Sveriges lantbruksuniversitet
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Abstract

The hunting dogs have increased in Sweden during the last thirty years, in total number of dogs and in number of hunting dog breeds. There has been a shift in the breed composition, new hunting methods and new game species that have resulted in more hunting opportunities which have brought new breeds of hunting dogs to Sweden. By studying forty-eight breeds of hunting dogs and seven game species in Sweden the results show significant relationships between the hunting dog breeds and the game species populations. The most interesting result is the rapid increase of wild boar population in southern Sweden, where they show a strong synergistic pattern with the hunting dog breeds. The results also show that the increase of the ungulate populations increases the abundance of blood tracking hounds. For future wildlife management, assumptions of an increasing game population are needed to be managed to prevent damage on agriculture, forestry and traffic accident. One suggested method to prevent those damages is to hunt, of which the hunting dog breeds are in highest importance for efficiency.

Sammanfattning

Under de senaste trettio åren har jakthundarna i Sverige ökat i det totala antalet jakthundar och i antal jakthundsraser. Det har genomgåtts en förändring i användandet från de traditionella jakthundsraserna till nya raser från Europa och Nordamerika. Nya jaktbara viltarter och jaktmetoder har tagit plats i den svenska jakten, vilket också har medfört fler jakthundsraser. Efter att ha studerat fyrtioåtta jakthundsraser och sju viltarter kopplade till dessa, har prediktionerna testats och gett signifikanta resultat att jakthundarnas antal är styrda av viltarterna. Mest intressant är den starka samvariationen i Söder- och Mellansverige mellan populationen av vildsvin och jakthundarna. Resultatet visar även att de stora populationerna av klövvilt samvarierar med en ökning av antalet eftersökshundar. För en framtida viltförvaltning, med utmaningar att reducera skador i lant- och skogbruket och trafikskador, orsakande av en ökande viltstam, kommer jakten vara en användbar metod i vilket jakthundarnas kompetens kommer att vara ovärderlig.

Introduction

Nature and wildlife have always been important values in Sweden with hunting being an essential way of surviving (Lindqvist et al., 2014). Today the role of hunting has changed from being a resource of meat to becoming an important aspect of recreation and wildlife management (Lindqvist et al., 2014). The hunting dog has a strong connection to our Swedish hunting system and to the Swedish hunter (Christoffersson, 2004) and there are over 95 different breeds of hunting dogs registered in the country (SKC, 2014). The number of hunted game is larger in Sweden today than ever before in modern times (Danell & Bergström, 2010). This is explained by a high number of different game species and that those are present in large populations (Milner et al., 2006, Ezebilo et al., 2012, Jarnemo & Wikenros, 2013, SAHWM, 2013 & Swedish EPA, 2014b). Introductions of new game species, reintroductions of extinct game species and a wildlife management that promotes game species are some reasons (Milner et al., 2006, SAHWM, 2013, Lindqvist et al., 2014) for this. With increasing populations of game species the development of hunting dogs is an interesting topic to study, as hunting dogs are required for different types of hunting methods (Danell & Bergström, 2010, Jaktförordningen, 1987). Next to its functional use, hunting dogs often share a strong friendship with the Swedish hunter (Christoffersson, 2004). More hunting days each year, due to a higher number of game species, may lead to an increase of hunting dogs and hunting dog breeds in Sweden.

Hunting culture in Sweden

The hunting culture has an old history in Sweden and the wildlife management is an essential part of the nature conservation (SAHWM, 2015a). All game species are protected by law during the whole year (Jaktförordningen, 1987), with hunting allowed during set periods (SAHWM, 2014). The game species populations are managed by the Swedish hunters which are delegated to follow the laws of the hunting system set by the Swedish government, Swedish Environmental Protection Agency and the 21 County Administrative Boards (Jaktförordningen, 1987, Swedish EPA, 2014a).

Today, there are approximately 300,000 Swedish hunters (Swedish EPA, 2014c). The average hunter is a man and a member in a hunting- and management organisation (Danell & Bergström, 2010), for example the Swedish Association for Hunting and Wildlife Management, an organization which had 155,428 members in the hunting season 2013-2014 (Schnakenburg, 2015). The number of female hunters has increased during the last years, but numbers are still low: at the hunting season 2012-2013, 6 % of the Swedish hunters were female (Svensk Jakt, 2013a). In average, the hunter spends more than 20 days hunting per year (Boman & Mattson, 2012). Approximately 40 % of the hunters are also owners of a hunting dog, which can be explained by tradition and the Swedish hunting legislation, which demands a retriever and blood tracking dog for ungulate and bird hunts (Danell & Bergström, 2010, Jaktförordningen, 1987).

Game species populations

Sweden has a rich fauna due to the biotic and abiotic north-south-gradient (Brännström, 1998). There is a difference in the variety of game species and different population sizes of the game species between the different areas of the country (SAHWM, 2014). Ungulates are highly appreciated among the hunters, but they also cause big damage to agriculture and forestry (Magnusson, 2010, Ezebilo et al., 2012, Månsson & Jarnemo, 2013, Wallgren et al., 2013). Small game such as birds, hares (*Lepus timidus and Lepus europaeus*) and foxes (*Vulpes vulpes*) have a higher recreational value rather than being hunted for consumption, for example moose (*Alces alces*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and wild boar (*Sus scrofa*) (Brännström, 1998, Grubbström, 1989). Also the large carnivores such as lynx (*Lynx lynx*) and bear (*Ursus actos*) are today allowed to be hunted which increases hunting opportunities (Swedish EPA, 2014a).

Moose is the game representing the symbol of the Swedish hunting (Lindqvist et al., 2014), which is not surprising since Sweden has one of the highest population density in the world (Ezebilo et al., 2012). It has been a popular game species in the whole country throughout the Swedish history (Boman et al., 2011, Lindqvist et al., 2014). Red deer and fallow deer have increased in the last decades (Milner et al., 2006). In the south and middle part of Sweden, the populations of red deer, fallow deer and wild boar have rapidly increased and created new opportunities for hunting with new methods and new hunting dog breeds (Jarnemo & Wikenros, 2013). The population of wild boar is increasing incredible fast in Sweden and spreading from the south into a northern direction, causing problem such as agricultural damage and traffic accidents (SAHWM, 2013, Schön, 2013). This increasing trend of wild boar population can be seen in national harvest data and has created many new hunting opportunities for the hunters, but it has also brought new thoughts and considerations of hunting safety for both hunters and hunting dogs (Magnusson, 2010, SAHWM, 2012a).

