Feral Swine Action Plan for Oregon

Portland State
UNIVERSITY

Center for Lakes and Reservoirs
Environmental Science & Resources

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Prepared for the
Oregon Invasive Species Council

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January 2007

Executive Summary

Feral swine are defined as free roaming animals of the genus *Sus* that are not being held under domestic management or confinement. Swine have spread from Europe and Russia to habitats around the world via human introduction. Currently, feral swine populations are established on every continent except Antarctica. Unlike other large mammal invaders, swine have a high reproductive capacity and are omnivorous, which allows for a quick assimilation into most habitats. Once a breeding population is established in an area, the population can quickly increase and negatively impact the ecosystem. A successful invasion of feral swine is difficult, and sometimes impossible, to reverse.

A feral swine pest risk assessment for Oregon, released in 2004, designated feral swine as a very high-risk species due to high potential for establishment, environmental and economic impacts, and disease transmission to wildlife, livestock and humans. Economic impacts on ecosystems and disease transmission to wildlife are difficult to assess, but restoration of ecosystems and losses to agriculture and livestock have been estimated to exceed US$800 million in the United States each year. Environmental impacts include facilitation of noxious weed invasions, shifts in dominant plant species, reduction of forest regeneration, and soil erosion. Facilitation of noxious weeds and erosion due to feral swine rooting are documented in Oregon. Feral swine in Oregon have not been implicated in disease transmission to humans, but the recent *E. coli* outbreak from spinach grown on a California farm that caused three deaths has been genetically traced to feral swine excrement deposited in spinach fields.

The feral swine population in Oregon is currently small and dispersed. Few disturbances have been documented but state and federal biologists report regular occurrence of disturbances due to feral swine. Actions to prevent the effects of an invasion fall into three categories: management, control or eradication. Of the three categories, only eradication efforts have successfully slowed or reversed the effects of swine invasions. Case studies from California, Australia, Hawaii, the Galapagos Islands and the Channel Islands off the coast of California show that management and control

efforts, while effective in the short term, have not successfully kept small feral swine populations from increasing to levels that are unmanageable and uncontrollable.

A four-year feral swine eradication plan is proposed. The Plan includes recommended legislative changes to facilitate eradication, outreach and education, population assessment, rapid response, and eradication elements. A 0.5 FTE position is required at the Oregon Department of Fish and Wildlife to implement the plan.

Specifically, the Plan includes:

- Source Control (Task 1)
  - Legislation to halt the release or escape of domestic swine
  - Legislation to facilitate the removal of feral swine from private and public land
  - Ear tags for all domestic swine for identification of feral swine and escaped domestic swine
- Population Assessment and Public Education (Task 2)
  - Survey to estimate population locations and size
  - A database of locations and control efforts
  - Education of public to facilitate citizen reports of swine disturbances
- Eradication (Task 3)
  - Planned eradication of the known populations
  - Rapid response system for swift removal of new sightings and introductions of swine
- Monitoring and Assessment (Task 4)
  - Monitoring of each eradication area for two years.
  - Lack of disturbance after two years will lead to a designation of eradication success for each site.

Eradication of feral swine in Oregon is estimated to require a four-year, $1.29 million effort. Follow-up control of new releases and escapes will require a maintenance effort estimated at less than $50,000 per year (excluding contingency funds for emergency response). These costs are small relative to the value of the $3.6 billion Oregon agriculture and livestock industries and the investment Oregon has made in riparian restoration efforts. Sustained control of feral swine in Oregon will require a long-term commitment that will include annual domestic swine marking, education, and monitoring.

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Acknowledgements

Brian Ferry, Mark Vargas and Clayton Barber from the Oregon Department of Fish and Wildlife provided background and current information on swine in Oregon. Roger Huffman from the Oregon Department of Agriculture provided the details of the Post and Antelope eradications. Tuch Koreiva from the Oregon Department of Forestry provided a history of actions taken in Coos and Curry counties for the Oregon case study. Kev Alexanian, of the Crook County Weed Control, provided details of invasive weeds in Oregon for the Oregon case study. Rob Klinger from the University of California at Davis provided the description of swine effects on island habitat for the Channel island case study. Justin Stevenson, USDA/APHIS/Wildlife Services, provided insight based on his knowledge of swine habit, behavior, and locations of burgeoning populations in Oregon. Martin Nugent and Dan Hilburn participated in initial meetings on this response plan and provided valuable comments and recommendations for the action plan. Jim Gores gave this plan his overall support and provided detailed recommendations. Robyn Draheim contributed research support and invasive species management expertise.

Since its inception, the Oregon Invasive Species Council has maintained steadfast support for feral swine management in Oregon; the Council funded preparation of the risk assessment that set the stage for this Plan. Funding for preparation of this plan was provided by the Center for Lakes and Reservoirs at Portland State University.

Feral Swine Action Plan for Oregon

Introduction

Feral mammals cause greater ecological damage than any other introduced, terrestrial taxonomic group due to their size and energy consumption (Ebenhard 1988), and feral swine are perhaps one of the most harmful mammalian species worldwide (Long 2003). Feral swine are a recognized threat to Oregon. The Oregon Invasive Species Council (OISC) placed feral swine on the 100 Most Dangerous Invaders list because of their impacts on ecosystem processes and their history of invasion around the world. Feral swine were classified as very high-risk species in a pest risk assessment developed for the OISC (Coblentz and Bouska 2004). The risk assessment concluded that the threat of destruction to natural habitat, agriculture, and livestock in Oregon is imminent without action. Currently, feral swine populations in Oregon are in isolated areas that are far from intensive agriculture and livestock production, thus Oregon has not experienced the deleterious effects of feral swine populations that plague other areas of the world with similar habitat (Barber 2006, pers com). This feral swine management plan was developed to prevent severe ecological, economic, and human health impacts in Oregon.

Feral Swine Lineage

Sus scrofa scrofa is the common ancestor of the true swine (boars, feral swine and domesticated swine) that are distributed worldwide (Choquenot *et al*. 1996, Mayer and Brisbin 1991, Sweeney and Sweeney 1982, Nowak 1991). Fossil evidence of *S. scrofa scrofa* has been found in Ethiopia, United Kingdom, Norway, Denmark, Siberia and isolated sections of eastern Asia (Mayer and Brisbin 1991). In more recent times the natural range of *S. scrofa scrofa* included Europe, most of Asia and the Northwest coast of Africa (Mayer and Brisbin 1991). The modern domesticated swine, *Sus scrofa domesticus,* was developed by selective breeding of *S. scrofa scrofa* by humans in Europe and Asia (Sweeney and Sweeney 1982, Mayer and Brisbin 1991, Choquenot *et al*. 1996). Wild boars are swine that have descended directly from *S. scrofa scrofa* and have no history of domestication in their ancestry. Feral swine are wild-living animals of the genus *Sus* with domestic ancestry; these include recently escaped or released swine and swine from populations that have been wild for more than one generation. Hybrid populations

consist of individuals with a recent ancestry that includes *S. scrofa domesticus* and *S. scrofa scrofa*. Most wild or free-living populations of swine are described as *S. scrofa* ssp. because they can include Eurasian wild boar, feral swine, or hybrids (Mayer and Brisbin 1991).

