Examensarbete
i ämnet biologi

Habitat preferences by wild boar Sus scrofa in southern Sweden based on clusters of GPS positions

Emilia Broberg

Handledare: Kjell Sjöberg & Henrik Thurfjell **30 Poäng, D-nivå**

Vilt, Fisk och Miljö **2008:11**
SLU
901 83 Umeå, Sweden

Examensarbete
i ämnet biologi

Habitat preferences by wild boar Sus scrofa in southern Sweden based on clusters of GPS positions

Emilia Broberg

Supervisors: Kjell Sjöberg & Henrik Thurfjell **30 Point, D-Level**

Wildlife, Fish, and Environmental Studies **2008:11**
Swedish University of Agricultural Sciences
SE901 83 Umeå, Sweden

Abstract

The wild boar is a reintroduced game species in Sweden which has become a problem species because of damage on crops and causing traffic accidents. This is a comparative study with the aim to answer the following questions: (i) which habitat sites are most frequently visited by wild boar (ii) what are the characteristic features of the most frequently used habitats, and (iii) in what way do the wild boar use these habitats? Clusters of sites frequently visited by wild boar were defined from a study in the southernmost part of Sweden, where one female (supposed to be the leader sow) in each group of 13 wild boar hoards was equipped with a GPS/GSM-collar. The GPS coordinates were managed in ArcGIS 9.1 to find the clusters. Only night clusters (between sunset and sunrise), were used, i.e. during the time animals are most active. *Clusters* (also called *wild boar positions*) were matched and compared with *random positions* (from the same habitat type). In the field the *clusters* were expected to be related to either a) food search, b) resting sites, c) farrowing nests or d) other activities in the following four defined habitat types (called terrain types below): 1) Deciduous forest, 2) Coniferous and mixed forest, 3) Open area, e.g. pasture for grazing or meadow and 4) Agricultural land (cultivated areas). In the defined study sites the following variables were measured; vegetation in the ground layer, field layer, bush layer and tree layer, direct light on the ground, humidity and shelter.

One third of the observed *wild boar positions* shown to be feeding sites, i.e. sites with supplementary food for the wild boar provided by hunters. However, those *clusters* were not included in the analyses because the study focused on natural conditions. The terrain type among 1) Deciduous forest, 2) Coniferous and mixed forest, 3) Open area and 4) Agricultural land most frequently visited by wild boar showed to be Coniferous and mixed forest, which also contributed to most of the sites for supplementary feeding. *Clusters* defined as farrowing nests made up about one tenth of the *clusters.* The remaining *clusters* were assumed to have been used for food search or other activities. The results showed significant differences within matched pairs in habitat defined as Open area. There, the wild boar visited more areas with bushes and trees compared to random samples. Significant difference were also found between *wild boar positions* and *random positions* for mosses *Bryophyta* and *Marchantiophyta*, Wood-sorrel *Oxalis acetosella* and European beech *Fagus sylvatica*. No significant differences for the variables Direct light on the ground or Humidity appeared in this study.

Sammanfattning
Vildsvin är en i Sverige återinförd jaktbar viltart som nu orsakar betydande problem då djuren skadar jordbruksgrödor och förorsakar trafikolyckor. I denna jämförande studie är syftet att (i) beskriva de habitat som är mest välbesökta av vildsvin samt (ii) dokumentera vilka egenskaper dessa prioriterade habitat har och (iii) på vad sätt vildsvinen nyttjar dem. Kluster av områden besökta av vildsvin studerades genom observationer av 13 olika vildsvinsgrupper i södra Sverige, där den sugga man antog var ledarsugga försetts med GPS/GSM-halsband. Koordinaterna hanterades i ArcGIS 9.1. för att definiera aktivitetskluster för tiden mellan solnedgång och soluppgång, då djuren är mest aktiva. Varje *kluster*, också kallad *vildsvinsposition*, matchades och jämfördes mot en *slumpposition* (från samma habitat). I fält antogs *kluster* utgöra a) födosök, b) viloplatser, c) grisningsbo eller d) andra aktiviteter i fyra typer av habitat (även kallat terräng) definierade som; 1) lövskog, 2) barr- och blandskog, 3) öppna områden, som betes- eller ängsmark och 4) jordbruksmark (odlad mark). De parametrar som mättes och studerades vid respektive studieplats var; vegetationen i markskikt, fältskikt, buskskikt och trädskikt samt solinstrålning till marken, fuktighet och tillflyktsplatser.

En tredjedel av de observerade *vildsvinspositionerna* visade sig vara utfodringsplatser för vilt. Dessa *kluster* uteslöts dock ur studien då syftet var att studera naturliga förhållanden. Utav de fyra terrängtyperna, d.v.s. 1) lövskog, 2) barr- och blandskog, 3) öppna områden och 4) jordbruksmark, visade sig terrängen barr- och blandskog vara den som mest besöktes av vildsvin. Denna terräng innehöll även flest utfodringsplatser. *Kluster* definierade som grisningsbo utgjorde en tiondel av *klustren*. Återstående *kluster* förmodades främst utgöra födosöksplatser. Resultatet visade på signifikant skillnad inom matchade par i den terrängtyp som definierades som *öppna områden*. Här hade vildsvinen besökt fler ytor som var tätare bevuxna med buskar och träd jämfört med de slumpade ytorna. I vegetationsanalysen, där vegetationsskikten i varje terräng studerades som en enhet, påvisades signifikanta skillnader för blad- och bålmossor (*Bryophyta resp. Marchantiophyta)*, harsyra *Oxalis acetosella* och bok *Fagus sylvatica*. Däremot uppvisades i denna studie inga signifikanta skillnader inom parametrarna solinstrålning till marken och fuktighet.

Table of contents

1. Introduction

Today it is possible to find wild boar, *Sus scrofa*, in both southern and central Sweden (Förare, 2008; Bengtsson *et al.*, 2004). The wild boar was reintroduced into the Swedish fauna in the 1970´s by escaped individuals from fenced stocks in Skåne and Södermanland (Tham, 2004). Possible limiting factors for wild boar establishment further north are food availability rather than climate (Rosvold & Andersen, 2008). Because of the adaptability of wild boars, their omnivorous habit, and high rate of reproduction, the population has increased to such a level that it now causes serious problems to farmers (cf. Schley & Roper, 2003; Liljelund & Pettersson, 2007). The damages on crops are expensive and in addition several traffic casualties have been caused by wild boar, which creates a need for more research and for efficient management methods (Liljelund & Pettersson, 2007). Wild boars even have an impact on other species of animals (e.g. Singer *et al*., 1984; Focardi *et al*., 2000; Purger & Meszaros, 2006) and plants (Schmidt *et al*., 2004; Cocca *et al*., 2007) both in positive and negative ways (Massei & Genov, 2004).

Habitat studies of wild boar have been conducted in many parts of Europe, and often show that wild boars frequently use forest as habitat (Gerard *et al.*, 1991; Lemel, 1999; Welander, 2000; Fonseca, 2008). Marshes are also frequently used all the year round, which provides food, use of wallows, rooting, safe bedding sites and farrowing nests. The use of marshes depends on the water level, especially for the rooting which is more frequent at low levels (Dardaillon, 1986) and the use of farrowing nests which often are located near water in areas with abundant vegetation cover (Dardaillon, 1986; Dellmeier & Friend, 1987; Fernandez-Llario 2004). Intake of water is of importance during the lactation period (Fraser & Phillips, 1989). The sow stays in and around the farrowing nest for 1 – 2 weeks before returning to the group with her litter (Jensen, 1986). The wild boars' activity pattern is related to sunset (Boitani *et al.*, 1994; Lemel, 1999). Most of the time is spent resting (Blasetti *et al*., 1988) during daytime in forests (Boitani *et al.*, 1994), in central Sweden particularly in young stands of Norway spruce *Picea abies* (Nomenclature according to Krok & Almquist, 2003; Anderberg, 2007)(Lemel, 1999). The nocturnal activities of the wild boar are focused on foraging and travelling into pastures and cultivated areas, but for resting, they mainly use uncultivated pastures (Boitani *et al.*, 1994). In central Sweden, the foraging patterns of wild boars are more directed towards older Norway spruce forests. Rooting activity here is more frequent in ground layers where broad-leaved grasses *Calamagrostis* spp. and bilberries *Vaccinium myrtillus* grow (Lemel, 1999). Seasonal changes in foraging patterns influence the frequency of the wild boars use of open habitats; they prefer woodland and other habitats with safe resting sites (Boitani *et al.*, 1994; Wilson, 2004). A study made by Fonseca (2008) showed that wild boar in Poland prefer mixed forests with European beech *Fagus sylvatica* and hornbeam *Carpinus betulus,* and avoid European silver-fir *Abies alba* forest. A study in central Sweden (Lemel, 1999) showed that the preferred habitats of wild boar were dominated by agricultural land and mixed forest with Norway spruce, Scots pine *Pinus sylvestris*, silver birch *Betula pendula* and downy birch *B. pubescens*. Plant species mentioned in this work are all listed in the glossary (7.1. glossary, in Appendix) with their English, Latin and Swedish names, species nomenclature follows Krok & Almquist, 2003; Anderberg, 2007).

A study of the diet of wild boar by Schley and Roper (2003) showed a preference for mast, roots, green plants like grasses and stems and agricultural crops. Lemel (1999) showed that if supplementary food was available for the wild boar, only one-fifth of the stomach contents consisted of natural food sources. During a year in central Sweden, 86 % of the natural food intake consisted of plants and mushrooms and 14 % of animal origin. From

January to March the diet was composed of roots and green plants (Lemel, 1999). Rooting activity increases between these months while the food availability is limited (Wilson, 2004). The rooting activity differs among landscape areas (Howe & Power Bratton, 1976; Welander, 2000). Rooting has an impact on, for example, grasslands (Dardaillon, 1986; Cocca *et al*., 2007) and wild boars in such habitats also eat earthworms (Baubet *et al*., 2003). Between April and June the diet is based on green plants, which in Lemel´s study (1999) was dominated by cryptogam (mostly horsetail *Equisetaceae*). Consumption of mushrooms during the first six months of the year was mainly constituted by hart truffle *Elaphomyces* spp. From July to September the diet was dominated by fruits and seeds, synchronized with the ripening of the agricultural crops (Dardaillon, 1986; Lemel, 1999). During that period wild boars create damage by rooting or by directly feed on the crops (e.g. Schley & Roper, 2003; Genov, 1981 in Wilson, 2004; Herrero *et al*., 2006). From October to December the diet is based on roots (Lemel, 1999). Acorn and nuts from e.g. European oak *Quercus robur* and European beech trees make their greatest contribution in the autumn (Henry & Conley, 1972; Wood & Roark, 1980; Groot Bruinderink *et al.*, 1994). During the winter season the diet also contains a high proportion of food consumed at feeding sites (supplementary feeding for e.g. hunt, Lemel, 1999). To summarize; the wild boar is a generalist omnivore and can feed on a wide variety of food, which changes depending on the season.

