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Sus scrofa (mammal)

Taxonomic name: *Sus scrofa* (Linnaeus, 1758)
Synonyms:
Common names: kuhukuhu (Maori), kune-kune (Maori-New Zealand), petapeta (Maori), pig (English), poretere (Maori), razorback (English), te poaka (Maori), Wildschwein (German)
Organism type: mammal

Feral pigs like other introduced mammals are major drivers of extinction and ecosystem change. They have been introduced into many parts of the world, and will damage crops and home gardens as well as potentially spreading disease. They uproot large areas of land, eliminating native vegetation and spreading weeds. This results in habitat alteration, a change in plant succession and composition and a decrease in native fauna dependent on the original habitat.

Description
Pigs are large omnivorous mammals with powerful bodies and coarse hairy coats. Their thick necks, wedge-shaped heads and mobile snouts are used in feeding to uproot the ground and find prey or plant material.
Ecological characteristics of feral pig activity, group size and home range size should be considered in any management strategy aimed to control pig numbers or reduce their negative impact. Feral pig activity varies between different habitats and climates. High activity has been reported to occur in early morning and late afternoon in tropical climates (Diong 1982). However, in India pigs have been reported to feed nocturnally to raid croplands (Sekhar 1998, in Wolf and Conover 2003). On Santa Cruz Island (California) the milder weather of fall and late winter causes pigs to be more active in the morning and evening, while the short cool and often rainy days of winter causes midday activity. Pigs on the island were active at night mostly when conditions were warm and dry (Van Vuren 1984, in Wolf and Conover 2003).
In terms of group structure, in North-western Australia mob sizes are generally about 12 or less, although occasionally mobs of 30 pigs are seen. Adult boars are mostly solitary. Estimated litter size is 4.5 viable young per sow (Twigg *et al* 2005). In South Carolina the average home range of boars is 226 hectares, while the average for sows is 181 hectares (Wood and Brenneman 1980, in Wolf and Conover 2003).

Occurs in:
agricultural areas, coastland, disturbed areas, natural forests, planted forests, range/grasslands, riparian zones, scrub/shrublands, urban areas, wetlands

Habitat description
The feral pig adapts to a variety of environments from Mediterranean oak woodland forests to the semi-arid rangelands of Eastern Australia, from the flood plains, billabongs and grassland savannas of tropical North-western Australia to the gray beech forests of the Smoky Mountains

in America and from the wetland and lowland evergreen monsoon forests of Australia to the fresh water marshes and brackish water marshes of South Carolina (Wood and Brenneman 1980, in Wolf and Conover 2003). Wild pigs are rarely found over 1650m (Bulmer and Bulmer 1964, in hide 2003), but are known to be found at altitudes as high as 3000m in New Guinea (Flannery 1995, in Hide 2003).
Home ranges of pigs are smaller during the dry season than during the wet season. During the dry season on Santa Catalina pigs preferred cool moist canyon bottoms due to a physiological need for free water. Dense vegetation was more actively sought after than open areas such as grasslands (Baber and Coblentz 1986, in Wolf and Conover 2003).
The presence of crops in the near area (for example palm dates or oat hay cultivations) provide a food supplement and may greatly increase feral pig density; the close location of cereal crops in one study increased the density of feral pigs almost four-fold (Caley 1993, in Wolf and Conover 2003). Similarly the presence of adjacent palm cultivations in Malaysia was found to increase pigs density by 10 to 100 times (Ickes Paciorek and Thomas 2005).
High densities of pigs may also be attributed to water availability. The recent expansion in feral pig distribution in Australia has been attributed to the increase in suitable habitats, in particular, an increase in water availability from farm dams and developing forest industries (Spencer and Hampton 2005).