The lineage of feral swine determines their aggressiveness. Populations closely related to wild boars are more aggressive toward humans and cause more destruction to habitat during disturbances than populations descended directly from domestic swine (Koreiva 2006, pers com). Hybridization of swine populations due to interbreeding has made it difficult to determine the origin of many swine populations (Oliver and Brisbin 1993, Sweeney and Sweeney 1982); but a few, general characteristics can be used as clues to lineage. Feral swine descended from wild boars tend to have large body sizes (up to 200 kg), long skulls, mottled coloration, and thick hair that is curly and wool-like on the underside. Descendents of domestic swine have smaller body sizes, short and broad skulls, black coloration, and short but straight hair (Mayer and Brisbin 1991).

History of Feral Swine Dispersal and Invasion

S. scrofa expansion from Eurasia began with introduction of swine into the islands of the Pacific as a human food source (Tomich 1996). The expansion reached Melanesia and Polynesia about 3500 years ago (Long 2003). Swine were introduced by Polynesians to Hawaii around 1000 A.D. (Oliver and Brisban 1993, Mayer and Brisbin 1991, Nowak 1991, Tomich 1969). The Polynesian-introduced swine were small compared to the *S. scrofa* subspecies that the European explorers introduced to islands of the Pacific in the 1700's and 1800's. The European-introduced swine included *S. scrofa scrofa* and well as *S. scrofa domesticus* (Ellis 1917). Because *S. scrofa scrofa* is more aggressive than *S. scrofa domesticus*, the Polynesian-introduced domestic swine have all but disappeared from the larger gene pool on Pacific islands and most feral swine on Pacific islands are indistinguishable from *S. scrofa scrofa* (Kramer 1971, Billy 2006 pers com).

European distribution of *S. scrofa* in North America began immediately after European discovery of the New World (Clarke and Dzieciolowski 1991). Columbus introduced domestic swine to the West Indies in 1493 and DeSoto introduced them to Florida in 1593 (Sweeney and Sweeney 1982). The first populations of wild *S. scrofa* in North America began during the 1500's in the southeastern United States as escaped domestic swine from Spanish colonists

(Long 2003). American Indians also assisted swine naturalization by acquiring animals and allowing them to roam free (Hanson and Karstad 1959).

Swine traveled to western North America with European settlers; by 1769 Spanish settlers reached California with domestic swine (Barrett 1977, Van Vuren 1984). It was common practice among Spanish settlements of that time to release swine to forage in woodlands. It is very likely that some of them escaped and became California's feral swine population (Groves and Di Castri 1991). Currently in the United States, dense populations of feral swine occur in the Southwest, Midwest, and California (Figure 1).

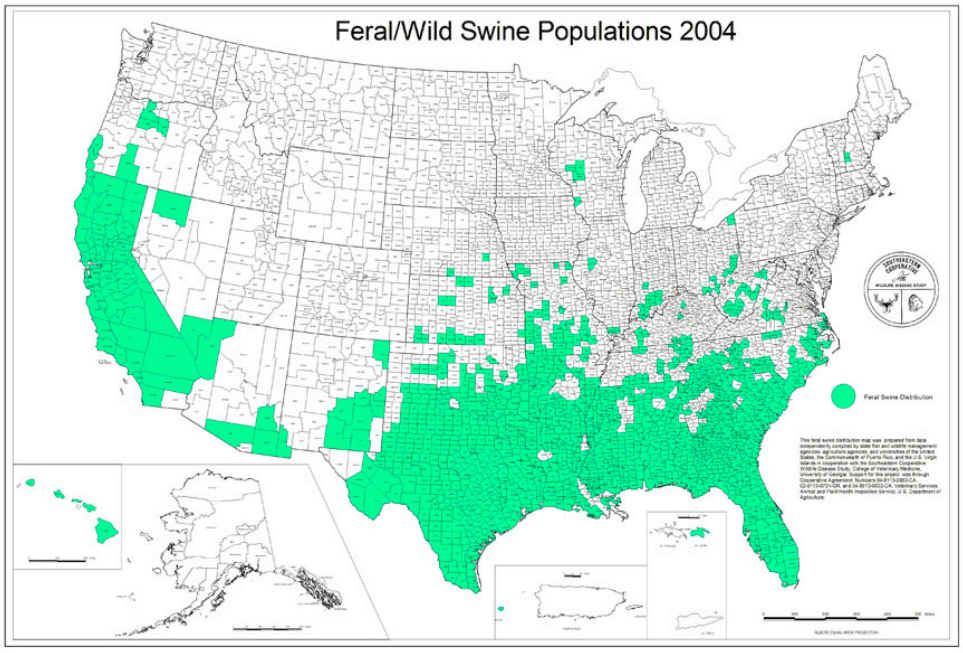

Figure 1. Feral swine distribution in the United States (Southeastern Cooperative Wildlife Disease Study, Ga)

Feral swine have been present in Oregon for nearly 200 years. The first permanent settlers arriving at present day Astoria in 1811 on the *Tonquin* as part of the John Astor's trading venture brought swine that escaped and formed a "large and troublesome pack of wild swine". (McDougal Journal, March 27-28, 1811, as cited by Ronda 1990). Although the current population distribution in Oregon is not well described, established populations were reported in 2004 Coos, Crook, Curry, Jackson, Jefferson, Josephine, Klamath, Wasco and Wheeler counties by Coblentz and Bouska (Figure 2), and a new population was reported in 2006 in Harney County (Stevenson 2006 pers com). Feral swine in Coos and Curry Counties are aggressive and have long skulls, which suggests that they are closely related to wild boars (Koreiva 2006, pers

com). The wild boar traits in the south coast feral swine suggest that they may have been intentionally released or escaped after importation of wild boars to Oregon or that they are immigrants from the expanding population in Northern California. Feral swine in the eastern and southern counties are less aggressive, which suggests that they are escapes or intentional releases of domestically raised swine. Presence of small feral swine populations for long periods prior to rapid and large population expansion is a common phenomenon. Indeed, long latent periods prior to population explosion is common for invasive species in general (Williamson 1996), and lack of major feral swine impacts in Oregon to date is not a good predictor of the likelihood of impacts in the future.

