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THE ENVIRONMENTAL IMPACT OF WILD BOAR

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ABSTRACT

In recent decades, wild boar numbers have increased worldwide. Wild boar can adapt to a wide range of habitats and foods and have the highest reproductive rate among ungulates. Therefore, wild boar can have a very substantial environmental impact and affect many ecosystem components. This paper summarises studies of the environmental impact of wild boar. Very few studies have quantified the impact of wild boar on plant and animal communities. Most of those studies indicate that wild boar can greatly affect species abundance, species richness. soil chemestry and food webs.

Key words: animal communities, environmental impact, plant communities, *Sus scrofa*, wild boar.

INTRODUCTION

The wild boar (*Sus scrofa*) is one of the most widely distributed mammals in the world. Its range extends from Western Europe and the Mediterranean Basin to Eastern Russia and Japan, throughout Southeast Asia (Sjarmidi and Gerard 1988). In the Northern Hemisphere, this species has recently re-colonized Sweden, Finland, Estonia, and Soviet Karelia (Erkinaro et al. 1982). Wild boar that have escaped from farms have established wild populations in England (Goulding 2001). European wild boar have been introduced to North America (Barrett 1978) and feral pigs belonging to the same species, occur in Australia and New Zealand (Choquenot et al. 1996).

In Europe, wild boar numbers have increased in recent decades, possibly due to a combination of factors, such as the depopulation of rural areas, changes in agricultural practices, reintroduction, lack of predators, reduced hunting pressure, and climatic changes (Genov 1981a, Erkinaro et al. 1982, Sáez-Royuela and Tellería 1986).

Wild boar occupy an extremely wide range of habitat types, where they feed opportunistically on plant and animal species (including crops and livestock). In addition, wild boar have the highest reproductive rates among ungulates, and their local density can double in one year. Consequently, the widespread increase in numbers and geographical range of this species might have a remarkable impact on many

plant and animal species, habitat structure, and crop and livestock production. The aim of this review is to summarise the studies of the environmental impact of wild boar, and to highlight the major gaps in this field of research.

METHODS

Very few studies explicitly focused on the impact and role of wild boar on the ecosystem; however, many studies indicate that wild boar can have a considerable impact on plant and animal species. In the present paper, we present a brief synopsis of the ecology and behaviour of the wild boar and a review of the environmental impact of this species. For ease of presentation, the impact of wild boar on plant communities and animal communities is described in separate sections.

The biology of wild boar

Wild boar are ungulates in the *Suidae* family. Adult wild boars weigh between 35 and 230 kg, the smallest individuals occuring in Mediterranean countries and the largest found in the Northeastern part of the species' range (Sjarmidi and Gerard 1988). Wild boar can reach a maximum age of 12 years (Massei 1995) but, where hunting occurs, mean life expectancy is 23 months (Jezierski 1977).

Wild boar occupy a wide variety of habitats, but prefer those that offer high-energy food, such as acorns, and cover from predators (including hunters) (e.g. Kurz and Marchinton 1972, Massei and Genov 1995a).

Plants represent between 80 and 90% of the diet of wild boar, which also feeds opportunistically on a large number of animal species. (e.g., Genov 1981a, Dardaillon 1987, Gerard and Campan 1988, Massei et al. 1996, Schley and Roper 2003). Wild boars spend a large amount of time rooting for tubers, roots, bulbs, and invertebrates. They also commonly exploit fruit, fungi, carrion, many vertebrate and invertebrate species, crops, and occasionally, eggs and livestock (Gerard and Campan 1988, Genov 1981a and 1981b, Choquenot et al. 1996). Wild boar are mono-gastric; consequently, they are less capable than are ruminant ungulates to extract carbohydrates from cellulose. Energy-rich foods, such as acorns and beech mast, represent the preferred natural diet of this species (Barrett 1978, Jedrzejewska et al. 1994, Massei et al. 1996). If crops or high-energy food become temporarily unavailable, wild boar can migrate over distances of up to 100-150 km (Andrezjewski and Jezierski 1978, Singer et al. 1981). Annual home range sizes in wild boar vary between 3-400 ha and 15000 ha (Janeau and Spitz 1984, Massei et al. 1997, Jullien et al. 1990).

The abundance of energy-rich foods influences the proportion of breeding sows and their litter size (e.g., Aumaitre at al. 1984, Massei et al. 1996). With the highest reproductive rates among ungulates, wild boars are capable of annual increases in population size of up to 150% (Briedermann 1986, Kozlo 1975, Massei and Tonini 1992).

