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Pest Risk Assessment for Feral Pigs in Oregon

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This pest risk assessment follows the format used by the Exotic Forest Pest Information System for North America. For a description of the evaluation process used, see http://www.exoticforestpests.org/english/guidelines/eval.htm.

IDENTITY
Name: *Sus scrofa domesticus*, *Sus scrofa scrofa* Linnaeus
Taxonomic Position: Mammalia: Artiodactyla: Suidae
Common names: feral pig, feral hog, wild boar, Russian boar

RISK RATING SUMMARY
Numerical Score: 18
Relative Risk Rating: Very High

RISK RATING DETAILS
Establishment Potential is HIGH

Justification:

Feral pigs, wild boars, and hybrids either currently inhabit, or have been successfully introduced to every continent except Antarctica, and many oceanic islands. There are thirteen current known localities of feral pigs in Oregon (see Appendix A), distributed in various locations in southern and central Oregon. The biology of feral pigs indicates that these animals are capable of inhabiting virtually all available habitat west of the Cascade mountains, and the majority of the habitat east of the Cascades, with preference for riparian regions. Reports of feral pig biology and ecology in other regions in the United States, as well as around the world, give no indication of any limits to distribution, with the exception of high elevations.

Economic Impact Potential is HIGH

Justification:

Issues concerning the economics of feral pigs are dichotomous in that they are considered assets by some and pests by others. ORS 610.002 and 496.004 designate feral pigs as predators and wildlife animals under the jurisdiction of Oregon Department of Fish and Wildlife, and ORS 608.510 makes it unlawful to allow hogs to run at large or upon the property of another. These designations remove some of the conflicts experienced between other state governments and sport hunting interests, although the importation of wild “Russian boar” to trophy hunt ranches still occurs in Oregon.

Feral pigs are capable of becoming agricultural pests in Oregon, as they have in other states and countries. In the US, feral pigs are responsible for an estimated $800 million in damage each year to agricultural commodities, and there is no reason, given their dispersal capabilities, phenomenal reproductive rate, and biological and ecological generalist characteristics, that Oregon’s agricultural economy could not add to this estimate. Feral pigs are also considered to be vectors for disease, many of which are transmissable to other wildlife, livestock, and even humans.

In addition, control costs of feral pigs, although very low (< $1 million) in comparison with the damage estimates, are continuous, and resource managers are often discouraged by the constant need for trapping and killing required (70% of the population annually) just to maintain the current population. Feral pigs were restricted to a few coastal Californian counties prior to 1950, but by 1999, they occupied 49 of 58 counties. California's situation prior to 1950 was not unlike the situation that exists in Oregon today. However, California's costs of control today are much higher than they would have been 50 years ago, and statewide eradication is no longer even a consideration. In Oregon, current costs of eradicating the existing populations may be substantial, but worthwhile given the high potential of range expansion and the resulting demands on the economy.

Environmental Impact Potential is HIGH

Justification:

Feral pigs have been shown to restrict timber growth, reduce and/or remove understory vegetation, and destabilize soils, causing increased erosion and compaction, while simultaneously decreasing stream quality. Rooting and grubbing activities have also been shown to facilitate the invasion of noxious weeds and other non-native vegetation. thereby reducing site diversity and the distribution of native species. Feral pigs are capable of consuming virtually all available oak mast, thereby competing with native wildlife and severely limiting oak regeneration, a process that would negatively affect Oregon's already threatened white oak (*Quercus garryana*) savannahs. In addition, pigs prey upon herpetofauna, small mammals, and the young of larger mammals (i.e., lambs, deer fawns), thus presenting an additional source of mortality upon these organisms.

GEOGRAPHIC DISTRIBUTION

Wild pigs (*Sus scrofa* ssp.) are native to the Old World, but with the advent of world-wide travel, they have been introduced to all continents except Antarctica, and many oceanic islands (Oliver and Brisbin 1993). Although the Polynesians are credited with the first introductions of domestic pigs (*Sus scrofa domesticus*) to Hawaii as early as the 400 A.D. (Stone 1985), they first arrived in the West Indies with Christopher Columbus in 1493 (Sweeney and Sweeney 1982, Mayer and Brisbin 1991), and these populations are what sustained further expeditions to the mainland, such as that of Hernando De Soto in 1593 (Hanson and Karstad 1959, Sweeney and Sweeney 1982, Mayer and Brisbin 1991, Cox 1999). De Soto traveled over 3000 miles in his explorations of what is now the southeastern United States, and unsurprisingly, over the course of his travels, many of the pigs brought along as a food resource escaped (Hanson and Karstad 1959). There are accounts of Native Americans utilizing the resulting generations of feral pigs as a free-ranging resource, and future settlers of North America continued these practices (Sweeney and Sweeney 1982, Mayer and Brisbin 1991). Existing feral populations were bolstered by the release of domestic pigs for hunting (Mayer and Brisbin 1991, Cox 1999), and their range expanded with the movement of settlers across the country, continued use of free-ranging livestock practices, and accidental escapes (Sweeney and Sweeney 1982, Mayer and Brisbin 1991, Kotanen 1994, Cox 1999).

European wild boar (*Sus scrofa scrofa* Linnaeus) were introduced to a small game preserve on Hooper Bald, North Carolina, by George Moore in 1912, and have since interbred with feral domestic pigs, resulting in wild boar-feral pig hybrids that are still present in the southeastern United States (Laycock 1966, Mayer and Brisbin 1991). Wild boar were introduced into California by George Moore as well, again to establish a hunting population (Laycock 1966). This population has also interbred with pre-existing populations of feral pigs, producing hybrid stock (Waithman et al. 1999).

Currently, feral pig populations exist throughout the southeastern United States, from Florida to Texas (Sweeney and Sweeney 1982, Cox 1999) and Oklahoma, as well as in a band from Ohio and West Virgina to Colorado (Cox 1999). Populations are also documented in New Mexico, Arizona, California, Oregon, and Hawaii (Sweeney and Sweeney 1982, Mayer and Brisbin 1991, Cox 1999).

