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Wild boar in Norway – is climate a limiting factor?

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- is climate a limiting factor?

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ABSTRACT

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Swedish wild boar have largely increased in numbers and distribution during the recent decades and are now entering south-east Norway. Presently, wild boar are put on the Norwegian black list of unwanted alien species and central to management is to know whether the prevailing climate and future climate change will influence the chance for establishment and growth of populations in Norway. This report is a review of existing literature on factors affecting the distribution and population dynamics of wild boar. The review includes published literature from large parts of Europe but with a focus on the northern part of the animals range. It also includes preliminary results from research on wild boar in Norway in prehistoric times.

Central findings:

- Wild boar have in the past been a part of the Norwegian fauna, but seem to have been limited to the broad leaved deciduous forests along the coast.
- The modern distribution of the species shows that wild boar have settled in areas with harsher climate than is found in most parts of Norway.
- The establishment of wild boar seems mainly to be limited by food availability and not by climate *per se*, thus, climate may be a limiting factor through its effect on food availability.
- Farming and supplementary feeding have allowed the wild boar to persist in areas that may have been inhabitable before.
- The Norwegian landscape with a mosaic of forests and agricultural fields should provide a good habitat for wild boar in large parts of the country.
- Future climatic change will likely increase the potential population densities of the animals in Norway, by reducing energy needs during winter and increasing food availability. The wild boar will eventually settle and suitable areas should be assessed.

Key words: wild boar, climate, distribution, population dynamics, habitat requirement

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SAMMENDRAG

Rosvold, J. & Andersen, R. 2008. Villsvin i Norge – er klima en begrensende faktor? – NTNU Vitenskapsmuseet Rapp. Zool. Ser. 2008, 1: 1-23.

Den svenske villsvinstammen har økt kraftig i antall og utbredelse de siste tiår og er nå på vei inn i Sørøst-Norge. For tiden er villsvin satt på Norsk svarteliste over uønskede fremmede arter og forvaltningen ønsker å vite hvorvidt dagens klima og fremtidige klimaendringer vil påvirke sjansen for etablering og vekst av populasjoner i Norge. Denne rapporten er en sammenfatning av eksisterende litteratur om faktorer som påvirker utbredelse og populasjonsdynamikk hos villsvin. Sammenfatningen inkluderer publisert litteratur fra store deler av Europa, men med et fokus på den nordlige delen av artens utbredelsesområde. Den innholder også foreløpige resultater fra undersøkelser gjort på villsvin i Norge i forhistorisk tid.

Sentrale funn:

- Villsvin har tidligere vært en del av den norske faunaen, men virker å ha vært begrenset til edelløvskogene langs kysten.
- Den moderne utbredelsen til arten viser at villsvin har slått seg ned i områder med hardere klima enn det som finnes i det meste av Norge.
- Etableringen av villsvin virker å være mer begrenset av mattilgang enn av klima direkte, klima vil derfor kunne være en begrensende faktor på villsvinbestander gjennom sin påvirkning av mattilgang.
- Jordbruk og tilleggsforing har tillat villsvinet å overleve i områder som kan ha vært ubeboelige før.
- Det norske landskapet med en mosaikk av skoger og åkre vil trolig være et godt villsvinhabitat i store deler av landet.
- Framtidige klimaendringer vil trolig redusere villsvinets energibehov vinterstid og øke mattilgangen, og dermed øke den potensielle populasjonstettheten av dyrene i Norge. Villsvin vil sannsynligvis til slutt etablere seg i Norge, og egnede områder bør derfor kartlegges.

Emneord: villsvin, klima, utbredelse, populasjonsdynamikk, habitatkrav

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CONTENT

FOREWORD

Dispersal of alien species is currently considered as one of the major threats to biodiversity. In addition to introductions caused by humans climatic change is one of the main reasons of foreign species dispersing into new territories. Wild boar are one of these species and are currently regarded as unwanted. As a consequence of population developments in Sweden and observations of the species in Østfold there is reason to believe that wild boar will be a part of the Norwegian fauna within a few years. Because of this it will be important to obtain an overview of the species climatic and habitat demands and how this affects it at the borders of its natural distribution range. This might help us to predict the future of wild boar in Norway and how it may respond to future climate change.

This report is a review of the relevant existing literature of factors affecting wild boar distribution and population dynamics, with special reference to northern Europe. Predictions are made regarding Norwegian conditions.

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1 INTRODUCTION

According to Ronald Reagan (1972) "*pig stands for pride, integrity and guts*". The last statement is certainly true. Pigs (Suidae) are among the most adaptable and widespread animals in the world. With or without human aid they have achieved a global distribution where they occupy a wide range of habitats and climates (Powel 2004). The wild boar (*Sus scrofa*), found on every continent except Antarctica (Spitz 1999, Powel 2004), is the most widespread of the wild pigs. It is primarily an inhabitant of temperate and tropical forests, but seems to thrive in a range of habitats from semi-arid to taiga and mountain areas, and from oceanic to continental climates (Spitz 1999, Powel 2004). It is a medium sized ungulate with body weights ranging from 35-350 kg and 55-110 cm in height (Powel 2004), with a short stocky body constructed for rooting in the ground. Sporting a coarse fur witch develops a dense underlay during the winter they are resistant to fluctuations in temperature (Jakt- og viltvårdsberedningen 1980). Wild boar are mainly active after sunset (Lemel *et al*. 2003) but change their behaviour according to its environment (Powel 2004). They are highly omnivorous and a typically r-selected species with a high reproductive potential (Geisser & Reyer 2005). Sows are protective of their young and may defend them forcefully using their sharp canines (Jakt- og viltvårds-beredningen 1980, Powel 2004). The wild boar has long been a symbol of strength and ferocity, and is a respected animal in many cultures (Werness 2004).

