APHIS – Feral Swine Program History and Additional Background Information

Feral swine are a harmful and destructive non-native, invasive species. Their geographic range is rapidly expanding, and their populations are increasing across the United States (U.S.) (Waithman et al. 1999, Barrios-Garcia and Ballari 2012). Feral swine are also known to occur in portions of the U.S. Territories such as American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), Guam, Puerto Rico, and the Virgin Islands. Feral swine inflict significant damage to property, agriculture (crops and livestock), native species and ecosystems, and historic and cultural resources. They also pose a threat to the health of wildlife, domestic animals, and humans. Damage and risks to animal and human health are expected to increase as feral swine densities increase and their populations continue to expand across the country. The difficulty in managing swine damage and associated management costs increases as swine populations increase.

The purpose of the proposed survey is to develop a national estimate of the benefits and costs of feral swine damage and risks to agriculture, animal health, human health, and property, in the United States. APHIS seeks to achieve this goal cooperatively and with the assistance of other agencies at the international, Federal, State, Territorial, Tribal, and local levels, and the cooperation of private management interests. The national feral swine program is intended to guide APHIS interactions with program partners, provide a system for allocation of project resources, and identify management methods which APHIS programs may use to address feral swine damage. The feral swine survey is designed to establish crucial baseline levels of damage to American producers of economically important crops including but not limited to corn, soybeans, wheat, rice and peanuts. Additionally, important information regarding producer utilization of control methods and the benefits and costs of hunting feral swine will also be gathered to guide national control efforts.

In this survey, the term *feral swine* is used to refer collectively to free-ranging swine (*Sus scrofa*), belonging to the family *Suidae*. This term includes escaped (estray4) domestic and pet swine and their descendants, Polynesian pigs, and Eurasian wild boar and their hybrids. Terms used by other entities may include wild pig, feral pig, wild hog, and wild boar.

The earliest swine introductions, to what eventually became the United States and its Territories, occurred in Hawaii, American Samoa, CNMI, Guam, where swine arrived with early human settlers from Southeast Asia (Larson et al. 2007, American Samoa Historic Preservation Office 2014). Christopher Columbus is believed to have brought the first European domestic swine to North America in 1493 (West Indies). The Spanish explorer Hernando de Soto is credited with the first recorded introduction of European domestic swine to mainland North America in Florida in 1539 (Wood and Barrett, 1979). European settlers and explorers made subsequent similar introductions to other portions of the United States and its Territories. Historic swine production practices commonly involved allowing the swine to range free outside fenced pastures and pens. Escaped animals and animals from free-ranging domestic herds formed the basis of the feral swine population in the United States and its Territories. In the early 1890s,

Eurasian wild boar were first introduced to North America for use in fenced hunting preserves, with subsequent introductions to fenced and unfenced areas.

Until the late 1980s, feral swine populations in the continental United States were primarily found in the southern tier of States and States on the west coast. In 1982, feral swine were thought to occur in only a small percentage of counties located in 17 States (Mayer and Brisbin 1991, Miller and Sweeney 2013, National Feral Swine Mapping System (http://swine.vet.uga.edu/nfsms/)). Over the past several years, their numbers have increased significantly. Feral swine are now known to exist in at least 38 States and the above-mentioned Territories. Based on data from APHIS Wildlife Services' (APHIS-WS) National Wildlife Disease Program (NWDP), the Southeastern Cooperative Wildlife Disease Study, and APHIS' Veterinary Services (APHIS-VS), feral swine are now present in approximately 40% of all counties in the United States. The national feral swine population is currently estimated to exceed more than 6 million individual animals (Mayer 2014).

Feral swine populations have increased and expanded for a number of reasons. High reproductive capacity and the ability to adapt to nearly any environment enable feral swine to thrive wherever they are found. Feral swine are also a prized game animal for some hunters because of their size, intelligence, and reputation for aggressive behavior, (e.g., wildhoghunters.com, boarmasters.com 2013), as well as the meat they provide. Recent rapid range expansion is primarily due to humans transplanting them to new areas to increase hunting opportunities, either intentionally through release of animals into the wild, or unintentionally through escapes from hunting preserves (Waithman et al. 1999). Additionally, large-scale weather events, such as hurricanes, can force coastal populations of feral swine to move inland (Shaw 2013).