Population density can vary from 0.2 to 43 animals / km^2, and exhibit high inter-annual variation (Kozlo 1975, Jedrzejewska et al. 1994, Hone 2002). As the density of wild boar and the extent of rooting are directly correlated at high densities wild boar can have a strong impact on animal and plant communities (Hone 1995, Hone 2002).

Impact on plant communities

By feeding directly on whole plants or on vegetative parts, such as fruits, bulbs, and tubers, wild boars can affect the abundance and richness of plant species (Genov 1981a and b, Howe et al 1981, Singer et al. 1984) (Figure 1). Most studies report rooting as a major cause of disturbance to plant communities (e.g., Howe and Bratton 1976, Singer et al. 1984, Piroznikow 1998, Hone 2002). Rooting at an average depth of 5-15 cm affects the species that are directly consumed by wild boar, as well as those that are not eaten, but whose roots are left exposed (Bratton 1975). Where the density of wild boar is high, rooting can lead to a reduction of up to 80-95% of the herbaceous cover and to the local extinction of individual plant species (Bratton 1974, Howe et al. 1981). In Poland, rooting by wild boar in Oak-Linden-Hornbeam (*Tilio-Carpinetum*) forest reduced the density of seedlings by 1.5 to 6 times (Piroznikow 1998). Furthermore, the loosening of the soil surface caused by rooting may lead to erosion on steep slopes (Bratton 1974).

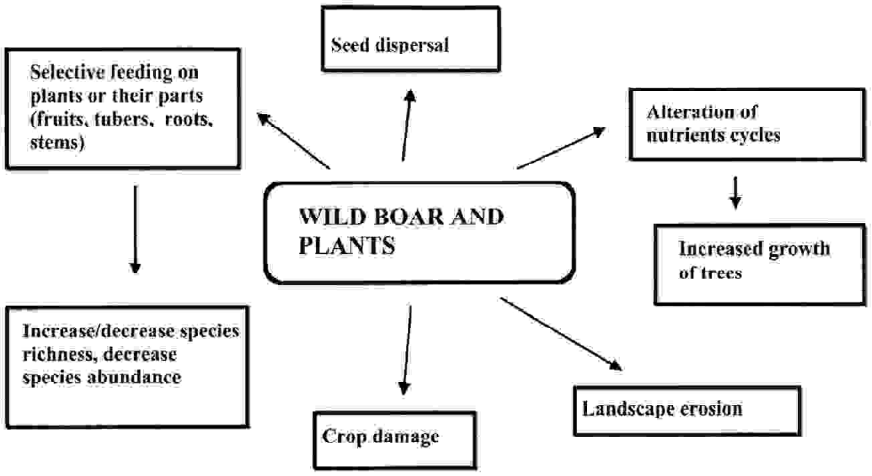

Figure 1. Impact of wild boar on plant communities.

The spatial and temporal dynamics of rooting can vary in relation to habitat type, soil, and year, with more rooting occurring in deciduous than in coniferous forests, and in damp, rather than dry soil (Welander 2000).

Although most studies agree on the negative impact of wild boar on the relative abundance of plant species, there is conflicting evidence regarding its impact on species richness. For instance, in Sweden, the number of plant species increased in a wide range of habitats where wild boar rooting activity was recorded (Welander 1995). In California, Kotanen (1995) showed that species richness was reduced in rooted areas in the first year following disturbance, but increased thereafter, often exceeding the richness of undisturbed control areas.

One of the few comprehensive studies of the environmental impact of wild boar was conducted in the Great Smoky Mountains National Park, USA (Howe et al. 1981). The study showed that rooting at a specific site can occur as many as 3 to 7 times per growing season, and 80% of the surface area of mesic hardwoods can be rooted every year. In tha study area, the five forbs species preferred by wild boar decreased in abundance from 30% in areas unoccupied by wild boar to 1% in areas where wild boar had been present for over 20 years. Similarly, the corms of spring beauty (*Claytonia virginica*), which appeared in 98% of the wild boar stomachs analysed, were reduced from a mean of 607 kg/ha in areas unoccupied by wild boar to 138 kg/ha in occupied areas. Another study at the same site showed that the depth of forest litter and weight of leafy material were about 60% lower in intensively rooted stands (Singer et al. 1984). The significant differences in Ca, P, Mg, Mn, Zn, Cu, H and cation exchange capacity found between rooted and non-rooted areas indicated that rooting accelerated nutrients cycling in the upper soil horizons. As a consequence, beech trees (*Fagus grandifolia*) exhibited significantly greater shoot growth in rooted sites than in areas unoccupied by wild boar (Lacki and Lancia 1986). Rooting by wild boar also accelerates decomposition of organic matter by incorporating forest litter into the soil (Jezierski and Myrcha 1975). In Germany, the introduction of wild boar to young conifer plantations resulted in the removal of competitive vegetation, which enhanced the regeneration and growth of Norway spruce (*Picea abies*) (Kepka 1989 in Brownlow 1994).