In the present study I use data from an existing project of wild boar where sows from different groups of wild boar were equipped with GPS collars. I became interested in the pattern that the GPS positions from those individuals created clusters of positions in certain habitats. Are those clusters based on environmental factors such as vegetation cover, distribution of plant species and the amount of vegetation? Could the direct light on the ground and/or the humidity have an impact? Thus, the aims of my study are:

i) What habitats sites are most frequently visited by wild boar?

ii) What are the characteristic features of the most frequently used habitats?

2. Material and Methods

2.1. Study area

The field research was conducted in southern Sweden in the county of Skåne (Figure 1), at Högestad and Christinehof estates with an area of 13000 ha, and on some farmland outside the estate. About 7000 ha of the total acreage consists of productive forests of both coniferous and deciduous forest. The main part of the forests as well as the coniferous forest is located around Christinehof estate, and is dominated by Norway spruce and Scots pine. The most common tree species around Högestad estate are European beech, European oak, silver and downy birch, and on the wetter parts, alder *Alnus glutinosa*. The vegetation mostly consist of different kinds of grasses, herbs and bushes like hawthorn *Crataegus* spp. and wild raspberries *Rubus idaéus.* There is a high diversity of plant and animal species in the area. The remaining area of Högestad and Christinehof, 6000 ha, consists of agricultural land containing cultivation areas and pastures providing food for cattle. Some of the land is used for pasture generally containing grass *Poaceae* spp., clover *Trifolium* spp. or lucerne *Medicago* spp. Cultivated crops are mainly grain, such as barley *Hordeum vulgare*, rye *Secale cereal* and wheat *Triticum aestivum*, as well as sugar beet *Beta vulgaris* and rapeseed *Brassica napus* ssp. *oleifera* and *B. rapa* ssp. *oleifera*. The property is managed by

the administrative unit *Högestad and Christinehof joint-stock company*, which leases out some of the land for farming, hunting and residences. Some parts of the surroundings of the estate are nature preserves (Company presentation Högestad & Christinehof Förvaltnings AB., 2004). The topography of the study area is characterized by a rolling mosaic landscape with a mixture cultivation, pastures, forests and wet areas like marshes and lakes. Several roads are also cross the area.

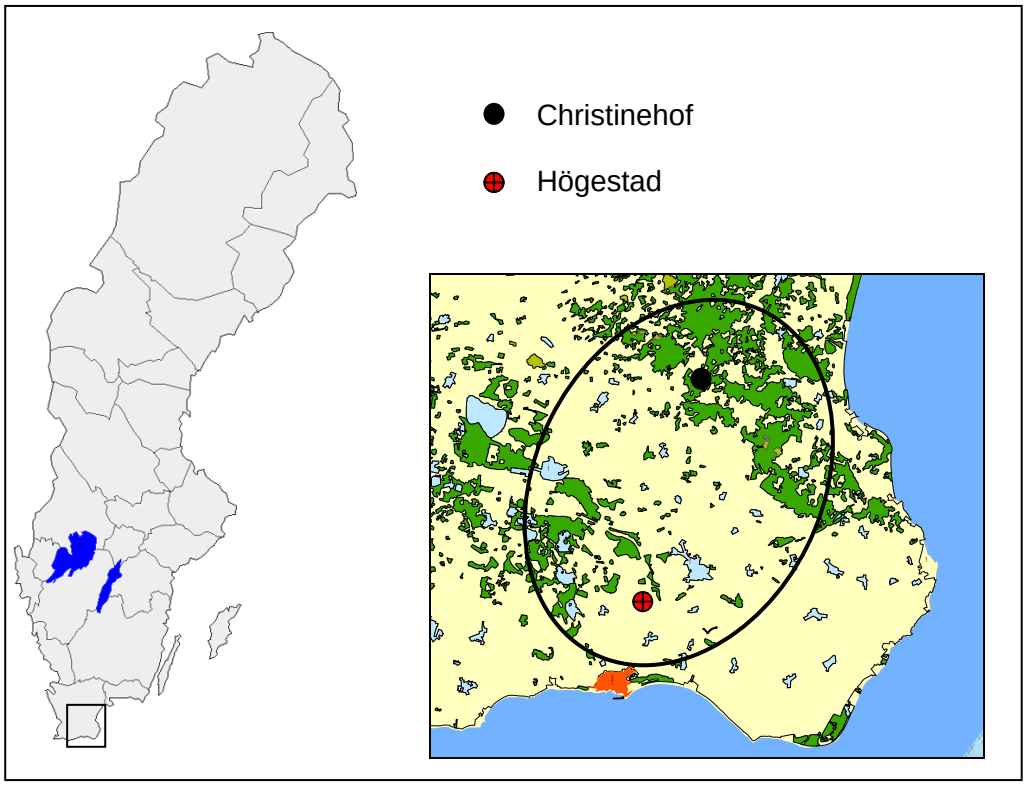

Figure 1. Location of the study area in the southern part of Sweden (the boxes), with Ystad marked in red. Locations of estates two main buildings are market with symbols and the study area with the ellipse. (Figure to the left: http://www.wartoft.nu/program/seterra/blindkarta-sverige.aspx, and to the right: © Lantmäteriverket Gävle 2008. Medgivande I 2008/1117).

Environments used by wild boar in this study are divided into four habitat types;

1) *Deciduous forest* (Figure 2, A) mostly containing European beech, European oak, but is sometimes mixed with other deciduous tree species silver and downy birch.
2) *Coniferous and mixed forest* (Figure 2, B) consists of e.g. Norway spruce and Scots pine solely or is mixed with tree species found in the deciduous forest.
3) *Open area* (Figure 2, C) excluded crop cultivated areas, consists of areas with fields of e.g. grassland or pastures with some bushes and trees.
4) *Agricultural land* (Figure 2, D) comprises land often cultivated with crops.

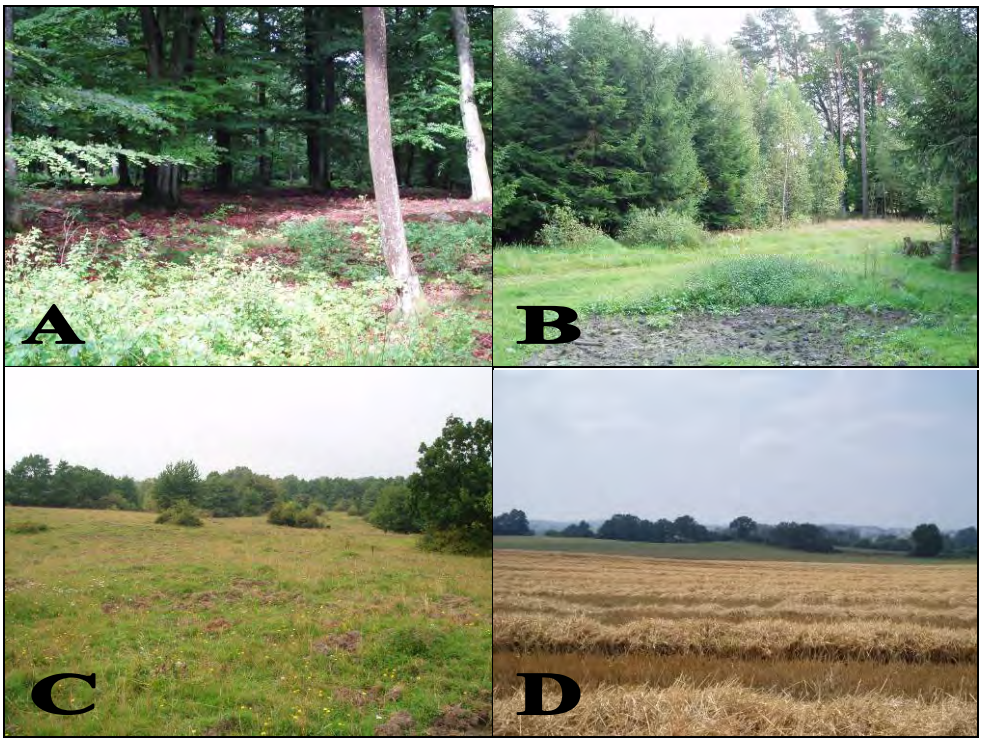

Figure 2. Terrain types; A) Deciduous forest, B) Coniferous and mixed forest, C) Open area and D) Agricultural land (Photos by Emilia Broberg, 2007).

2.2. Previously collected data

The clusters of sites frequently visited by wild boars were based on information collected from one female (assumed to be the leader sow) in each group of 13 wild boar hoards equipped with a GPS/GSM-collar (Table 1). The GPS/GSM-collars were reporting coordinates of the female positions, date and time of the day, by sending SMS two times per hour to a database established on the *Department of wildlife, fish and environmental studies* in Umeå, Sweden. The same technology as used in the study of real-time moose *Alces alces* tracking (Dettki *et al*., 2004), was used to track the wild boars. In the present study GPS information from wild boar females equipped with collars was collected between the year 2004 and 2006. The longest period of receiving SMS reports from a collar was eleven months and eighteen days (Table 1). The field study for this report was conducted in August 2007.

Table 1. Collars reporting time for each wild boar in this study.

Wild boar number	Year	Months	In use (months, days)
B 977	2004	Aug - Sep	1m 15d
K 1008	2004	Oct - Nov	1m 21d
Ca 1007	2004 - 2005	Oct - Feb	4m 4d
Mt 1010	2004 - 2005	Oct - May	7m 23d
Lo 975	2004 - 2005	Dec - Jan	1m
Mk 1474	2005	May - Oct	4m 31d
Mi 1473	2005 - 2006	May - Feb	10m 11d
Ch 1476	2005 - 2006	June - Feb	8m 12d
Le 1475	2005 - 2006	June - May	11m 18d
Ad 1478	2005 - 2006	Aug - Feb	5m 4d
Aa 1472	2005	Sep - Dec	3m 8d
Ml 1008	2005 - 2006	Sep - Feb	5m 29d
Ae 1482	2005 - 2006	Sep - May	9m 13d

To manage the data e.g. GPS coordinates to find the clusters, the GIS program ArcGIS 9.1 (ESRI, 2005) and GSD-topographic map, 1:50 000, RT90GONWPRJ, (Lantmäteriverket, 2005) were used. To get information about the most visited environment a tool called *Batch fixed kernel density estimator,* in ArcGIS were used. This tool is used to sort out raster cells storing most information to find the locations with the most reported GPS positions constituting a cluster. Settings to define clusters were: smoothing factor (20), scaling factor (20) and raster cell size (25). Density was 5 % of raster cells with the most information, which were defined as clusters. The selected numbers were estimated. Observations were only made on nocturnal clusters (time between sunset and sunrise) in accordance with knowledge that the wild boar is more active in the night than the day. Day clusters were expected to be mainly resting sites (Boitani *et al.*, 1994; Lemel, 1999) which were of less interest in this study. *Clusters* were assumed to be related to food search, resting sites, farrowing nests or other activities (Dardaillon, 1986; Blasetti *et al.*, 1988).