Sharing many ecological characteristics with humans, e.g. high adaptability and an omnivorous diet (Powel 2004), the wild boar has been an important species economically. Boars are attracted to human waste and seem to have adapted well to human development (Sáez-Royuela & Tellería 1986, Jedrzejewska *et al*. 1997). This has made them an easy species to domesticate and exploit (Griffin 1998, Haber & Dayan 2004). During the last century the populations of wild boar have increased dramatically all over Europe (Sáez-Royuela & Tellería 1986) and they have become one of the most important game species (Jakt- og viltvårdsberedningen 1980). Swedish populations are also increasing and at present there are about 60.000 wild boar in Sweden (Naturvårdsverket 2007). Some of these are reported crossing the Norwegian border into eastern Norway, in particular Østfold County (Hardeng 2004, Bevanger 2007). Their close associations with humans have however also made them a competitor. Fear of damages to croplands or spread of diseases to domestic animlas has led to them being viewed as a pest in many areas (Andrzejewski & Jezierski 1978, Jakt- og viltvårdsberedningen 1980, Goulding *et al*. 2003, Wildrisk Group 2005). In Norway, boars are on the "Norwegian Blacklist" (Gederaas *et al*. 2007), and hunting of them may be done on a year round basis. Nevertheless, there is an increasing interest in the reintroduction of wild boar based on conservational grounds (Leaper *et al*. 1999, Wildrisk Group 2005, Bjartnes 2006), and local people in Østfold are starting to view the immigration of wild boar as a positive event (Eriksen 2007). According to the recommendations of the World Conservation Union there should be made a number of studies on the ecology of the species before possible reintroductions (IUCN 1995). This report aims to review the natural constraints upon wild boar for their spread into Norway in order to see what role climate might play to limit their distribution.

2 THE PREHISTORIC WILD BOAR IN NORWAY

Not long after the end of the last ice age sharp tusks and long snouts were ploughing through Norwegian soil in search of food. Early human inhabitants quickly saw the potential of wild boar as a source of nourishment and have left evidence of the presence of these animals in their garbage. Such garbage heaps, or middens, are the only evidence of the existence of wild boar in Norway. It is apparent that boars were a valuable prey to early hunters, as their bones are found on most archaeological sites from the Old Stone Age (Mesolithic) in southern Scandinavia (Magnell 2005). The earliest trace of wild boar in Norway stems from Tørkop (Lie 1990), a human settlement in Østfold dated to about 7500 BC (Mikkelsen *et al*. 1999). Not long after, bones of wild boar are found in western Norway in Vistehulen near Stavanger (Degerbøl 1951). The animals seems to have spread fairly quickly along the Norwegian coast from southern Sweden were they were present about 8600 BC (Liljegren & Ekström 1996). During the period of the wild boar spread into Norway (the Boreal) forests of pine (*Pinus sylvestris*), birch (*Betula* spp.) and hazel (*Coryllus avellana*) were already established and broad leaved forests were starting to increase (Moe *et al.* 1996). Prehistoric wild boar in Norway seems to have been of a relatively small stature (Degerbøl 1951, Hufthammer 1992).

The distribution of prehistoric wild boar in Norway and the time of its extinction is the subject of ongoing research (Rosvold *et al*. in prep.). Many of the archaeological sites containing bones of wild boar have not been adequately dated and much of its prehistory in Norway is not well understood, especially the reasons and timing of its decline and eventual disappearance. The biggest obstacle, in this regard, lies in differentiating bones of wild from domestic pigs, which may have coexisted for some time and were similar in shape and size. By dating the supposedly oldest bones of pigs in different parts of Norway and comparing the results with an analysis of ancient DNA and isotopic values it is aimed to unravel more its story. Preliminary results from this study show that wild boar in Norway is a typical coastal species (figure 1). Its geographic limit during the Holocene warm period (about 8000-4000 BC), which most bones of wild boar stems from, seems to have been limited to the boreonemoral vegetation zone. This is a transition zone between the typical boreal forests to the north and the more southerly deciduous forests (Moen 1998). The boreonemoral zone is a mixture of broad-leaf and conifer forest and is the main limit of many mast producing species, like beech (*Fagus sylvatica*) and oak (*Quercus* spp.). Much of this area is characterized by a relatively mild and wet climate, with little snow during the winter (Moen 1998). During the Holocene warm period the climate was even wetter and warmer than today and the vegetation zones were shifted a bit more northwards and upwards compared to today (Moen 1998). Isotopic values of teeth collagen collected from 19 prehistoric wild boar from Hordaland (figure 2) shows a classic C^3-profile (Rosvold *et al*. in prep.) indicating a typical herbivore diet of C^3-plants, comparable with other herbivores like red deer (*Cervus elaphus*). There are no indications of any animal matter in their diet, as their $\delta^{15}N$ level is the same as that of the prehistoric red deer.