Feral swine can cause significant damage to agricultural and natural resources and property, and they pose risks to human and animal health. The International Union for Conservation of Nature (IUCN), Invasive Species Specialist Group (ISSG) has included feral swine in their listing of "100 of the World's Worst Invasive Alien Species" (Lowe et al. 2000). In accordance with program authorities, the APHIS-Wildlife Services (WS) program has been working to address specific localized feral swine damage problems. Although many of these actions have been successful at the local level, numbers of feral swine, their range, and associated damage is increasing in many parts of the country. Cost and difficulty of damage management increase as populations increase. There is a need for a nationally coordinated Feral Swine Damage Management (FSDM) program to aid Federal, State, Territorial, Tribal, local, and private management efforts to reduce damage, and threats to human and animal health from feral swine. A national feral swine survey will provide crucial information regarding the current level of damage caused by feral swine as well as allow for the economically efficient targeting of damage management efforts to protect American agriculture. A national strategy may also help Federal agencies, States, Territories, and Tribes in preventing feral swine from spreading to areas where they do not already occur, and in effectively responding to incipient or low populations.

Feral swine are considered a major emerging threat to American agriculture (Seward et al. 2004). Recent data shows the proportion of U.S. counties with agricultural production that also have feral swine present. Over the period of 1998–2013, the proportion of counties with dairy, hog, and crop production that are affected by feral swine has increased. While most large commercial farms have strong biosecurity measures in place to minimize the chance of contact between feral swine and domestic herds, smaller transitional herds may be more at risk of threats associated with feral swine. In addition to the direct damage and disease risks discussed below, disease outbreaks, which substantially impact interstate and international trade, would not only impact livestock producers, but also grain producers, particularly corn and soybean farmers, transportation industry and others.

Feral swine damage crops through direct consumption of crops and other behaviors, such as rooting, trampling, and wallowing, which can destroy fields or reduce productivity. Field crops commonly damaged by feral swine include sugar cane, corn, grain sorghum, wheat, oats, peanuts, and rice, among others. Vegetable and fruit crops, such as lettuce, spinach, melons, and pumpkins are also damaged (Schley and Roper 2003, Seward et al. 2004). Rooting out seeds and trampling seedlings impacts regeneration of forest plantations (Lipscomb 1989). Feral swine also can reduce the vigor of larger trees, retarding growth or causing a decline in nut crops, such as pecans and almonds (Campbell and Long 2009*a*).

Hogs will feed on almost any agricultural crop they find, especially crops adjacent to riparian areas. They eat seeds, seedlings, mature crops, hay, turf, and gardens. Feral swine damage pasture and agricultural crops by consumption, rooting, digging, and trampling (Seward et al. 2004). Rooting can affect the plant composition of a pasture by promoting the growth of undesirable plants where hogs have destroyed desirable forage grasses. Once pastures are degraded in this way, landowners must spend considerable money and time restoring them to pre-swine conditions (Whitehouse 1999, Mapston 2004).

Feral swine will travel long distances to consume attractive foods. One study reported that feral swine traveled 6 miles to forage on sorghum (Mungall 2001). In a survey of extension agents in Texas, Rollins (1993) found the most common complaint was damage to crops, including hay, small grains, corn, and peanuts. Crops such as vegetables, watermelons, soybeans, cotton, tree fruits, and conifer seedlings were also affected by wild pigs. The presence of feral swine in agricultural areas is likely to lead to requests for assistance to manage and prevent damage to agricultural crops. Feral swine also cause damage to pastures, land used for hay, and sod farms by their rooting and wallowing activities (Beach 1993).

Feeding activities of feral swine on agricultural crops can lead to increased erosion due to the removal of vegetation, leaving bare soil. Since feral swine often travel in family groups, damage from rooting and wallowing can be extensive and encompass several

acres. Use of agricultural crops as a forage resource by feral swine may make up 71% of the plant material consumed (Mayer and Brisbin 2009). A single group of feral swine can destroy a 10-acre cornfield in less than a week (Gates 2012).