In the study, comparisons were made between a *wild boar position* (*cluster*) and a *random position*, thus creating matched pairs. A *wild boar position* is based on one defined GPS cluster where the wild boar has been frequently, and a *random position* is a GPS position that the computer randomly had chosen in similar terrain type as the matched *cluster*. The matched pairs found and defined in ArcGIS 9.1 (Table 2) had a total number of 134; of this only 81 could be visited in the field because of lack of time. At least 29 pairs had to be excluded from the study when *clusters* showed to be feeding sites or the matched positions showed to be situated in different terrains when visited in the field. From the rest of the matched pairs, statistical analyses could be done on 34 pairs (the rest had to be excluded because of limited sample size of individuals and GPS positions, Table 2). Only one matched pair from each individual per terrain was represented. Therefore, a terrain type contained only eight or nine matched pairs each (Table 2). All thirteen wild boars included in the study did not have positions in all four terrain types, but the terrain types were represented of the same amount of individuals.

Table 2. Distribution of matched pairs (*wild boar positions* and *random positions*) in the study.

	Number of Matched pairs		
Total matched pairs found	134		
Number of pairs checked	81		
Number excluded (feeding sites)	29		
Number used for statistical analyses	34		*Sample size*
Within the terrain types	**Distribution of total pairs**	**Distribution of feeding sites**	**Number of pairs**
Number in Deciduous forest	19	2	8
Number in Coniferous & mixed forest	46	21	9
Number in Open area	30	6	9
Number in Agricultural land	39	0	8

2.3. Data collected in field

The *wild boar positions* and the *random positions* were located by means of a topographic map and a handheld GPS pre-programmed with these coordinates. At the defined positions a study site (also called test frame) within a circle of 20 m in diameter was established. The circle was defined with a 10 m long string tied to a stick placed in the centre of the circle.

The diameter of the test frame was determined by the fact that the GPS positions can differ about 10 m from the exact positions of the sites established from the centre positions of the clusters (Dettki *et al.*, 2004; Visscher, 2006). Within the test frame, in all four terrain types, vegetation composition and structure, direct light on the ground, humidity and shelter different variables and conditions were recorded.

2.3.1. Vegetation

Within each test frame (Ø = 20 m) the vegetation was divided into four layers; ground, field, bush, and tree layer (Figure 3). In the *ground layer* the vegetation on the ground up to 15 cm height, like mosses *Bryophyta* and *Marchantiophyta* (nomenclature Hallingbäck *et al.*, 2006), was documented. The *field layer* covered the vegetation within a height from 15 cm to 2 m, e.g. herbs and grasses. The *bush layer* comprises the vegetation between the heights of 2 m to 6 m, but also bushes (definition; branches and wooded structure) not reaching 2 m heights were included in the bush layer. Finally, the *tree layer* covered the vegetation above 6 m.

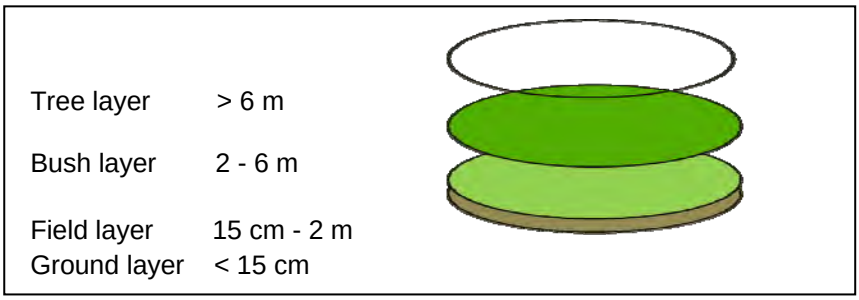

Figure 3. Distribution of vegetation in the four layers that are part of a test frame (Ø = 20 m).

The vegetation in the ground layer, field layer and bush layer were all estimated in proportion (%) to what degree the different plant species of the specific layer were covering the projection within the test frame (Figure 3). The trees in the tree layer were counted within the circle and not measured as proportions like in the other layers, but in the calculation, transformation from amount to proportion was made to easier combine the different vegetation layers with each other.

An assumption was that the vegetation on a location was the same at the time of the field study, as at the time the wild boars made their visit. However, the type of crops actually growing at the study sites when the GPS positions were obtained was collected from the farmer and *The Swedish Board of Agriculture* that stored information on the request for EU benefits in a database called Blockdatabasen. The same procedure was made for all four terrain types, but for the terrain type Agriculture land, observations in the field was combined with information from *The Swedish Board of Agriculture*.

2.3.2. Shelter

The Shelter variable was constructed from environmental descriptions from the field study by which the environment was interpreted from the animals point of view e.g. if they had a shelter within or close to the study site (between one to fifty meters from the position in the test frame). The distance was estimated and not calculated or measured. The shelter could be a nearby forest, hedge or a rock wall following a boundary between properties.

2.3.3. Direct light on the ground

The estimation of direct light on the ground surface was divided in five classes depending on how much of the test frame (with a circle of 20 m in diameter) that was illuminated. The classes were 0 – 20 %, 21 – 40 %, 41 – 60 %, 61 – 80 % and 81 – 100 %. The first class, 0 – 20 %, comprises forests where the test frame was nearly or totally without light, and the fifth class, 81 – 100 %, describes a test frame nearly or totally covered with light, e.g. a field without trees and bushes (like agricultural land). The variable Direct light on the ground was intended to investigate if the covering vegetation of bushes and trees influenced the wild boar's choice of habitat.

2.3.4. Humidity

The Humidity variable was also recorded on a relative scale, where dampness was estimated by looking at the plants growing there as well as the soils dampness. The humidity was divided into four classes, *dry*, *middle dry*, *semi wet* and *wet*. The *dry* class comprises really dry areas like agriculture land or meadows with soils dried by the sun and where soil particles could blow away in windy weather. The *middle dry* class contains dry soil that still stays on the ground in windy weather and does not show wetness when standing on it. The class *semi wet* contains soils where the wetness can be detected by pressing your feet in it. The last class, *wet*, comprises areas like marshes or riparian wood land. The first two classes got vegetation that prefer dry soil to grow in, like Scots pine or cowberry *Vaccinium vitis-idaea* and in the last two classes such vegetation that likes wetter soil were growing, e.g. alder or meadowsweet *Filipendula ulmaria*.

2.4. Subsequent data managing

2.4.1. Farrowing nests

A minor calculation was made to find out the number of nests discovered within the observed *wild boar positions* (the 34 randomly chosen positions from the four terrain groups on which the statistic calculations were based upon). Because the farrowing nest is used by the sow and her litter for 1 - 2 weeks (Jensen, 1986) and a sow visits or stays in the nest for at least 20 positions per day, farrowing nests ought to be detectable as clusters in the GPS data.

2.4.2. Feeding sites

Nearly all defined matched pairs in ArcGIS 9.1 (ESRI, 2005) were visited in field. Positions defined as feeding sites (supplementary feeding for e.g. hunt) were counted to estimate their proportion of all observed *wild boar positions*. The feeding sites were not included or further utilized in the analyses, as the purpose of this study was to look at natural conditions and not artificial ones, even if the feeding sites as such certainly could influence the movement patters of the wild boar in the area.

2.5. Statistics and calculations

The collected field data was stored and revised in Excel (Microsoft, 2007). The nonparametric statistical test, Sign test (Siegel & Castellan, 1988) was used for analyses of vegetation to compare the amount of vegetation (without regard to plant species) between

the matched pairs (of a *wild boar position* and a *random position*, Table 3). Each plant species in the vegetation layers (Figure 3) was compared between *wild boar positions* and *random positions* (without regard to the four terrain groups) with Wilcoxon signed ranks test (Siegel & Castellan, 1988). The Wilcoxon signed ranks test was also used for comparison within the matched pairs in the respectively, two variables, Direct light on the ground and Humidity. Farrowing nests (Table 1 – 4 in Appendix) and variable Shelter were not statistically analyzed because of a small sample size.

3. Results

The total number of *clusters* within the four terrain types (Table 2, Figure 2), i.e. Deciduous forest, Coniferous and mixed forest, Open area and Agricultural land) defined in this study showed that the terrain type Coniferous and mixed forest was the most visited by the wild boar (although not statistically analyzed). However, in this terrain type were also most of the man-made feeding sites with supplementary food situated.

3.1. Vegetation

My analysis revealed only two significant differences in the amount of vegetation within the matched pairs analyzed, and they were in the bush and tree layer in the terrain type Open area (Table 3). There were no significant differences in the other layers or terrains. The plots of the plant species distribution show that in the ground layers the mosses and grasses are the most dominant species. Only mosses (group of moss species, because of the difficulty in identifying single species) and wood-sorrel *Oxalis acetosella* showed significance in the ground layers (Figure 4). In the field layers, grasses (the group of grass species) were most abundant in this layer (Figure 5). The bush layers were dominated by common reed *Phragmites australis* and wild raspberry (Figure 6). For the tree layers, Norway spruce, silver and downy birch were the most common species, but here the European beech was significantly avoided (Figure 7). The names of all plant species mentioned are all listed in the glossary (7.1. glossary, in Appendix).

Table 3. Results (Sign test) of difference within matched pairs regarding amount of vegetation, in each vegetation layers in the four terrain types. N = the total number of signs (+/-), x = the sum minimum of signs, p = probability, * significant value at * and *** level, - value is missing.

Terrain types/ Vegetation layers		Deciduous forest	Coniferous and mixed forest	Open area	Agricultural land
Ground layer	N	8	9	9	6
	x	-3	-3	+3	-3
	p	0.363	0.254	0.254	0.656
Field layer	N	8	8	8	7
	x	-3	+3	+3	+3
	p	0.363	0.363	0.363	0.5
Bush layer	N	8	9	9	2
	x	-4	+3	0	0
	p	0.637	0.254	0.002**	-
Tree layer	N	6	8	8	-
	x	-3	-3	-1	-
	p	0.656	0.363	0.035*	-

Figures 4 - 7 show the distribution of the plant species represented in ground, field, bush and tree layers in the four terrain types (Figure 2, i.e. Deciduous forest, Coniferous and mixed forests, Open area and Agricultural land) to investigate the possible influence of different plant species. Wilcoxon signed ranks tests revealed a significance difference for mosses (probability, p = 0.0244, sum of rank (rs, positive + or negative -), rs+ = 124 and total number of ranks, N = 17 for *wild boar positions*) as well as wood-sorrel (p = 0.0078, rs- = 28, N = 7 for *random positions*) in the ground layers (Figure 4) and European beech (p = 0.0156, rs- = 27, N = 7 for *random positions*) in the tree layers (Figure 7). Plant species close to being significantly different, were barley (p = 0.0625, rs+ = 10, N = 4 for *random positions*, and grasses (p = 0.0768, rs+ = 212, N = 24 for *wild boar positions*) both found in the field layer (Figure 5).