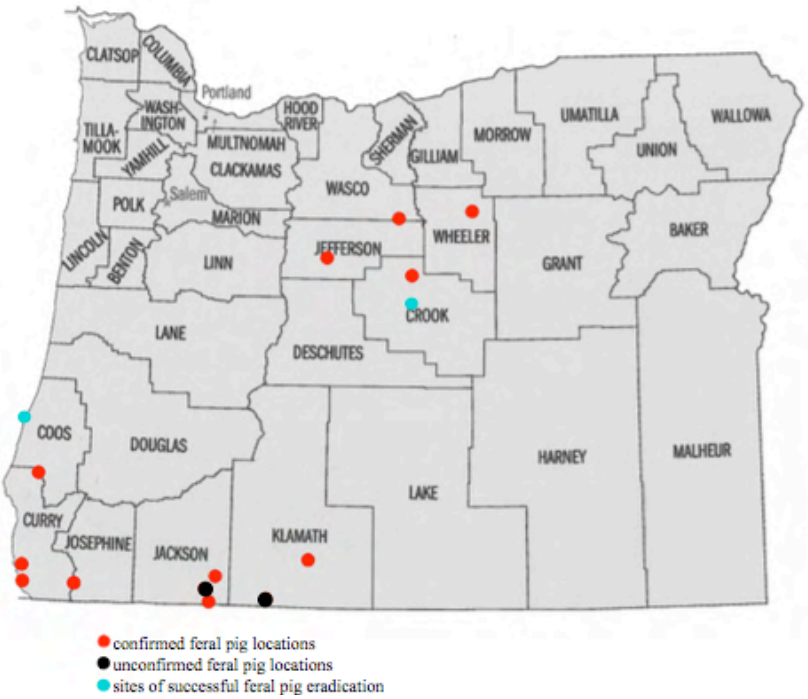

Figure 2. Map of known locations of feral swine in Oregon as of June 2004 (from Coblentz and Bouska 2004)

Impacts of Feral Swine

Ecological Impacts

Feral swine impacts are well documented in areas with large swine populations. Lack of noticeable ecological damage in Oregon is likely due to the relatively small population size currently in the state (Barber 2006, pers com). Swine have the greatest reproductive capacity of all free-ranging, large mammals in the United States (Wood and Barrett 1979) and population

expansion can occur rapidly. A feral sow reaches reproductive age at eight months and can produce up to two litters per year that contain 10-12 swine each (Tisdell 1982).

Feral swine degrade ecosystems through predation and competitive impacts on native fauna, grazing on native plants, and physically altering habitats by rooting. Rooting creates large, disturbed areas that can lead to extensive erosion, displace native species, and facilitate invasion by non-native, weedy species (Sweitzer and Van Vuren 2002, Waithman *et al*. 1999, Choquenot *et al*. 1996, Mayer and Brisbin 1991, Sweeney and Sweeney 1982, Wood and Barret 1979, Hanson and Karstad 1959). Massive erosion due to swine rooting has occurred in California (Barrett 1977), Hawaii (Tomich 1969) and Australia (Bomford and Hart 2002). Acorn survival in oak woodlands in California is reduced by feral swine rooting. Oak woodland impacts include a reduction in above ground biomass, availability of acorns for germination, and availability of mast for consumption by native wildlife (Sweitzer and Van Vuren 2002). Feral swine have rooted mast and acorns in open meadows and on the edges of white oak (*Quercus garryana*) stands in Oregon (Barber 2006, pers com).

Feral swine caused a shift in dominance in the native plant comunities in national parks in Australia and Hawaii. The floor of Eucalyptus forests in Australia's Namadgi National Park (NNP) are naturally dominated by the herbaceous Vanilla lily (*Arthropodium milleflorum*). Rooting by feral swine has led to a decrease in vanilla lily and an increase in shrubs (*Leptospermum* ssp.) in the park (Hone and Stone 1989). Swine rooting led to invasion of non-native, noxious weeds in Hawaii. Soil disturbance in some areas has altered the floor to such an extent that they are unable to support any native plant species (Diong 1982). Dominant, native forest floor species, such as ohi's (*Metrosideros polymorpha*) and koa (*Acacia koa)*, have been replaced by invasive species such as strawberry guava (*Psidium cattleianum*) and curuba (*Passiflora mollissima*) (Hone and Stone 1989). Swine rooting in upper elevation grasslands and lower elevation forests of Hawaii has caused an increase in cover of non-native velvet grass (*Holcus lanatus*). *Deschampsia nubigena*, a native bunchgrass, cover declined and velvet grass cover increased from 9.5 to 15.3 percent in swine-disturbed areas of the Kalapawili grasslands in Haleakala National Park, Hawaii, between 1973 and 1986. The increase in velvet grass cover stopped after swine were removed from the area (Stone *et al*. 1992).

Impacts of feral swine have been noted in diverse habitats in Oregon, although most reports are anecdotal and detailed documentation of impacts is lacking. Soil erosion and facilitation of noxious weed invasions due to rooting have been reported in grassland habitats in the central and southwest counties (Alexanian 2006 pers com, Ferry 2006 pers com, Huffman 2006, pers com), in open meadows and riparian zones in the coastal counties (Koreiva 2006, pers com), and in woodland habitats in southwestern counties (Barber 2006, pers com).

Facilitation of weed invasion by disturbance is a major concern in Oregon. Rooting in riparian areas may be contributing to the spread of knotweed in Oregon (Gores 2006, pers com). Weed invasion associated with rooting has been reported in dry areas, seep areas from underground springs, and in riparian zones (Ferry 2006, pers com). Infestation of noxious weeds in the steppe grasslands east of Madras (spotted knapweed [*Centaurea maculosa*], diffuse knapweed [*C. diffusa*], russian knapweed [*C. repens*], whitetop [*Cardaria draba*] and medusahead rye [*Taeniatherum caput-medusae*]) are worse in areas that swine have disturbed, and once weeds are established, continued disturbances by swine compounds further weed dispersal (Alexanian 2006, pers com).

Agriculture Impacts

Agricultural areas are very susceptible to swine rooting due to the high density of easily accessible food and well-irrigated, moist soil. Losses of row crops in areas with swine populations are regularly reported (Schley and Roper 2003, Caley 1997, Wood and Lynn 1977). Losses due to feral swine rooting and consumption to agriculture in the United States are estimated to be greater than $800 million per year (Pimental *et al*. 2000). Damage to agriculture in Texas, the state with the highest density of feral swine, exceeds $50 million (Hutton *et al*. 2006). Feral swine in Australia cause more than AU$100 million per year in damage to the agriculture industry (Choquenot *et al*. 1996). In areas of high swine density, single rooting events have caused up to AU$25,000 in damage (Hone *et al*. 1980 as cited in Coblentz and Bousk 2004).

Losses to Oregon agriculture caused by feral swine are not well-documented, but the potential is great. Oregon's agriculture is a $3.6 billion industry (Table 1). Many of the top 40 Oregon crops are favorites of feral swine worldwide. Grain, grass, hay, wheat, which are top 10 products in Oregon, are preferred by feral swine in other parts of the United states and in

Australia (Choquenot *et al.* 1996). If feral swine populations expand to areas of the state with high value crops, losses could be in the millions of dollars.