General impacts
Rooting by pigs disturbs the seed bank, reduces surface vegetation and alters the soil by increasing soil temperature, increasing or decreasing the nitrogen content, increasing oxidation and increasing the leaching of Ca, P, Zn, Cu and Mg (Kotanen 1994, Singer Swank and Clebsch 1984, Arrington, Toth and Koebel 1999, in Wolf and Conover 2003). In addition, rooting creates large unattractive open spaces, reduces perennial cover and increases the growth of alien annual grasses (Kotanen 1994, in Wolf and Conover 2003). In its native range in Sweden the pig generally roots extensively in deciduous forests and damp soil, preferring these locations to grassland areas with dry soils; most rooting occurring from autumn to early spring (Welander 2000, in Wolf and Conover 2003).

The feral pig may enhance diversity of wetland plant assemblages (on the Kissimmee River floodplain, for example); or it may destroy coastal marsh habitats, increasing the loss of wetlands (Arrinton, Toth and Koebel 1999, Ford and Grace 1998, in Wolf and Conover 2003).

Pigs disrupt the ecosystem on a number of levels. In the Great Smoky Mountains they reduce herbaceous understory cover to 5% of its expected value, they destroy the leaf litter habitat of the red-back vole and the short-tailed shrew, they consume the threatened red-cheeked salamander and Jones middle-toothed snail. They reduce the level of microinvertebrates in the soil by an estimated 80%. Lastly their rooting habit accelerates soil erosion and increases siltation in rivers (Peine and Farmer 1990, in Wolf and Conover 2003).

Native tree ferns are the staple diet of the feral pig in Hawaii. Feral pigs directly kill several species of native trees by felling or barking them. This destruction of tree ferns and epiphytes brings substantial cover loss to the koa-ohia forest; feral pigs are also known to actively disperse the seeds of the invasive exotic strawberry guava (Diong 1982). Pigs have an impact on native invertebrates, such as earthworms and snails, which they consume in large amounts (e.g. Meads *et al*. 1984).

On Santiago island (Ecuador) feral pigs have reduced giant tortoise and sea turtle numbers by preying on their eggs (MacFarland *et al*. 1974a, Green *et al*, Coblentz 1987, in Patry 2001). Pigs probably also eat the eggs and young of seabirds such as albatrosses, shags and boobies (Moors and Atkinson 1984). Unlike on Hawaii, on Santiago island the pigs do not have a negative impact on the native vegetation; this is due to the increased resistance of plants to generalised herbivores, in particular, the native giant tortoise (Colblentz Baber 1987, in Wolf and Conover 2003).

Pig rooting also damages cultivated crop species. In one study conducted in 40 counties of California an economic loss of approximately US$ 1 730 000 was recorded due to pigs (Frederick 1998, in Wolf and Conover 2003). In Texas (between 1989 and 1994) crop damage due to feral hogs was reported to be between $10 000 and $300 000 (Tolleson *et al* 1995, in Wolf and Conover 2003). Rooting damages irrigation systems and ponds (Frederick 1998, in Wolf and Conover 2003). Pigs significantly reduce seedling recruitment in longleaf pine plantations (Lipscomb 1989, in Wolf and Conover 2003). Pigs are reputed to increase rates of

dieback disease caused by the fungus *Phytophthora cinnamomi* (Auld and Tisdell 1986).

Feral pigs are capable of transmitting brucellosis, psuedorabies, leptospirosis, foot-and-mouth disease and Japanese encephalitis (Tolleson *et al* 1995, in Wolf and Conover 2003; Hampton *et al*. 2004). Feral hogs may threaten human health by carrying helminth parasites that are passed to humans through the consumption of improperly cooked meat (Tolleson *et al* 1995, Pavlov 1988, in Wolf and Conover 2003). In Spain wild pigs hunted for food carry *Toxoplasma gondii* (Gauss *et al*. 2005).

Uses
Captain Cook used the pig in trading with the natives as early as 1777. "A small pig of 10 or 12 pounds" was traded for a spike but a "hog" was exchanged for a hatchet (Cook 1784, in Diong 1982).
In central Europe the false spruce webworm (*Cephalcia abietis*) causes defoliation of Norway spruce trees; high densities of boars are able to cause high mortality to insect larvae by up to 70%, however they also cause damage to tree roots making the perceived benefit negligible (Fuhrer and Fischer 1991, in Wolf and Conover 2003).