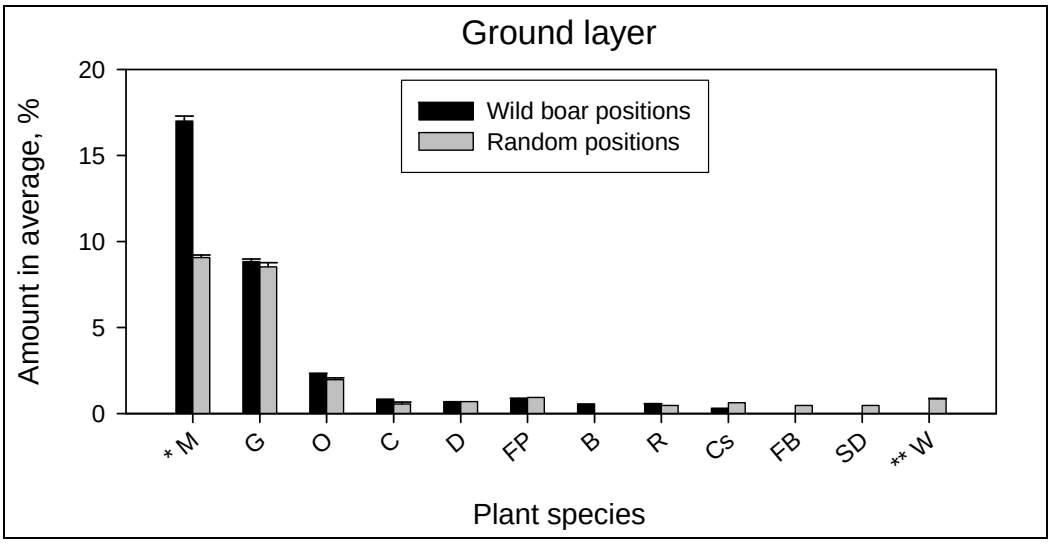

Figure 4. Average proportion of plant species or groups represented in the vegetation of *ground layers* in the four terrains together (Figure 2), within *wild boar positions* and *random positions*. In the figure is the standard deviation for each column defined by the error bar on top. M = mosses *Bryophyta* and *Marchantiophyta* (group of moss species), G = grasses *Poaceae* (group of grass species), O = Other (group representing species without enough samples), C = clovers *Trifolium* spp. (group of clover species), D = dandelions *Taraxacum* spp. (group of dandelion species), FP = field pansy *Viola arvensis*, B = barley *Hordeum vulgare*, R = redshank *Persicaria maculosa*, Cs = corn spurrey *Spergula arvensis*, FB = field bindweed *Convolvulus arvensis*, S&D = sorrel and dock *Rumex* spp. (group of sorrel and dock species) and W = wood-sorrel *Oxalis acetosella*. * = significance at * and *** level. Patches without any vegetation constituted together 68 % of the *wild boar positions* and 75 % of the *random positions*. In the figure *wild boar positions* makes a total of 100 % included patches without vegetation, also the same conditions regards *random positions*.

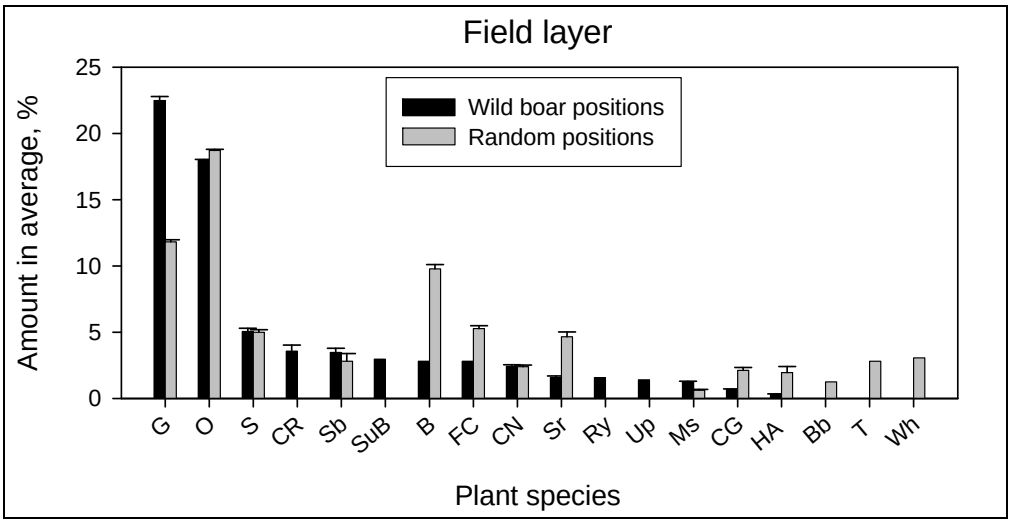

Figure 5. Average proportion of plant species or groups represented for vegetation of *field layers* in the four terrains together (Figure 2), within *wild boar positions* and *random positions*. In the figure is the standard deviation for each column defined by the error bar on top. G = grasses (group of grass species), O = Other (group representing species without enough samples), S = sedges *Carex* spp. (group of sedge species), CR = common reed *Phragmites australis*, Sb = small balsam *Impatiens parviflora*, SuB = sugar beet *Beta vulgaris*, B = barley, FC = forage crops (group of species grown as ley), CN = common nettle *Urtica dioica*, Sr = soft-rush *Juncus effusus*, Ry = rye *Secale cereal*, Up = upright hedge-parsley *Torilis japonica*, Ms = meadowsweet *Filipendula ulmaria*, CG = cryptogam (group of cryptogam species), HA = hemp-agrimony *Eupatorium cannabinum*, Bb = bilberry *Vaccinium myrtillus*, T = triticales *Triticosecale* spp. (group of triticale species) and Wh = wheat *Triticum aestivum*. Patches without any vegetation made up together 30 % of the *wild boar positions* and 28 % of the *random positions*. In the figure *wild boar positions* make a total of 100 % included patches without vegetation, also the same conditions regards *random positions*.

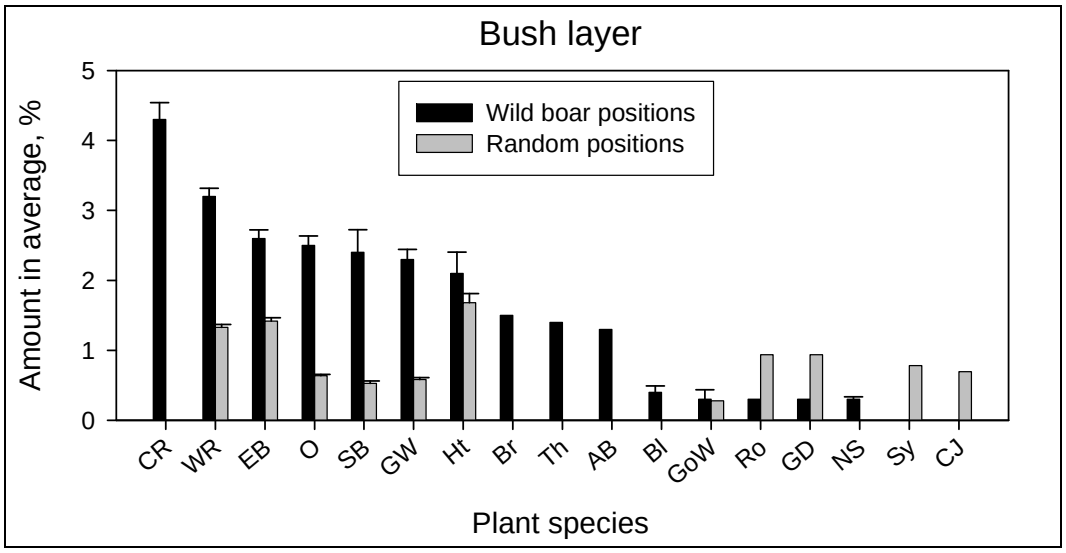

Figure 6. Average proportion of plant species or groups represented for vegetation of *bush layers* in the four terrains together (Figure 2), within *wild boar positions* and *random positions*. In the figure is the standard deviation for each column defined by the error bar on top. CR = common reed, WR = wild raspberry *Rubus idaéus*, EB = European beech *Fagus sylvatica*, SB = silver *Betula pendula* and downy birches *B. pubescens* (group of birch species), GW = grey willow *Salix cinerea*, Ht = hawthorns *Crataegus* spp. (group of hawthorn species), Br = bracken *Pteridium aquilinum*, Th = thistles *Cirsium* spp. (group of thistle species), AB = alder buckthorn *Frangula alnus*, O = Other (group representing species without enough samples), Bl = blackthorn *Prunus spinosa*, GoW = goat willow *Salix caprea*, Ro = rowan *Sorbus aucuparia*, GD = glaucous dog-rose *Rosa dumalis*, NS = Norway spruce *Picea abies*, Sy = sycamore *Acer pseudoplatanus* and CJ = common juniper *Juniperus communis*. Patches without any vegetation constituted together 76 % of the *wild boar positions* and 90 % of the *random positions*. In the figure *wild boar positions* make a total of 100 % included patches without vegetation, also the same conditions regards *random positions*.

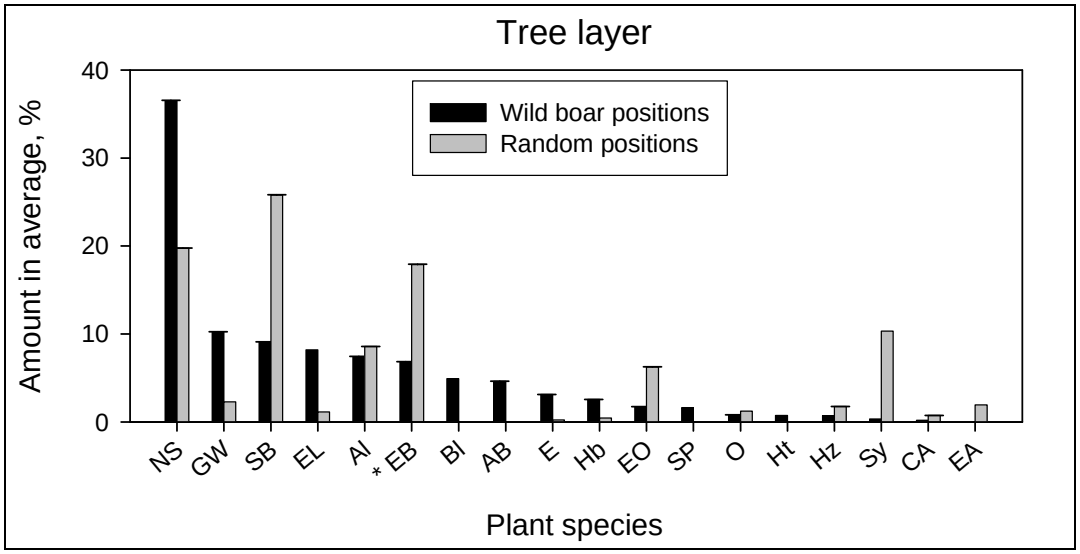

Figure 7. Average proportion of tree species or groups represented for vegetation of *tree layers* in all terrains together, excluding the terrain type Agricultural land (Figure 2, A – C), within *wild boar positions* and *random positions*. In the figure is the standard deviation for each column defined by the error bar on top. NS = Norway spruce, GW = grey willow, SB = silver and downy birches (group of birch species), EL = European larch *Larix deciduas*, Al = alder *Alnus glutinosa*, EB = European beech, Bl = blackthorn, AB = alder buckthorn, E = elm *Ulmus glabra*, Hb = hornbeam *Carpinus betulus*, EO = European oak *Quercus robur*, SP = Scots pine *Pinus sylvestris*, O = Other (group representing species without enough samples), Ht = hawthorns (group of hawthorn species), Hz = hazel *Corylus avellana*, Sy = sycamore, Ca = crab-apple *Malus sylvestris*, EA = aspen *Populus tremula*. * = significance at *** level. Patches without trees in the terrain type Open area made up to a total number of 7 % of *wild boar positions* and 26 % of *random positions*. In the figure *wild boar positions* make a total of 100 % included patches without vegetation, also the same conditions regards *random positions*.