Many wild boar populations cause substantial damage to agricultural crops, particularly when energy-rich food is scarce (Mackin 1970, Andrzejewski and Jezierski 1978). Virtually every type of cultivated plant appears in the diet of wild boar. In Europe crops damaged by wild boar include wheat, maize, rice, grapes, barley, oats, rye, and potatoes (reviewed by Genov 1981a and Schley and Roper 2003). The factors influencing the amount of crop damage include the local density of wild boar, the availability of wild fruits in woodlands, and the proximity of

cultivated fields to forested areas (Mackin 1970, Meriggi and Sacchi 1992). The amount of damage to cultivated specie results from the combined action of direct feeding and mechanical disturbance to plants that are not consumed.

Wild boars are thought to play a role in seed dispersal because the seeds of fleshy fruits often pass intact through their digestive tract. For instance, Aplet et al. (1991) mentioned the role of feral pigs as seeds dispersers in the Hawaii Volcanoes National Park, and Massei et al. (1996) found many intact seeds of Mediterranean species in the faeces of wild boar and suggested that wild boar could facilitate the dispersal of these plants. Similarly, a study in Northern Queensland, Australia, established that feral pigs disperse viable seeds of the invasive woody weed *Prosopis pallida* (Lynes and Campbell 2000).

Impact on animal communities

Numerous studies indicated that wild boar feed on a very wide range of vertebrate and invertebrate species (Figure 2). Animal food, expressed as percentage volume, comprises a relative small proportion of the diet of wild boar and ranges between 2 and 11%. When expressed as frequency of occurrence, however, animal matter is found in up to 94% of the stomachs analysed, (Genov 1981b, Howe et al. 1981, Fournier-Chambrillon et al. 1995, Baubet et al. 1997). Invertebrates, such as insect larvae, earthworms, and snails are often reported as staple food in the diet of wild boar, although the availability of all of these species varies greatly throughout the year. For instance, Pavlov and Edwards (1995) estimated that the reduction of earthworms caused by feral pig predation in Queensland varied from 62% to 93%. A study in the French Alps demonstrated that earthworms occurred in 92% of the wild boar faecal and stomach samples examined and that these invertebrates were consumed by wild boar in all seasons (Baubet et al. 2003). Several studies (reviewed by Genov 1981a) mentioned that predation by wild boar on the larvae of insect pests such as sawflies and moths can significantly decrease the damage caused by these invertebrates to commercial tree plantations.

Vertebrates do not appear to be a staple item and wild boar are reported to feed occasionally on carcasses, small rodents, reptiles, amphibians, and fish. In Australia, feral pigs can have a strong impact on lambs, and predation was reported to affect up to 32% of all newborn lambs in a year (Choquenot et al. 1996). In continental Europe, wild boar is thought to have a negative impact on ground-nesting birds by feeding on their eggs. Predation by wild boar on ground-nesting birds, such as red-legged partridge (*Alectoris rufa*), has occurred in Spain (Calderón 1977) and suggested for pheasants (*Phasianus colchicus*) in northern Italy (Marsan et al. 1990).

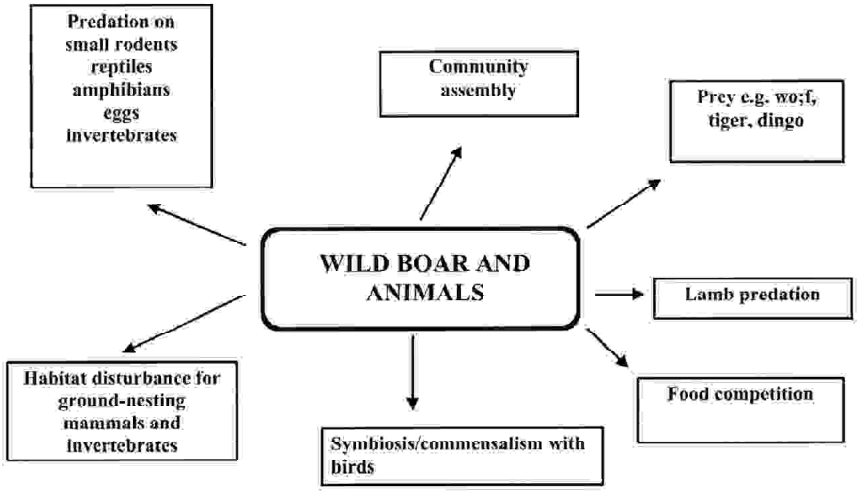

Figure 2. Impact of wild boar on animal communities.