Table 1. Top 40 agricultural commodities in Oregon in 2002 (Modified from "Oregon agriculture: facts and figures." http://www.ods.state.or.us/information/pdf/statsfacts.pdf in Coblentz & Bouska 2004)

Agricultural Commodities (1-20)	Value ($)	Agricultural Commodities (21-40)	Value ($)
*†Greenhouse & nursery	714,026,000	Crab landings	20,654,000
*†Cattle & calves	473,806,000	*Hops	20,103,000
*†Hay	357,729,000	*Blueberries	20,075,000
*Grass seed	277,574,000	*Hazelnuts	18,009,000
*Milk	273,652,000	*Apples	17,609,000
*Christmas trees	160,190,000	*Strawberries	16,613,000
*†Wheat	135,565,000	*†Sheep & lambs	14,550,000
*Potatoes	134,908,000	Groundfish landings	14,229,000
*Onions	80,974,000	*Vegetable & flower seed	13,106,000
*Pears	68,004,000	*†Hay silage	11,923,000
*Eggs	43,947,000	*Garlic	11,877,000
*†Wine grapes	32,340,000	*Squash & pumpkins	11,761,000
*†Sweet corn	28,782,000	Shrimp landings	11,340,000
*Mint for oil	28,509,000	*Sugarbeets	11,186,000
*Cherries	28,169,000	*Cranberries	10,543,000
*†Grass & grain straw	26,568,000	*†Hogs	9,027,000
*†Corn, grain & silage field	25,637,000	*†Barley	8,880,000
*†Horses & mules	24,043,000	*Tomatoes	8,704,000
*Blackberries	21,871,000	*Raspberries	8,691,000
*Snap beans	20,951,000	*†Oats	7,546,000

*Commodities that could potentially incur depredation by feral swine
†Commodities that have incurred depredation in other regions

Disease Transmission

Feral swine are susceptible to, and can be carriers of, a wide range of infectious diseases that are detrimental to wildlife populations, livestock, and humans (Choquenot *et al.* 1996) (Table 2). Pseudorabies and swine brucellosis are considered the two most potent disease threats to the commercial pork industry and bovine tuberculosis is a serous threat for the cattle industry in the USA. The USDA has established a national eradication program for eliminating these three diseases (Witmer *et al*. 2003). Currently, when feral swine are harvested by USDA/APHIS/Wildlife Services personnel they are sampled for pseudorabies, swine brucellosis, and classical swine fever, which is a foreign-animal disease of concern. This sampling effort is currently being done at the expense of USDA/APHIS/Wildlife Services in Oregon and testing is provided by USDA/APHIS/Veterinary Services (Stevenson 2006, pers com). Disease

surveillance is the only way to determine the threat of transfer of bovine tuberculosis, pseudorabies or swine brucellosis from feral swine to Oregon livestock.

Table 2. A partial list of viral and bacterial diseases to which feral swine are susceptible (Compiled by Witmer *et al.* (2003) from Williams and Barker (2001) in Hutton *et al.* (2006)).

Viral Diseases	Bacterial Diseases
Bovine Herpesvirus	Anthrax
Classes Swine Fever (hog cholera)	Brucellosis
Coronaviral infections	Erysipelothrix infections
Encephalomyocarditis	Helicobacter
Foot-and-mouth disease	Letpospirosis
Influenza A	Bovine tuberculosis
Louping-ill virus	Pasteurellosis
Malignant catarrhal fever	Plague
Menangle virus	Salmonellosis
Papillomavirus infections	Yersiniosis
Parainfluenza virus	
Pestvirus infections	
Pseudorabies	
Rabbit hemorrhagic disease	
Rinderpest	
San Miguel sea lion virus	
Swinepox	
Swine vesicular disease	
Vesicular swine virus	
Vesicular stomatitis	

Foot and mouth disease (FMD) can be transmitted by feral swine and has impacted livestock industries in other countries. In 2001, an outbreak in the United Kingdom cost the livestock industry $12 billion (Hutton *et al*. 2006). In 1997, FMD wiped out Taiwan's hog industry and cost the country $25 billion (Pearson *et al*. 2005). Large economic costs are incurred by a state's livestock industry if it loses disease-free status due to FMD, pseudorabies, bovine tuberculosis or brucellosis. Testing requirements, shipping and marketing restrictions drastically reduce profitability (Witmer *et al*. 2003). For example, domestic swine in the United States recently achieved pseudorabies-free status after a 17-year effort and the expenditure of approximately $200-250 million dollars (Hutton *et al*. 2006).

Feral swine can also transmit disease to humans. Recently, the death of three people and illness in 200 people in the USA and Canada was attributed to feral swine spreading *Escherichia. coli* via excrement onto spinach fields in California (Nordqvist 2006). Diseases that can infect humans from feral swine include brucellosis, balantidiasis, leptospirosis, salmnellosis,

toxoplasmosis, trichinosis, trichostrongylosis, tuberculosis, tularemia, anthrax, rabies and plague. Most human cases cause mild flu-like symptoms and often go unreported (Hutton *et al*. 2006). A notable exception, however, was the 1918 Spanish flu that was caused by an H1N1 virus that originally infected swine (Tautneberger 2006, Fanning *et al.* 2002, Schlotissek 1994). The Spanish flu pandemic killed over 50 million people worldwide (Johnson and Mueller 2002).

Case Studies

California, Hawaii, Australia, the Galapagos Islands, and the Channel Islands off the coast of California are important examples of actions to reduce the impacts feral swine because these areas have large populations that cause significant financial and ecological damage in habitats similar to habitats occupied by feral swine in Oregon. These areas report widespread negative impacts to agriculture. At one point, these areas had feral swine populations with characteristics very similar to the current status of Oregon populations – populations were small, dispersed, and limited to a few isolated areas with limited impact (Cruz *et al*. 2005, Long 2003, Sweitzer 1998, Choquenot *et al*. 1996, Tomich 1969).

Actions taken to reduce the impacts of feral swine fall into three categories in the following case studies: control, management or eradication. Control is utilized to keep feral swine from invading a specified control area. It is not meant to diminish the population, but is used to limit population expansion into protected areas. Management, primarily with commercial or sport hunting, is used to regulate and maintain population size in areas with desired populations. Eradication is the complete removal of the population.

<u>Australia</u>

Queensland, New South Wales, the Northern Territory, and Western Australia have the largest feral swine populations in Australia (Choquenot *et al*. 1996). Management efforts began in the late 1800's when bounties were offered by local governments as a way to reduce feral swine populations (Pullar 1953). The bounty system became officially supported by the government in 1945 and lasted until 1977 (Choquenot *et al*. 1996). In Queensland alone, the government paid between 25,000 and 130,000 bounties per year during that time (Pullar 1953). The bounty system was eventually abolished due to fraud, the deliberate spread of pest animals, and failure to reduce swine populations (Rolls 1969). In Australia, each territory sets it's own standards and rules regarding feral swine, but a resolution was passed by the Vertebrate Pest

Committee in 1975 recommending that bounty payments be phased out. Territory governments now recognize bounties as an ineffective control method (Choquenot 1996).

Each territory in Australia has passed it's own legislation concerning feral swine, but the territories with the highest populations (Queensland, New South Wales, Northern Territory and Western Australia) have passed similar legislation to control feral swine, but the effectiveness of the legislation is limited by the economic value feral swine have acquired. The Rural Lands Protection Act of 1985 requires that Queenslanders destroy feral swine that live on their property. The Department of Lands recognizes feral swine as an important resource for the commercial harvesting industry and, as a consequence, feral swine are controlled in Queensland only if they have a negative economic impact on business or on local agriculture.

New South Wales passed similar legislation in 1989. Landowners are required to manage swine on private and leased land and the government controls swine on public land. As in Queensland, commercial harvesting is an important source of income in the territory and, as a result, populations persist in all areas. The Territory Parks and Wildlife Conservation Act of 1988 declared feral swine as a pest in the Northern Territory but no legal obligation is placed on land managers to control or manage them. Therefore, control of feral swine is conducted only in areas where agriculture is impacted. In Western Australia, the Agriculture and Related Resources Protection Act of 1976 places legal obligation of feral swine control on the landowner. Similar to the Queensland and the Northern Territory, control efforts are only taken in areas where agriculture is affected (Choquenot 1996). Overall, the management and control approaches adopted by the territories of Australia have not been successful (Izac and O'brien 1991).