3.2. Shelter

The two terrain types Deciduous forest and Coniferous and mixed forest provided shelter near to all studied positions (Figure 2, A & B). The terrain type Agricultural land had the same distribution and exhibited now statistical difference for both *wild boar* and *random positions*, but the two columns of *No shelter* have a slightly higher value than columns of *Shelter*. In the terrain type Open area, all *wild boar positions* had shelter nearby which was different from *random positions*, of which some of them did not have shelter nearby (Figure 8).

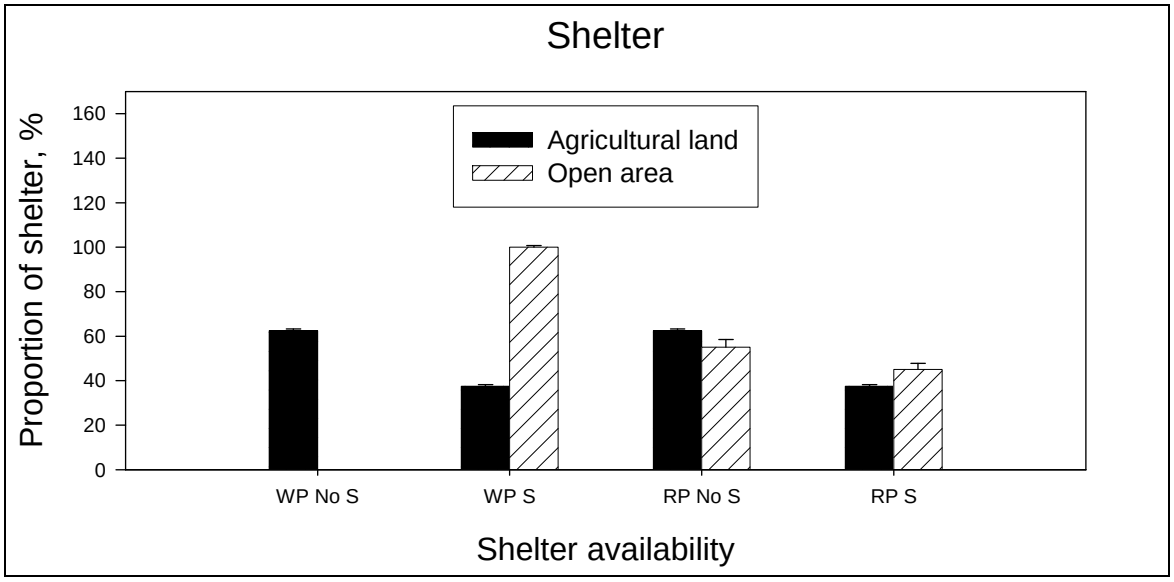

Figure 8. The variable Shelter measured in percent of available shelter in the terrain types Agricultural land and Open area (Figure 2, C – D), symbolized by the different colours. WP No S = *Wild boar positions* misses (no) shelter nearby, WP S = *Wild boar positions* have got shelter nearby, RP No S = *Random positions* misses (no) shelter nearby and RP S = *Random positions* have got shelter nearby. The maximum value for each column made up to 100 %. In the figure is the standard deviation for each column defined by the error bar on top. The figure shows the distribution of the shelter, not results from statistics.

3.3. Direct light on the ground

There is no significant difference within matched pairs in the different terrain types in the condition of direct light on the ground (Figure 9). The terrain type Deciduous forest showed values of $p = 0.1875$, $rs+ = 20$ and $N = 7$. The terrain type Coniferous and mixed forest had $p = 0.3828$, $rs- = 12.5$ and $N = 6$. The terrain type Open area got values of $p = 0.3438$, $rs- = 13$ and $N = 6$. Finally, the terrain type Agricultural land had no values to calculate.

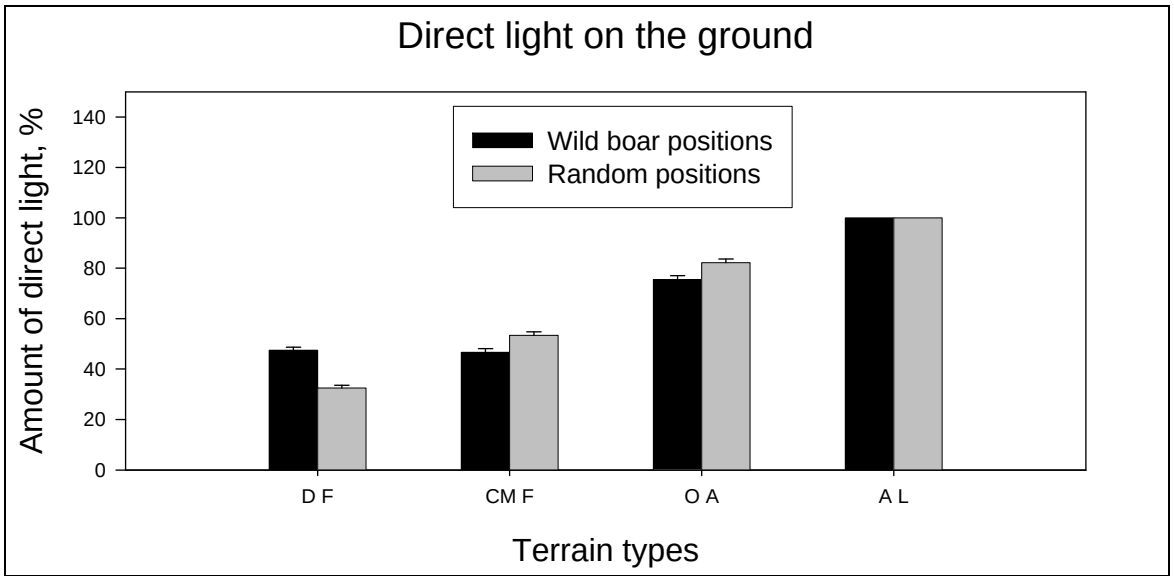

Figure 9. The Direct light on the ground in the different terrain types (D F = Deciduous forest, CM F = Coniferous and mixed forest, O A = Open area and A L = Agricultural land, Figure 2), within *wild boar positions* and *random positions*, measured in percent, based on the average of classification value 0 – 20 %, 21 – 40 %, 41 – 60 %, 61 – 80 % and 81 – 100 %. The maximum value for each column is 100 %. In the figure is the standard deviation for each column defined by the error bar on top.

3.4. Humidity

There was no significant difference within matched pairs in the different terrain types in humidity (Figure 10). Deciduous forest showed values of p = 0.3594, rs+ = 9.5 and N = 5. Coniferous and mixed forest had p = 0.4532, rs- = 8.5 and N = 5. The terrain type Open area got values of p = 0.25, rs+ = 5 and N = 3. The terrain type Agricultural land had no p-value when rs+ = 1 and N = 1.

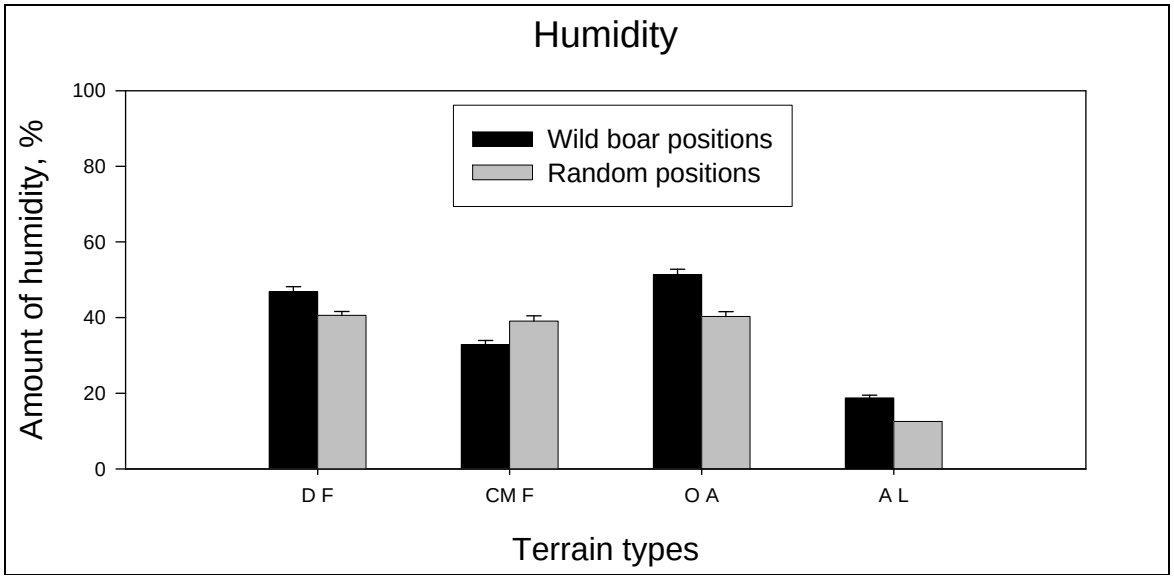

Figure 10. The Humidity in the different terrains (D F = Deciduous forest, CM F = Coniferous and mixed forest, O A = Open area and A L = Agricultural land, Figure 2), within *wild boar positions* and *random positions*, measured in percent, based on the average of classification value 25 %, 50 %, 75 % and 100 %. The maximum value for each column is 100 %. In the figure is the standard deviation for each column defined by the error bar on top.

3.5. Farrowing nests
The data demonstrates that about one-tenth of the observed *wild boar positions* in the study (the 34 randomly chosen positions on which the statistic calculations are based upon, with their matched *random position*) are defined as nests (Table 1 – 4 in Appendix). The farrowing nests were in this small calculation found in the terrain types Deciduous forest and Open area which together contained three nests (Table 1 and 3 in Appendix).