In California, feral pigs were restricted to a few coastal counties prior to the 1950s (Mansfield 1986). By the mid-1980s, feral pig populations had expanded into 33 of California's 58 counties, and were estimated at 70,000 to 80,000 animals (Waithman et al. 1999). As of 1994, the feral pig population was estimated at 133,000 and animals were present in 49 counties (Waithman et al. 1999). The northern and central coast regions of California host 81.7% of the state's feral pigs, who depend on permanent water sources and prefer oak (*Quercus* spp.) woodlands (Sweeney and Sweeney 1982, Waithman et al. 1999). They are also associated with hardwoods, conifer, coastal sage scrub, chaperral-chamise (*Adenostoma fasciculatum*) scrublands, grasslands, and riparian areas (Waithman et al. 1999). Very dry conditions limit range expansion into eastern and southeastern portions of California, but there are no conditions, aside from lack of cover and resources at very high elevations, that would restrict range expansion in the northern and central coast regions (Waithman et al. 1999). In fact, even high elevations may not be a limiting factor of the potential range of these animals at low latitudes. In Hawaii, feral pigs have been found on Mauna Loa and Mauna Kea at elevations as high as 3,030 meters (Stone 1985). The potential for expansion into higher elevations, however, is dependent upon freezing levels; feral pigs are not successful at higher elevations where the frost layer reaches depths greater than 2.54 cm (Hanson and Karstad 1959, Singer 1981), which presumably, inhibits their ability to root for subterranean invertebrates and tubers.

In Oregon, feral pig populations have been reported in nine counties (see Appendix A): Coos and Curry Counties (Dement Creek/Sixes River area, Pistol River, and Thomas Creek), Josephine County (Rough and Ready Creek), Jackson County (Sampson, Slide, and Conde Creeks), Klamath County (Swan Lake Ridge, Klamath River), Wasco and Jefferson Counties (Ashwood area), Crook County (Ochoco National Forest), and Wheeler County (Spray/Service Creek/Waterman Triangle area). Two additional populations existed along the coast of Coos County (North Spit) and in Crook County (east of Post on highway 380), but have been eradicated. The existing populations have resulted from a combination of unauthorized releases for hunting and ranch escapes and consist of feral domestic pigs, although the Crook County population reportedly consists of feral pig-wild boar hybrids (Ferry 2004, *pers comm*). Reports indicate that current populations are small, relatively isolated from each other, and seem to be limited by hunting pressure, and government control efforts (Huffman 2004, *pers comm*), although range expansion can be expected given that pigs are food and habitat generalists (Duncan 1974, Bratton 1975, Coblentz and Baber 1987, and others).

POTENTIAL RANGE IN OREGON

Although feral pig populations are currently limited to small isolated populations in southern and central Oregon (see Appendix A), feral pigs could successfully inhabit any region west of the Cascade Mountains where forage and water is readily available and the amount of herbaceous vegetation and understory cover is more than adequate to provide suitable habitat for feral pig populations. Presumably, forage would be limited at higher elevations in the Cascade Range, but existence would be feasible during the summer months, although seasonal altudinal migrations would be necessary for survival. In central and eastern Oregon, there are limitations to range expansion tied to the availability of water, forage, and adequate cover for thermoregulation. Riparian areas, golf courses, irrigated fields and pastures (which are most likely adjacent to riparian areas) are areas most susceptible to range expansion of feral pigs in the drier regions of Oregon.

BIOLOGY

A great deal of the difficulty associated with control of feral pig populations is due to high fecundity and early onset of sexual maturation. As a result, population growth rates can be astonishing. The growth rate of a population of European boar on the Belowesh Preserve in Poland has been as high as 178%, although typical growth values are 40% or higher (Cabon 1958, Kozlo 1970). In the United States, sows are sexually mature between 4-9 months (Lasley 1958, Sweeney 1970, Duncan 1974), with an average of 6 months in California (Pine and Gerdes 1973, Sweeney and Sweeney 1982). Boars may reach puberty between 7-12 months in Great Smoky Mountain National Park (Duncan 1974), and were observed attempting to breed at 6 months in California, but do not typically breed successfully until they are at least 12 months old (Barrett 1978).

Feral pigs are capable of reproducing year-round (Hanson and Karstad 1959, Duncan 1974, Barrett 1978), with peak farrowing periods in July and November (Sweeney and Sweeney 1982). Gestation lasts approximately 115 days (Henry 1968). Litters of California feral pigs typically consist of an average of 5.6 young (Barrett 1978, Sweeney and Sweeney 1982), and under favorable conditions, sows will produce two litters per year (Duncan 1974, Barrett 1978, Baber and Coblentz 1986). Farrowing success is tied to forage quality and availability; sows with access to irrigated pasture when other forage was limited were capable of producing 20% more fetuses than sows who did not have access to the higher quality forage (Barrett 1978). Nutritive deficiencies can result in delayed puberty and periods of anestrous (Matschke 1964, Duncan 1974) Unlike wild boar, feral pigs will attempt to reproduce even when resources are severely limited (Matschke 1964).

Feral pigs often travel in sounders, groups of eight or less comprised of one to three adult females and their subadult offspring (Kurtz and Marchinton 1972, Sweitzer et al. 2000).

It is uncommon to find more than three adults in a sounder, and mature boars are most often found alone (Hanson and Karstad 1959, Kurtz and Marchinton 1972). Home range estimates vary between sexes, subspecies, and season, which in turn affects temperature, water and forage availability. The mean home range of feral pigs in California, as taken from several studies (n = 31) was 2.53 km^2 (Sweitzer et al. 2000). It is interesting to note that the range of the wild boar-type is typically larger, reported at 7.48 km^2 in California and 6.85 km^2 as an average from several regions (Sweitzer et al. 2000). Females have demonstrated smaller home ranges than males, regardless of region (Barrett 1978, Wood and Brenneman 1980, Caley 1997, Dexter 1999), and for approximately three weeks following parturition, their home range use is further restricted to the area immediate to their nesting site (Kurtz and Marchinton 1972).

Seasonal variations in habitat use are evident. Lacking sweat glands as a physiological means of thermoregulation, pigs employ behavioral mechanisms to regulate body temperatures. Thus, the sites most preferred by pigs, especially during the summer months, are areas with quality forage, readily accessible water, and copious amounts of cover (Hanson and Karstad 1959, Coblentz and Baber 1987, Dexter 1999), which is why they are often associated with riparian areas, bottomlands, and swamp-like habitats (Singer 1981, Sweeney and Sweeney 1982, Dexter 1998, Waithman et al. 1999, and others). Similarly, nocturnal foraging and other associated movements are often observed during periods of high temperatures (Hanson and Karstad 1959, Kurtz and Marchinton 1972, Duncan 1974, Caley 1997).