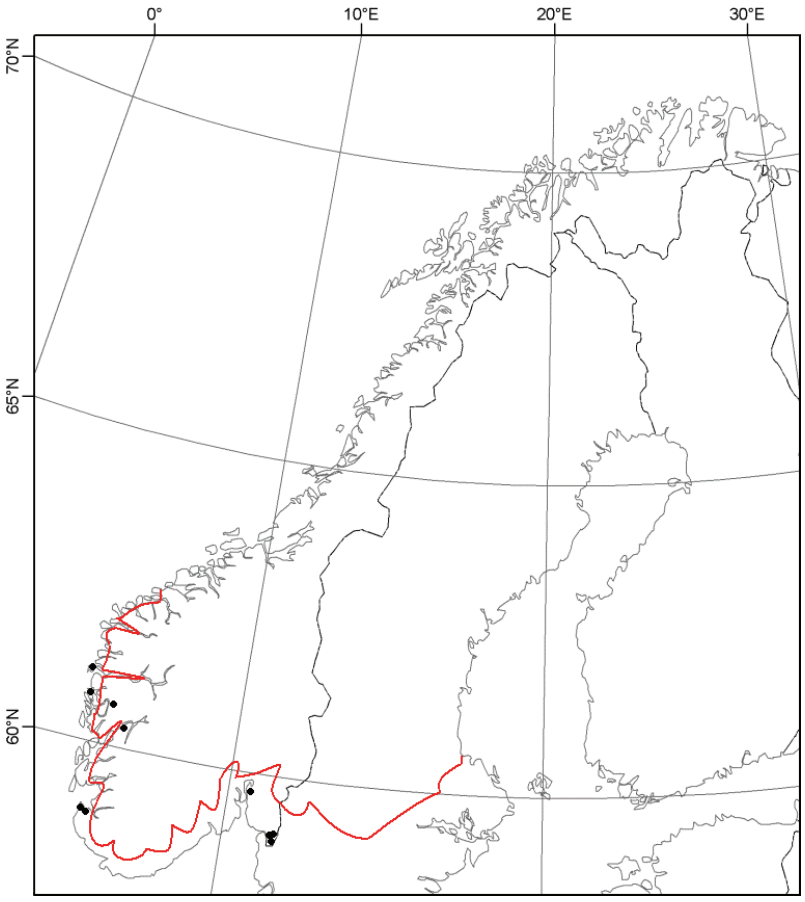

Figure 1. Sites with finds of wild boar bones in Norway in the Holocene warm period, 8000-4000 BC (modified from Rosvold *et al*. in prep.). Red line shows the present border between boreonemoral and the southern boreal vegetation zones (after Moen 1998).

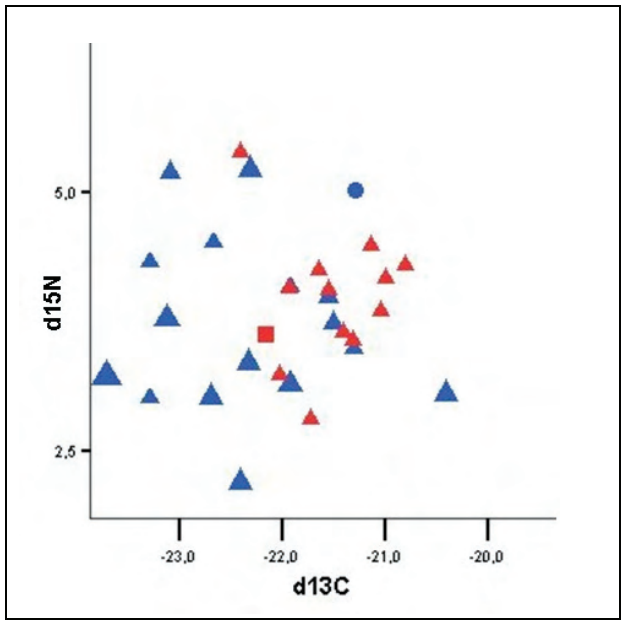

Figure 2. Isotopic values from teeth collagen of prehistoric wild boar (blue) and red deer (red) in western Norway (modified from Rosvold *et al*. in prep.).

3 NORTHERN DISTRIBUTION

As noted, the wild boar is an adaptable species with a wide climatic tolerance. Wild boar are now found in most parts of Europe and Asia, and their distribution is increasing northwards (Spitz 1999, Powel 2003). Swedish wild boars, originally escaped farm animals, have established themselves up to about Gävle on the east coast (Lemel 1999). As with the prehistoric Norwegian boar, its distribution pattern fits very well with the boreonemoral vegetation zone. Wild boar are however found north of this line. In the European part of Russia it is recorded as far north as about 66° 5´ in Karelia (Danilov *et al*. 2003) but not regularly and not breeding further north than about 62-63° (Danilov *et al*. 2003, Markov *et al*. 2005). Breeding wild boar are recorded also in Finland, and males are spotted as far north as the Gulf of Botnia (Erkinaro *et al*. 1982), but the population size is only a few hundred animals (Ermala 1996). As one progress northwards across its Eurasian range population densities decrease by three orders of magnitude (Melis *et al*. 2006). Melis *et al*. (2006) found that mean January temperature were the primary factor influencing this change in population density. Formozov (1946) noted early that the historical northern distribution of wild boar across Eurasia coincides with 30-40 cm snow depth isolines. It is easy to imagine that a short and stocky animal like the wild boar, which also is dependent on rooting the top soil, could be hampered by deep snow and frozen ground. Several examples of mass deaths of wild boar are known after very cold and snowy winters (Formozov 1946) and its northward expansion has partly been explained by a series of warm winters with little snow (Erkinaro *et al*. 1982, Danilov et al. 2003). A disruptive mutation in a gene expressed in brown adipose tissue in newborn mammals has caused the piglets of many pig species, including wild boar, to have poor thermoregulation and be sensitive to cold exposure (Berg et al. 2006). The wild boar has however evolved mechanisms to compensate for this, including dense winter fur (Foley et al. 1971) and the construction of farrowing nests (Algers & Jensen 1990). Temperatures in these nests have been measured to about 20°C and are unaffected by outer climatic conditions despite temperatures as low as -20°C (Algers & Jensen 1990). Food availability and human development might be more important factors as there are examples of wild boar settling very cold and snowy areas (e.g. table 1) (Erkinaro *et al*. 1982, Danilov *et al*. 2003, Markov *et al*. 2005), and such a gradient could just be a reflection of the species current expansion (Markov *et al*. 2005). Snow depth and mean temperature of the autumn and winter are shown to be an important factor during the northward dispersal over new territories (Markov 1997). However afterwards, climatic factors seem to have lesser importance on population dynamics, with the number of snow covered days being the most important.