Hawaii

Until the early 1900's, no official action was taken to manage, control or eradicate swine in Hawaii. In 1910, the Hawaii Territorial Board of Agriculture and Forestry instituted a policy of swine eradication on State and Forest Reserves (Diong 1982). Although thousands of swine were removed, feral populations spread across reserve boundaries at rates up to 4 km/year (Hone and Stone 1989). After 1959, responsibility for swine was transferred to the Hawaii Fish and Game Department and populations were managed to maintain a sustained yield of swine for hunting (Stone and Loope 1987). Despite high hunting success and the removal of hundreds of

swine per year from park areas, swine densities remained high. Management by citizen-hunters only removed swine from easily accessible areas while populations in inaccessible areas were unaffected (Stone and Loope 1987). In Hawaii Volcanoes National Park (HAVO), hunting with dogs, trapping, baiting, snaring and fencing began in 1980. Eradication was achieved in a few, small, fenced areas (Stone and Loope 1987) but populations persisted in many fenced and unfenced areas (Hone and Stone 1989). From 1985 to 1989 they were controlled in the Kalapawili grasslands with fences, which led to disturbance of native grassland from pig rooting in the swine populated areas (Stone *et al* 1992). Currently swine serve as a game animal on private and public land in Hawaii. Eradication efforts have ceased, but there is an ongoing effort to protect the native forested watersheds by fencing to exclude swine (Billy 2006, pers com).

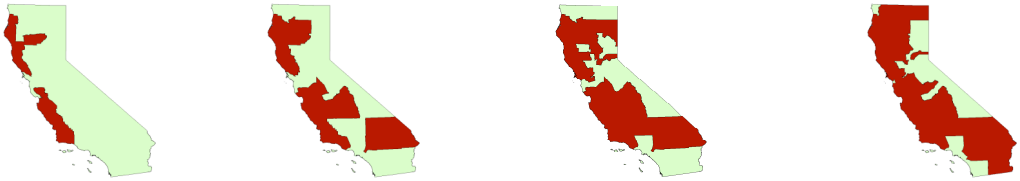

Figure 3. Range expansion of wild swine in California based upon annual Game Take Hunter Surveys during four survey periods from 1959 to 1994. (a) 1965-1967 (b) 1974-1974 (c) 1983-1985 (d) 1992-1994. Red areas indicate counties with establish feral swine (adapted from Waithman *et al*. 1999).

California

Feral swine in California illustrate how rapidly small, relatively low-impact, populations can expand. In 1957 feral swine populations were small and restricted to a few coastal counties (Mansfield 1986) (Figure 3). There were no regulations and no game status until 1957 when they were classified as big game animals (Mayer and Brisbin 1991). By the mid 1980's, the swine population had increased to 80,000 and the public raised concerns over damage to agriculture and ecological resources (Waithman *et al*. 1999). Statewide management action was taken in 1992 when hunters were required to fill out a "pig tag" for every swine killed. The "pig tags" provided detailed information on the location of the hunter-killed animals for determination of statewide swine population sizes and densities (Waithman *et al*. 1999). Swine hunting season ranges from six months to year round, depending on the county, with a bag limit of one in most

areas (Mayer and Brisbin 1991). The objective of hunting regulations is to manage feral swine populations, but even with the removal of up to 50,000 swine per year by hunters, the feral swine population remains above 133,000 statewide (Waithman *et al*. 1999).

Channel Islands

Swine hunting on the Channel Islands, off the coast of southern California, is limited by reserve areas and accessibility. The lack of hunting has led to swine densities that impact island ecosystems (Baber and Coblenz 1986). A management effort began on Santa Catalina in 1990 to reduce feral swine numbers and alleviate their impacts. The goal of the first phase, from November 1990 to April 1991, was to evaluate the effectiveness of swine removal techniques in a control area located on the island. The 3492-ha control area was isolated from the rest of the island by a 5-kilometer long bison fence. Ground hunting with and without dogs, trapping, and aerial hunting by helicopter were evaluated. Phase 1 results indicated ground hunting needed to be accompanied by trapping and helicopter hunting only worked in open areas. Phase 2, February 1992 to June 1996, expanded the efforts across the entire island and consisted of a combination of techniques: trapping, ground hunting with and without dogs, and aerial hunting. Although Phase 2 was planned as an eradication program, financial constraints limited it to a control effort. Over 3000 swine were removed from the 194-km^2 island during Phase 2, but swine effects on ecosystems remained high. After 3 years, phase 3 was implemented with the goal of eradication in the original control area. Beginning in 1996 the intensity of hunter days, the number of dogs per hunter, the number of traps, and the number of aerial hunting hours were increased. The result was complete eradication by 1998 in the control area. The final step was an expansion of the eradication effort to the entire island. In Phase 4, the island was divided into four sections separated by fences to isolate swine groups and the same intensity of techniques utilized in phase 3 were implemented. The result was near eradication by 2001 with the total removal of 11,855 swine over 15 years at a cost of $3,175,000 (Schuyler *et al*. 2002). A similar effort to eradicate feral swine from Santa Cruz Island is currently underway, with no published results at this time (Klinger 2006, pers com).

Galapagos Islands

Swine control efforts began in 1968 on Santiago Island, the largest and most densely populated island in the archipelago. The specifics of the hunting methods were not recorded, but

swine were hunted, trapped and snared sporadically. Recorded hunting began in 1974 and included shooting with 0.22 caliber rifles and hunting with dogs. By 1985 the number of hunter-days/year were increased to 1500 and a poisoning routine, which consisted of injecting goat carcasses with sodium monofluoroacetate and placing them in areas of known swine populations, was implemented. By 1989, control efforts had removed 1896 swine from the island. The next year, with similar effort, only 523 swine were removed, and efforts in subsequent years were reduced.

The control efforts became an organized eradication plan in 1998. The island was divided into blocks with a team of 12-15 hunters and 1-2 dogs per block. Hunters carried radios and GPS units to coordinate hunting and document daily coverage. Poisoning efforts continued and night hunts were organized to supplement daytime hunting. In April 2000 the last swine was shot and an extensive monitoring program began in July 2000. Non-toxic goat carcasses were place and routinely checked for disturbance and hunters checked for swine signs in marginal habitat. Following four months of monitoring and 2414 monitoring hours, the last swine was detected and removed in October 2000. In total, the eradication of feral swine from Santiago Island removed 18,800 swine over 30 years for an undisclosed sum in the millions of US dollars (Cruz *et al*. 2005).