Densities of feral pigs are dependent on forage availability and hunting pressure. Density increases observed in populations in California between 1994 (0.7 pigs/km^2) and 1995 (3.8 pigs/km^2) were positively correlated with higher rainfall and increased forage (Sweitzer et al. 2000). In addition, the same study reported lower densities of animals in intensely hunted areas than in lightly or unhunted areas (Sweitzer et al. 2000).

Invasion rates vary from region to region, and invasions are often sporadic, depending on available resources (Singer 1981). In California, range constriction was observed during a drought, but when the drought ended, the range of the population expanded into previously occupied areas (Waithman et al. 1999). The establishment of new trails by solitary boars facilitates home range expansion, or invasion (Hanson and Karstad 1959). In Poland, 18.5% of a population at any time was emigrating or immigrating (Singer 1981), and in the oak woodlands of California's Sierra foothills, feral pigs expanded their home ranges by 5-8 km^2 per year (Barrett 1978).

Although animal material is consumed on a regular basis, the majority of the diet of feral pigs consists of plant material (Henry and Conley 1972, Coblentz and Baber 1987, Schley and Roper 2003). A study of European wild boar in Western Europe determined that at least one energy-rich food (e.g., mast, olives, cereal grains, agricultural crops, etc.) was always consumed, with corn being the most preferred agricultural crop, and mast preferred over all other vegetative food types when available (Schley and Roper 2003). Studies of feral pigs and wild boar in the United States gave similar results, with mast, fresh shoots and herbs, and roots being preferred in descending order, over all other food types (Wood and Roarck 1980). In the southern Appalachians, plant foods, mainly acorns and hickory nuts, comprised 89% of the diet of a population of wild boar during autumn (Henry and Conley 1972). In California, acorn mast regularly comprised 70% of the diet of feral pigs on Santa Cruz Island when available, and often approached 100% (Peart and Patten 1992). In addition, a single adult is capable of consuming 1300 pounds of mast/year (Cox 1999). Other foods commonly found in the stomachs of feral pigs and wild boar include earthworms and other invertebrates (Hanson and Karstad 1959, Henry and Conley 1972, Coblentz and Baber 1987, Schley and Roper 2003), carrion (Hanson and Karstad 1959, Barrett 1978, Galdikas 1978), herpetofauna and small mammals (Bratton 1974, Singer 1976), groundnesting birds (Bratton 1974, Wood and Lynn 1977), and the young of larger mammals, such as lambs (Choquenot et al. 1997) and deer (Schley and Roper 2003).

PEST SIGNIFICANCE

Economic Impact

Economic Impacts in Other Regions: Feral pig presence has both negative and positive economic impacts, and thus, there are mixed sentiments regarding their continued existence. Feral pigs are listed as a game species in California, Florida, Hawaii, North Carolina, West Virginia, and Tennessee (Sweeney and Sweeney 1982), and are a source of state income and are valuable to recreational hunters. In California, an estimated 30,000 wild pigs are legally taken by hunters annually, who pay up to $750 for trophy wild pig hunts on private lands (Waithman et al. 1999). Although feral pigs are considered pests in Texas, hunters pay between $25 and $1000 to hunt pigs on private lands, with an average of $169 per hunt (Higginbotham 1995). The 100,000 feral pig hunters in Australia contribute $5-15 million to the economy annually, and trapping, killing, and exporting pigs to Europe as “wildschwein” provides rural Australian economies with an estimated $12 million (O’Brien and Saunders 1986).

Despite these seemingly substantial economic benefits, the costs associated with feral pigs are daunting. In Australia, for example, agricultural damage (i.e., to crops, lamb depredation, pasture, fences, and watering points) was estimated to be $80 million per year (O’Brien and Saunders 1986, Land Protection 2003), and control costs were estimated at $0.13 million annually (O’Brien and Saunders 1986), although this obviously was not enough funding to constitute a serious effort at control. Damage to sugar cane, wheat, corn and groundnuts by wild boars is common in Pakistan, and in 1989 was estimated to be 7.6 million US dollars (Brooks et al 1989). Estimates of control costs were not provided, although they were presumably substantial. Changing to diurnal irrigation practices increased water loss and waste, converting sugar cane crops to varieties with lower sugar content and hard rinds likely lowered profits, and guarding fields, building electric fences, and poison-baiting the fields were all activities that may or may not have proven effective, but did have costs associated with them.

In the United States, an estimated $800 million in agricultural damages is incurred annually, while as of 2000, less than $1 million was spent each year in control costs (Pimental et al. 2000). Hawaii alone spends approximately $100/year/pig removed on control, totaling $450,000 annually (Pimentel et al. 2000). In Great Smoky Mountain

National Park, more than $1 million was spent between 1986 and 1989 to remove 1,327 animals (Cox 1999). In 2001, the Midpeninsula Regional Open Space District board in California authorized $35,000 to hire a company to trap and kill 150 feral pigs in the central coast region of California, an average of $230 per pig (Softky 2001). Other pig trapping contracts, paying per pig (avg. $200/pig) or per hour ($500 to trap the last pig on Mt. Diablo, CA) have proven expensive, but effective (Barry 2004, *pers comm*).

Although unquantified, feral pigs are also implicated in disease transmission. Feral pigs are believed to be vectors for the transmission of diseases such as leptospirosis, tuberculosis, sparganosis, meliodoidosis, Q fever, pseudorabies, swine pox, hog cholera, and brucellosis to other wildife, livestock, and humans (Land Protection 2003). For example, in Australia, an outbreak of foot and mouth disease would cost the Australian community an estimated $3 billion in lost export trade, even if it were eradicated immediately (Land Protection 2003).

Potential Economic Impact in Oregon - Agriculture is a key portion of Oregon's economy, providing $3.6 billion of the state's revenue each year. Many of Oregon's agricultural commodities could potentially be hard-hit by feral pig activities. The nursery and greenhouse industry is the top agricultural commodity in Oregon, grossing $714 million in 2002 (see Appendix B). In addition, Oregon is the largest producer of grass seed in the world. Over 1 million acres of land are in hay production. Oregon produces the highest number of blackberries, hazelnuts, loganberries, black raspberries, potted florist azaleas, and Christmas trees in the nation. Many of these commodities require irrigation, or have fruits, nuts or rhizomes that would encourage land use and crop depredation by feral pigs.