Since humans started to hunt game and keep livestock, there has always been and still is an ongoing conflict with the large carnivores (Large Carnivore Centre, 2004, Bjärvall, 2007). In Scandinavia bear, lynx, wolverine (*Gulo gulo*) and wolf (*Canis lupus*) have been the big actors in this conflict and during history, political management control measures have driven these population to a severe decline and even extinction of wolves. Bear is one of the large carnivores that have recovered after the intense hunt (Swenson et al., 1995). Today, they are so abundant that they are considered to be a game species and are hunted in the counties of Norrbotten, Västerbotten, Jämtland, Västernorrland, Gävleborg, Dalarna and Värmland (Swedish EPA, 2014b). Forest grouse capercaillie (*Tetrao urogallus*) and black grouse (*Tetrao tetrix*) are two of the few game species that are decreasing (Danell & Bergström, 2010). The dominating factor causing the declining of these populations on national level is the development of the industrial forestry (Åhlen et al., 2013). Intense hunt is however also a contributory explanation (Åhlen et al., 2013).

Hunting dog breeds

The domestication of the dog (*Canis famailiaris*) from its ancestor wolf (*Canis lupus*) occurred in East Asia (Braude & Gladman, 2013) and the earliest dog remains have been dated to 12,000 and 31, 000 years ago (Germonpré et al. 2009). Humans have used the dog in many different fields and actively chosen behaviors and traits that were appropriate for certain tasks. These choices have led to the development of different breeds (Huson, 2012). Today, dogs are well accepted in the Swedish society and used as military working dogs, law enforcement dogs, search and rescue dogs, service dogs, therapy dogs, sledge dogs, farm dogs and hunting dogs (Huson, 2012). They also fulfil the role of a family member which is indicated by the fact that approximately one eighth of households own a dog in Sweden (Bendz, 2007). The popularity of different breeds has changed throughout history and today Sweden has more than 400 dog breeds registered by the Swedish Kennel Club (SKC, 2012), 95 of those are classified as hunting dog breeds (SKC, 2014) and nine of them are originating from Sweden (SCK, 2014a).The hunting dog breeds mainly originate from European countries, which have a long tradition of using hunting dogs (Andersson, 1996, Brännström, 1998, Christoffersson, 2004, Tham, 2004, Pedersen, 2006), in Sweden national and international breeds are widely used (Christoffersson, 2004).

A review of the scientific literature shows the dog to be well-studied. Much is known about the history and domestication of the dog (Germonpré et al. 2009, Kropatsch et al., 2011, Braude & Gladman, 2013), health and diseases (Fung et al., 2014, Pasquini et al., 2010), genetics and breeding (Brenøe et al., 2002, Lindberg et al., 2004, Leroy et al., 2009, Kropatsch et al., 2011, Leroy, 2011, Arvelius & Klemetsdal, 2013, Arvelius et al., 2013, Llewellyn, 2014) and the use of the dog in human society (Bendz, 2007, Huson, 2012). Many books, scientific articles and magazines focus on the description of traits and the use of the hunting dog breeds today (Kerbs, 1965, Andersson, 1996, Brännström, 1998, Christiansen et al., 2001, Christoffersson, 2004, Tham, 2004, Pedersen, 2006, Dahlström, 2012, The Field, 2014, SCK, 2015, Svensk jakt, 2015, Wild und Hunde, 2015). The use of hunting dogs also negatively affect wildlife populations by disturbance, which is well studied in several European countries (Casas et al., 2009, Neumann et al., 2009, Brøseth & Pedersen, 2010, Grignolio et al., 2011, Saïd et al., 2012, Jarnemo & Wikenros, 2013). However, I did not find any scientific literature about relations between the game species population, and the abundances of hunting dogs. An increase of game species populations may lead to an increase of hunting dogs and hunting dog breeds in Sweden, which leads to my aims and predictions.

Aims and predictions

The first aim is to investigate if there have been an increase in the abundance of hunting dogs and an increase in the number of hunting dog breeds in Sweden. I predict (A) that there have been increases in abundance of hunting dogs and in number of hunting dog breeds in the last decades due to more game. In accordance with that, I further predict that (B) there are more hunting dog breeds in the south than in the north, because there is a higher number of game species in the south than in the north.

The second aim is to detect if there is a relation between the abundance in hunting dogs and the abundance in game species population. I predict that (C) there is a relation between the hunting dogs and the game species populations, out of which the game species populations are the independent variable.

Materials and methods

Study area

The study covers Sweden, which is a long country stretching in north-south direction over Scandinavia (from 69° N, 20° E to 55° N, 13° E). It consists of 57 % productive forest land, 13 % high mountains, 12 % mires, 7 % arable land and 3 % urban land (Nilsson et al., 2014). The northern part is dominated by forest, high mountains and mires, while the middle and southern parts are dominated by urban and arable land (Nilsson et al., 2014).

I grouped 21 studied counties into four regions: North of Norrland (Region 1), South of Norrland (Region 2), Svealand (Region 3) and Götaland (Region 4), shown in *Figure 1* and *Table 1*, motivated by the distribution of the game species populations, legislation of the hunting periods of the game species, institutional role of the county boards and geographic proportion of the land area.

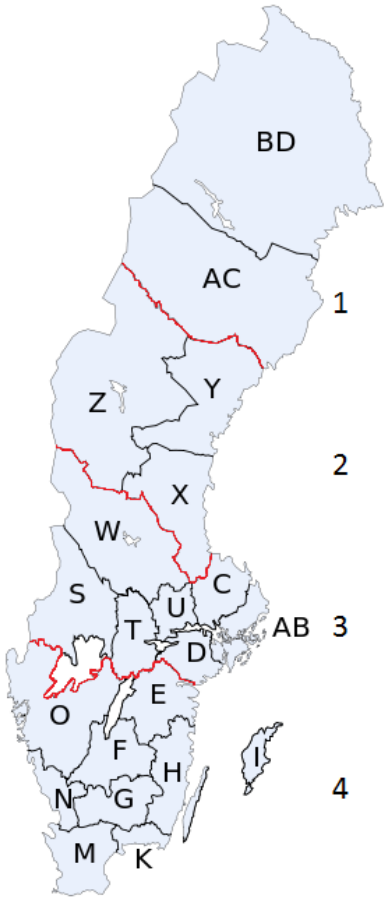

Figure 1. Map of Sweden's counties, marked with ID letters. The red line shows the border between the four Regions chosen to study.

The distributions of the game species populations judging from harvest data are different in the four regions. Some of the game species are distributed throughout the whole country, while others are only present in certain areas. Moose is distributed throughout the whole country except for the county of Gotland (SAHWM, 2015b). Red deer are distributed throughout all counties of Sweden except of the counties of Norrbotten and Gotland (SAHWM, 2012h). Fallow deer are distributed in the southern part of Sweden, mainly in Region 4 and Region 3 (IUCN, 2014). Wild boar is located in the southern counties, mainly in Region 4 but is spreading northeast along the coast to Region 3 (SAHWM, 2013, Schön, 2013). Bear is located in the seven northern counties, in Region 1, Region 2 and in the counties of Dalarna and Värmland (SAHWM, 2012e). Capercallie and Black grouse have their distribution range in Region 1, Region 2 and Region 3 (SAHWM, 2012g, SAHWM, 2012f).