Oregon

There have been two organized eradication efforts in Oregon. The first occurred in Crook County, near Post, from 2000 to 2005. An unfenced control area was designated after identification of the travel patterns of the local swine population. Ground and aerial hunting occurred and live traps were utilized for 90 days by the U.S. Department of Agriculture. Most of the control area was located on private land and most of the kills were by private hunters and were undocumented. Overall, the eradication effort removed 12-20 swine through trapping and shooting in the control area. No signs of swine disturbance or sightings of swine were reported after the first year of the five-year eradication plan (Huffman 2006, pers com). The second Oregon eradication effort occurred in Jefferson County, near Antelope, from 2001 to April 2006. It consisted of ground hunting by landowners and the public, and aerial hunting from a fixed-wing plane by the USDA/APHIS/Wildlife Services. Eradication was not accomplished by the end of the USDA/APHIS/Wildlife Services contract in April 2006, and there are still reports of

small populations and disturbances in the area. Lack of effective eradication of the Antelope-area swine was likely due to the lack of community involvement, tougher terrain for hunting, greater mobility by the family groups, and lack of use of helicopters in the control efforts compared to the effort near Post (Huffman 2006, pers com).

Additional swine were killed in Oregon by private individuals and USDA/APHIS/Wildlife Services in the past 10 years in Oregon. The number of swine removed by private landowners and hunters is unknown (Ferry 2006 pers com, Huffman 2006 pers com, Koreiva 2006 pers com, Vargas 2006 pers com). Three documented rapid response efforts have occurred. One swine was shot on federal land near the Upper Rogue River in the late 1990's (Vargas 2006, pers com), two swine were removed from Elliott State Forest in July 2006, and 11 were removed from private property near Spray in October by USDA/APHIS/Wildlife Services (Stevenson 2006, pers com).

Action Plan

Feral swine populations in Oregon are currently at levels similar to those in California 50 years ago. Left unchecked, feral swine populations are likely to grow and cause ecological, economic, and human health impacts in Oregon. Evidence from the Galapagos islands, Channel islands, and from Post, Oregon indicates that feral swine can be eradicated. Furthermore, the case studies demonstrated that efforts to control or manage (not eradicate) populations typically fail. Our current understanding of feral swine population size and distribution in Oregon is limited, however, known populations in eastern and southern Oregon can be eradicated. Dense vegetation and rugged topography in Coos and Curry counties, and the uncontrolled population in nearby areas of northern California will complicate eradication efforts there.

The strategies outlined in this action plan are aimed at reducing the threat of ecological, economic, and human health impacts by feral swine in Oregon. To be successful, the strategy will require a long-term commitment and application of a suite of control techniques used in an adaptive manner.

<u>Task 1. Source Control</u>

Successful eradication requires the elimination of swine introductions (Cruz *et al*. 2004, Schuler *et al*. 2002). Escapes or intentional releases from private property and immigration from

Northern California populations are probably the main sources of feral swine in Oregon. Escape from commercial pork production is not considered a major source. Legislation to stop releases and escapes is already in place but enforcement is difficult. ORS 496.004 defines feral swine as wildlife and ORS 498.052 restricts the release of domestically raised wildlife. ORA 603-010-0055 defines feral swine as free roaming animals of the genus *Sus* that are not being held under domestic management or confinement, are not domesticated, are not tame and are not claimed by any land owner within five miles of their location during the past five days. Despite the statutes, feral swine populations continue to be supplemented by releases and escapes. In most cases, enforcement of the law is inhibited by the difficulty of proving the source of new releases (Vargas 2006 pers com). Unless the swine is seen leaving private land, it is impossible to prove the source (Barber 2006 pers com).

In 2001 ORS 601 was amended to classify feral swine as unprotected wildlife to reduce restrictions on take. Along with the designation of feral swine as predators (ORS 610.002), ORS 601 has allowed the public to better harvest these animals when seen, either with a hunting license on public land or without a license on private land, acting as a landowner agent. On private land, it is unlawful to allow swine to run at-large (ORS 608.510), but immediate removal requires permission of the landowner. A precedent for the removal of at-large swine on private land was set in the Post and Antelope eradication efforts. In those cases, a landowner on adjacent property reported the release to State officials. Under ORS 570.405, a statute that describes the necessity of eradication of weeds and wildlife, a public hearing was held to establish a feral swine eradication area. Since the swine were seen on private land, that land was included in the eradication area (Huffman 2006 pers com).

Hearings to establish an eradication area under ORS 570.405 require several months, which is not practical for eradication of a small, mobile group of feral swine. The typical home range for feral swine is 2.53 km^2 and for wild boars it is 6.85 km^2, in good swine habitat (Sweitzer *et al*. 2000). During periods of drought or lack of resources, home ranges can expand to 50 km^2 (Tisdell 1982). Seasonally, movements span the entire home range. When sources of food are abundant, daily movements are slow, up to 0.1 km/h. If food is scarce, populations travel at >0.4 km/h and have been reported to transverse the entire home range in 24 hours (Singer *et al.* 1991). Because swine can be very active and under some conditions have large

ranges, a system is necessary for rapid response. The rapid response system must be immediate due to swine potential for movement, and should not be limited by migrations from public to private land.

Legislation requiring markers on domestic swine to facilitate identification

The source of escaped swine on public land is difficult to determine, and free-roaming swine on private land can require a five-day determination of ownership – too long for effective control of these mobile animals. A method to clearly identify domestic swine on private and public property is required; identification markers for all domestic swine are recommended. This program is aimed at easy identification of feral swine and protection of the pork production industry in Oregon. This marking program should be implemented in conjunction with the National Animal Identification system currently under development by USDA/APHIS/Veterinary Services, which would allow producers to register their premises and their livestock for disease control (Stevenson 2006, pers com).

The marker should be brightly colored, easily identified from a distance, and located on one ear of all domestic swine above 20 lbs. The marker should include a registration number that can be used to identify the owner of the swine if it is found on public land. Application of the ear tags could occur during regular disease treatments of domestic swine. Existing law should be amended or new law written that requires ear tags on domestic swine and the immediate removal of all swine without ear tags from public or private land (similar to ORS 570.510 for the control of noxious weeds). Together with ORS 498.052, these recommendations will allow for the rapid removal of <u>any</u> swine located on public land and <u>unmarked</u> swine on private land.

<u>Task 2. Population Determination and Public Education</u>

Feral swine database and mapping

A current and accurate database of swine populations and management actions should be created and maintained by a central office in ODFW designated to oversee feral swine eradication in Oregon. The most recent documentation on feral swine distribution in Oregon was prepared for the Pest Risk Assessment for Feral Swine in Oregon (Coblentz and Bouska 2004). While useful for identifying general locations, it does not indicate swine density or precise locations for swine removal. Due to the transient nature of feral swine populations, a map that is not periodically updated quickly becomes obsolete.

Survey

To determine the current status of feral swine, and to populate the database, a detailed survey of state and federal resource management agencies (Oregon Departments of Fish and Wildlife, Agriculture, Parks and Recreation, Transportation, Forestry; U.S. Bureau and Forest Service) for feral swine information is required. The survey should obtain information on signs of swine disturbance, cost associated with swine disturbance, swine sightings, number of swine sighted, likely population sources, numbers of swine removed, and any actions taken by private citizens or government officials dealing with feral swine within the past five years.

