental organizations on the potential for fires and fuel spills from WS aircraft accidents and incidents, relevant information was obtained from Mr. Norm Wiemeyer, Chief, NTSB Denver Field Office (pers. comm. 2000 as cited), the agency responsible for investigating aviation accidents. Mr. Wiemeyer stated that he had no recollection of any major fires caused by any government aircraft; he had been in that position since 1987. Mr. Jacob Wimmer, retired, was the WS National Aviation Program Safety Manager and Investigator in Charge from November 2005 to July 2015. Mr. Wimmer investigated all accidents and incidents during those dates and had a good working knowledge of accidents and incidents from 2000, since Mr. Wiemeyer’ s statement. Mr. Wimmer was able to confirm that WS aircraft have caused no major fires as a result of their operations. The only fire that was a result of WS aerial operations was at a Utah accident site in June 2007. The airplane crashed, ignited a post-crash fire, but the fire spread no further than the impact debris field and extinguished itself. The period of greatest fire danger typically occurs during the hotter summer months, but WS ordinarily conducts fewer aerial shooting operations during these months because ground cover and other conditions are not conducive for finding target animals. Since WS aircraft have not caused any documented major ground or forest fires in hundreds of thousands of hours flying, it is reasonable to assume that the risk of this occurring is minimal.

3.2.3 Petroleum Products Contamination

WS aircraft have caused no contamination due to leakage or spillage of petroleum products. There have been no reported fuel spills as a result of aircraft refueling operations either at fixed base operations or in field operations. No fuel or oil spillage has resulted through accident or incident and in all cases fuel tanks, fuel lines, oil tanks and oil lines have remained intact with the exception of the accident in Utah in 2007. The only rupture or leakage was a result of the accident named in the Fires and Spills section, but it was consumed by the subsequent fire before any seepage could occur.

Mr. Wiemeyer of NTSB stated that aviation fuel is extremely volatile and will evaporate within a few hours or less to the point that even its odor cannot be detected. Jet A fuel does not pose a large environmental problem if spilled at the maximum amounts used by WS under conditions where it is typically used by WS. It is a straight chained hydrocarbon with little benzene present and microbes would quickly break-down any spill residue through aerobic action (J. Kuhn, Montana Department of Environmental Quality, pers. comm., 2001). The quantities used by WS aircraft are relatively small (52 gallon maximum in a fixed-wing aircraft and 91 gallon maximum in the helicopters used by WS), and during much of each flight the amount of fuel on board would be considerably less than these maximum amounts. In some cases, not all of the fuel would be spilled. Thus, there should be little environmental hazard from unignited fuel spills. WS believes the low probability of a crash and subsequent spill, and one record of a minor fuel spill occurring from its aircraft fleet, poses negligible risk to the environment.

For privately owned aircraft, the aircraft owner or his/her insurance company is responsible for clean-up of spilled oils and other fluids, but only if required by the owner or manager of the property on which the accident occurred. In the case of Bureau of Land Management (BLM), USFS, and National Park Service lands, the land managing agency generally requires soil to be decontaminated or removed and properly disposed of. With the size aircraft used by WS, the quantities of oil capable of being spilled in any accident are small (i.e., 6-8 quarts maximum for reciprocating (piston) engines and 3-5 quarts for turbine engines) with minimal chance of causing environmental damage. Aircraft used by WS are single engine models, so the greatest amount of oil that could be spilled in one accident would be about 8 quarts. Due to the low quantities of oil on any given WS aircraft, the low probability of a crash, and subsequent spill, the risk to the environment is negligible.

Petroleum products degrade through volatilization and bacterial action, particularly when exposed to oxygen (EPA 2000). Thus, small quantity oil spills on surface soils can be expected to biodegrade readily. Even in subsurface contamination situations involving underground storage facilities, which would generally be expected to involve larger quantities than would ever be involved in a small aircraft accident, EPA guidelines provide for *natural attenuation* or volatilization and biodegradation to mitigate environmental hazards (EPA 2000). Thus, even where oil spills in small aircraft accidents are not cleaned up, the oil would not be expected to persist in the environment and would occur in such small quantities that the risk to drinking water and aquatic ecosystems is negligible.

4 UNCERTAINTIES AND CUMULATIVE IMPACTS

Uncertainty in this risk assessment is negligible as WS has over 60 years using aircraft for WDM activities and understands potential risks of using aircraft. The knowledge gained from this experience has helped reduce uncertainties associated with low-level flying.

Cumulative impacts could occur to target and nontarget animals. However, cumulative impacts are addressed in National Environmental Policy Act documents such as WS (2005, 2006, 2011, and 2016) and found not to be significant to any native population. From a human health perspective, the use of aircraft in WDM will not have any known cumulative impacts.

5 SUMMARY

WS uses aircraft as a tool in WDM programs including aerial shooting, capture and release of wildlife (typically associated with research/monitoring), dispersing wildlife from damage sites, surveying/monitoring wildlife, and conducting aerial bait drops. These are typically only one component of an integrated approach to managing wildlife issues. WS works cooperatively with other natural resource agencies at the state and national level to implement the use of aircraft. Implementation of program-specific measures designed to reduce accidents with aircraft has reduced the risk to the public and workers. WS will continue to evaluate and implement, where appropriate, new protection measures. WS believes that the risks to people from crashes and theft of an airplane, to nontarget wildlife from misidentification and aerial overflights, and to the environment from fires and spills as a result of an accident are minimal. In addition, the use of firearms in aircraft has resulted in very few problems. WS will continue to support and conduct extensive training for pilots and crewmembers to make them more effective and reduce these risks.