The hunting periods differ for different game species depending on the geographic location in the country (SAHWM, 2014). Open and closed seasons for hunting moose have two geographic divisions. One northern hunting area and one southern hunting area, the border is in the counties of Värmland, Dalarna and Gävleborg (SAHWM, 2014). In which the hunting seasons differ time wise from each other. Open and closed seasons for hunting red deer have two geographic divisions. One hunting period is specific for the county of Skåne, and one hunting period for the rest of the country (SAHWM, 2014). Open and closed seasons for hunting fallow deer have two geographic divisions. One hunting period for the area which include the counties of Örebro, Södermanland, Östergötland, Kalmar, Västra

Götaland and Skåne, and one hunting period for the rest of the country (SAHWM, 2014). Open and closed seasons for hunting wild boar has one hunting period throughout the whole country (SAHWM, 2014). Bear is only allowed to be hunted in Region 1, Region 2 and the counties of Dalarna and Värmland (SAHWM, 2014, Swedish EPA, 2014b). Open and closed seasons for hunting capercallie and black grouse have three geographic divisions, with the borders of Region 3 and Region 4. In which the hunting seasons differ time wise from each other (SAHWM, 2014).

The use of counties for geographic classification is connected to the institutional role of the county boards, which are obligated by the Swedish EPA to be the responsible organ for game management in each county (Jaktförordningen, 1987, CAB, 2015). The county boards regulate hunting permission and the opening of hunting periods in the counties (Jaktförordningen, 1987). They are also in charge of the management plans in the counties, affecting moose, red deer, bear, wolf, lynx, golden eagle (*Aquila chrysaetos*), great cormorant (*Phalacrocorax carbo carbo*) and wild boar (Swedish EPA, 2013, Swedish EPA, 2014a, Swedish EPA, 2014d). Those management plans have the purpose to include all stakeholders in the hunting unit and to fulfil agreements and goals regarding the different game species (Swedish EPA, 2014a).

In my study the counties of Sweden are divided into the four regions which are useful for detecting if there are any regional changes of the use of the functional groups of hunting dogs and how they are affected by the game species populations.

Table 1. *The 21 counties of Sweden ordered by Region ID, Region, County, County ID and Game species hunted in the county (SAHWM, 2013)*

Region ID	Region	County	County ID	Game species
1	North of Norrland	Norrbotten	BD	Moose, Bear, Capercallie, Black Grouse
1	North of Norrland	Västerbotten	AC	Moose, Red deer, Bear, Capercallie, Black Grouse
2	South of Norrland	Västernorrland	Y	Moose, Capercallie, Black Grouse, Bear
2	South of Norrland	Jämtland	Z	Moose, Capercallie, Black Grouse , Red deer, Bear
2	South of Norrland	Gävleborg	X	Moose, Red deer, Bear, Capercallie, Black Grouse
3	Svealand	Stockholm	AB	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
3	Svealand	Uppsala	C	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
3	Svealand	Västmanland	U	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
3	Svealand	Dalarna	W	Moose, Red deer, Fallow deer, Bear, Capercallie, Black Grouse
3	Svealand	Södermanland	D	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
3	Svealand	Örebro	T	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
3	Svealand	Värmland	S	Moose, Red deer, Fallow deer, Bear, Capercallie, Black Grouse
4	Götaland	Östergötland	E	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Jönköping	F	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Västra Götaland	O	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Gotland	I	n/a
4	Götaland	Kalmar	H	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Kronoberg	G	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Halland	N	Moose, Red deer, Fallow deer, Wild boar, Capercallie, Black Grouse
4	Götaland	Blekinge	K	Moose, Red deer, Fallow deer, Wild boar
4	Götaland	Skåne	LM	Moose, Red deer, Fallow deer, Wild boar

Data collection and categorizing of data

Data collection

To test my predictions (A, B and C) I have collected data of hunting dog breeds and the game species populations.

The data of hunting dog breeds are collected by the Swedish Kennel Club, which is the largest organization for dog owners in Sweden. I collected 95 breeds of hunting dogs from the time period 1977 to 2014. The register consists of numbers of individuals from a hunting dog breed, which are owner registered, including which county and year. Important to mention is that dog owner registrations are not mandatory in Sweden.

The game species population data is collected by the Wildlife Monitoring section of the Swedish Association for Hunting and Wildlife Management (SAHWM). Since there are harvest data for all my studied game species, except bear, for over fifty years (1960 until 2013), I used harvest data as an indicator to estimate population sizes. This is a valid method for estimating population size of game species, for example for ungulates and bears (Bender & Spencer, 1999, Sutherland, 2006, Davis et al., 2007, Kindberg et al., 2009). The data consists of harvest data, on both national- and county level. The harvest data for bear were collected from the Swedish National Veterinary Institute´s website (SNVI, 2014).

The harvest data from the SAHWM was completed during the whole time period, except the harvest data for moose, which was missing in the year 2001. Harvest data for bear had a shorter time period, compared to the other studied game species as bear harvest is only allowed from 2004 and on for the seventh northern counties of Sweden (Swedish EPA, 2014a, Swedish EPA, 2014b). The data are divided into two different time periods, 1977-2003 and 2004-2013, with the aim to test if there has been a change in the group of hunting dogs that are hunting bear after the new rules of hunting bear year 2004.

Categorization of data

By using the information from the Swedish Kennel Club (SKC, 2014a) and SAHWM 2012b, I used a combination of their two classifications of hunting dog groups, to be able to cover all hunting dog breeds in Sweden. This resulted in eleven different functional groups (FG), Elkhounds, Forest grouse spitz, Retrieving dogs, Gundogs, Pointing dogs, Burrow dogs, Short running hounds, Long running hounds, Bear hounds, Wild boar hounds and Blood tracking hounds. Each of the 95 collected hunting dog breeds were categorized into the functional groups, based on knowledge of which hunting method they are used for today (for deeper interest read Appendix *Table 8*). This method of categorizing led to the fact that one hunting dog breed had the potential to be categorized in more than one functional group, if they had qualities of more than one hunting trait. This results in that the borders between several functional groups cannot be clearly distinguished and the functional groups are co-varying. With this background it is important to emphasise that several hunting dog breeds belong to more than one functional group. This needs to be taken into consideration while interpreting the results.