Irrigated pastures and alluvial vegetation possess important nutritive value, especially during seasons of drought. Feral pigs grazing on irrigated pastures experienced greater growth and increased reproductive rates (Barrett 1978), and are cited as foraging in alluvial soils and meadowlands (Caley 1997, Rouys and Theuerkauf 2003). Corn was the preferred agricultural crop of wild boar in Western Europe (Schley and Roper 2003), but feral pigs and wild boar in the United States will readily invade grain crops (Caley 1997) and row crops (Wood and Lynn 1977). It was noted by Schley and Roper (2003) that "foods that are not generally consumed by wild boar can be eaten in relatively large quantities in specific localities where they are readily available," which implies a realistic potential to exploit any possible food source, especially those providing food for livestock or humans. In addition, consumption was responsible for only 5-10% of crop destruction in Western Europe; the remainder was a result of trampling (Schley and Roper 2003). Intensive damage to longleaf pine plantations in the southern United States (i.e., losses of up to 8,320 two-year old seedlings per acre, as well as regeneration losses through seed predation) has also been of economic importance in the past 50 years (Hanson and Karstad 1959, Wood and Lynn 1977).

Rooting adjacent to roadways can destabilize foundations, increasing maintenance costs (Wood and Lynn 1977). Similarly, rooting in pastures and fields has the potential to damage farm machinery (Wood and Lynn 1977), increasing costs for time, machine repairs, and lost productivity.

In addition to the aforementioned predation on wildlife, feral pigs are detrimental to sheep production in Australia, constituting a considerable source of lamb mortality. Rates of lamb predation were shown to increase with feral pig density, and interestingly, the presence of alternate food sources did not affect these rates (Choquenot et al. 1997). Feral pigs have also been reported breaking into pens and breeding with domestic pigs (Hanson and Karstad 1959), exposing the domestic livestock to disease and parasites, and lowering, or even negating, the value of the domestic sow's litter.

Control and monitoring costs can be expected to grow if range expansion of feral pigs occurs in Oregon. The statutes that have designated pigs as predatory wildlife animals (ORS 610.002 and 496.004) enhance public awareness and the ease at which the public can participate in control efforts. However, the risk of range expansion and further establishment of feral pigs is high, as is the potential for escalating control and damage costs.

Environmental Impact:

Rooting Effects – Feral pigs and wild boar spend a considerable amount of energy rooting (or grubbing) beneath the soil surface in search of bulbs, tubers, roots, and earthworms and other invertebrate food items. Rooting activities typically occur in the uppermost 25 cm of the soil layer (Lacki and Lancia 1983) mixing the surface organic soil horizons (A_1 and A_2) until they are no longer distinguishable from each other (Singer 1981, Lacki and Lancia 1983), and significantly reducing the litter layer (Bratton 1975). This, in turn, increases the natural decomposition rate of organic substances in the soil, increases nutrient cycling and acidity, and decreases the amount of nutrients available in the system (Wood and Lynn 1977, Singer 1981, Lacki and Lancia 1983, Singer et al. 1984, Stone 1985). These effects were typically associated with negative impacts to the community, although in Europe, the increased nutrient cycling resulting from wild boar rooting was believed to enhance pine growth in poor soils (Lacki and Lancia 1983), and in the southeastern United States, elongation of beech shoots was evident in areas of increased exposure to pig rooting (Lacki and Lancia 1986).

Because rooting disrupts and loosens the soil surface, it contributes to erosion, soil compaction, and subsequent siltation in streams (Bratton 1974, Bratton 1975, Howe and Bratton 1975, Singer 1976, Wood and Lynn 1977). In addition, rooting negatively affects herpetofauna and invertebrate communities by essentially removing their habitat (Bratton 1974). Rooting and wallowing near streams is detrimental to water quality and stream environments, increasing siltation and removing streamside vegetation (Howe and Bratton 1975, Singer 1981).

Rooting compromises understory complexity (Howe and Bratton 1975), and in combination with trampling, presents an effective barrier to regeneration, with seedling density decreasing with increasing activity (Peart and Patten 1992). Rooting accounted for greater than 35-65% of the soil disturbance in parts of California's oak woodlands where densities were greater than two pigs/km^2, resulting in significant declines in aboveground productivity (Sweitzer and Van Vuren 2002). In the Great Smoky Mountains National Park, the understory in areas inhabited by feral pigs or wild boars had been reduced 87%, or was only 2-15% as dense as expected, while areas uninhabited by feral pigs contained 80-110% the expected understory coverage (Singer 1981). The same study observed that the amount of bare ground increased 88%, while the litter layer was reduced 36% (Singer 1981).

The effects of rooting are most severe in high density situations and in sensitive plant communities (Singer 1981). Rooting has been shown to significantly reduce already low levels of regeneration of oaks in California (Sweitzer and Van Vuren 2002), and longleaf pine regeneration in the southern forests (Hanson and Karstad 1959, Wood and Lynn 1977, Wood and Roarck 1980). In fact, rooting and seed consumption by feral pigs was blamed for the loss of 8,320 two year-old pine seedlings per acre, with up to 200-400 seedlings per day being killed (Hanson and Karstad 1959). Rooting affects plant species composition (Sweitzer et al. 2002), favoring perennials and invasives (Stone 1985, Kotanen 1994, Kotanen 1997) and reducing species diversity (Singer 1976). Native species, especially those with starchy bulbs, tubers, rhizomes, and corms were especially at risk (Bratton 1975, Howe and Bratton 1976), and one author studying feral pig rooting activity and subsequent community modification in California suggested that in regions feral pigs have inhabited for at least 100 years, any sensitive species may have already been lost, and current studies only examine an already altered community (Kotanen 1994).

Competition – Competition with native wildlife for food resources, especially mast, is a valid concern given the rates of consumption of which feral pigs and wild boar are capable (i.e., 1300 lbs mast/year per adult). Typical competitors for mast in the southeastern United States include black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), turkey (*Meleagris galopavo*) and gray squirrels (*Sciurus carolinensis*) (Henry and Conley 1972, Bratton 1974, Wood and Lynn 1977, Wood and Roark 1980). The level of competition is dependent upon the quality and quantity of the mast crop, being the most intense when the mast crop is poor (Henry and Conley 1972, Wood and Roarck 1980).