Table 1. Climate data from Troitsko-Pechorskii administrative district were wild boar occur (after Markov *et al*. 2005)

Average snow depth at the end of the winter	Ca. 80 cm
Average January temperature	- 18-20 °C
Lowest temperatures	- 50-53 °C
Average July temperature	14,5-20 °C

4 FACTORS AFFECTING POPULATION PARAMETERS

4.1 Reproduction

The wild boar should be considered a typically r-selected species with high ecological plasticity, opportunistic feeding and a very high reproductive potential relative to its body size (Geisser & Reyer 2005). These traits allow the population a certain degree of buffer effect against bad years (Choquenot 1998, Bieber & Ruf 2005, Geisser & Reyer 2005). Wild boar may start to breed during their first year of life (Lemel 1999, Gethöffer *et al*. 2007) and may give birth throughout the whole year (Lemel 1999, Fruzinski & Labudzki 2002, Maillard & Fournier 2004). Most piglets are however born during spring (Powel 2004), and the timing of births and the degree of synchrony seems to depend upon the availability of food resources. In good acorn mast years births are earlier and significantly more synchronized than in poor years (Maillard & Fournier 2004). Also, in areas with a stronger climatic seasonality, with a short period of high food abundance, births are highly synchronous compared to areas with high food diversity all year round (Santos *et al*. 2006). In Swedish populations 85 % of all births happen between February and May (Lemel 1999). Mean litter size is highly variable between areas, and as many as 14 fetuses have been reported in one female (Servanty *et al*. 2007). In Europe, the largest average litters occur in the central part, where they vary between 4,3 and 6,9 (Fruzinski & Labudzki 2002, Náhilik & Sándor 2003, Gethöffer *et al*. 2007, Servanty *et al*. 2007). In southern Europe the average lies between 3,6 and 5 (Boitani *et al*. 1995, Fernández-Llario & Mateos-Quesada 1998, Fonseca *et al*. 2004). Data from Swedish wild boar, although of a small sample size, indicates a litter size comparable to the southern European (Lemel 1999). Fecundity in wild boar increases with age and is strongly correlated with the body size of the female (Fernández-Llario & Mateos-Quesada 1998, Náhlik & Sándor 2003, Gethöffer *et al*. 2007). Litter sizes and the proportion of pregnant females vary from year to year and are higher in good mast years (Groot Bruniderink *et al*. 1994, Gethöffer *et al*. 2007). Good food conditions will result in earlier onset of oestrus (Pépin *et al*. 1986) and more females will breed during their first year of life (Groot Bruniderink *et al*. 1994, Gethöffer *et al*. 2007). In particularly poor mast years, reproduction may fail completely (Groot Bruniderink *et al*. 1994). A study on feral pigs in Australia found that the rate of population increase did not decrease with increasing pig density, indicating that the population is more influenced by extrinsic variation in food availability (Choquenot 1998).

4.2 Growth

Pigs are able to adjust their growth pattern according to temperature, with animals raised in cold environments becoming stockier, reducing their extremities and developing denser fur (Weaver & Ingram 1969). Different ecotypes of wild boar morphology can be differentiated (Genov 1992). Males are larger, but don't increase their weight faster than females before after their first year of life (Pépin *et al*. 1986, Gallo Orsi *et al*. 1995, Moretti 1995, Markina *et al*. 2004). Piglets grow quickly and boars continue to grow throughout their lifetime (Groot Bruinderink *et al*. 1994, Markina *et al*. 2004). Body weight is sensitive to variations in food production (Pépin *et al*. 1986, Groot Bruinderink *et al*. 1994, Pedone *et al*. 1995), especially in areas with no supplementary feeding from agricultural crops (Groot Bruniderink *et al*. 1994). In years of poor mast availability average body weights may drop by as much as a factor of 1,6-2,6, being highest in juveniles, and decrease more in dense populations (Groot Bruniderink *et al*. 1994). Mysterud *et al*. (2007) compared the annual autumn body mass of roe deer and wild boar, up to two years old, in Poland with variation in winter and summer climate and plant phenological development. They found neither an effect of climate nor of vegetation, but a synchrony in the body mass variation of the two species indicates a common factor, probably variations in agricultural crop structure.

4.3 Longevity and mortality

Wild boar over 10 years are reported living in nature (Massei *et al*. 1997a), however, the average life expectancy is much lower. In a hunted population in Poland, Jezierski (1977) found an average length of life of 21 months for males and 24 months for females. The mortality rate is high during the first weeks of life (Fruzinski & Labudski 2002, Náhlik & Sandor 2003), and in hunted populations remains high the first few years, especially for males (Jezierski 1977, Lemel 1999, Fruzinski & Labudski 2002). In Sweden 60% of a cohort survives their first year, 20% reach 2 years and less than 10% becomes older than 4 years old (Lemel 1999). Being a popular game species the main cause of death is by far hunting (Okarma *et al*. 1995, Lemel 1999). Among the Swedish wild boar 94% of the mortality is caused by hunting, 4% by car accidents and only 2% by natural causes (Lemel 1999). Because of their high reproductive rate, wild boar are believed to be less sensitive to high hunting pressure (Jedrzejewska *et al*. 1997) and harvest rates may exceed the estimated pre-breeding population size (Fruzinski & Labudski 2002). Apart from human related mortality, the most important mortality factors are disease and starvation, and in Poland this is mainly influenced by snow depth and by acorn crops the previous year (Jedrzejewski *et al*. 1992, Okarma *et al*. 1995). Mortality increases during hard winters, when deep snow makes movement energetically costly and frozen ground limits rooting (Jedrzejewski *et al*. 1992, Okarma *et al*. 1995). In hard winters dead boars are found in their lairs, often several together and mostly young animals (Jedrzejewski *et al*. 1992). Compared to other ungulates, like red deer, roe deer and bison, wild boar are more prone to die from such conditions (Okarma *et al*. 1995). Death from disease and starvation grows proportionally with acorn production the previous year, as an effect of increased population size responding to good mast years of which many die the following year (Okarma *et al*. 1995).