The harvest data from the Swedish Association for Hunting and Wildlife Management had the limitation that only seven of the 36 collected game species had the geographic resolution at county level, which were required in the analysis of the study. The studied game species were moose, red deer, fallow deer, wild boar, bear, capercaillie and black grouse. Those six game species lead to that six of the eleven functional groups of hunting dogs were analysed in the study. 48 hunting dog breeds of the 95 were selected and grouped in Elkhounds (FG Moose), Deer hounds (FG Deer), Wild boar hounds (FG Wild boar), Bear hounds (FG Bear), Blood tracking hounds (FG Blood tracking) and Forest grouse spitz (FG Forest grouse). The FG Deer are covering the data of red deer and fallow deer, with the justification that they are hunted using the same hunting method (SAHWM, 2012c, SAHWM, 2012d). The same choice of categorization is used for capercaillie and black grouse, which are both analysed by FG Forest grouse (Brännström, 1998, Christoffersson, 2004). The FG Blood tracking is analysed by red deer, fallow deer and wild boar, motivated by the fact that those game species are the most difficult to track when they are wounded and it is needed to have an efficient dog (Tham, 2004). As described earlier blood tracking hounds are mandatory, when hunting bear, moose, red deer, fallow deer, roe deer and wild boar. The collected harvest data from the Swedish Association for Hunting and Wildlife Management was complete for the whole time period, except for the harvest data for moose which was missing for year 2001. Harvest data for bear had a shorter time period, compared to the other studied game species, explained by the annual harvest allowed since 2004, for the seventh northern counties of Sweden (Swedish EPA, 2014a, Swedish EPA, 2014b).

Data analysis

To answer the aims and test the predictions in my study I divided the analysing process of the collected data into two main parts, followed by several steps. To test the first prediction (A), the first step was to monitor the development of the abundance of hunting dogs and the number of hunting dog breeds in the four Regions, during the time period of 1977-2013. Followed by that, I also tested prediction (B) by monitoring how the development of the abundance of hunting dogs and the number of hunting dog breeds were higher in the south than in the north. The results were showed by graphs and tables.

To test the third prediction (C), the first step was to investigate how the seven game species populations had developed in the four regions, during the time period of 1960-2013. The second step was that I plotted the abundance of hunting dogs and abundance the game species populations in graphs for the regions, during the time period of 1977-2013. This visually shows how the trend for each functional group of hunting dogs and the game species population in each region has developed.

The third step was to test how the abundance of game species populations (X) was explaining the abundance of hunting dogs (Y) by doing a regression analysis, assuming that it would be a linear relation. I used the statistical software JMP Pro 11 (SAS Institute Inc., 2014), the function "Fit Y by X" which plots the relations between the dependent variable hunting dogs (Y) and the independent variable game species population (X). Thereafter I used the function "Fit line" to show if there was a positive or a negative relation, the R^2-value and level of significance (p-value). I also wanted to investigate if there were time delays (TD) in the relation of abundance of hunting dogs and the game species populations. The fourth step was therefore to compare the data of game species population with the data of hunting dogs with a time delay from 0-5 years.

The results were showed in a relation table for each function group of hunting dogs and their connected game species, for all regions. I chose to show the results of the time delay which were significant (p-value < 0.05) and had the highest R^2-value.

While studying the pattern of the harvest data for the forest grouse, large fluctuations between years could be found. Therefore, a correlation analysis was performed between FG Forest grouse and the harvest data of forest grouse with using moving average (MA). The MA is used to filter the noise of random fluctuations in the harvest data of the forest grouse. This is a working indicator because it is based on the past value in the data. The harvest data is highly fluctuating from year to year and the aim with the method is to find a reasonable trend over the years. Also here I used the statistical software JMP Pro 11 (SAS Institute Inc., 2014), the function “Multivariate”, which produced a matrix of correlations. The results are shown in a correlation table.

Results

Development of the hunting dogs and the game species

The numbers of hunting dogs and the hunting dog breeds have change during the time period, and in general there are more dogs and more hunting dog breeds in Sweden today then for thirty years ago. The number of hunting dogs, including the six FGs consisting of 48 breeds, is supporting prediction A; there has been an increase during the time period from 1977 to 2013 (*Table 2*) and prediction B; more dogs in the south than in the north of Sweden. For each of Region 1, 2, 3 and 4 the total number of hunting dogs in year 1977 and 2013 is showed, with an increasing gradient from Region 1 to Region 4. The same pattern follows in the mean value of the total number of hunting dogs of the time period 1977-2011. When studying the result of the functional groups separately there is no gradient in abundance of hunting dogs from south to north and are not supporting prediction B. Region 1 and Region 2 have FG Moose as the functional group with the highest number of hunting dogs, while Region 3 and Region 4 have FG Deer.

Table 2. *Describing the number of hunting dogs, in total and each FG, for total the year 1977 and 2013 and the mean for the time period of 1977-2011. Columns are showing the value for Region 1, 2, 3 and 4.*

	Region 1	Region 2	Region 3	Region 4
Total number of hunting dogs (1977)	1342	1752	3308	5774
Total number of hunting dogs (2013)	3432	4060	7361	10724
Mean number of hunting dogs per year (1977-2011)				
All FGs summarized	2849	3780	7058	10095
FG Moose	1199	1437	920	698
FG Deer	187	581	2742	5043
FG Wild boar	n/a	98	274	602
FG Blood tracking	407	472	2440	3724
FG Bear	685	973	554	n/a
FG Forest grouse	370	220	126	28

The breed compositions of the six FGs are shown for all of the four regions (*Table 3*). In opposite to the number of hunting dogs, the breed composition is not following prediction B. The total number of breeds 1977 and 2013 show that there has been an increase during the time period, with the largest increase in Region 2, from 16 breeds 1977 to 66 breeds 2013. The southern regions have more breeds throughout the whole period than the northern regions; Region 3 is continuously in top of the breed composition, with over 51 breeds. The functional groups of FG Deer and FG Blood tracking have the highest number of breeds throughout all four regions, compared to the other functional groups of hunting dogs. There are interesting results for FG Bear: there has been an increase of breeds after 2004. The functional group that has differed least from region to region is FG Forest grouse.

Table 3. *The breed composition in total number of hunting dog breeds, in total and each FG, for total the year1977 and 2013 and the mean for the time period of 1977-2011. Columns are showing the value for Region 1, 2, 3 and 4.*

	Region 1	Region 2	Region 3	Region 4
Total number of breeds (1977)	17.0	15.0	30.0	24.0
Total number of breeds (2013)	45.0	66.0	79.0	64.0
Mean number of breeds per year (1977-2011)	33.6	44.7	51.7	40.3
FG Moose	7.5	7.3	7.2	5.5
FG Deer	9.4	11.9	14.9	12.9
FG Wild boar	n/a	6.8	8.1	6.6
FG Blood tracking	9.7	11.4	14.4	13.5
FG Bear (1977-2003)	4.7	4.9	4.5	n/a
FG Bear (2004-2013)	5.8	7.1	7.1	n/a
FG Forest grouse	2.0	2.0	2.0	1.8

Region 1 (*Figure 2*) has an increasing pattern of hunting dog breeds during the period, FG Blood tracking is the most numerous FG with a peak year 2003 with 17 hunting dog breeds, closely followed by FG Deer. FG Moose and FG Bear have similar patterns of increase to each other, with the difference that FG Bear has fewer hunting dog breeds. The FG Forest grouse is constant with 2 hunting dog breeds during the whole time series.