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7 PREPARERS

7.1 APHIS-WS Methods Risk Assessment Committee

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

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Data Contributor: Joey Millison
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7.2 Internal Reviewers

USDA APHIS Wildlife Services

Reviewer: Lloyd Burraston (retired)
Position: USDA-APHIS-WS, Aviation Training and Operations Center, Manager, Cedar City, UT
Education: FAA Certificated Commercial Pilot, Instrument and Multi Engine Fixed Wing rating. FAA Certified Flight Instructor and FAA Maintenance Instructor. FAA Certificated Airframe and Powerplant Technician. FAA Inspection Authorization. Graduate AS, Aeronautical Technology.
Experience: Special expertise in light aircraft maintenance technology with 31 years of light aircraft flight instruction. Eleven years WS Aviation Training and Operations Center Manager.

Reviewer: Rodney Hamilton (left the agency)
Position: USDA-APHIS-WS National Aviation Coordinator, Las Vegas, NV
Education: BS Aerospace Science Technology - Central Washington University; MAS Aerospace Science Management - Embry Riddle Aeronautical University; U.S. Air Force Air Command and Staff College, U.S. Air Force Aviation Safety Officer School University of Southern California, Aviation Accident Investigator School National Transportation Safety Board, FAA Certificated Airline Transport Pilot.
Experience: Expertise in aviation training, aircraft flight instruction, flight operations management, flight safety program management, and aircraft mishap investigations. Six years of service in APHIS as WS National Aviation Coordinator. Retired U.S. Air Force Pilot (20 years).

Reviewer: Philip Mastrangelo (retired)
Position: USDA-APHIS-WS, State Director/Supervisory Wildlife Biologist, Bismarck, ND
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Reviewer: Alan May (retired)
Position: USDA-APHIS-WS, State Director/Supervisory Wildlife Biologist, Albuquerque, NM
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Experience: Special expertise in wildlife biology, ecology, and damage management including supervising an aerial operation program. Twenty nine years of service in APHIS Wildlife Services in TX, NH, VT, MS, and NM with experience in a wide variety of programs (livestock , aquaculture, dairy, property, and natural resource protection) including predator, bird, beaver, feral swine, and rodent damage management activities.

Reviewer: Lee Sherman (left the agency)
Position: USDA-APHIS-WS, National Aviation Safety Manager, Cedar City, UT
Education: FAA Certified Airline Transport Pilot -Airplane Multi-Engine, Rotorcraft Helicopter, Commercial Pilot - Single-Engine Land and Seaplane, FAA Certified Flight Instructor – Airplane Single and Multi-Engine, Rotorcraft Helicopter, Instrument Airplane and Helicopter. B.S. Aviation-Flight Operations.
Experience: Dual rated pilot with 21 year background in civil and military aviation.

Reviewer: John Steuber
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property and resource protection (aquatic rodent and feral hog damage management). Expert in managing statewide aviation programs (CA, OK, and MT). Sixteen years of experience as a State Director (OK and MT) managing a statewide APHIS Wildlife Services program.

Reviewer: Jacob Wimmer (retired)
Position: WS National Aviation Safety Manager, Miles City, MT
Education – University of Southern California Aviation Safety and Security Program, U.S. Army Aviation Safety Center and U.S. Army Aviation Rotary Wing Flight School
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Reviewer: Michael Yeary
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USDA APHIS Marketing and Regulatory Business Services, Investigative Enforcement Division (IES)

Reviewer: Timothy Fordahl
Position: USDA-APHIS-Investigative Enforcement Services (IES), Western Regional Director, Fort Collins, CO
Experience: Expertise in regulatory investigations and APHIS policy with 16 years of service in APHIS IES. Retired U.S. Marine Corps (20 years) with expertise in investigations.

7.3 Peer Reviewers

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

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

Reviewer: Association of Fish and Wildlife Agencies
Reviewer: Michigan Department of Natural Resources
Reviewer: New Mexico Department of Game and Fish
Reviewer: Pennsylvania Game Commission Bureau of Wildlife Management
Reviewer: North Dakota Game and Fish Department

7.3.2 Comments

Comments with concerns and a response regarding the risk assessment:

1. **Comment:** The crew training and communication is critical to safety.
   Response: We added additional language about the importance of communication and crew safety and training to this Risk Assessment.

2. **Comment:** Replace the term aerial hunting with aerial shooting.
   Response: WS agrees and replaced the term in this Risk assessment.

3. **Comment**: A statement about aerial operations potentially affecting livestock should be included in the document.
   Response: WS agrees and a statement was added on page 17 to addresses the potential to impacts livestock.

4. **Comment:** A commenter asked for specific policies and procedures to be referenced regarding training requirements.
   Response: WS added additional language to the RA to clarify training and certification requirements. WS Directives and the Aviation policy manual include training requirements and are referenced throughout the document.

5. **Comment:** A comment was received about the structuring of aviation personnel positions since a 2010 program review.
   Response: The WS Aviation program structure is in place and the ATOC is responsible for maintaining the highly trainied staff and personnel for the WS operational aviation program. The 2015 OIG WS program audit found that the ATOC and WS aviation operations were operating at a high level and found no apparent issues.

Comments regarding the quality of the risk assessment not needing a comment:

1. **Comment:** Assumptions and uncertainties were addressed adequately, and references were appropriate.

2. **Comment**: Data was sufficient in the risk assessment to assess effectiveness and safety.

3. **Comment:** The risk assessment was well-written, comprehensive, and included all pertinent information.

4. **Comment:** I have no concerns or suggestions for improvement..

Peer reviewers provided a few editorial comments on the manuscript. These were appreciated and incorporated into the final document.