Although it is certainly not realistic to suggest that the entirety of the $223 billion in crop production (2012) in the United States is at risk of being destroyed, it is worth noting that between 60 and 80% of row crop production takes place in States that have a confirmed feral swine population (NASS 2014). In states where feral swine have been established for several years, data documenting feral swine damage to agriculture exists. In one study area in Texas, 48 cooperators estimated damages and expenditures to manage feral swine totaling $2,228,076 on 230,017 acres they owned or controlled. In Georgia, respondents to a questionnaire developed by the Georgia Feral Hog Working Group reported an average loss to crops and/or crop related damage due to feral swine during 2011 at $12,646 per respondent (response rate of 39.25%; Mengak 2012). In 2011, it was estimated that feral swine caused in excess of $57 million dollars in damages to agriculture and an additional $24 million in damage to non-crop values in Georgia (Mengak 2012). In 29 counties in northern Florida in 2009, feral swine damaged and estimated $314,739 of corn, $327,943 of cotton, $1,151,178 of peanuts, and $30,815 of soybeans (Ober et al. 2011). In California, agricultural commissioners reported feral swine caused $ 1,731,920 in damages (Seward et al. 2004).

No detailed national studies are available quantifying potential damage to row crops by feral swine. One commonly cited national estimate of annual damage to row crops uses an estimate of $200 in agricultural crop damage per feral swine per year and a U.S. feral swine population estimate of 4 million animals to generate a nationwide estimate of $800 million in damages to the U.S. agricultural sector annually, and as much as $1.5 billion per year in total damage and control costs (Pimentel 2005). This estimate is likely very conservative because it uses a conservative estimate of the national feral swine population and it does not consider livestock predation, disease transmission, or environmental degradation. Results from the proposed survey would provide the first statistically valid estimate of crop damage to American agricultural production to states significantly impacted by feral swine damage to crops.

Feral swine are omnivorous. They will kill calves and lambs, and also occasionally kill adult animals that are vulnerable while giving birth (Pavlov and Hone 1982, Choquenot et al. 1997). There is no estimate of the level of predation by feral swine to livestock production in the United States. The proposed survey would potentially provide the first estimates of this nature. Feral swine sometimes prey on livestock, including lambs, kids (goats), newborn cattle, poultry, and exotic game. Predation on young livestock animals usually occurs on calving or lambing grounds where feral swine may be attracted by afterbirth (Wade and Bowns 1985, Gallagher undated). Though predation is usually concentrated on young animals, livestock giving birth are sometimes killed and consumed (Wade and Bowns 1985). In addition to directly preying on livestock, when

feral swine damage fencing they leave livestock vulnerable to predators and offer opportunities for livestock to escape (West et al. 2009).

Wild pig predation on livestock can be difficult to verify because the entire carcass is usually consumed, leaving little evidence. In addition, pigs will scavenge carcasses killed by other animals. If the whole carcass is not consumed, however, feral swine usually follow a characteristic feeding pattern that can be used to identify the source of the damage (Pavlov and Hone 1982). They typically kill their prey by biting and crushing the skull or neck (Frederick 1998). The carcass typically will be skinned and the rumen or stomach contents consumed (Wade and Bowns 1985).

Feral swine cause serious economic loss to the livestock industry, although exact numbers and values are uncertain. This is due, in part, to the misidentification of the cause of predations. For example, signs of coyote (*Canis latrans*) and feral swine predation appear very similar; therefore cases reported as coyote predation may actually be feral swine (Seward et al. 2004). In 1990, 1,243 sheep and goats were documented as being lost to feral swine in Texas, with an estimated value of $63,000 (Rollins 1993). Barrett and Birmingham (1994) reported 1,473 sheep, goats, and exotic game animals were killed by feral swine in Texas and California in 1991. Texas produces 1.1 million goats annually; about 90% of the goats raised in the United States (Scrivner et al. 1985, and Pearson 1986) reported that predators killed 18% of adults and 34% of kids. The number of goats lost to feral swine predation in unknown, but is likely substantial (> $1 million; Seward et al. 2004).