Few authors have quantified the impact of wild boar on animal populations. In Austria, wild boar feeding in Norway spruce stands caused 35.2% mortality in a population of sawfly *Cephaleia abietis* (Führer and Fischer 1991 in Brownlow 1994). In the Hawaiian rain forest, the removal of feral pigs led to the abundance of springtails (*Collembola* spp.) increasing by 3.5 times (Vtorov 1993). In the same study area, seven years after removal of feral pigs, the total density of microarthropods in the forest nearly doubled and their biomass increased by 2.5 times. Similarly, in The Great Smoky Mountains National Park, the species richness of soil macroinvertebrates did not change, but their abundance declined from 2.2 x 10^6/ha to 0.5 x 10^6/ha after introduced wild boar had occupied the area for more than 20 years (Howe et al. 1981).

Singer et al. (1984) showed that, together with direct predation, wild boar can also have an indirect, negative impact on the density of ground-dwelling small mammals. Repeated rooting destroys the habitat of surface-tunnelling rodents and decreases the food available to small insectivores. The study by Singer et al (1984) indicated that two vertebrates that depended largely on habitat such as the leaf litter, red-backed vole (*Clethrionomys gapperi*) and short-tailed shrew (*Blarina brevicauda*) were nearly eliminated from intensively rooted areas. Conversely, in the same area, the density of semiarboreal small rodents (whose habitat was not affected by rooting) remained unchanged.

No study has specifically quantified the diet overlap and possible competition between wild boar and other vertebrates, although Massei et al. (1996) and Singer et al. (1981) mentioned that competition between wild boar and various mammals is likely.

Where large carnivores are present, wild boar invariably appear in their diet and sometimes are one of the most important prey. For instance, wild boar are a substantial part of the diet of wolves (*Canis lupus*) in northern Italy (Meriggi et al. 1996) and Poland (Okarma et al. 1995). In Nepal, wild boar is the second most important prey of the tiger (*Panthera tigris*) (Stoen and Wegge 1996) and, in Australia, the mortality of feral pigs is significantly correlated with the numbers of dingoes (*Canis familiaris*) (Woodall 1983).

Wild boar can establish cleaning/feeding symbioses with corvids. For instance, Massei and Genov (1995b) repeatedly observed black-billed magpies (*Pica pica*) grooming wild boar, and Kilham (1982) reported a similar relationship between common crows (*Corvus brachyrhynchos*) and feral pigs.

A recent study illustrates the role of introduced feral pigs in the restructuring of an entire island food web. Roemer et al. (2002) showed how introduced pigs provided a new source of abundant food and enabled golden eagles (*Aquila chrysaetos*) to recolonise the California Channel Islands. Eagles started to prey heavily also on the native island fox (*Urocyon littoralis*), whose resulting drastic decline caused an increase in the competitively inferior island skunk (*Spilogale gracilis*).

Discussion

The vast majority of studies of the ecology of wild boar are in agreement abut the significant impact of wild boar on plant and animal communities. However, with a few notable exceptions, however, there is a surprising lack of quantitative data on the environmental impact of wild boar and feral pigs. Studies that have specifically analysed the impact of this species focussed on one or very few components of the plant or animal communities, and often collected data over only one or two years. Comprehensive studies aimed at examining the environmental impact of wild boar on many plant and animal species, as well as on factors, such as soil chemistry, are urgently required. Ideally, such studies should extend over a few years because wild boar density and, presumably, the relative environmental impact, can change dramatically between years.

Given the complexity of the interactions between wild boar and other components of the ecosystems, a multidisciplinary approach, in which experts collaborate, is highly desirable. Such an approach would require experts in feeding ecology, chemistry, physiology, and behaviour to collaborate with researchers working on population dynamics, predator-prey interactions, and plant-animal interactions.

Questions, such as ˝Can wild boar regulate the dynamics of particular plant or animal species?”, ˝How does the environmental impact of wild boar change when

preferred foods are not available?', ˝Are there "threshold" boar densities (or/and intensity of rooting episodes) above which species richness is significantly decreased?', and ˝What is the diet overlap and possible competition between wild boar and other vertebrates?˝, still need to be answered.

As wild boar and feral pigs numbers and geographical range continue to expand worldwide, the threats they might pose to native flora and fauna is increasing. Research on the implications for biodiversity in woodland, grassland, and agricultural habitats is central to any management plan aimed at controlling or eradicating wild boar populations. Where eradication is carried out, it would be important to study how plant and animal communities respond to the removal of such an important component of the ecosystem.

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