3.6. Feeding sites
More than one-third of all observed *wild boar positions* in the field study were feeding sites and of these locations two-third were placed in the part of the estate called Christinehof. Observation of the GPS positions in field showed that different groups of wild boar hoards use the same shelter, located in edges of woods near a feeding site.

4. Discussion
Among the main terrain types in my study area (Figure 2, i.e. Deciduous forest, Coniferous and mixed forest, Open area and Agricultural land), Coniferous and mixed forest were the terrain type most visited by wild boars. They prefer habitats which provide shelter, e.g. within forested and other habitats with safe resting sites (Boitani *et al.*, 1994; Wilson, 2004). Subsequently, in my study, in the terrain type Open area, bush and tree layers showed significant more wild boar positions than random positions. This observation is further confirmed by Tham (2004) who stresses the fact that dense vegetation gives shelter and Boitani *et al*. (1994) state that pastures and cultivated areas, i.e. open landscapes with less shelter, are mainly used for nocturnal activities. However, utilization of the different habitats does vary seasonally (Boitani *et al.*, 1994).

In the study area, feeding sites with supplementary food present were abundant and mainly in forested areas. They were frequently visited by the wild boars involved in my study. However, as I mainly was interested in the most frequently used natural habitats and not man-made artificial feeding sites, they were not included in the analyses, but they could of course to some extent have influenced the distribution of the wild boar in the landscape. It was also obvious based on my field observations that concentration of wild boar positions created clusters on the maps could be very temporary and heavily dependent on season. For example, fruit trees like apples and cherry trees could be very attractive for wild boar when the fruits were falling to the ground, creating distinct clusters of wild boar positions during a limited time period. Such clusters were difficult to discover and interpret in my study, and thus certainly underrepresented.

4.1. Vegetation
In the terrain type Open area (Figure 2, C) the wild boar seem to prefer places with more bushes and trees, perhaps because such landscape elements provide some shelter, as shown in Table 3 and Figure 8. Alternatively, the reason might be that more food is found there, like acorns from European oaks (cf. Groot Bruinderink, *et al.*, 1994; Focardi *et al*., 2000), or they provide both shelter and food (cf. Boitani *et al.*, 1994). However, European oaks are not common in my study area (Figure 7).

Plant species preferring wet conditions were more often found at *wild boar positions* than at *random positions* (Figure 4 – 7). For example, the bush layers (Figure 6) are dominated by common reed *Phragmites australis*, alder Buckthorn *Frangula alnus* and grey willows *Salix cinerea*, which indicate fairly damp or wet sites (Mossberg & Stenberg, 2003).

Dardaillon (1986) reports that marshes are important habitats for various activities of wild boar all year round. Other studies that the wild boars' foraging pattern changes seasonally and influences their use of open habitat, but that they prefer woodland and other habitats with safe resting sites (Boitani *et al.*, 1994; Wilson, 2004). In the other three terrain types (Deciduous forest, Coniferous and mixed forests and Agricultural land (Figure 2, A, B & D) there were no significant differences in the amount of vegetation. This may suggest that wild boars choose their habitat mainly because of what plant species are growing there and not because of the amount of vegetation. Furthermore, the distribution of the plant species represented in the different layers (apart from the terrain types, Figure 4 – 7) shows that different species of grasses are among the dominant plant species in *clusters* for both ground layers (Figure 4) and field layers (Figure 5). Grasses are one of the groups of species together, treated as groups because of the difficulty to identify single species.

4.1.1. Ground layers

Mosses were present in significantly larger number in *wild boar positions* (or *clusters)* compared to *random positions*, and wood-sorrel showed significant higher numbers at *random positions*. These were the only species groups (mosses) or species in the ground layers (Figure 4) that showed significant difference between *clusters* and *random positions*. This could mean that wild boars prefer habitats where mosses could be found, like in for example damp or/and shady sites (e.g. Hallingbäck *et al.*, 2006). However, although wood-sorrel also grows at damp and shady sites in e.g. forest (Mossberg and Stenberg, 2006), in this study the species was mainly found at *random positions*. Therefore mosses and wood-sorrel could not indicate if damp and shady places are preferred or not by wild boar. Thus, mosses growing at other sites might be interesting to study.

The main part of the plant species represented in the ground layers (Figure 4) were found in the terrain type Agricultural land, but perhaps seasonal variation could have influenced the result, as the species present in that terrain type was heavily influenced by the harvesting situation in the fields at the time when the study was performed.

4.1.2. Field layers

A high diversity of plant species was present in the field layers (Figure 5) and the bush layers (Figure 6). The field layers had the most species and several are represented in the group named *Other*, constituting about 18 % of the species in a test frame at *wild boar positions* in field layers (Figure 5). Several species found in field layers in *wild boar positions* (or *clusters*) and *random positions* were represented by few but big samples in each of them. Plant species only found at *clusters* but with too few samples to test for significance differences were common reed, sugar beet, rye and upright hedge-parsley *Torilis japonica*. It is worthwhile to note that barley, forage crops, bilberry, triticales *Triticosecale* spp. and wheat are crops or berries that dominated *random positions* compared to the matched *cluster* (Figure 5). Surprisingly, wild boar did not seem to prefer these crops. Barley was close to being significant ($p = 0.0625$). This might be because the long awns on barley that may be unpleasant for the wild boar to eat. In my study, the reason why the crops were less important than grasses but still important enough to be included in the study could be that crops are seasonal and that grasses are available a longer period. Boitani *et al.* (1994) and Lemel (1999) report that agricultural land is the most preferred habitat for foraging when the crops are ripe in late summer. The group of grasses was also close to being significant, $p = 0.07$, but for *wild boar positions* (Figure 5). Grasses have

been demonstrated to be one of the most consumed food resources for wild boar according to Schley and Roper (2003) and Lemel (1999).

4.1.3. Bush layers

Vegetation in *clusters* in the bush layers (Figure 6) was richer than at *random positions.* This is the case for plant species like common reed, grey willow, bracken *Pteridium aquilium* and alder buckthorn, which mainly grow in wet conditions. This could also indicate that wild boar uses wet areas with dense vegetation that gives good cover for e.g. breeding. Other dominant species are: wild raspberry, thistles *Cirsium* spp., blackthorn *Prunus spinosa*, hawthorns *Crataegus* spp., plants of European beech, Norway spruce and the group of birches (silver and downy birch, Figure 6), a finding in accordance with that reported by Dardaillon (1986). Furthermore, common juniper *Juniperus communis,* sycamore *Acer pseudoplatanus*, glaucous dog-rose *Rosa dumalis* and rowan *Sorbus aucuparia*, which were the only species to be richer at *random positions*. Therefore, common juniper is often found at open areas and such habitats might not provide a good shelter for wild boars. Sycamore stands at *random positions* in both the bush and the tree layers, and therefore this species does not seem to be a preferred plant species by wild boar, possibly because sycamore is a foreign species in Sweden (Mossberg & Stenberg, 2003).

4.1.4. Tree layers

In the tree layers at *wild boar positions* (Figure 7) there was more Norway spruce, Scots pine and European larch than at *random positions*, which could indicate that the wild boars are fond of scrub trees with resin. Furthermore, grey willow, alder buckthorn and alder all indicated a preference for wet areas. Blackthorn, hawthorn and European oak were more common in *clusters* in pastureland. Finally hornbeam and elm *Ulmus glabra* could be found at several places, and were also richer at *clusters*.

Sites with European oak and European beech are thought to be visited frequently by wild boar because of the production of mast by those species, and mast is an important food for wild boar (Henry & Conley, 1972; Groot Bruinderink *et al.*, 1994). Forests of European beech and hornbeam are in Poland the most frequently visited habitats by wild boar (Fonseca, 2008). However, in my study these tree species are more common at *random positions*, where European beech was significantly more common (Figure 7). The result could be explained by the fact that *random positions* in Deciduous forests like European beech woods were mostly located within the forest, while *clusters* often were located in the forest edge, and thus with smaller number of trees. Even silver and downy birch also grew more richly at *random positions* (although not significantly, Figure 7). As these tree species where richer at *clusters* in the bush layers then in tree layers, it could be interpreted as indicating that silver and downy birch are more preferred by wild boar as shoots than as grown trees.

The most common species in the vegetation analysis was Norway spruce which constituted about 35 % of the species in a test frame (at *wild boar positions*, Figure 7). Mixed forests with Norway spruce, silver and downy birch and Scots pine were preferred habitat in a study by (Lemel, 1999) and the reason could be that wild boar often prefers such habitats as resting sites (Boitani *et al.* 1994; Lemel, 1999). Lemel (1999) reported that in central Sweden wild boar often used young dense Norway spruce forests as resting sites and those old forests are preferred as foraging sites.

4.2. Shelter

Because the variable Shelter (Figure 8) was defined as nearby items like a hedge, a forest or a stone wall, the terrain types Deciduous forest and Coniferous and mixed forest were not in focus in this analysis, although both provide shelter.

The variable Shelter suggests that for the terrain type Open area all *wild boar positions* (*or clusters*) provide shelter (Figure 8). The result is a reflection of the bush layer and tree layer in terrain type Open area, which was also significant for the *clusters* in the vegetation analysis (Table 3). However, there was no difference between *wild boar positions* and *random positions* for the terrain type Agricultural land (Figure 8), but there was a difference within both the *wild boar positions* as well as the *random positions*, also for the terrain type Open area (Figure 8). According to Boitani *et al.* (1994) nocturnal activities are focused on foraging and travelling into pastures and cultivated areas. For the *clusters* studied in the terrain type Agricultural land the wild boar appeared more frequently in open fields without shelter (Figure 8), the effort of searching food in this type of field might be higher compared to visiting fields that also provides shelter. Also, because this study was concentrated on nocturnal activities, the item *wild boar, no shelter* (WP No S) showed a higher proportion than the options *wild boar, shelter* (WP S, Figure 8), and that the shelter is of less importance at night or that the crops itself gives shelter. These results are not fully in accordance with that reported by hunters, who report that the wild boars like to hide in the shade of e.g. trees at the full moon (pers. comm. Broberg, 2007; Tham, 2004).

4.3. Direct light on the ground and Humidity

Humidity is described in the literature as being of importance for the wild boars choice of habitats, especially presence of water, but this was not confirmed in my study. Surprisingly though, neither the variables Direct light on the ground (Figure 9) nor Humidity (Figure 10) showed a significant difference within matched pairs. A sow selects the site for her farrowing nest and the habitat during her lactation period to be located close to water (Fraser & Phillips, 1989). Furthermore, marshes are frequently used for many reasons, e.g. for food searching and for wallowing (Dardaillon, 1986). However, the variable Direct light on the ground might be difficult to interpret because during the field study this variable was observed in daylight but in the analyses were related to night-time activities of the wild boars. This might be the case for the variable Humidity as well. The intention was to test for a preference for wetter areas, as reported by Welander (2000) who noted more rooting activity by wild boar in damp soil. Wet and muddy places are apparently also good for wallowing activities (Dardaillon, 1986). Most of the *clusters* in the analysis were collected in autumn and winter (Table 1 – 4 in Appendix), i.e. when deciduous trees have lost their leaves and the weather conditions are quite wet. This certainly had an impact on the results, because the field observation where made in late summer when the trees were green and the weather quite dry, i.e. the wild boars might have less concern regarding wet conditions when it is wet and cold and subsequently do not to wallow as much.