Feral swine can serve as hosts for endemic diseases readily transmissible to domestic livestock. Livestock diseases cause economic loss through morbidity, mortality, decreased production, decreased feed efficiency, lower reproductive success, and the costs associated with veterinary diagnostics and treatment. Severity of impact depends on several factors, including type of disease, size of operation, and spread before detection. Feral swine have been implicated in both increasing the likelihood of a disease event and potentially extending a disease event if one occurs (Meng et al. 2009). A foreign animal disease (FAD) is a disease that is not found in the United States. These diseases may have been in the United States at one point, but have been eradicated or have never been present in this country. Feral swine could potentially play a role in the spread of a FAD. Emergence of a FAD could cause substantial damage to America's economy. A FAD outbreak would not only negatively impact livestock producers and trade, but also grain producers, corn and soybean farmers, energy companies, and manufacturing jobs, among others. The cattle and swine industries are the industries at greatest of potential impact by feral swine. The cattle industry's $49.2 billion in production (2012) could be dramatically impacted by diseases transmitted by feral swine, as could the $15.8 billion swine industry. While a disease incident is unlikely to affect either industry entirely, trade with other countries could very likely be impacted. U.S. pork exports in 2012 totaled over $5.1 billion, while beef exports were over $4.7 billion (USITC 2014).

Pork production in the United States accounts for about 10% of the total world's supply. The United States is one of the world's largest producers of pork and is the second largest exporter of pork. The retail value of pork sold to consumers exceeds $30 billion annually (USDA 2008). Disease transmission by feral swine is likely to occur where domestic livestock and feral swine have a common interface, such as at water sources and livestock feeding areas. Transitional domestic swine raised in fenced enclosures are at greatest risk of disease transmission from feral swine.

Feral swine are capable of carrying numerous parasites and diseases that potentially threaten the health of livestock (Forrester 1991, Williams and Barker 2001, Sweeney et al. 2003). Feral swine can harbor at least 30 significant viral and bacteriological diseases (Williams and Barker 2001) and feral swine in Florida have been documented to have as many as 45 different parasites and infectious diseases (Forester 1991).

These include 37 parasites (12 protozoans, 17 nematodes, 1 acanthocephalan, 1 sucking louse, 4 ticks, and 2 mites), 7 bacteria, and 1 virus. The diseases of most concern to the livestock industry include pseudorabies, swine brucellosis, bovine tuberculosis, leptospirosis, and vesicular stomatitis (Nettle et al. 1989, Davidson and Nettles 1997, Williams and Barker 2001, Davidson 2006). These and the possibility of an exotic disease outbreak, such as foot and mouth disease, a contagious viral disease of ungulates (e.g., pigs, sheep, cattle, goats, and deer) (Pech and McIlroy 1990), or classical swine fever (a contagious viral disease of wild and domestic swine), could have serious repercussions for the United States livestock industries (Hone et al. 1992). On the other hand, feral swine may serve as a surveillance tool for the early detection of exotic diseases (Mason and Fleming 1999; Witmer et al. 2003).

Feral swine in the United States have tested positive for several of these diseases listed above. Corn et al. (1986) found that out of a larger sample, 124 feral swine tested positive for diseases in Texas; pseudorabies (36%), brucellosis (3%), and leptospirosis (33%). A study in Oklahoma that collected samples from 120 feral swine found they tested positive for antibodies of porcine parvovirus (17%), leptospirosis (44%), IAV-S (11%), and porcine reproductive and respiratory syndrome virus (2%; Saliki et al. 1998). Since 2006, NWRC has implemented disease monitoring programs for swine brucellosis, pseudorabies and classical swine fever across the nation. NWRC periodically also monitors for other diseases in feral swine in partnerships with state and federal agencies and research institutions.