In many highland areas of New Guinea pigs are deliberately placed into gardens at the end of a harvest sequence and prior to gardening to remove remaining sweet potato tubers and to assist in turning and aerating the soil before replanting (Westermann 1968, Paglau 1982, Wood and Humphreys 1982, Tucker 1986, Kohun in hide 2003).

Geographical range
Native range: The native range of *S. scrofa* extends throughout Europe and continental Asia as far south and east as Peninsular Malaysia, as well as to the islands of Sumatra and Java (Oliver 1993, in Ickes Paciorek and Thomas 2005). They are now extinct over much of their former range, including Southern Scandinavia, the Nile valley and Britain (Tisdell 1982).
Known introduced range: Pigs introduced by early seafarers have often been displaced by domestic pigs that have gone wild. Absence of records of pigs in a particular place should not be taken to mean they are not present; pigs are sometimes considered too commonplace to be remarked upon.

Invasion pathways to new locations
Other: Released as food.
Other: Expansion into new areas can result from transport for hunting, escape from confined facilities, dispersal of wild populations and escape of domestic swine from free ranging commercial ranches (Gipson Hlavachick And Berger 1998, in Wolf and Conover 2003).
Transportation of domesticated animals:

Local dispersal methods
Escape from confinement: Pigs introduced by early seafarers have often been displaced by domestic pigs that have gone wild.
Self-propelled (local): Pigs are very mobile animals and when under some form of stress may disperse considerable distances. In Australia, feral pigs have been recorded moving 20 km in 48 hours when suffering from food shortage (Auld and Tisdell 1986).

Management information
Poisoning with sodium monofluoracetate (1080) is the most popular method used to control feral pigs. Most pigs vomit within four hours of ingestion. This may be potentially hazardous to nontarget organisms and may result in the survival of the pig. The use of anti-emetics such as metoclopramide, thiethylperazine and prochlorperazine may prevent vomiting at high doses (O'Brien *et al*. 1986, in Wolf and Conover 2003).
A vaccine for pseudorabies and swine brucellosis in fish meal bait may be used in late summer (when natural food supplies are low) to control these diseases (Fletcher *et al*. 1990, in Wolf and Conover 2003).
In the mid 1900s New Zealand conservation practitioners applied mainland hunting techniques to eradicate feral pig populations from small islands (<200 ha, Veitch and Bell, 1990, in Cruz *et al*. 2005). More recently poisoning techniques have been developed to control or eradicate feral pig populations (Choquenot et al., 1990; O'Brien and Lukins, 1990, in Cruz *et al*. 2005). Hunting and poisoning techniques used in combination, now facilitate pig eradication efforts on larger islands (Lombardo and Faulkner, 2000, Schuyler et al., 2002, Veitch and Bell, 1990, in Cruz *et*

al. 2005).
In Hawaii, snaring has been used to control pigs within 600–800 km2 fenced enclosures located in remote areas of rain forest in the Haleakala National Park (Maui) (Anderson and Stone 1993). Many people place a high cultural value on pigs (ie: using them as a food convenient food source) so that removing them from designated areas may not be acceptable without a clear idea of the benefits. Snaring would is not always be an acceptable method of control. In addition, the fact that pigs are highly mobile means it is uneconomic for an individual landowners or controlling agency to control them (as pigs as they quickly move in from adjacent properties to replace the removed ones).
Much wisdom and insight can be gained from the case study of pig removal from Santiago Island in the Galapagos Archipelago (off the coast of Ecuador). Factors that proved critical to the successful eradication of the feral pig on the island were: (1) a sustained effort, (2) an effective poisoning campaign, (3) a hunting program, (4) access to animals by cutting more trails and, (5) an intensive monitoring program. Throughout the 1970s and 1980s, hunting effort was low (<500 hunter-days/year), while in the early 1990s effort increased but fluctuated. In contrast, the revised campaign in the mid-1990s resulted in a continuous, minimum annual effort of 1500 hunter-days/year. Hunter access to pigs was critical. Extra trails were cut and goats were not hunted in order to keep vegetation suppressed (allowing hunters and dogs access to all areas of the island). Motivating hunters was a continual challenge, especially when pigs were at low densities. However, social, moral boosting events and financial incentives maintained hunter motivation. While the poisoning campaign killed relatively few pigs compared to hunting, the low cost of the poisoning made such efforts especially cost-effective. The compounds used were toxic to most species, and thus the pros of using them for eradication had to be balanced with the potential impact on non-target species (Donlan *et al*., 2003a, in Cruz *et al*. 2005). In 2000, six months after the last pig was shot, the last pig was poisoned following an intensive monitoring effort. A sustained monitoring effort was critical to successful eradication. The lack of such an effort is responsible for many eradication failures (Campbell *et al*., 2004, in Cruz *et al*. 2005).