Predation – Feral pigs ingest mostly plant material, but animal material is common as well. They are known to predate the nests of groundnesting birds (Hanson and Karstad 1959, Henry and Conley 1972, Bratton 1974, Wood and Lynn 1977), and in Switzerland and Luxembourg, increases in wild boar populations were correlated with decreases in woodcock (*Scolopax rusticola*) populations (Schley and Roper 2003). Feral pigs have been known to ingest reptiles and amphibians (Bratton 1974, Coblentz and Baber 1987, Schley and Roper 2003), small mammals, such as voles (*Microtus* spp.) and shrews (*Blarina* spp.) in the southeastern United States, and larger animals in western Europe: hares (*Lepus* spp.), rabbits (*Oryctolagus cuniculus*), roe deer fawns (*Capreolus capreolus*), and pheasants (*Phasianus colchicus*) (Schley and Roper 2003). In the Galapagos, feral pigs prey on the eggs and hatchlings of the green sea turtle (*Chelonia mydas*), the giant tortoise (*Geochene elephantopus*), and dark-rumped petrels

(*Pterodroma phaeopygia*), and are believed to have assisted in the extinction of land iguanas (*Conolophys subcristatus*) from Santiago Island (Coblentz and Baber 1987).

Potential Impacts in Oregon - Although there have not been any studies of the impacts of feral pigs in Oregon, their presence undoubtedly affects understory cover, soil qualities, water and stream quality, and exotic plant invasion in a manner similar to those described from other regions, altering nutrient cycling pathways and successional patterns. The Oregon white oak (*Q. garryana*) is found in low elevations throughout the western part of the state and areas in southern and southwestern Oregon near known feral pig populations (Martinez 1996). Oak savannah habitat is slowly disappearing in Oregon, and invasion of savannah regions by feral pigs could seriously diminish this habitat of concern. Native wildlife dependent on mast of the Oregon white oak and the canyon live oak (*Q. agrifola*) in southern Oregon would be, and perhaps already are, suffering the effects of competition for mast with feral pigs, and are required to locate supplemental food sources during the mast season.

DETECTION AND IDENTIFICATION

Feral pigs are typically intermediate in size between domestic hogs and the European wild boar. They tend to be dark, either black or brown in color, but mottling or spotting is not uncommon, and occasionally they will be white. They tend to have a lean, "gamey" look that is different from domestic hogs, with longer tusks and coarser coats, although there is considerable variation between individuals (Sweeney and Sweeney 1982). Because their activity is often crepuscular or nocturnal, feral pigs may not be seen, but if they are inhabiting or foraging in an area, there should be ample evidence of their presence. Rooting and foraging activity often occur in moist or irrigated soil, simulating the effect of a rototiller in a garden churning up the soil. Wallows appear as distinct oval-shaped mud holes utilized for thermoregulation, and rubbing places can be seen low on the trunks of nearby trees. In instances in which feral pigs have broken through fencing, hairs may be present in the wire.

MEANS OF MOVEMENT AND DISPERSAL

Feral pigs have demonstrated a remarkable ability for range expansion (Waithman et al. 1999). Home ranges tend to be smaller in regions and seasons where resources are abundant, but expand in areas or seasons where resources are limited (Singer 1981). They prefer habitat types that provide ample cover and water, but are quite capable of adapting to harsher environments. Adult females and subadults travel in groups of eight or less; boars are usually solitary, creating trails that are used as main thoroughfares or highways through their home range. The ranges of boars are typically larger, and as they expand and create trails into new territories, the female groups eventually begin utilizing them as well, slowly expanding the range of a population that, under optimal circumstances, is capable of doubling every four months (Katahira et al. 1993).

CRITICAL INFORMATION NEEDS

The most important piece of information relating to feral pig management that is missing in Oregon is actual quantified estimates of population sizes, densities, and ranges of the known populations. Their presence has been affirmed, but actual numbers have yet to be determined. Until this is quantified, it will be difficult to obtain solid cost estimates for eradication.

DISCUSSION

Feral pigs are a plague on the environment, ripping up riparian meadows, denuding understory vegetation, increasing soil erosion, compaction, and siltation, and competing with native wildlife for resources. In short, they alter ecosystem function and processes in both predictable and unpredictable ways. Although it is difficult to place a dollar value on environmental damages, cost estimates of economic damages incurred because of feral pigs are illustrative of the immense nuisance that feral pigs present. They have enormous negative economic potential; in the US alone, feral pigs are estimated to cause $800 million in agricultural damages annually, although less than $1 million is spent on control (Pimentel et al. 2000).

Approximately $3.6 billion of Oregon's economy is dependant upon agricultural commodities. Feral pigs have been observed foraging in agricultural fields when habitat quality and associated forage availability is low, as in late summer and fall in semi-arid regions (Baber and Coblentz 1986). They are known to depredate agricultural crops during other seasons as well (see Appendix B), often causing thousands of dollars' worth of damage. For example, an incident that occurred in a single night in 1972, a herd of feral pigs were responsible for $25,000 damage to a sorghum crop in Australia (Hone et al. 1980).

An integral part of any management or eradication program is an estimate of the current population size. In the past, these have typically been generated by mark-recapture studies, which are both labor-intensive and expensive, and are often limited by recapture difficulties, especially with respect to adults (Baber and Coblentz 1986). Sweitzer et al. (2000) conducted a modified mark-recapture study using baited camera stations and found that they were able to use photographs to identify individual pigs and obtain minimum population estimates that were similar to mark-recapture estimates. In their study, Sweitzer et al. (2000) determined that the costs associated with the camera-sighting method were lower than that of traditional mark-recapture programs. The estimated costs of capturing and tagging 20 wild pigs at one site with 3 traps in a traditional mark-recapture project, including an estimated 10-18 days/site for surveying, construction and setup, and capturing and processing animals was estimated to be between $3,681 and $5,494. Initial costs, including the purchase of 4 camera systems ($550 each), for sighting wild pigs at a site for the camera-sighting method were between $3,942 and $4,539. The amount of field work required was reduced by as many as 5 days with the camera-sighting method, repair costs were relatively small (<$50/system), and once the initial purchase of the camera systems were made, total costs for the project decreased even more. The cost estimates presented here are dated to 1995, and are most likely lower than they would be today. Current (2004) costs of Trailmaster® camera systems similar to that used in Sweitzer et al. (2000) are between $650 and $750 each.