Therefore there is concern relative to the role feral swine could pose to the pork industry as a reservoir for disease. The introduction of a FAD to the commercial herd would have serious implications to agricultural industries. Although the U.S. has not experienced a FMD outbreak since the 1920's, several other developed countries (e.g., Taiwan, the U.K., the Netherlands, Ireland, France, and Italy) have experienced outbreaks in recent decades, leading to concerns about FMD in the U.S. (Paarlberg et al. 2003). Outbreaks of FMD in domestic swine in the U.K., Ireland, France, and the Netherlands necessitated the destruction of 6 million head of livestock, which had an estimated value

of $11 - $12 billion (FAO 2009). If FMD or other foreign animal disease were to occur in the feral swine population, it would substantially increase the cost and complexity of management and eventual eradication of the disease.
Cozzens et al. (2010) modeled the potential spread of FMD from feral swine to livestock and within livestock in Missouri using the North American Animal Disease Spread Model (NAADSM) and predicted an expected livestock loss of 18,658 animals until the disease was eliminated. This implies a direct economic loss of $7.5 million resulting from a disease outbreak lasting 45 days. Indirect losses were estimated at $4.4 million, based on a decrease in producer revenue of $7.5 million. Thus, the expected total economic impact of feral swine FMD outbreak was nearly $12 million from a 45-day disease outbreak.

PRV is by no means the only disease that could create a significant impact to the swine and other livestock industries, and effects of other diseases potentially could be even more significant. Swine brucellosis, for example, poses a risk not only to swine and other livestock, but can also infect humans who come into contact with infected pigs. Swine-carried tuberculosis is a similarly zoonotic hazard.

Bovine tuberculosis (*Mycobacterium bovis*) has been a recurring concern for the Hawaiian island of Molokai (USDA 2006). In 1985, the entire population of cattle on the island was depopulated in an effort to eradicate the disease. However, in 1997, a cow that originated from Molokai was determined to be infected with *M. bovis* with subsequent depopulation of the infected herd. No additional infected animals were found. A wildlife survey was conducted which found feral pigs infected with *M. bovis*. The area the feral pigs were sampled was located in the same area the infected cow resided. DNA fingerprinting of the *M. bovis* strain found in infected cow showed a similar profile to the *M. bovis* strain found in the feral swine.

In 2006, APHIS conducted a risk assessment to study the transmission of bovine tuberculosis from feral swine to cattle on the Hawaiian island of Molokai (USDA 2006). At the time of the risk assessment, a testing protocol was in place to reduce the risk of infected animals mixing with animals from portions of the island and state where the disease does not occur. The testing program included annual complete herd testing of cattle and goats as well as testing for movement other than for slaughter. Costs associated with one round of testing for bovine tuberculosis on Molokai, Hawaii were $17,499 with two rounds of testing needed prior to export.

Although the source of livestock disease outbreaks can be difficult to identify, a risk of transmission and the spreading of diseases to domestic swine and other livestock exists wherever feral swine and domestic livestock interact. A disease outbreak not only has negative economic implications to the individual livestock producer but also can cause economic losses that can negatively affect the statewide swine industry.

Feral swine damage pasture grasses and consume, contaminate, and destroy supplemental feed and mineral sources provided for livestock (Wigley 1995, Bach and

Conner 1997). Feral swine also damage farm facilities, such as fences, water supplies, irrigation ditches, guzzlers (West et al. 2009), and rice field levees (Bennett 2013). Feral swine commonly cause significant damage to agriculture infrastructure. In addition to directly damaging crops, feral swine can damage fences, irrigation ditches, roads, dikes, and other structures. Rooting and wallowing in agricultural fields creates holes that, if unnoticed, can damage farming equipment and pose potential hazards to equipment operators (Nunley 1999). In Texas, 72% of surveyed extension agents reported additional damage to ranch facilities (e.g., fences, water supply, irrigation ditches, and guzzlers) (Seward et al. 2004). Feral swine wallowing can severely muddy ponds and streams and cause algae blooms, oxygen depletion, bank erosion, and soured water (Mapston 2004).

Because of their size and strength, feral swine can damage even robust fences, thus compromising the fence's ability to contain livestock and exclude predators. Fence damage, including torn netting, holes, and weakened wires and posts, can allow livestock to wander, give access to predators, and result in costly repairs (Mapston 2004). Although no one has estimated the economic impact of this damage, it has the potential to be significant in terms of fence repair costs and escaped livestock (Beach 1993).