In Europe wolves (*Canis lupus*) are their main predator killing mostly piglets and young animals (Jedrzejewski *et al*. 1992, Okarma *et al*. 1995). Lynx (*Lynx lynx*) rarely kill boars, but some piglets are taken by stray dogs (Okarma *et al*. 1995). We found no data on predation by bears (*Ursus arctos*) or wolverines (*Gulo gulo*) and consider this to be low. Studies of carnivores in Poland show that wild boar are not a preferred prey and are taken significantly less often than expected from their proportion in the ungulate community (Jedrzejewski *et al*. 1992, Okarma *et al*. 1995). In southern Europe however, wild boar are the main wild ungulate prey of wolves (Meriggi & Lowari 1996).

4.4 Population density and increase rates

Several environmental factors have been shown to influence population densities of wild boars. Markov (1997) found that climatic factors had relatively little influence on changes in population size in Sverdlovsk oblast, but were an important factor in determining the distribution pattern over the area. In the Bialowieza Primeval Forest of Poland and Belarus densities are positively correlated with mean annual temperatures and negatively with the amount of snow cover (Jedrzejewska *et al*. 1997). In snowless winters the mean annual population increase was 19% and approached zero when snow cover exceeded 15 cm. However, the availability of acorns seems to be the crucial factor, and together with boar density and snow cover it explains 75% of the total variation in the population increase rate. No effect was found of changes in hunting pressure. For a population in Switzerland, Geisser & Reyer (2005) found that the population densities correlated positively with winter and spring temperatures, the frequency of mast years and the area of maize cultivation. No significant effect was found of precipitation in the form of rain or snow and, as in Bialowieza, no effect of hunting effort. Melis *et al*. (2006) investigated the influence of vegetation productivity, winter temperature

and wolf predation on the variation in abundance across the western Eurasian range of wild boar. They found that mean January temperature were the primary factor, followed by vegetation productivity. However, the vegetation productivity does not capture the varying availability of mast (Melis *et al*. 2006), nor supplementary feeding on agricultural crops. Wolf density seems to have higher effect in southern Europe (Melis *et al*. 2006), but also in Poland and Belarus they have a negative, although small, effect on boar densities (Jedrzejewska *et al*. 1997).

The elasticity of the population growth rate to vital rates has been shown to vary under different environments (Bieber & Ruf 2005). In poor environments (low food availability and cold winter) the survival rate of adults seems to have the largest impact on the population growth rate, but as conditions improve juvenile survival becomes increasingly important. In poor environments only high survival rates will result in population increase (Bieber & Ruf 2005). Because of their high intrinsic capacity for increase and their dependence on pulsed resources like mast, the population densities of wild boar changes fast and often with high amplitude (Jedrzejewska *et al*. 1997, Massei *et al*. 1997b, Chaill & Llimona 2004). Populations with good access to supplementary feeding seem to be much more resilient to such changes (Groot Bruniderink *et al*. 1994). Agricultural crops are known to increase the reproductive success of females (Neet 1995), and is considered as one of the main causes of the increasing densities of wild boar in Europe (Andrzejewski & Jezierski 1978, Sáez-Royuela & Tellería 1986, Fruzinski 1995, Bieber & Ruf 2005, Geisser & Reyer 2005). Future climatic changes are also believed to be positive for wild boar in that it will reduce snow cover and increase food availability (Jedrzejewska *et al*. 1997, Bieber & Ruf 2005, Geisser & Reyer 2005, Melis *et al*. 2006).

4.5 Migration

Wild boar generally live in large family groups made up of several breeding females, and contact and exchange is maintained by long distance dispersal of young males (Spitz 1992). These males also make up the frontier of the population spreading across new territories (Erkinaro *et al*. 1982). Maximum dispersal takes place when the animals reach puberty and males usually stray the furthest (Janeau *et al*. 1995, Truvé & Lemel 2003). Of 393 marked and retrieved wild boar in Sweden 11% of females and 55% of the males dispersed more than 10 km (Truvé & Lemel 2003). An average natal dispersal distance of 16,6 km were found for males and 4,5 km for females. Some of the males dispersed over 100 km (Truvé & Lemel 2003) and migrations over 250 km have been reported in Poland (Andrzejewski & Jezierski 1978). In addition, wild boar are known to perform seasonal altitudinal migrations in response to food availability (Singer *et al*. 1981).

As discussed above, in the northern distribution section, wild boar seem to be most sensitive to climatic factors during its dispersal period over new northern territories (Markov 1997). In addition population density and habitat structure are important factors. Populations living in open habitats and at lower densities are more prone to long distance dispersal than forest populations at higher densities (Cargnelutti *et al*. 1992). The proportions of dispersing individuals are negatively correlated with population density (Janeau & Spitz 1990, Truvé *et al*. 2004) but density does not seem to affect dispersal distance (Truvé *et al*. 2004). At lower densities wild boar live in isolated and unstable groups (Spitz 1992). Agricultural areas have proved important corridors for wild boar spreading into northern areas and the presence of predators seems to have had little impact on its expansion (Erkinaro *et al*. 1982). In Finland its rate of spread was estimated to about 50 km/year and due to its good swimming capabilities it has also been spotted on remote islands (Erkinaro *et al*. 1982).