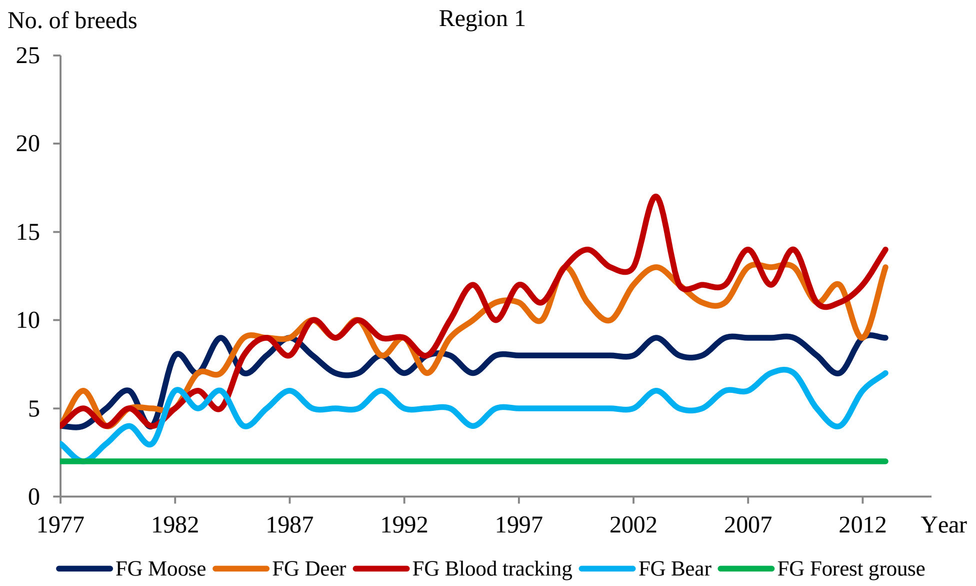

Figure 2. Graph illustrates the breed composition for Region 1, during the time period of 1977-2013. The Y-axis shows the number of hunting dog breeds for the functional groups: FG Moose, FG Deer, FG Blood tracking, FG Bear and FG Forest grouse.

Region 2 (*Figure 3*) has a higher number of hunting dog breeds in general compared to Region 1, explained by the fact that FG Wild boar now is present. The FG Blood tracking and FG Deer closely follows each other and increase during the time period. The hunting dog breeds number of FG Wild boar has an increase from 7 2004 to 12 2006 and continue the increase to 13 2008. The FG Moose and FG Bear are increasing from 1977 to 1987 and until 2004 there is a slight increase, while they are at the same number of hunting dog breeds 2013. Similarly Region 1 FG Forest grouse is constant with 2 hunting dog breeds during the whole time period.

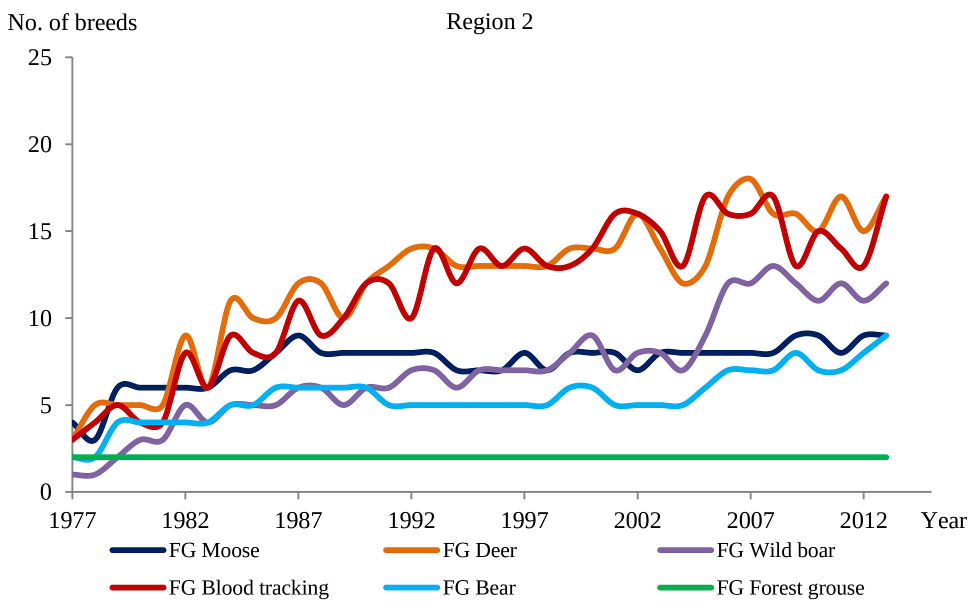

Figure 3. Graph illustrates the breed composition for Region 2, during the time period of 1977-2013. The Y-axis shows the number of hunting dog breeds of the functional groups: FG Moose, FG Deer, FG Wild boar, FG Blood tracking, FG Bear and FG Forest grouse.

Region 3 (*Figure 4*) is the region with the highest total number of hunting dog breeds and it is also that region which the richest breed composition. The six FGs have a net increase year 2013, except from FG Forest grouse which fluctuates between 1 and 2 hunting dog breeds during the time period. FG Deer and FG Blood track are in the top of number of hunting dog breeds. FG Wild boar shows a rapid increase from 2002. FG Moose and FG Bear are following the same pattern like in region 2.