4.4. Farrowing nests

Not surprisingly, a couple of farrowing nests were found in the study (Table 1 – 4 in Appendix). A wild boar sow delivers one to two litters per year (Tham, 2004), and thus clusters of GPS positions were created at the farrowing nest in this study. However, the assumption that a sow visits or stays in the nest for at least 20 positions per day, makes it

possible to misinterpret such a cluster of GPS positions, when it in fact could be positions of a site where the sow had taken shelter for some days as a result of hunting (Tham, 2004). The observed environments by the farrowing nests contained similar vegetation types, dense vegetation nearby water, as supported by Dardaillon (1986) and Fernandez-Llario (2004). The farrowing nests were often built of bracken, sedge *Carex* spp., soft-rush *Juncus effusus*, common reed or grass, depending on what were available in the sows' surroundings. By comparing GPS cluster with observations at that kind of study site, gives an opportunity to find farrowing nests (Table 1 & 3 in Appendix).

4.5. Feeding sites

In a study from central Sweden Lemel (1999) showed that only one-fifth of the stomach content from wild boars consists of natural source if supplementary food is available. My analysis suggests that feeding sites are of importance to wild boars, based on the fact that more than one-third of all observed clusters were feeding sites. The reason why most of these clusters are located in the area around the Christinehof estate is that different hunting teams managed their own supplementary feeding sites (pers. comm. Jonsson, 2008). At the Högestad estate the game manager uses a different hunting method, where the wild boars get supplementary food only about one month before the start of the hunting period (pers. comm. Jonsson, 2008). In my study area manmade feeding sites with supplementary food present were abundant and found mainly in forested areas. Thus, in my field study different groups of wild boar could use the same shelter while they were waiting for it to be safe to enter the feeding sites. One reason for this might be that they sometimes seem to use the same track to get there and that the shelter site often also provides suitable scrub trees. These observations in the field were supported by Broberg (pers. comm., 2007), Söderberg (pers. comm., 2008) and by Tham (2004).

4.6. Quality aspects of the data set and further studies

When interpreting the results, one must consider that GPS technology can fail, missing some positions in dense cover completely, or recording positions more than about 10 m from the true location (Dettki *et al.*, 2004; Visscher, 2006). The topographic maps used for the GIS approach were about 10 years old and did not always correspond to the present situation. To make the study possible, I assumed that the vegetation at a location is the same at the time of the field study and at the time of wild boar´s visit. This might not have been the case because the field study was not preformed immediately after the GPS positions were collected. This is something that could be improved in a repeat of this study. Further studies could for example include variables like pH, different soil types and study the same individuals during a whole year. A bigger sample size would also be preferable because my study had just 34 matched pairs in the analysis. Collected GPS coordinates from wild boars, such as those in this study, give many opportunities to further studies to improve wild boar management. It would be interesting to observe clusters of farrowing nests and feeding sites to improve knowledge of the importance of the surroundings and their effects on the wild boar as well as other animal species. Also to further analysis the other clusters (that have been used during a long period of time) that not included farrowing nests and feeding sites would be of great interest. Additional suggestions for further research projects would be to observe the wild boars reaction to different kind of hunting activities. The GPS positions tell us that wild boars can move several miles away from the ordinary home ranges after hunting and stay there for a period before returning. In this project some of the wild boars were killed by cars on their way back from such temporary areas. Such observations are supported by Söderberg (pers. comm., 2008). Thus traffic

accidents in relation to hunting activities would also be a relevant and important research project.

4.7. Conclusions

Results from this study show that wild boars in the southernmost part of Sweden prefer habitats that provide shelter with bushes and trees even when visiting open areas e.g. pasture land. In the study area the wild boars showed a preference for the terrain type Coniferous and mixed forest, which contained dense Norway spruce and mixed forests which provide excellent shelter for the wild boar. The low utilization of European oak and beech forests compared to studies in other European countries might be explained by the lower proportion of these forest types and/or the effect of seasonal variation.

Wild boars prefer wet and shady sites for various activities (Blasetti *et al.*, 1988). Although mosses and wood-sorrel in the ground layers (species that might be able to indicate this conditions) in my study were not in accordance with these previous observations, other aspects in my and other studies indicate the wild boars' preference by for wet and shady sites.

The frequent use of supplementary food at feeding sites in the study area was supported in this study, as more than one third of clusters of GPS positions of wild boars were caused by visits to feeding stations created by hunters for wild boars.

Hopefully the results of studies on the wild boar population could be utilized to improve research and wildlife management. Also, it has perhaps highlighted the need for further studies of wild boars in Sweden, as well in other countries.

5. Acknowledgements

I would like to thank Earl Carl Piper who gave us the opportunity to perform this study at the estate of Christinehof and Högestad, and to Andreas Jonsson, Håkan Lindgren and other employees at the estate who supported me during my field work. Thanks also to my supervisors Kjell Sjöberg and Henrik Thurfjell at SLU in Umeå, who guided me through the work with advice and support, and allowed me to take part in the ongoing wild boar project. I am also thankful to the personnel at *The Swedish Board of Agriculture* who found time to answer me questions – answers which have been of great importance and value for my study. Many thanks also to Göran Adelsköld, environmental analyzer in GIS at SLU in Uppsala. Further gratitude goes to my father Lennart Broberg. With his enthusiasm and knowledge he has been an important resource for me during discussions about wild boars. Two other persons important for my work were Bo Söderberg, with his deep knowledge about the wild boar, and Åke Lindelöw at SLU in Uppsala, expert on insects. At last but not least many thanks to all my friends, especially Hedvig Åkesson and Bodil Lindström, who have supported me through the work with this thesis. It has been worth all effort and for me it is hopefully just the start to find more knowledge about management aspects of wild boars in Sweden.

6. References

Anderberg, A. and Anderberg, A-L. http://linnaeus.nrm.se/flora/ 080920. Den virtuella floran. The Swedish Museum of Natural History. (In Swedish)

Baubet, E., Ropert-Coudert, Y. and Brandt, S. 2003. Seasonal and annual variations in earthworm consumption by wild boar (*Sus scrofa scrofa* L.). - Wildlife Research 30: 179-186.

Blasetti, A., Boitani, L., Riviello, M.C. and Visalberghi, E. 1988. Activity budgets and use of enclosed space by wild boars (*Sus scrofa*) in captivity. - Zoo Biology 7: 69-79.

Bengtsson, G., Jensen, P-E., Karlsson, B., Meirik, M., Mörner, T. and Wirdheim, A. 2004. Nya jägarskolan - viltet. Jägareförlaget/Svenska Jägareförbundet. Kristianstads boktryckeri AB, Kristianstad. (In Swedish)

Boitani, L., Mattei, L., Nonis, D. and Corsi, F. 1994. Spatial and activity patterns of wild boars in Tuscany, Italy. - Journal of Mammalogy 73 (3): 600-612.

Cocca, G., Sturaro, E., Dal Compair, L. and Ramanzin, M. 2007. Wild boar (*Sus scrofa*) damage to mountain Grassland. A case study in the Belluno province, eastern Italian Alps. - Italian Journal of Animal Science 6 (Suppl. 1): 845-847.

Company presentation Högestad and Christinehof joint-stock company. 2004. Att leva av landskapet. En presentation av jord- och skogsbruksföretaget Högestad & Christinehof Förvalting AB. (In Swedish)

Dardaillon, M. 1986. Seasonal variations in habitat selection and spatial distribution of wild boar (*Sus scrofa*) in the Camargue, Southern France. - Behavioural Processes 13: 251-268.

Dellmeier, G.R. and Friend, T. H. 1987. Behavior of sows farrowing on unmaintained pasture. - Journal of Animal Science 63 (Supplement 1): 168.

Dettki, H., Ericsson, G. and Edenius, L. 2004. Real-time moose tracking: An internet based mapping application using GPS/GSM-collars in Sweden. - ALCES 40: 13-21.

(ESRI) Environmental Systems Research Institute. 2005. ArcMap 9.1. Environmental Systems Research Institute Incorporated, Redlands, California, USA.

Fernández-Llario, P. 2004. Environmental correlates of nest site selection by wild boar *Sus scrofa*. - Acta Theriologica 49 (3): 383-392.

Focardi, S., Capizzi, D. and Monetti, D. 2000. Competition for acorns among wild boar (*Sus scrofa*) and small mammals in a Mediterranean woodland. - Journal of Zoology, London 250: 329-334.

Fonseca, C. 2008. Winter habitat selection by wild boar *Sus scrofa* in southeastern Poland. - European Journal of Wildlife Research 54: 361-366.

Fraser, D. and Phillips, P.A. 1989. Lethargy and low water intake by sows during early lactation: a cause of low piglet weight gains and survival? - Applied Animal Behaviour Science 24: 13-22.

Förare, J. www.jagarforbundet.se/viltvetande/artpresentation/vildsvinstammen.asp. 080516 The Swedish Association for Hunting and Wildlife Management. (In Swedish)

Gerard, J-F., Cargnelutti, B., Spitz, F., Valet, G. and Sardin, T. 1991. Habitat use of wild boar in a French agroecosystem from late winter to early summer. - Acta Theriologica 36 (1-2): 119-129.

Groot Bruinderink, G.W.T.A., Hazebroek, E. and Van der Voot, H. 1994. Diet and condition of wild boar, *Sus scrofa scrofa*, without supplementary feeding. - Journal of Zoology, London 233: 631-648.