5 HABITAT REQUIREMENTS

5.1 Diet

Wild boar will eat almost everything and they find their food primarily on or in the ground. They are very opportunistic feeders and change their diet according to the season and the relative availability of different food sources (Genov 1981a, Groot Bruinderink *et al*. 1994, Lemel 1999, Schley & Roper 2003, Baubet *et al*. 2004). An extensive survey of the diet of wild boar in most of its European range has been made by Schley & Roper (2003), showing around 400 species of plants, animals and fungi. The bulk of the food consists of plant material; mast, roots, green plants and agricultural crops. Energy rich plant food, like mast or agricultural crops, are especially important and are always included in their diet. The availability of these seems to determine the consumption of other food sources. Of these, acorns (*Quercus* spp.) and beechnuts (*Fagus sylvatica*) are the most important and when available are preferred over all other food sources, including supplementary food (Mackin 1970, Andrzejewski & Jezierski 1978, Sjarmidi *et al*. 1992, Groot Bruinderink *et al*. 1994, Schley & Roper 2003). When not available on the surface, wild boar exploit hoards collected by small mammals in the underground (Focardi *et al*. 2000). Of agricultural crops oats (*Avena sativa*), potatoes (*Solanum tuberosum*) and maize (*Zea mais*) are the preferred, but most crops are consumed when accessible (Mackin 1970, Jezierski & Myrcha 1975, Genov 1981b, Schley & Roper 2003). Animals are regular components in the diet of the wild boar but in relatively small quantity compared to vegetable matter (Schley & Roper 2003). Insects and earthworms are the most important, however most small animals including birds, mice and invertebrates as well as carcasses of larger animals are consumed opportunistically (Genov 1981a, Schley & Roper 2003). Boars are also known to feed on refuse heaps (Erkinaro *et al*. 1982).

The wild boar diet is not affected by age or sex, except that juveniles seems to consume more animal matter (Groot Bruinderink *et al*. 1994). The diet is however quite different from area to area. In the French Alps the most common food item is roots and bulbs, constituting up 39% of the diet, followed by fleshy fruits (21%) and green plant material (17%) (Baubet *et al*. 2004). The consumption of roots increased with altitude and above 1900m it constituted 71% of the diet. In the Siberian mountain taiga pine cones are another valued food source (Formozov 1946). An analysis of stomach contents from wild boar in Södermanland in Sweden revealed that as little as one fifth of the total contents in 91% of the stomachs were of natural origin and not from supplementary feeding (Lemel 1999). Of the natural food sources 86% were plants and mushrooms and 14% animals. Of these, ferns and especially horse tails constitutes the main food source between April and June, but during the rest of the year it is plant material from seed plants. The green parts of the plants are primarily consumed during the spring and summer, seeds and fruit during the autumn and roots during the winter. Like most mammals, wild boar increase their feeding during the autumn to prepare for the winter (Andrezejewski & Jezierski 1978). During hard winters with lots of snow and frozen ground, wild boar often starve (Jedrzejewski *et al*. 1992, Okarma *et al*. 1995) and are forced to eat twigs, bark and lichens (Formozov 1946). This high plasticity in diet might be one of the main reasons for the wild boar wide geographic distribution.

5.2 Environment

The habitats of wild boar are as varied as their diet. Home range and activity change with season and the availability of food resources (Massei *et al*. 1997a, Genov 1981b, Singer *et al*. 1981, Welander 2000, Lemel *et al*. 2003) and they are characterized as having low habitat specificity (Santos

et al. 2004). However, some factors seem to be important for the density of animals. Wild boar are more abundant in old mature deciduous forests and areas with high food and landscape diversity (Jedrzejewska *et al*. 1994, Spitz & Janeau 1995, Lemel 1999, Welander 2000, Acevedo *et al*. 2006). Managed forests with a higher degree of conifers support far fewer animals (Jedrzejewska *et al*. 1994). When agricultural fields are available, wild boar are most comfortable in the edge areas between forests and fields where they have easy access to both food and hiding places (Meriggi & Sacchi 1992, Spitz & Janeau 1995, Lemel 1999, Fruzinski & Labudzki 2002, Sodeikat & Pohlmeyer 2003). The protective advantage of the forest is essential for wild boar. Resting places and breeding nests are always located in areas of dense vegetation where they feel safe and are protected from bad weather (Dardaillon 1986, Lemel 1999, Fernández-Llario 2004). Cattle grazing do not seem to affect wild boar negatively (Madhusudan 2004, Kuiters *et al*. 2005), but rural desertion causing fields to overgrow have led to increases in the wild boar density in Spain by providing more shelter (Nores *et al*. 1995).

Climatic factors have a strong effect on the animals' distribution in an area, causing non-uniformity in the distribution of animal groups (Markov 1997). Factors that affect food availability, like deep snow and drought making the soil hard, are especially important and animals move away from these areas at such times (Dardaillon 1986, D´Andrea *et al*. 1995, Markov 1997, Acevedo 2006). During cold snowy days they choose their resting places on sun exposed slopes (Singer *et al*. 1981, D´Andrea *et al*. 1995) and during hot dry days they seek the cool moist forests with an abundance of wallows (Singer *et al*. 1981). Moisture is very important as the ground is easier to root and scents are better picked up (Lemel 2003, Welander 2000) and wild boar are much more active under moist conditions (Lemel 2003). Nest sites are always located in close proximity to water (Dardaillon 1986, Fernández-Llario 2004).