Feral swine consume supplemental food and damage feeders and food plots intended for livestock and wildlife. When feral swine frequent these sites other animals often avoid them (Mapston 2004). Additionally, feral swine compete with livestock by rooting up and eating vegetation intended for livestock feed (Mapston 2004).

Feral swine consume large quantities of herbaceous vegetation (3–5% of their body weight daily) and have been linked to 95% declines of understory vegetation in some systems (Cole et al. 2012). Understory animal species (from arthropods to mammals) decline with the absence of understory vegetation (Singer et al. 1984). Rooting, soil compaction, and wallowing influence plant community structure, succession patterns, and nutrient cycles. Consumption of seeds, nuts, and seedlings also reduces the potential for forest regeneration (Campbell and Long 2009*a*), and may influence future over-story composition and reduce tree diversity directly through consumption of seeds (Tolson and LaCour 2013). Sites disturbed by rooting and wallowing are often vulnerable to erosion and colonization by non-native invasive plant species which often prefer disturbed sites and become established more quickly than many native plants. In some habitats, feral swine may preferentially browse or uproot protected, sensitive, unique, or rare plant species.

Habitat damage by feral swine can be most pronounced in wet environments where plant communities and soils may be more sensitive to disturbance (Engeman et al. 2003, 2004; West et al. 2009). Near waterways, this can result in destabilization of banks. Unfortunately, these types of areas are often preferred by feral swine. Wet soils may make it easier for feral swine to obtain some of the foods they favor, such as the roots, tubers, and bulbs that are characteristic of many wetland ecosystems.

Federal land management agencies, Federal agencies such as the USDA Natural Resources Conservation Service (NRCS), and State, Territorial, Tribal, local, and private land management agencies and organizations continually work to preserve and restore habitat for native species. When resources must be used to restore sites damaged by feral swine, that money is not available for other essential projects.

Feral swine diets overlap with those of native wildlife, including threatened or endangered (T&E) species, which may result in competition for important and limited natural food supplies, although documentation of competition is limited (Mayer 2009*a*, Barrios-Garcia and Ballari 2012). Mast crops5 are a preferred food of feral swine and also a critical food source for many native wildlife species. Consumption of seeds, seedlings, and other vegetation reduces availability for native species (Campbell and Long 2009*a*, Mayer 2009*a*). Feral swine are omnivorous and will prey on many smaller native animals and invertebrates, including some T&E species such as insects, earthworms, voles, shrews, turtles, amphibians, and shrub- or ground-nesting birds. Feral swine will destroy nests and consume eggs of reptiles and ground-nesting birds, such as alligators (Elsey et al. 2012), quail, turkey, and shorebirds (Campbell and Long 2009*a*). In some areas, feral swine can have adverse impacts on T&E species and their habitats and are a factor in the continuing endangerment of multiple plant and animal species (Waithman et al. 1999, Gurevitch and Padilla 2004, Engeman et al. 2010). The preference of feral swine for wet environments also creates competition for limited water resources with native wildlife during dry seasons in generally arid environments.

Feral swine also can serve as hosts for and transmit diseases to wildlife. Some of these diseases, such as pseudorabies and other pathogens, can be fatal to wildlife, including T&E species (Pedersen et al. 2013). Feral swine have also been implicated in the promotion of mosquito habitat. Mosquito habitat and increases in mosquito populations contribute to the prevalence of avian malaria and avian pox which impacts native birds (NPS 2013).

Soil disturbance and vegetation loss associated with trampling, wallowing, and rooting by feral swine increases erosion and associated problems with water contamination and siltation. Siltation and water contamination in stream reaches and coastal areas with swine activity have contributed to declines in aquatic organisms, including freshwater mussels and insects (West et al. 2009).