Costs of control efforts vary considerably, and are dependent on the densities of feral pig populations and the structure and complexity of the invaded habitat, with eradication cost and difficulty increasing with increasing vegetative density. Populations subject to hunting pressure have been shown to have lower densities (Sweitzer et al. 2000), and encouraging hunting pressure on lands inhabited by feral pigs is certainly a plausible management action, and has been implemented through the establishment of a temporary Feral Swine Control Area in Crook County by Oregon Department of Agriculture (1999). Trapping, poison baiting, and shooting have been used as control methods, with a combination of poison baiting and shooting being most successful (Coblentz and Baber 1987). Trapping is reportedly the most expensive and inefficient method of control (Coblentz and Baber 1987), but recent pig control contracts in California have utilized this method, at costs ranging from $200 to $500 per pig, likely because of potential secondary non-target poisoning associated with poison baiting (McIlroy 1983, O'Brien et al. 1986). However, despite the high costs, the documented trapping efforts have been successful in eradicating pigs from the target areas. This kind of success, although costly, serves to protect the integrity of existing communities, while allowing damaged systems to recover, thereby presenting benefits that are difficult to assign dollar values to, but are nonetheless highly valuable.

Given the current knowledge of feral pig distribution and numbers in Oregon, it is probable that the existing populations could be eradicated with reasonable costs and efforts. However, a parallel probability exists that these populations could grow and expand in manner similar to populations in California, so that complete state-wide eradication efforts would be too costly to attempt, and would offer little or no hope for long-term success. Fortunately, the outlook for control of Oregon's feral pig populations is not yet bleak. Oregon's statutes designating feral pigs as predatory wildlife, that anyone with a current hunting license can legally take on public land, or on private land with the landowner's permission, potentially gives us the advantage on controlling or eradicating this invasive generalist mammal. However, without enhancing public knowledge, restricting imports of all wild pigs for trophy hunting ranches, and somehow limiting livestock escapes, feral pigs will always be a part of Oregon's biotic landscape, albeit on a small scale.

BIBLIOGRAPHY

Baber, D.W. and B.E. Coblentz. 1986. Density, home range, habitat use, and reproduction in feral pigs on Santa Catalina Island. Journal of Mammalogy, 67(3): 512-525.

Baber, D.W. and B.E. Coblentz. 1987. Diet, nutrition, and conception in feral pigs on Santa Catalina Island. Journal of Wildlife Management, 51(2): 306-317.

Barrett, R.H. 1978. The feral hog on the Dye Creek Ranch, California. Hilgardia, 46(9): 283-355.

Barry, S. 11 May 2004. Natural Resource Advisor, Santa Clara County, CA. Personal communication.

Bratton, S.P. 1974. An integrated ecological approach to the management of European wild boar (*Sus scrofa*) in Great Smoky Mountains National Park: Management Report No. 3. National Parks Service, 49 pp.

Bratton, S.P. 1975. The effect of the European wild boar, *Sus scrofa*, on gray beech forest in the Great Smoky Mountains. Ecology, 56(6): 1356-1366.

Brooks, J.E., E. Ahmad, I. Hussain, and M.N. Khan. 1989. The agricultural importance of the wild boar (*Sus scrofa* L.) in Pakistan. Tropical Pest Management, 35(3): 278-281.

Cabon, K. 1958. Das Massensterben von Wildschweinen im Naturstaatspark von Bialowiezc im Winter 1955/56. Acta Theriol., 2: 71-82.

Caley, P. 1997. Movements, activity patterns and habitat use of feral pigs (*Sus scrofa*) in a tropical habitat. Wildlife Research, 24(1): 77-87.

Choquenot, D., B. Lukins, and G. Curran. 1997. Assessing lamb predation by feral pigs in Australia's semi-arid rangelands. Journal of Applied Ecology, 34: 1445-1454.

Coblentz, B.E. and D.W. Baber. 1987. Biology and control of feral pigs on Isla Santiago, Galapagos, Ecuador. Journal of Applied Ecology, 24: 403-418.

Cox, G.W. 1999. Alien Species in North America and Hawaii: Impacts on natural ecosystems. Island Press, Washington, D.C. and Corelo, California.

Dexter, N. 1998. The influence of pasture distribution and temperature on habitat selection by feral pigs in a semi-arid environment. Wildlife Research, 25(5): 547-559.

Dexter, N. 1999. The influence of pasture distribution, temperature and sex on home-range size of feral pigs in a semi-arid environment. Wildlife Research, 26(6): 755-762.

Duncan, R.W. 1974. Reproductive biology of the European wild hog (*Sus scrofa*) in the Great Smoky Mountains National Park. M.S. Thesis, University of Tennessee, 69 pp.

Ferry, B. 26 April 2004. Oregon Department of Fish and Wildlife, Prineville Office. Personal communication.

Galdikas, B.M. 1978. Orangutan death and scavenging by pigs. Science, 200(7): 68-70

Hanson, R.P. and L. Karstad. 1959. Feral swine in the Southeastern United States. Journal of Wildlife Management, 23(1):64-74.

Henry, V.G. 1968. Length of estrous cycle and gestation in European wild hogs. Journal of Wildlife Management, 32(2): 406-408.

Henry, V.G. and R.H. Conley. 1972. Fall foods of European wild hogs in the Southern Appalachians. Journal of Wildlife Management, 36(3): 854-860.

Higgenbotham, B. 1995. Feral hogs: the good, the bad or the ugly? http://agnews.tamu.edu/stories/WFSC/feralhog.htm.

Hone, J., J. O'Grady, and H. Pedersen. 1980. Decisions in the control of feral pig damage. AGbulletin 5, Department of Agriculture New South Wales, 22 pp.

Howe, T.D. and S.P. Bratton. 1976. Winter rooting activity of the European wild boar in the Great Smoky Mountains National Park. Castanea, 41: 256-264.

Huffman, R. 28 April 2004. Oregon Department of Agriculture, Animal Health and Identification Division. Personal communication.

Katahira, L.K., L. Finnegan, and C.P. Stone. 1993. Eradicating feral pigs in montane mesic habitat at Hawaii Volcanoes National Park. Wildlife Society Bulletin. 21: 269-274.

Kotanen, P.M. 1994. Effects of feral pigs on grasslands. Fremontia, 22(2): 14-17.

Kotanen, P.M. 1997. Effects of experimental soil disturbance on revegetation by natives and exotics in coastal California meadows. Journal of Applied Ecology, 34: 631-644.