Photo: Jørgen Rosvold

6 THE FUTURE OF WILD BOAR IN NORWAY

Wild boar have guts. Their adaptability and low habitat specificity will ensure that wild boar become a part of the Norwegian fauna whether we want them or not. As seen above, boars have settled areas with much harsher climate than even northern Norway, indicating that climate alone will not be enough to stop them from settling. Climate does seem to have some effect on densities of the animals and higher lying areas with lots of snow may prove unsuitable wild boar habitat. Most of the coastal parts of Norway are however mild and have a relatively short duration of snow cover and would pose little problem for the wild boar. The primary influence of climate on wild boar is working through vegetation and food availability. Food availability is the decisive factor influencing population increase and the availability of at least one high energy food seems important for the establishment of wild boars. Wild boar are primarily tied to the temperate deciduous forests and prehistoric wild boar in Norway seem to have been restricted to the boreonemoral vegetation zone (figure 1), which has a greater diversity of plant species and especially mast producing species (Moen 1999). However, this only reflects its occurrence before farming became established and the landscape has changed a lot since then. Both cereal and potato fields exist as far north as Finnmark and could become potential food sources of wild boar. Cultivated areas in Norway are typically surrounded by outlying land of forest (Moen 1999) which is an ideal situation for boars. Climatically Norway is although not the optimal habitat and would fall more often under the poor environmental conditions described by Bieber & Ruf (2005) indicating that adult survival will be more important for the population growth rate. Survival will depend in large parts on hunting but also on the availability of food during winter. In Sweden wild boar are artificially fed by owners of hunting estates (Lemel 1999). If that happen in Norway this would likely increase winter survival, especially in snow rich areas. Relatively strong seasonal changes in climate and food availability will most likely result in more seasonal population dynamics with a high degree of synchrony in reproduction and more fluctuating population sizes. Because of the low abundance of wolves we do not expect predators to have any great effect on the populations of wild boar in Norway. However it is worth noting that those wolves that are established live in the south-east close to the border of Sweden, which is where the immigrating wild boar will first enter the country.

We would expect the greatest densities of wild boar to be along the southern and western Norwegian coast. Because of high agricultural activity and mild winters even Trøndelag should offer good habitats for wild boar. Higher lying areas with high snow fall in eastern and northern Norway would limit the densities of wild boar, but even here we would expect to see the animals, mostly stray males and possibly seasonal migrators. The distribution of wild boar might in many ways become comparable to the distribution of red deer (*Cervus elaphus*). Future climate change is believed to increase winter temperatures especially in eastern and northern Norway (Engen-Skaugen *et al*. 2007) and the amount of snow is predicted to decrease for most parts of the country but may increase in the mountains (Roald *et al*. 2002). There is expected to be an increase the length of the growing season (Førland *et al*. 2004, Skaugen & Tveito 2004) which will benefit agriculture (O´Brien *et al*. 2006) and potentially increase the distribution of mast producing tree species like beech, hazel (*Coryllus avellana*) and oak (Sykes & Prentice 1995, Niemelä *et al*. 2001). This will improve the conditions for wild boar in Norway and should lead to increased population densities and distribution, as well as reduced seasonality.

In conclusion, climate seems not to be a limitation for the distribution of wild boar in Norway, but will be a limiting factor on the population densities and the uniformity of distribution across the country. Wild boar will eventually settle and suitable areas should be assessed.

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Rapportserien

«Norges teknisk-naturvitenskapelige universitet, Vitenskapsmuseet Rapport zoologisk serie» er en videreføring av »Vitenskapsmuseet Rapport Zoologisk Serie» og presenterer stoff fra de zoologiske fagområdene ved Vitenskapsmuseet. Serien bringer i hovedsak arbeider fra oppdragsprosjekter og andre undersøkelser og forskning ved Seksjon for Naturhistorie. Serien er ikke periodisk og antall numre varierer pr. år. Serien startet i 1974 og det finnes parallelle botaniske og arkeologiske rapportserier ved Vitenskapsmuseet. Mindre arbeider og utredninger som av ulike grunner trenger en rask publisering og distribusjon presenteres i en egen notatserie: »Norges teknisk-naturvitenskapelige universitet, Vitenskapsmuseet Zoologisk notat».

Til forfatterne

Manuskripter
Manuskripter bør leveres som papirutskrift og som tekstfil i Word. Vitenskapelige slekts- og artsnavn kursiveres. Manuskripter til rapportserien skal skrives på norsk, unntatt abstract (se nedenfor). Unntaksvis, og etter avtale med redaktøren, kan manuskripter på engelsk bli tatt inn i serien. Tekstfilen(e) skal inneholde en ren «brødtekst», dvs. med færrest mulig formateringskoder. Hovedoverskrifter skal skrives med store bokstaver, de øvrige overskrifter med små bokstaver. Manuskriptet skal omfatte:

1. Eget ark med manuskriptets tittel og forfatterens/forfatternes navn. Tittelen bør være kort og inneholde viktige henvisningsord.
2. Et referat på norsk på maksimum 200 ord. Referatet innledes med bibliografisk referanse og avsluttes med forfatterens/forfatternes navn og adresse(r).
3. Et abstract på engelsk som er en oversettelse av det norske referatet.

Manuskriptet bør for øvrig inneholde:
4. Et forord som ikke overstiger en trykkside. Forordet kan gi bakgrunnen for arbeidet det rapporteres fra, opplysninger om eventuell oppdragsgiver og prosjekt- og programtilknytning, økonomisk og annen støtte, institusjoner og enkeltpersoner som bør takkes osv.
5. En innledning som gjør rede for den faglige problemstillingen og arbeidsgangen i undersøkelsen.
6. En innholdsfortegnelse som viser stoffets inndeling i kapitler og underkapitler.
7. Et sammendrag av innholdet. Sammendraget bør ikke overstige 3 % av det øvrige manuskriptet. I spesielle tilfeller kan det i tillegg også tas med et «summary» på engelsk.
8. Tabeller og figurer leveres på separate ark og skrives i egne filer. I teksten henvises de til som «Tabell 1», «Figur 1» osv.

Litteraturhenvisninger
En oversikt over litteratur som det er henvist til i manuskriptteksten samles bakerst i manuskriptet under overskriften «Litteratur». Henvisninger i teksten gis som Haftorn (1971), Arnekleiv & Haug (1996) eller, dersom det er flere enn to forfattere, som Sæther *et al.* (1981). Om det blir vist til flere arbeider, angis det som «som flere forfattere rapporterer (Haftorn 1971, Thingstad *et al.* 1995, Arnekleiv & Haug 1996,)», dvs. forfatterne nevnes i kronologisk orden, uten komma mellom navn og årstall. Litteraturlisten ordnes i alfabetisk rekkefølge: det norske alfabetet følges: aa = å (utenom for nederlandske, finske og etniske navn), ö = ø osv. Flere arbeid av samme forfatter i samme år angis ved a, b, osv. (Elven 1978a, b). Ved lik alfabetisk prioritet går to forfattere foran tre eller flere («*et al.*»).