In some areas, feral swine have been implicated as the cause of elevated waterborne bacteria levels in streams, including levels which exceeded thresholds for the protection of human health (Kaller et al. 2007). Feral swine also serve as vectors in the spread of bacteria and parasites in surface waters and soils associated with agricultural production (Atwill et al. 1997, Cooley et al. 2007, Jay et al. 2007). Use of contaminated water for irrigation of foods marketed for direct human consumption could lead to food illness outbreaks Feral swine foraging, rooting, and wallowing can damage landscaping,

golf courses, recreational fields, cemeteries, parks, and lawns. Rooting by feral swine also damages roadsides, dikes, and other earthen structures.

On average, adult feral swine weigh from 75–250 pounds depending on ancestry and local environment, with individual animals weighing considerably more (West et al. 2009). Consequently, collisions with vehicles such as motorcycles, automobiles, and aircraft can cause substantial damage. Other damage to property includes feral swine attacks on domestic dogs. For example, in two separate reports, feral swine attacked domestic dogs in Tioga County, New York, killing one dog and injuring another (USDA 2010). Additionally, feral swine can transmit diseases, including pseudorabies, to pets. Dogs, particularly hunting dogs, become infected with pseudorabies after coming into contact with infected feral swine. Once a dog is infected, there is no treatment, and death typically occurs 48–72 hours after symptoms appear (HAID 2014).

Feral swine are not a part of native ecosystems in the United States and its Territories and, therefore, can damage these ecosystems. Depending on the values of the individual recreationists, the presence of feral swine (or feral swine damage) can either negatively or positively impact the enjoyment of the recreationists. Feral swine activities influence the distribution and abundance of native plants and animals, generally reducing opportunities for recreationists to view native wildlife. The destruction and irreversible degradation of cultural resources caused by feral swine activities also reduce opportunities for the public to enjoy these resources. Potential for adverse impacts on recreational experience may be greatest in wilderness areas.

Feral swine can also adversely impact abundance and distribution of native species sought by licensed hunters, trappers, and fishermen. Consequently, although feral swine hunting has value to some individuals, the presence of feral swine may adversely impact opportunities to hunt native species.

Sites damaged by feral swine rooting and trampling behavior include parks, historic sites and other locations, including private property, valued for their aesthetic beauty and/or cultural importance. Rooting and wallowing by feral swine causes physical damage to these sites, and adversely impacts the aesthetic enjoyment of these locations for some individuals.
For the purpose of this study, aesthetic values also include existence value. Existence value is the enjoyment that some individuals have in knowing that something exists even though they personally may never view or experience the resource in question. Knowledge that a valued resource is being adversely impacted by feral swine can adversely impact existence values.

As populations of feral swine have spread and increased in size they have also begun to expand into new habitats not previously occupied (Extension 2012*c*) including urban and suburban environments. Feral swine can cause significant damage in suburban/urban areas with their foraging activities. The most common foraging impact observed is rooting. In urban areas this type of damage primarily affects grassed areas

such as residential lawns, parks, golf courses, sports fields, cemeteries, and levees/dikes. In addition to the damaged turf, rooting can also cause other physical impacts to the affected landscaping areas (erosions, slope failure, down-grade sedimentation). Foraging by feral swine in developed areas can also result in the depredation of ornamental species planted in landscaped areas. Further depredation impacts by feral swine have been observed in backyard fruit and vegetable gardens (Extension 2012*c*). Feral swine have also been observed to disperse garbage and refuse as a result of their foraging activities, creating both litter and sanitary issues (Extension 2012*c*).

Additionally, rooting damage to levees and dikes caused by feral swine leaves the soil vulnerable to being washed away during a flood (SEAFWA 2012) and increases risk of flooding damage. In addition to costs associated with repair and prevention of feral swine damage to property, feral swine damage can adversely impact property values. Conversely, the presence of feral swine may be considered a positive impact on property values in areas where feral swine hunting is desired and permitted by law.

Feral swine can damage lawn irrigation and sprinkling systems by digging up and breaking the piping associated with these systems to get at the water contained in the lines. There have been instances of feral swine entering commercial businesses or private residences. Feral swine can cause significant property damage trying to escape from confined surroundings (Extension 2012 *c*).