Kozlo, P.G. 1970. Faktory, opredelyayuschchie dinamiku chislennosti Kabana (*Sus scrofa*) V Belovezhsko_ Pushche. Zool. Zh., 49: 422-430.

Kurtz, J.C. and R.L. Marchinton. 1972. Radiotelemetry studies of feral hogs in South Carolina. Journal of Wildlife Management, 36(4): 1240-1248.

Lacki, M.J. and R.A. Lancia. 1983. Changes in soil properties of forests rooted by wild boar. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies, 37: 228-236.

Lacki, M.J. and R.A. Lancia. 1986. Effects of wild pigs on beech growth in Great Smoky Mountains National Park. Journal of Wildlife Management, 50(4): 655-659.

Land Protection. 2003. Feral pigs in Queensland: distribution, ecology, and impact. Land Protection, Queensland Government, Natural Resources and Mines, 4 pp.

Lasley, J.F. 1968. Estrous cycles. Pp. 81-97 *In*: E.S.E. Hafez (Ed.), Reproduction in farm animals (2^{nd} Ed.). Lea and Febiger, Philadelphia, Pennsylvania.

Laycock, G. 1966. The Alien Animals: The story of imported wildlife. The Natural History Press, Garden City, New York.

Mansfield, T.M. 1986. Wild pigs can be problems. Outdoor California, 47: 23-24.

Matschke, G.H. 1964. The influence of oak mast on European wild hog reproduction. Proc. 18^{th} Annu. Conf. SE Game and Fish Commiss., 18: 35-39.

Martinez, P. 1996. Oregon white oak series. Siskiyou National Forest website. http://www.fs.fed.us/r6/siskiyou/QUGA400.PDF

Mayer, J.J. and I.L. Brisbin, Jr. 1991. Wild Pigs of the United States: Their history,morphology, and current status. University of Georgia Press, Athens.

McIlroy, J.C. 1983. The sensitivity of Australian animals to 1080 poison. V. The sensitivity of feral pigs *Sus scrofa* to 1080 and its implications for poisoning campaigns. Australian Wildlife Research, 10: 139-148.

O'Brien, R.E. Kleba, J.A. Bleck, and P.J. Baker. 1986. Vomiting by feral pigs after 1080 intoxication: nontarget hazard and influence of anti-emetics. Wildlife Society Bulletin, 14: 425-432.

O'Brien, P.H. and G.R. Saunders. 1986. Socio-economic and biological impact of the feral pig in New South Wales: an overview and alternate management plan. The Australian Rangeland Society, 4^{th} Biennial Conference, Armidale. Working papers, 200-203.

Oregon Department of Agriculture. 21 December 1999. Control area order for feral swine in portions of Crook County, Oregon.

Peart, D. and D.T. Patten. 1992. Feral pig activity associated with coast live oak regeneration on Santa Cruz Island, California. In: Ecology and Management of Oak and Associated Woodlands: Perspectives in the Southwestern United States and Northern Mexico. (Ffolliott, P.F. et al., tech. coords.), Symp. April 27-30, 1992, Sierra Vista. USDA Forest Service Gen. Tech. Rep. RM-218: 162-164.

Pimentel, D., L.Lach, R. Zuniga, D. Morrison. 2000. Environmental and economic costs of non-indigenous species in the United States. Bioscience, 50(1): 53-65.

Pine , D.S. and G.L. Gerdes. 1973. Wild pigs in Monterey County, California. California Fish and Game, 59: 126-137.

Rouys, S. and J. Theuerkauf. 2003. Factors determining the distribution of introduced mammals in nature reserves of the southern province, New Caledonia. Wildlife Research, 30(2): 187-19 1.

Schley, L. and T.J. Roper. 2003. Diet of wild boar, *Sus scrofa*, in Western Europe, with particular reference to consumption of agricultural crops. Mammal Review, 33(1): 43-56.

Singer, F.J. 1976. The European wild boar project, Great Smoky Mountains National Park: Problem analysis and proposed research. National Park Service SE Regional Uplands Research Laboratory GSMNP, 66 pp.

Singer, F.J. 1981. Wild pig populations in the national parks. Environmental Management, 5(3): 263-270.

Singer, F.J., W.T. Swank, and E.E.C. Clebsch. 1984. Effects of wild pig rooting in a deciduous forest. Journal of Wildlife Management, 48: 464-473.

Softky, M. 07 March 2001. Open space district traps, kills wild pigs. The Almanac. http://www.almanacnews.com/morgue/2001/2001_03_07.pigs.html

Stone, C.P. 1985. Alien animals in Hawai'i's native ecosystems: toward controlling the adverse effects of introduced vertebrates. In: Stone, C.P. and J.M. Scott, eds. 1985. Hawai'i's Terrestrial Ecosystems: preservation and management. Cooperative National Park Resources Studies Unit, University of Hawaii, Honolulu, HI.

Sweeney, J.M. 1970. Preliminary investigations of a feral hog (*Sus scrofa*) population on the Savannah River Plant, South Carolina. M.S. Thesis, University of Georgia. 58 pp.

Sweeney, J.M. and J.R. Sweeney. 1982. Feral hog (*Sus scrofa*). In: Chapman, J.A. and G.A. Feldhamer, eds. 1982. Wild Mammals of North America: biology, management, economics. The Johns Hopkins University Press, Baltimore, MD.

Sweitzer, R.A., D.Van Vuren, I.A. Gardner, W.M. Boyce, and J.D. Waithman. 2000. Estimating sizes of wild pig populations in the north and central coast regions of California. Journal of Wildlife Management, 64(2): 531-543.

Sweitzer, R.A. and D.H. Van Vuren. 2002. Rooting and foraging effects of wild pigs on tree regeneration and acorn survival in California's oak woodlands ecosystems. USDA Forest Service Gen. Tech. Rep. PSW-GTR-184.

Waithman, J.D., R.A. Sweitzer, D. Van Vuren, J.D. Drew, A.J. Brinkhaus, I.A. Gardner, W.M.