Eksempler:

Tidsskrift/serie
Slagsvold, T. 1977. Bird song activity in relation to breeding cycle, spring weather, and environmental phenology. – Ornis Scand. 8: 197-222.

Arnekleiv, J.V. & Haug, A. 1996. Fiskebiologiske undersøkelser i Holmvatnet og Rundtuvvatnet, Rana kommune, Nordland, 1995. – Vitenskapsmuseet Rapp. Zool. Ser. 1996, 3: 1-22.

Kapittel
Nilsson, S.G. & Ericson, L. 1992. Conservation of plants and animal populations in theory and practice. s. 71-112 i Hansson, L. (red.). Ecological principles of nature conservation. – Elsevier Appl. Sci., London.

Monografi/bok
Urke, H. A. 2001. Utvikling av sjøtoleranse og vandringsåtferd hos Atlantisk laks (*Salmo salar* L.) med og utan oppdrettsbakgrunn. – Cand.scient. oppgave i akvakultur. Norges teknisk-naturvitenskapelige universitet, Zoologisk institutt. 79 s. Upubl.

Haftorn, S. 1971. Norges Fugler. – Universitetsforlaget, Oslo. 862 s.

Illustrasjoner
Figurer (i form av fotografier, tegninger osv.) leveres separat, på egne ark, dvs. de skal ikke inkluderes eller monteres i brødteksten. På papirutskriften av manuskriptet skal det i venstre marg angis hvor i teksten figurene ønskes plassert. Strekfigurer, kartutsnitt o.l. figurer skal være trykkeferdige fra forfatterens hånd. Skal rapporten inneholde fargebilder, bør også disse leveres som jpg-filer.

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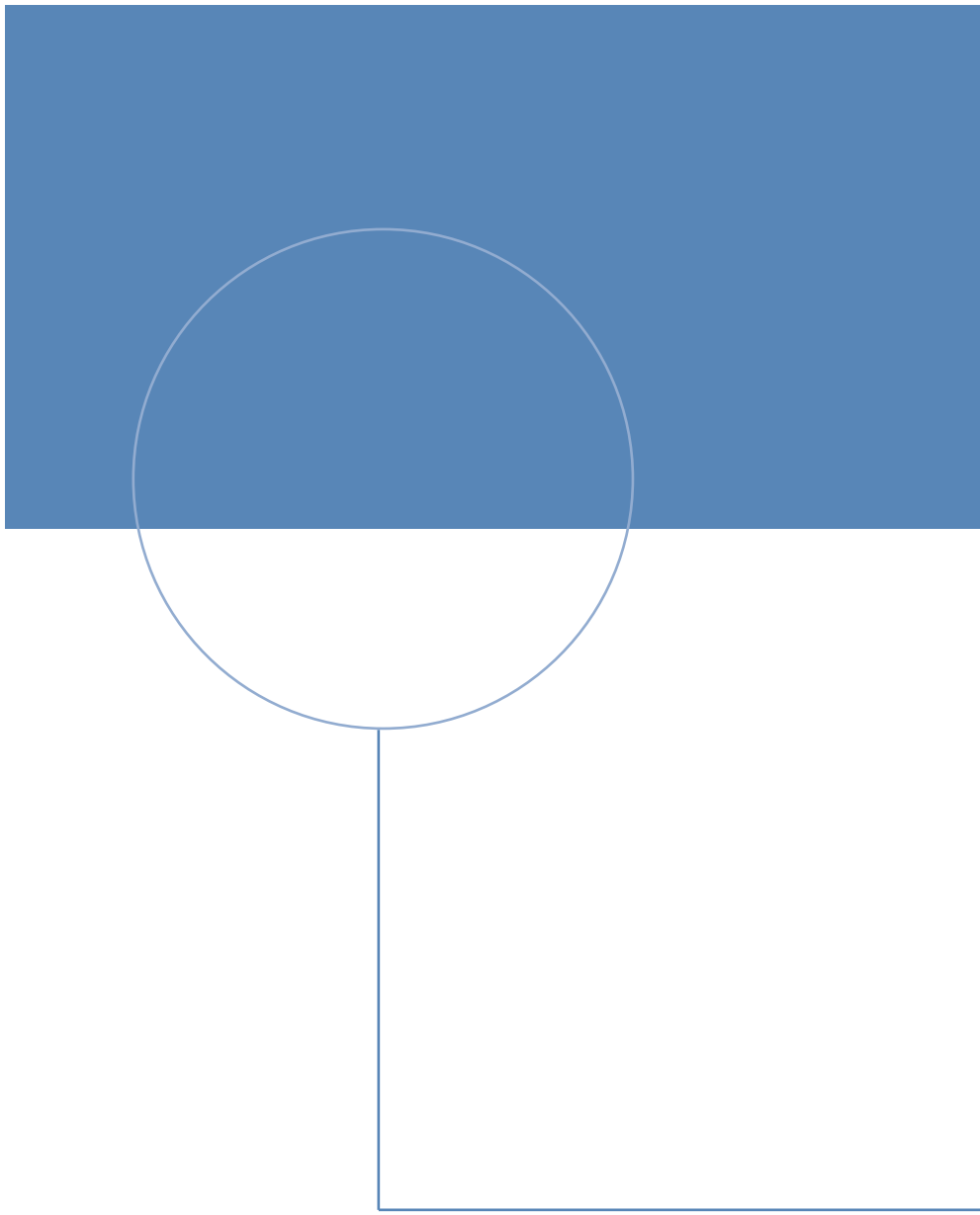

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