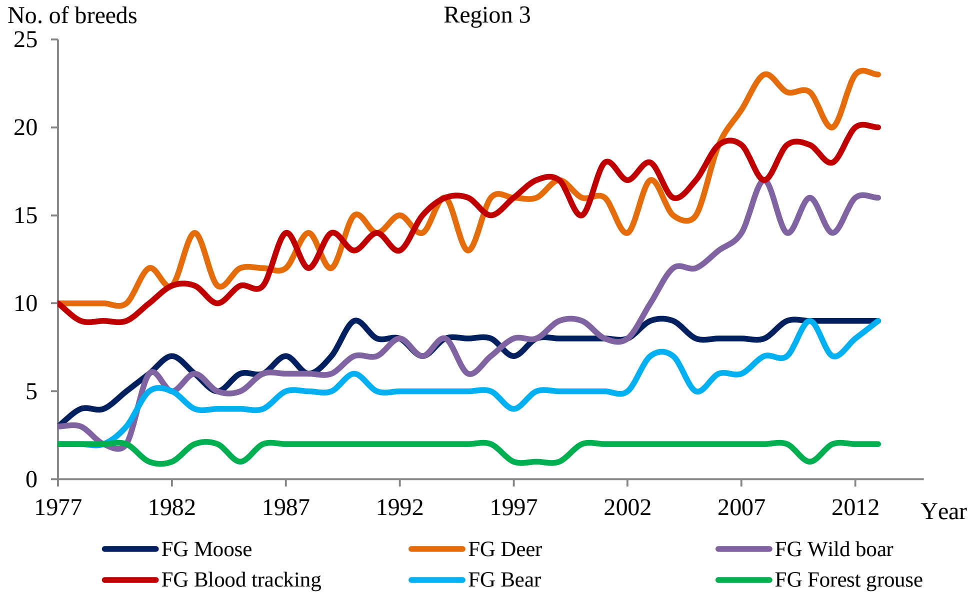

Figure 4. Graph illustrates the breed composition for Region 3, during the time period of 1977-2013. The Y-axis shows the number of hunting dog breeds for the functional groups: FG Moose, FG Deer, FG Wild boar, FG Blood tracking, FG Bear and FG Forest grouse.

Region 4 (*Figure 5*) consist of five FGs, and there are patterns that is comparable with Region 3. Like in all of the regions FG Blood tracking and FG Deer are the FGs with most hunting dog breeds. FG Wild boar is increasing rapidly in numbers from year 2003 to 2012. The FG Moose has the same pattern through all the regions and there is no difference in Region 4, and like in Region 3 FG Forest grouse is fluctuating between 1 and 2 hunting dog breeds during the whole time period.

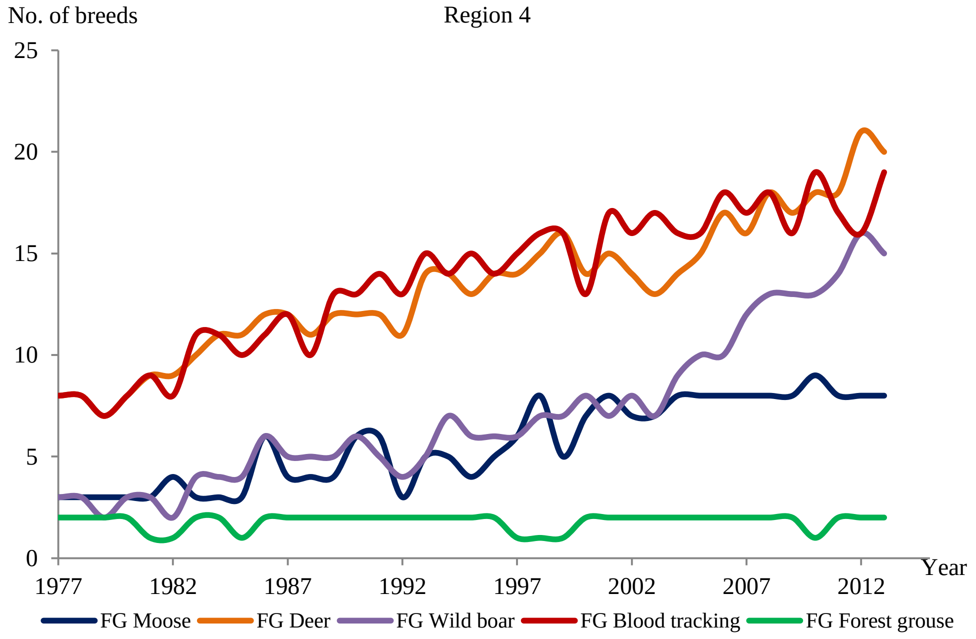

Figure 5. Graph illustrates the breed composition for Region 4, during the time period of 1977-2013. The Y-axis shows the number of hunting dog breeds for the functional groups: FG Moose, FG Deer, FG Wild boar, FG Blood tracking and FG Forest grouse.

Development in game species populations

The harvest data show similar pattern through the whole country. Region 1, 2, 3 and 4 have local changes of the number of harvest for each of the game species. For Region 1 (*Figure 6*) the highest harvest data is from the forest grouse of the time period and it is also higher than the other regions, with the highest peak in 1981 of 57200. The harvest data is highly fluctuant during the whole time period, especially during the 70´s. Moose has a pattern in the harvest data which follows in Region 2 and Region 3, with an exponential increase during the 70´s, a peak at the early 80´s and a slowly declining pattern until middle 90´s, while it during the 00´s and 10´s increases again. The harvest of deer has slowly increased since 1996, but is still on a low scale under 100 shot deer (including red deer and fallow deer) per year. The bear harvest shows a near to linear increase, except a dip 2008, from 2004 to 2012.

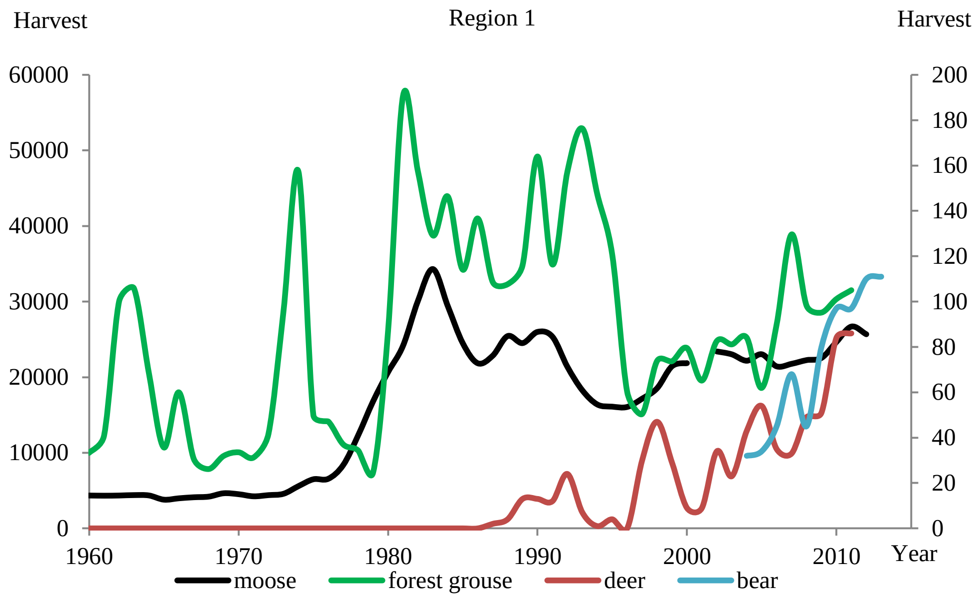

Figure 6. Harvest data of the yearly harvest from Region 1, during the time period 1960-2013. The left Y-axis shows the number of harvest for moose and forest grouse, while the right Y-axis shows the number of harvest for deer and bear.