Hallingbäck, T., Lönnell, N., Weibull, H., Hedenäs, L. and von Knorring, P. 2006. Nationalnyckeln till Sveriges flora och fauna, Bladmossor: sköldmossor – blåmossor. Bryophyta: Buxbaumia – Leucobryum. Artdatabanken, SLU, Uppsala. Ruter Media Group. Laholm. (In Swedish)
Henry, V. G. and Conley, R. H. 1972. Fall foods of European wild hogs in the Southern Appalachians. - Journal of Wildlife Management 36 (3): 854-860.
Herrero, J., García-Serrano, A., Couto, S., Ortuño, V. M. and García-González, R. 2006. Diet of wild boar *Sus scrofa* L. and crop damage in an intensive agroecosystem. - European Journal of Wildlife Research 52: 245-250.
Howe, T. D. and Power Bratton, S. 1976. Winter rooting activity of the European wild boar in the Great Smoky Mountains National Park. - Castanea 41 (3): 256-264.
Jensen, P. 1986. Observations on the maternal behavior of free-ranging domestic pigs. - Applied Animal Behaviour Science 16: 131-142.
Krok, Th.O.B.N. and Almquist, S. 2003. Svensk flora – fanerogamer och ormbunksväxter. 28th ed. Liber AB. Elanders Gummessons. Falköping. (In Swedish)
Lantmäteriverket. 2005. Organization number: 202100-4888. Gävle. (In Swedish)
Lemel, J. 1999. Populationstillväxt, dynamik och spridning hos vildsvinet, *Sus scrofa*, i mellersta Sverige. - Final report, The Swedish Association for Hunting and Wildlife Management, Uppsala. (In Swedish)
Liljelund, L. E. and Pettersson, C. 2007. Redovisning av regeringens uppdrag ifråga om förvaltning av vildsvin m.m. The Swedish Environmental Protection Agency. Dnr 412-5130-06. (In Swedish)
Massei, G. and Genov, P. V. 2004. The environmental impact of wild boar. - Galemys 16: 135-145.
Microsoft. 2007. Microsoft Office Excel. Microsoft Corporation, Redmond, Washington, USA.
Mossberg, B. and Stenberg, L. 2003. Den nya nordiska floran. 2nd ed. Wahlström & Widstrand. PDC Tangen. Norway. (In Swedish)
Purger, J .J. and Mészáros, L. A. 2006. Possible effects of nest predation on the breeding success of Ferruginous Ducks Aythya nyroca. - Bird Conservation International 16: 309-316.
Rosvold, J. and Andersen, R. 2008. Wild boar in Norway - is climate a limiting factor? - Norges teknisk-naturvitenskapelige universitet, Vitenskapsmuseet. - Rapport Zoologisk Serie 2008 1: 1-23.
Schmidt, M., Sommer, K., Kriebitzsch, W-U., Ellenberg, H. and Von Oheimb, G. 2004. Dispersal of vascular plants by game in northern Germany. Part I: Roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). - European Journal of Forest Research 123 (2): 167-176 (10).
Schley, L. and Roper, T. J. 2003. Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. - Mammal Review 33 (1): 43-56.
Siegel, S. and Castellan, N. J. 1988. Nonparametric Statistics for the Behavioral Sciences, 2nd edition. McGraw-Hill Book Company. New York.
Singer, F.J., Swank, W.T. and Clebsch, E.E.C. 1984. Effects of wild pig rooting in Deciduous forest. - Journal of Wildlife Management 48 (2): 464-473.
Tham, M. 2004. Vildsvin - beteende och jakt. Bokförlaget Prisma, Stockholm. (In Swedish)
The Swedish Board of Agriculture. 2004-2006. Blockdatabasen. (In Swedish)
Visscher, D. R. 2006. GPS measurement error and selection functions in a fragmented landscape. - Ecography 29: 458-464.

Wilson, C.J. 2004. Rooting damage to farmland in Dorset, southern England, caused by feral wild boar *Sus scrofa*. Mammal Society, - Mammal Review 34 (4): 331-335.
Welander, J. 2000. Spatial and temporal dynamics of wild boar (*Sus scrofa*) rooting in a mosaic landscape. - Journal of Zoology, London 252: 263-271.
Wood, G. W. and Roark, D. N. 1980. Food habits of feral hogs in coastal South Carolina. - Journal of Wildlife Management 44 (2): 506-511.

6.1. Personal communications

Broberg, Lennart. 2007-2008. Hunter, Fastighet AB Brobo. Höör.
Jonsson, Andreas. 2008. Game manager, Högestad & Christinehof Förvalting AB. Ystad.
Söderberg, Bo. 2008. Biologist and hunter, Company - Viltteknik. Jönåker.

7. Appendix

Table 1. Wild boar positions within the terrain type **Deciduous forest**. The cluster number, year and date of visits, number of visiting days, total number of visits all nights together and visits per night. # = Farrowing nest

Cluster number	Year	Date	Number of days	Total number of visits, nights	Number of visits per night
38 Ml 1008	2005 - 2006	25/12 - 3/2	41	415	10,12
75 B 977	2004	20/8 - 19/9	31	297	9,58
3 Mk 1474	2005	19/10 - 29/10	11	236	21,45 #
49 Le 1475	2005 - 2006	1/8 - 20/3	232	148	0,64
65 Ca 1007	2004 - 2005	8/11 - 4/2	89	29	0,33
113 Aa 1472	2005	4/10 - 27/11	55	9	0,16
21 Mi 1473	2005	26/10 - 11/11	17	6	0,35
82 Ae 1482	2005	26/10 - 8/11	14	5	0,36

Table 2. Wild boar positions within the terrain type **Coniferous and mixed forest**. The cluster number, year and date of visits, number of visiting days, total number of visits all nights together and visits per night.

Cluster number	Year	Date	Number of days	Total number of visits, nights	Number of visits per night
88 Ae 1482	2005 - 2006	2/9 - 14/3	155	497	3,21
64 Ca 1007	2004 - 2005	13/10 - 6/2	117	457	3,91
62 Ch 1476	2006	20/1 - 11/2	23	349	15,17
36 Mt 1010	2004 - 2005	15/10 - 11/2	120	115	0,96
46 Le 1475	2005 - 2006	1/11 - 21/3	141	76	0,54
136 Ad 1478	2005 - 2006	30/12 - 10/1	12	74	6,17
5 Mk 1474	2005	14/7 - 14/10	93	55	0,59
56 K 1008	2004	26/10 - 16/11	22	27	1,23
109 Aa 1472	2005	5/10 - 30/11	57	9	0,16

Table 3. Wild boar positions within the terrain type **Open area**. The cluster number, year and date of visits, number of visiting days, total number of visits all nights together and visits per night. # = Farrowing nest

Cluster number	Year	Date	Number of days	Total number of visits, nights	Number of visits per night
59 Ch 1476	2005 - 2006	4/6 - 14/2	202	755	3,74
84 Ae 1482	2005 - 2006	23/9 - 4/5	224	374	1,67
127 Ad 1478	2005	25/11 - 2/12	8	248	31,00 #
22 Mi 1473	2005 - 2006	25/7 - 3/2	194	164	0,85
54 K 1008	2004	6/11 - 21/11	16	128	8,00
28 Mt 1010	2005	27/1 - 21/2	26	66	2,54
39 a Ml 1008	2006	5/2-7/2	3	55	18,33 #
112 Aa 1472	2005	9/9-12/11	65	18	0,28
79 B 977	2004	12/8-13/9	33	14	0,42

Table 4. Wild boar positions within the terrain type **Agriculture land**. The cluster number, year and date of visits, number of visiting days, total number of visits all nights together and visits per night.

Cluster number	Year	Date	Number of days	Total number of visits, nights	Number of visits per night
63 Ca 1007	2004 - 2005	6/10 - 7/2	125	300	2,40
126 Ad 1478	2005	12/11 - 3/12	22	248	11,27
24 Mi 1473	2005	10/7 - 22/12	135	190	1,41
42 Lo 975	2004 - 2005	15/12 - 15/1	32	113	3,53
11 Mk 1474	2005	14/6 - 4/10	83	30	0,36
83 Ae 1482	2005 - 2006	10/9 - 29/4	232	17	0,07
80 B 977	2004	10/9 - 18/9	9	11	1,22
100 Aa 1472	2005	20/11 - 5/12	16	9	0,56

7.1. Glossary

Nomenclature according to Krok & Almquist, 2003; Hallingbäck *et al.*, 2006; Anderberg, 2007

English	Latin	Swedish
Alder	*Alnus glutinosa*	Klibbal
Alder buckthorn	*Frangula alnus*	Brakved
Aspen	*Populus tremula*	Asp
Barley	*Hordeum vulgare*	Korn
Bilberry	*Vaccinium myrtillus*	Blåbär
Blackthorn	*Prunus spinosa*	Slån
Bracken	*Pteridium aquilinum*	Örnbräken
Broad-leaved grasses	*Calamagrostis* spp.	Gräs (släkte, Rör)
Clover	*Trifolium* spp.	Klöver (släkte)
Common juniper	*Juniperus communis*	En
Common nettle	*Urtica dioica*	Brännässla
Common reed	*Phragmites australis*	Vass
Corn spurrey	*Spergula arvensis*	Åkerspärgel
Cowberry	*Vaccinium vitis-idaea*	Lingon
Crab-apple	*Malus sylvestris*	Vildapel
Cryptogam	*Tracheophyta*	Kärlkryptogamer (ordning)
Dandelion	*Taraxacum* spp.	Maskrosor (släkte)
Downy birch	*Betula pubescens*	Glasbjörk
Elm	*Ulmus glabra*	Alm
European beech	*Fagus sylvatica*	Bok
European larch	*Larix deciduas*	Lärk
European oak	*Quercus robur*	Ek
European silver-fir	*Abies alba*	Silvergran
Field bindweed	*Convolvulus arvensis*	Åkervinda
Field pansy	*Viola arvensis*	Åkerviol
Forage crop	-	Vallgröda
Glaucous dog-rose	*Rosa dumalis*	Nyponros
Goat willow	*Salix caprea*	Sälg
Grass	*Poaceae*	Gräs (familj)
Grey willow	*Salix cinerea*	Gråvide
Hart truffle	*Elaphomyces* spp.	Hjorttryffel (släkte)
Hawthorn	*Crataegus* spp.	Hagtorn (släkte)

Hazel	*Corylus avellana*	Hassel
Hemp-agrimony	*Eupatorium cannabinum*	Hampflockel
Hornbeam	*Carpinus betulus*	Avenbok
Horsetail	*Equisetaceae*	Fräken (familj)
Ley	-	Fodervall (artblandning)
Lucerne	*Medicago* spp.	Lucern (släkte)
Meadowsweet	*Filipendula ulmaria*	Älggräs
Mosses	*Bryophyta & Marchantiophyta*	Blad- & Levermossor (klass)
Norway spruce	*Picea abies*	Gran
Rapeseed	*Brassica napus* ssp. *oleifera* *B. rapa* ssp. *oleifera*	Raps Ryps
Redshank	*Persicaria maculosa*	Åkerpilört
Rowan	*Sorbus aucuparia*	Rönn
Rye	*Secale cereal*	Råg
Scots pine	*Pinus sylvestris*	Tall
Sedge	*Carex* spp.	Starr (släkte)
Silver birch	*Betula pendula*	Vårtbjörk
Small balsam	*Impatiens parviflora*	Blekbalsamin
Soft-rush	*Juncus effusus*	Veketåg
Sorrel & dock	*Rumex* spp.	Syra & skräppa (släkte)
Sugar beet	*Beta vulgaris*	Sockerbeta
Sycamore	*Acer pseudoplatanus*	Tysklönn
Thistle	*Cirsium* spp.	Tistlar (släkte)
Triticale	*Triticosecale*	Rågvete
Upright hedge-parsely	*Torilis japonica*	Rödkörvel
Wheat	*Triticum aestivum*	Vete
Wild raspberry	*Rubus idaéus*	Vildhallon
Wood-sorrel	*Oxalis acetosella*	Harsyra