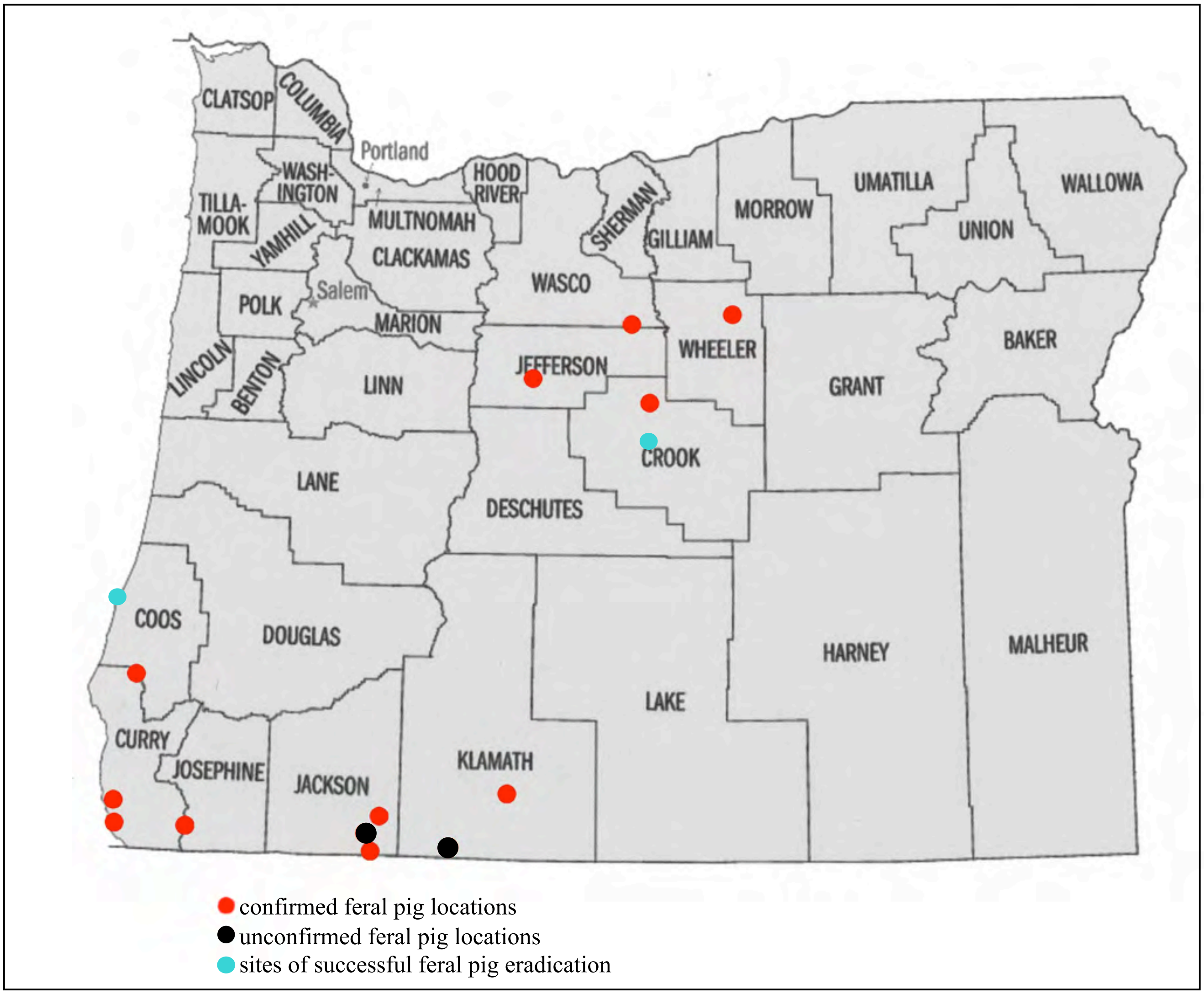
Boyce. 1999. Range expansion, population sizes, and management of wild pigs in California. Journal of Wildlife Management, 63(1): 298-308.

Wood, G.W. and R.E. Brenneman. 1980. Feral hog movements and habitat use in coastal South Carolina. Journal of Wildlife Management, 44(2): 420-427.

Wood, G.W. and T.E. Lynn, Jr. 1977. Wild hogs in Southern forests. Southern Journal of Applied Forestry, 1(2): 6pp.

Wood, G.W. and D.N. Roarck. 1980. Food habits of feral hogs in Coastal South Carolina. Journal of Wildlife Management, 44(2): 506-511.

Appendix A



Map of known locations of feral pigs in Oregon as of June 2004.

Appendix B

Appendix B. Top 40 agricultural commodities in Oregon in 2002. (*Modified from "Oregon Agriculture: Facts and Figures."* http://www.oda.state.or.us/information/pdf/statsfacts.pdf

Agricultural Commodities (1-20)	Value ($)
*†Greenhouse & nursery products[1]	714,026,000
*†Cattle & calves[1]	473,806,000
*†Hay[1]	357,729,000
*Grass seed	277,574,000
*Milk	273,652,000
*Christmas trees	160,190,000
*†Wheat[2,3]	135,565,000
*Potatoes[3]	134,908,000
*Onions	80,974,000
*Pears	68,004,000
*Eggs	43,947,000
*†Wine grapes[1]	32,340,000
*†Sweet corn [1,2,3]	28,782,000
*Mint for oil	28,509,000
*Cherries	28,169,000
*†Grass & grain straw[1]	26,568,000
*†Corn, grain & silage field [1,2]	25,637,000
*†Horses & mules[1]	24,043,000
*Blackberries	21,871,000
*Snap beans	20,951,000

Agricultural Commodities (21-40)	Value ($)
Crab landings	20,654,000
*Hops	20,103,000
*Blueberries	20,075,000
*Hazelnuts	18,009,000
*Apples	17,609,000
*Strawberries	16,613,000
*†Sheep & lambs[4,3,5]	14,550,000
Groundfish landings	14,229,000
*Vegetable & flower seed	13,106,000
*†Hay silage[1]	11,923,000
*Garlic	11,877,000
*Squash & pumpkins	11,761,000
Shrimp landings	11,340,000
*Sugarbeets	11,186,000
*Cranberries	10,543,000
*†Hogs[1]	9,027,000
*†Barley[3]	8,880,000
*Tomatoes	8,704,000
*Raspberries	8,691,000
*†Oats [1,3,6]	7,546,000

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

[1] Resource losses reported to California's Wildlife Services program during the fiscal year of 2002.
[2] Brooks, et al. 1989
[3] Hone, et al. 1980
[4] Choquenot, et al. 1997
[5] O'Brien and Saunders 1986
[6] Baber and Coblentz 1986