Region 2 (*Figure 7*) is one of the two regions which has harvest data for all the 5 groups of game species and also the region which has the highest harvest data of both moose and bear. The harvest data for moose has an exponential increase during a 20-year period from 1960 to 1980, while it after the peak (with 55214 shot moose year 1982) rapidly decreases to a yearly harvest around 30,000, which it roughly stays around for the rest of the time period. The forest grouse harvest follow a similar pattern as moose, but with the difference that the yearly harvests fluctuates more. There is a peak 1984 with 45800 shot birds, and then it decreases in a 5-year period which is stabilizing around a yearly harvest around 15000. Harvest data for deer and wild boar are still marginal in Region 2, with less than 100 shot animals per year the time period 2000 to 2013. The harvest data for the bear is the highest of Region 1 and Region 3, and has a rapid increase from 2004 to 2011 with a peak of 159 shot animals, which decreases to 2013 to 130 shot bears.

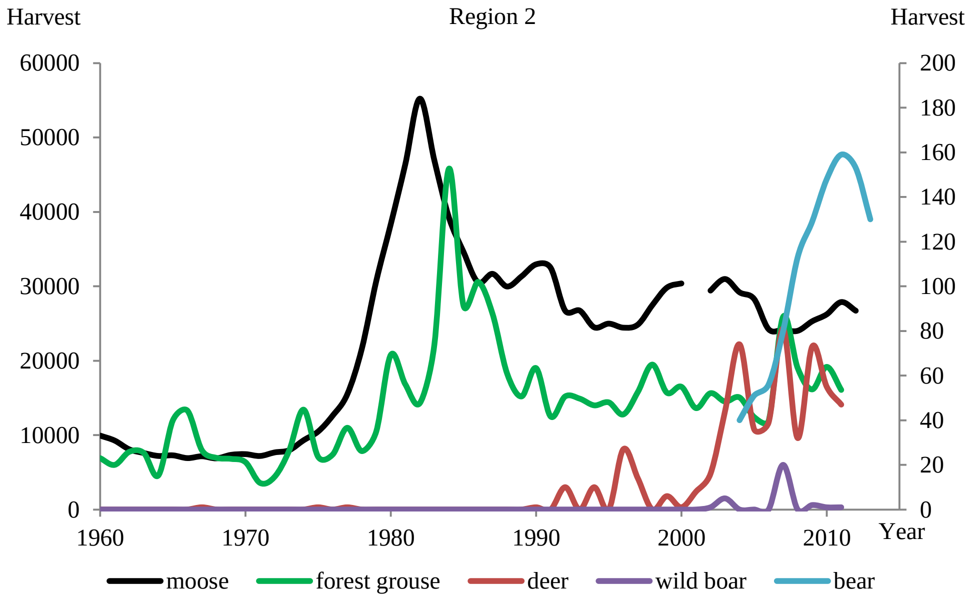

Figure 7. Harvest data of the yearly harvest from Region 2, during the time period 1960-2013. The left Y-axis shows the number of harvest for moose and forest grouse, while the right Y-axis shows the number of harvest for deer, wild boar and bear.

Region 3 (*Figure 8*) is the second of the two regions which have harvest data for all the five groups of game species. It dominates hunting moose, which follows the same pattern as Region 2. The harvest data of forest grouse have dropped in yearly harvest, compared to Region 1 and Region 2, to a level of 10000 shot birds. The harvest data for deer and wild boar have in Region 3 increased to a level of 10000 shot animals per year during 2000 to 2013. The harvest data of bear in Region 3 shows the lowest level of the three regions.

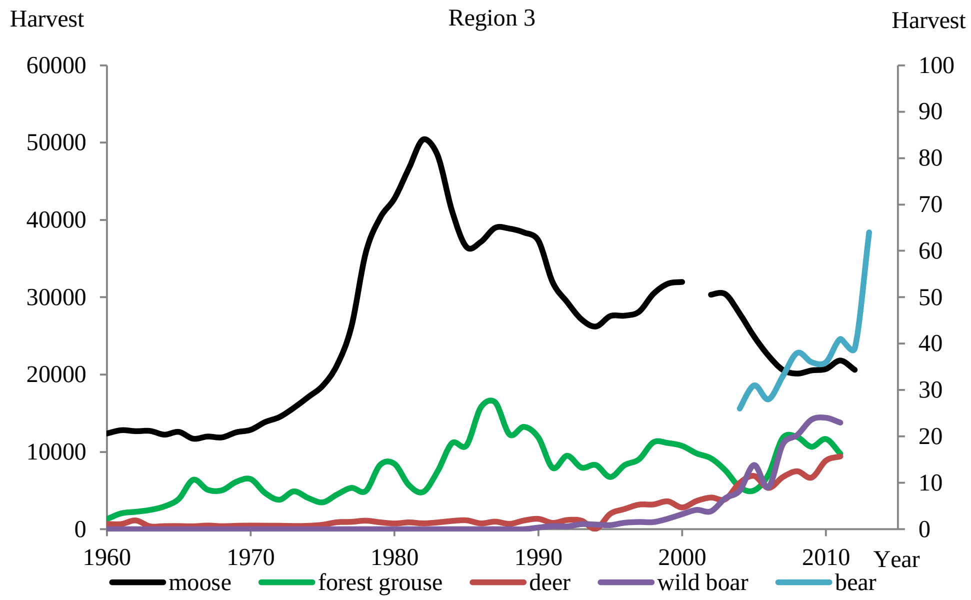

Figure 8. Harvest data of the yearly harvest from Region 3, during the time period 1960-2013. The left Y-axis shows the number of harvest for moose, forest grouse, deer and wild boar, while the right Y-axis shows the number of harvest for bear.

Region 4 (*Figure 9*) is the region which had the earliest increase of harvest data for deer and wild boar during the late 1990´s. The distinct difference from the other regions is that the harvest data of wild boar shows an extreme increase from 2006-2009: within the period of three years have the harvest data increased from 14,982 to 51,682. The pattern of increase started already year 2000, but then with a lower ratio of increase. The second most hunted game species in the region is moose which follows a similar pattern as the earlier region but at a lower level, with the peak spitted into two peaks 1983 and 1989. The forest grouse is the group of game species which is hunted the least in the region.