Education

ODFW district biologists receive most of their information about feral swine locations from reports from private citizens about swine rooting and swine sightings (Ferry 2006, pers com). APHIS and ODA also receive the vast majority of their information on feral swine populations from private citizen reports (Stevenson 2006). If the public is not informed about the deleterious effects of feral swine populations to local ecosystems, wildlife, agriculture and livestock, the likelihood of a report to local agency officials will be minimal (Barber 2006, pers com). Therefore, providing the public with information on feral swine, the damage they cause, and how to report sightings is important for accurate population assessment (Huffman 2006, pers com). In addition, an informed public is necessary for mounting and sustaining a successful eradication effort that typically requires long-term commitment of public resources and agency attention.

An informed public was critical to development of current knowledge of the status and impacts of feral swine in Oregon. Furthermore, the success of the Post eradication relied upon reports from local landowners and hunters. Local knowledge helped set up a control area before the eradication and locate individual swine during the eradication. Education efforts in each ODFW district should include annual talks to local hunter associations; discussions with local farmers and livestock owners about the negative effects of feral swine populations; fliers and signs at trailheads, ranger stations and kiosks; and communication with various outdoor groups. Education efforts should be coordinated through OISC invasive species education and outreach activities.

Task 3. Eradication

Based upon the Pest Risk Assessment, and personal communication with district biologists, current Oregon populations were grouped into three zones (Figure 4). Each zone contains similar habitat and will require similar techniques to eradicate. Zones 1 and 2 are in open habitat, with little cover, in which eradication is very likely given the successful eradication near the city of Post, located in Zone 1. Therefore, organized efforts should begin with the seven established populations located in Zones 1 and 2. This approach allows development of additional expertise and methods that will be necessary in Zone 3, which contains more difficult terrain with dense cover. Initially, control areas may be required to prevent spread of populations in Zone 3; however, once the Zone 1 and 2 populations are eradicated the control areas should be targeted for eradication.

Eradication of feral swine in Oregon will require long-term commitment and a well-conceived strategy. Reports of feral swine sightings in areas outside existing, known core populations should receive high eradication priority and a rapid response system should be organized and put in place. Contracts with USDA- Wildlife Services should be in place to permit rapid response statewide throughout the year.

All potential eradication techniques should be applied where appropriate including ground hunting with dogs, aerial hunting, and trapping. All successful feral swine eradications have included a combination of methods, e.g., hunting and trapping and aerial shooting (Cruz *et al*. 2005, Schuyler *et al*. 2002). The successful Crook County eradication relied mainly on ground hunting; however, traps and aerial hunting were sparingly utilized but limited due to low population density (Huffman 2006, pers com).

The time required to eradicate swine from an area will be a function of population size and accessibility. Large populations may require the designation of a control area and require several breeding seasons for eradication. Eradication efforts may be lengthy, such as in Post, but not all eradications will need such an effort. Contracts with USDA-Wildlife Services should be developed to target known swine populations in Oregon. Rapid response eradications, such as the Elliott State Forest removal, will also be crucial to Oregon swine eradication.

Task 4. Monitoring and Assessment

Swine have been known to reinvade, or be reintroduced, six months to a year following eradication (Schuyler *et al*. 2002) and monitoring is required to document and reinforce the eradication effort. Monitoring includes visitation of the site to check for disturbances and communication with local citizens about possible swine sightings. All areas are to be checked for subsequent disturbance by district biologist for two years following the removal effort. A minimum of two years is suggested for monitoring areas in which swine have been eradicated (Oregon Invasive Species Council 2005).

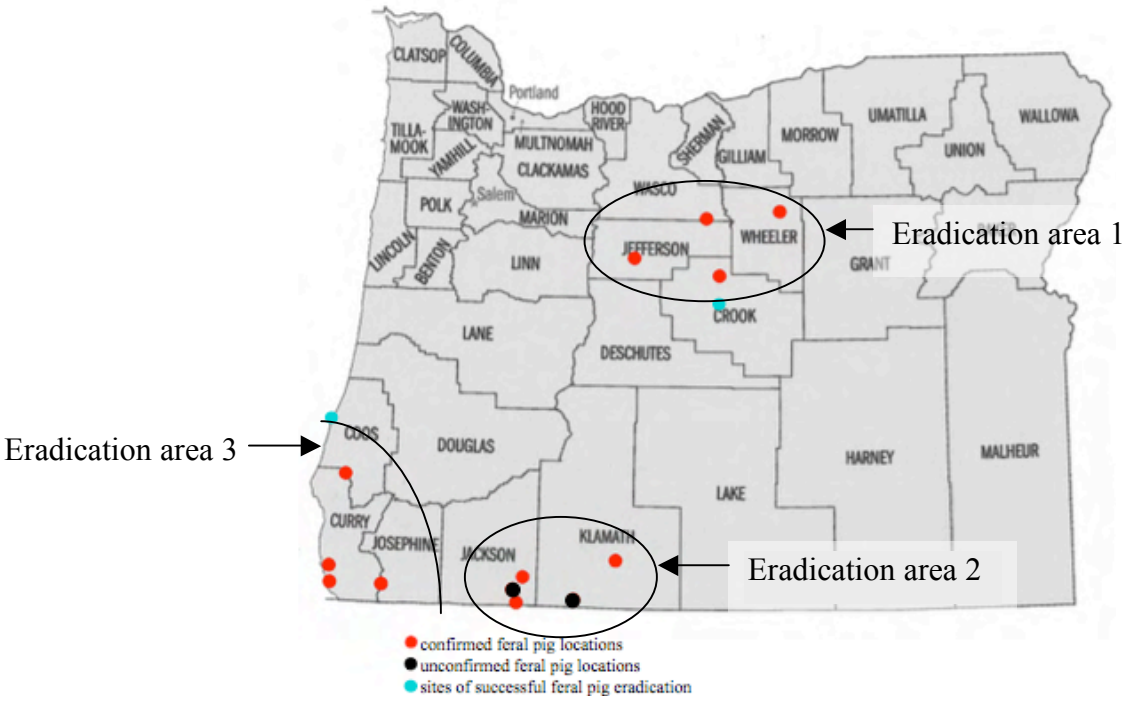

Figure 4. Recommended priority of areas for eradication during the first three years of the Oregon feral swine eradication effort.

Budget

A four-year eradication, and an ongoing maintenance budget are proposed. The budget includes a 0.5 FTE feral swine eradication program manager at ODFW who will be primarily responsible for contracting, surveys, database maintenance, outreach and education, and overall program direction. Funds are budgeted for the swine ear tag program, signs and educational materials, and eradication. Funds for rapid response to new sightings and eradication will be an

ongoing requirement. Eradication funds would focus on Zones 1 and 2 in the first year and on Zone 3 in the third and fourth years.

Compared to other, large-scale eradications, the price of eradicating the small, sparse populations in Oregon will be small. Conservative estimates of the cost of feral swine eradication efforts are $400-500 per swine in areas with sparse populations (Schuyler *et al*. 2002). Eradication costs here are based on cost of the Antelope-area eradication effort. The proposed population assessment will further inform the estimated eradication costs. In addition, experience gained in Zones 1 and 2 may result in a more efficient eradication effort in Zone 3.

Table 3. Estimated costs of the four-year eradication and ongoing maintenance program for feral swine management in Oregon.