Nutrition
Pigs lack the multiple stomachs found in ruminants such as cattle and goats. Feral pigs are omnivores with an opportunistic diet, including high-fibre (> 25%) low-protein grasses, legumes, herbs and roots. They readily feed on crops, fallen fruits, seeds and small animals (McIlroy 1990). Pigs regularly root the ground in search of roots, fungus, nuts, seeds and grubs (Frederick 1998, Sicuro 2002, in Wolf and Conover 2003). In their native Mediterranean woodland the wild boar compensates for the reduced supply of acorns in the spring by raiding underground hoards of acorns collected and buried by small mammals (the availability of acorns is critical to female boars as they need the extra nutrition for lactation) (Focardi Capizzi and Monetti 2000, in Wolf and Conover 2003).
Pigs adapt their diet to best utilise local resources. In the semi-arid rangelands of eastern Australia and in New Guinea feral pigs will regularly hunt and devour lambs (particularly twin lambs (which are weaker) (Choquenot, Lukins and Curran 1997, in Wolf and Conover 2003; Hide 2003). On Horn Island, Mississippi, hogs take advantage of high seasonal abundances of insects, crabs and dead fish (Baron 1982, in Wolf and Conover 2003). On Santa Cruz Island, California, acorns and new growth of grasses and forbs are major components of the feral pig's diet (Van Vuren 1984, in Wolf and Conover 2003).
In South Carolina fruits, especially acorns, are the most common food type consumed in fall and winter; herbage and foliage are most common in the spring; roots are most common in the summer. Invertebrates and vertebrates are also consumed, though they were not as important. The consumption of woody plants may be underestimated in stomach contents surveys as the starches and sap obtained from the roots of such plants go undetected (Wood and Roark 1980, in Wolf and Conover 2003).
In the western South Texas Plains (introduced range) feral pigs have a spring-summer diet that consists mainly of vegetation, while acorns are their winter food source. Their autumn diet consists of roots and corn. Animal matter consisting of deer, morning doves, reptiles and other birds represents a small portion of the hog's diet. Of these, reptiles were the most susceptible to predation (Taylor and Hellgren 1997, in Wolf and Conover 2003).
In one study conducted in Hawaii by Diong 1982, food habits were characterised by (1) an omnivorous diet consisting mainly of plant matter, (2) a staple of tree ferns, (3) a seasonal switch from tree ferns to strawberry guava, and (4) a strong reliance of earthworms as a source of animal protein. The dietary range covered 40 plant species (63% herbaceous species, 33% trees and woody vine). Tree ferns were the most concentrated source of sugar and starch.

Reproduction
Feral pigs are polyoestrus: adult females have a 21-day oestrus cycle and a gestation period of about 112-114 days. In New Zealand they probably breed throughout the year, though mainly in spring and summer (Wodzicki 1950; J. McIlroy unpublished). Their litter size is usually between 6 and 10 piglets, but usually only half this number survive. They reach breeding age at between 10 and 12 months (Wodzicki 1950).
In one study females were found to have about 5 young every 0.86 years with some females having two litters per year. In this study fertility continued to increase with age until it peaked at two to three years of age. 58% of piglets died before weaning (Baber and Coblentz 1986, in Wolf and Conover 2003).

Lifecycle stages
Pigs are normally social animals but adult boars over 18 months old are invariably solitary (McIlroy 1990).

This species has been nominated as among 100 of the "World's Worst" invaders

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