Cultural sites impacted by feral swine have included national historic sites, Tribal sacred sites and burial grounds, cemeteries, and archaeological sites and digs (Native American and European origin). Feral swine cause destruction or irreversible degradation of surface and subsurface archaeological sites, historic structures, cultural landscapes, or ethnographic resources and traditional cultural properties. Feral swine damage can affect the significance and integrity of historic properties through physical disturbance to structures, vegetation, and soils. Foraging and habitat damage by feral swine can adversely impact the distribution and abundance of plants and animals which may be used for traditional purposes.

Feral swine can carry at least 30 viral and bacterial diseases, and nearly 40 parasites that may affect humans, domestic livestock, and wildlife species (Ruiz-Fons et al. 2008, Meng et al. 2009). Feral swine can also harbor the causative agents of important foodborne diseases (e.g., E. coli, toxoplasmosis, and trichinosis). Domestic swine are important intermediate hosts for an assortment of influenza A viruses of avian, swine, and human origin, potentially leading to the generation of new strains of influenza (Clavijo et al. 2012).

Feral swine collisions with vehicles and aircraft result in damage to property and pose substantial risks to the safety of drivers/pilots and passengers. Additionally, feral swine in urban and suburban areas become less wary of human presence over time. In November of 2014, a feral swine initiated an unprovoked attack on a woman walking

her dogs in Solano County, California, repeatedly cutting her with its tusks. This is thought to be the first unprovoked attack by a feral swine on a human in California. Feral swine have aggressively approached golfers, picnickers, and others recreating in urban and suburban parks (Colorado State University 2012*a*, Mayer 2013). This behavior may be particularly problematic where they have come to associate humans with food because of feeding, improper food storage, or waste disposal. The potential for animals to become habituated to human resources, then become aggressive towards humans is seen in many species (e.g., bears at camp sites) exists and may become more of a risk for feral swine particularly if they are fed by humans, intentionally or unintentionally.

No comprehensive estimate of damage to American crops exist, all estimate are from limited regional studies. This survey proposes to provide a statistically valid estimate of damage to select US crops to aid the FSDM program in the efficient use of taxpayer funds to combat feral swine impacts to US agriculture. The decision to be made based on this survey is programmatic in nature, and will serve as the primary guide for management of feral swine damage. The selected alternative will define the general strategy for FSDM and specific management methods available for use at the local and national level.

APHIS' overall goal is to reduce damage to agriculture, natural resources, property, animal health, and human health and safety in the United States, American Samoa, CNMI, Guam, Puerto Rico, and the Virgin Islands in cooperation with agency partners, Tribes, and others.

The following objective was developed with regard to the survey to achieve the overall goal of reducing or eliminating feral swine damage through the alternatives discussed in this document:

- Develop predictive models for population expansion and economic impacts of feral swine, along with risk analysis to agriculture, animal health, and human health.

USDA is authorized by law to protect American agriculture and other resources from damage associated with wildlife (Act of March 2, 1931 (46 Stat. 1468; 7 U.S.C. 426–426b) as amended, and the Act of December 22, 1987 (101 Stat. 1329–331, 7 U.S.C. 426c). Within the USDA, this authority has been delegated to the APHIS-WS program. APHIS-WS' mission, developed through its strategic planning process (USDA, 1999), is: 1) *"to provide leadership in wildlife damage management in the protection of America's agricultural, industrial and natural resources, and 2) to safeguard public health and safety.*" APHIS-WS recognizes that wildlife is an important public resource greatly valued by the American people. By its very nature, however, wildlife is a highly dynamic and mobile resource that can cause damage to agriculture and property, pose risks to human health and safety, and affect industrial and natural resources. APHIS-WS

conducts programs of research, technical assistance, and applied management to resolve problems that occur when human activity and wildlife conflict.

APHIS-WS is a cooperatively funded, service-oriented program. Before any operational wildlife damage management is conducted, a Work Initiation Document, or similar document, must be completed by APHIS-WS and the landowner/administrator. APHIS-WS cooperates with other Federal, State, Tribal, and local government entities, educational institutions, private property owners and managers, and with appropriate land and wildlife management agencies, as requested, with the goal of effectively and efficiently resolving wildlife damage problems in compliance with all applicable Federal, State, and local laws.