	Yr 1	Yr 2	Yr 3	Yr 4	4-Yr Total	Ongoing
Pig eradication coordinator						
(0.5 FTE@ $75,000 salary and benefits)	37500	37500	37500	37500	150000	37500
Travel	2000	2000	2000	2000	8000	2000
Task 2						
Signs	3000	2000	2000	1000	8000	500
Task 3						
Rapid Response Contract	5000	5000	5000	5000	20000	5000
Planned Eradication Contract	300000	300000	300000	200000	1100000	100000*
	347500	346500	346500	245500	1286000	135780

* contingency

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Appendix: Oregon Revised Statues and Administrative Rules

WILDLIFE

ORS 496.004 Definitions**.** As used in the wildlife laws, unless the context requires otherwise:

(1) "Angle" means to take or attempt to take a fish for personal use by means involving hook and line.
(2) "Commission" means the State Fish and Wildlife Commission created by ORS 496.090.
(3) "Compatible" means capable of existing in harmony so as to minimize conflict.
(4) "Department" means the State Department of Fish and Wildlife created by ORS 496.080.
(5) "Director" means the State Fish and Wildlife Director appointed pursuant to ORS 496.112.
(6) "Endangered species" means:
    (a) Any native wildlife species determined by the commission to be in danger of extinction throughout any significant portion of its range within this state.
    (b) Any native wildlife species listed as an endangered species pursuant to the federal Endangered Species Act of 1973 (P.L. 93-205, 16 U.S.C. 1531), as amended.
(7) "Fund" means the State Wildlife Fund created by ORS 496.300.
(8) "Fur-bearing mammal" means beaver, bobcat, fisher, marten, mink, muskrat, otter, raccoon, red fox and gray fox.
(9) "Game mammal" means antelope, black bear, cougar, deer, elk, moose, mountain goat, mountain sheep and silver gray squirrel.
(10) "Hunt" means to take or attempt to take any wildlife by means involving the use of a weapon or with the assistance of any mammal or bird.
(11) "Manage" means to protect, preserve, propagate, promote, utilize and control wildlife.
(12) "Optimum level" means wildlife population levels that provide self-sustaining species as well as taking, nonconsumptive and recreational opportunities.
(13) "Person with a disability" means a person who complies with the requirement of ORS 496.018.
(14) "Shellfish" has the meaning given that term in ORS 506.011.
(15) "Species" means any species or subspecies of wildlife.
(16) "Take" means to kill or obtain possession or control of any wildlife.
(17) "Threatened species" means:
    (a) Any native wildlife species the commission determines is likely to become an endangered species within the foreseeable future throughout any significant portion of its range within this state.
    (b) Any native wildlife species listed as a threatened species pursuant to the federal Endangered Species Act of 1973 (P.L. 93-205, 16 U.S.C.

1531), as amended.

(18) "Trap" means to take or attempt to take any wildlife by means involving the use of a trap, net, snare or other device used for the purpose of capture.

(19) "Wildlife" means fish, shellfish, wild birds, amphibians and reptiles, feral swine as defined by State Department of Agriculture rule and other wild mammals.

ORS 498.052 Releasing domestically raised or imported wildlife without permit prohibited. No person shall release within this state any domestically raised wildlife or wildlife brought to this state from any place outside this state unless the person first obtains a permit therefor from the State Fish and Wildlife Commission.

CONTROL AREAS

ORS 570.405 Department may establish control areas; limitations**.**

(1) The State Department of Agriculture may establish, in accordance with the provisions governing the procedure for the declaring of quarantines contained in ORS 561.510 to 561.590, control areas within this state, if after careful investigation it determines that such areas are necessary for the general protection of the horticultural, agricultural or forest industries of the state from diseases, insects, animals or noxious weeds or for the eradication or exclusion from such areas of certain plants or their produce, trees, diseases, animals, insects or noxious weeds that may be a menace to such areas and generally to horticultural, agricultural or forestry industries. Whenever eastern filbert blight is found to exist, the department may declare it a hazard and may establish a control area without having to prove how the disease is transmitted.

(2) The power and authority to establish such control areas and for the eradication or exclusion of certain plants or their produce, trees, diseases, insects, animals or noxious weeds existing therein or to be excluded therefrom shall be exercised reasonably and justly considering the exigencies of the particular situation, the danger to the interests sought to be protected and the immediate and continuing effect upon the property and the owners of the property in the areas established. Such powers shall in no case be exercised unreasonably, unjustly or arbitrarily.

(3) The department in such determination shall define the boundaries of the areas and specify the character and kinds of plants or their produce, trees, diseases, insects, animals or noxious weeds to be eradicated or excluded and the manner and method of such eradication or exclusion.

CIVIL LIABILITY

ORS 608.015 Civil liability for animals trespassing on adequately fenced land situated on open range.

(1) As used in this section, "open range" means an area wherein livestock may lawfully be permitted to run at large.

(2) A person who permits a horse, mule, ass, sheep, goat or animal of the bovine species to trespass on land enclosed by an adequate fence and situated on open range shall be liable to the owner or lawful possessor of the enclosed land for damage done by the animal. The person seeking to recover the damages shall plead and prove that the fence of the person consisted of structures, masonry, hedges, ditches, rails, poles, planks, rivers, streams, ponds, lakes, wire fences, natural or artificial barriers of any kind or any combination thereof. The adequacy of the fence shall be determined by reference to the customs and practices of good husbandmen in the particular area with reference to fences. The question of the existence of the fence and the adequacy thereof are questions of fact.

(3) Nothing contained in subsection (2) of this section is intended to modify the provisions of ORS 608.310 to 608.400

FENCING AGAINST HOGS

ORS 608.510 Fencing against hogs. The owner or occupant of premises is not required to fence against hogs. No owner or person entitled to the possession of a hog shall permit it to run at large or upon the property of another person

PREDATORY ANIMALS

ORS 610.002 "Predatory animals" defined. As used in this chapter, "predatory animal" or "predatory animals" includes feral swine as defined by State Department of Agriculture rule, coyotes, rabbits, rodents and birds that are or may be destructive to agricultural crops, products and activities, but excluding game birds and other birds determined by the State Fish and Wildlife Commission to be in need of protection.

ORS 610.105 Authority to control noxious rodents or predatory animals. Any person owning, leasing, occupying, possessing or having charge of or dominion over any land, place, building, structure, wharf, pier or dock which is infested with ground squirrels, and other noxious rodents or predatory animals, as soon as their presence comes to the knowledge of the person, may, or the agent of the person may, proceed immediately and continue in good faith to control them by poisoning, trapping or other appropriate and effective means.

DEPARTMENT OF AGRICULTURE

OAR 603-010-0055 Feral swine are animals of the genus Sus which meet the following conditions:

(1) The animals are free roaming on public or private lands and not being held under domestic management confinement;

(2) No notification to the land owner, manager, or occupant has been made by the swine owner or their representative of specifically identified and described swine having escaped domestic management confinement within a radius of five (5) miles during the past five (5) days;

(3) The swine under consideration do not appear to be domesticated and are not tame; and

(4) The swine under consideration do not meet the identification and description of escaped swine in section (2) above.