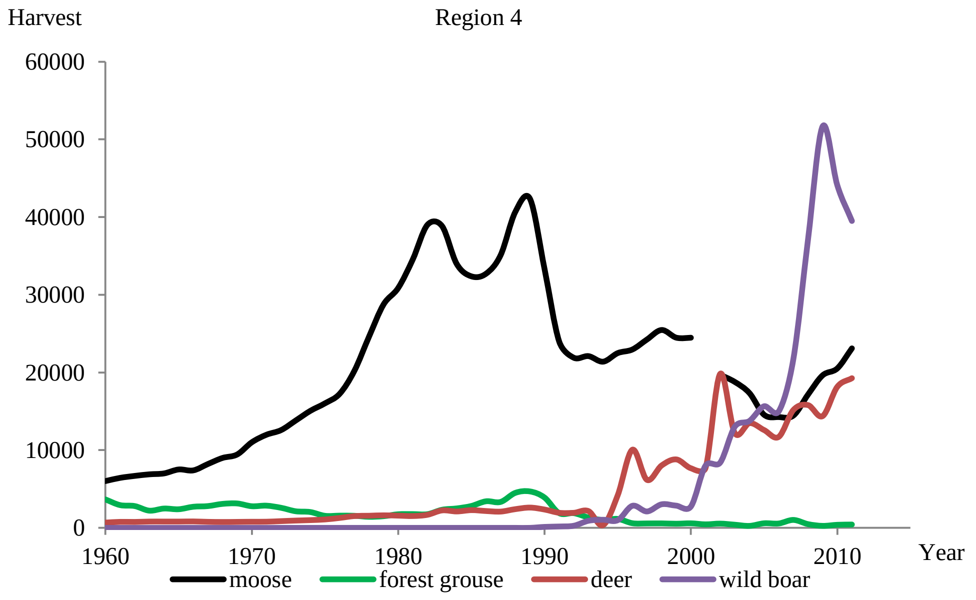

Figure 9. Harvest data of the yearly harvest from Region 4, during the time period 1960-2013. The Y-axis shows the number of harvest for moose, forest grouse, deer and wild boar.

The connection between the game species populations and the hunting dogs

The results indicate that there are connections between the functional groups of hunting dogs and the studied game species populations. Here follows a comparison between the yearly between the yearly number of harvest moose (Moose) and yearly number of registered elkhounds (FG Moose), during the time period 1977-2013 (*Figure 10*) show that there are following trends in Region 1 and 2. The trends are not completely overlapping and are better fitting for Region 1 than for Region 2. In Region 3 is there not a continuing trend, especially not during the time period 1982-1992, where elkhounds is increasing in abundance but the moose population is decreasing in abundance. For Region 4 the elkhound is not completely following the moose harvest data indexing the population development, but a weak trend can be seen during the time period of 1989-2000.

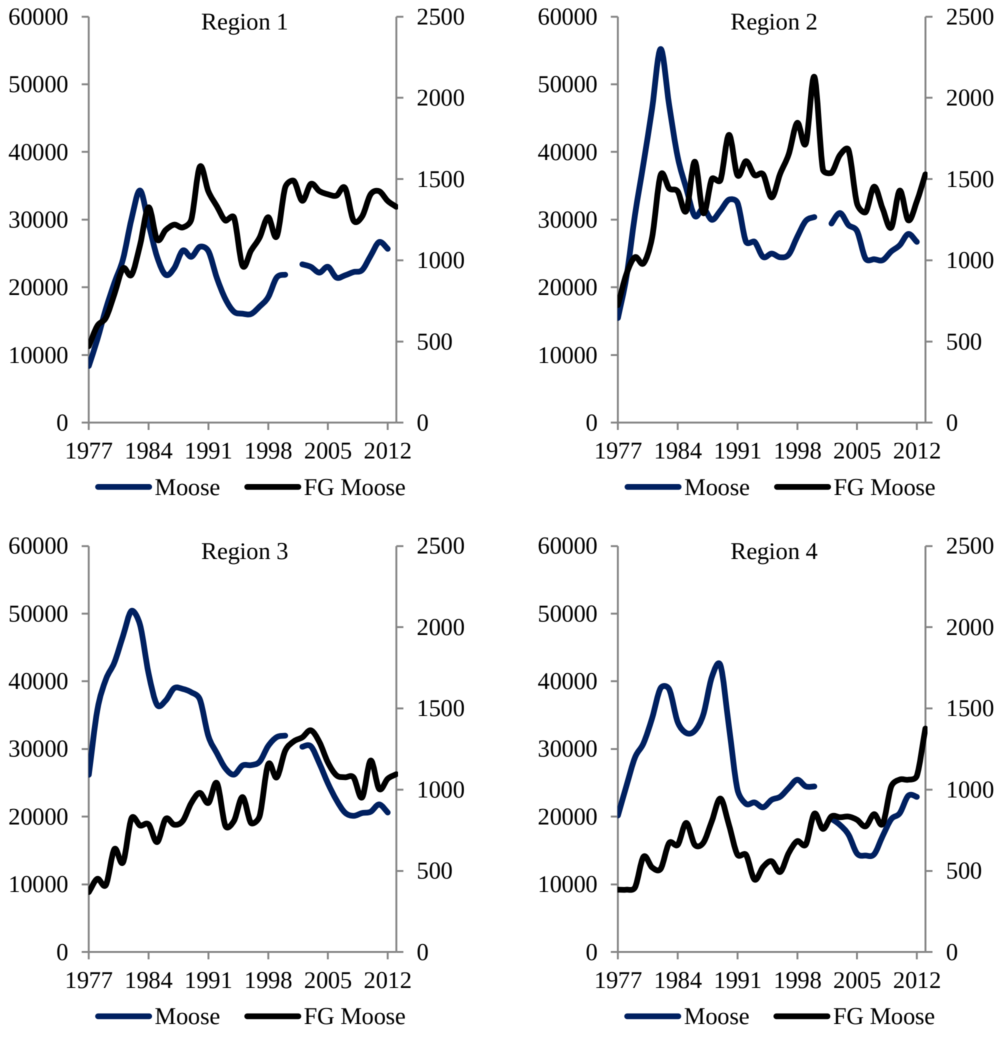

Figure 10. Comparison between yearly number of harvest moose and yearly number of registered elkhounds (FG Moose) from Region 1 to 4, during the time period 1977-2013. The left Y-axis shows the number of harvest for moose, while the right Y-axis shows the number of elkhounds (FG Moose). The R^2-value for Region 1: 0.26 and slope of the fitted regression line is +0.0271, Region 2: 0.014 and slope of the fitted regression line is + 0.004, Region 3: 0.22 and slope of the fitted regression line is -0.014 and Region 4: 0.023 and slope of the fitted regression line is -0.004.

Here follows a comparison between the yearly number of harvest wild boar (Wild boar) and yearly number of registered wild boar hounds (FG Wild boar), during the time period 1977-2013 (*Figure 11*). For both Region 3 and 4 is there following trends, for which Region 3 show a slightly better trend than Region 4.

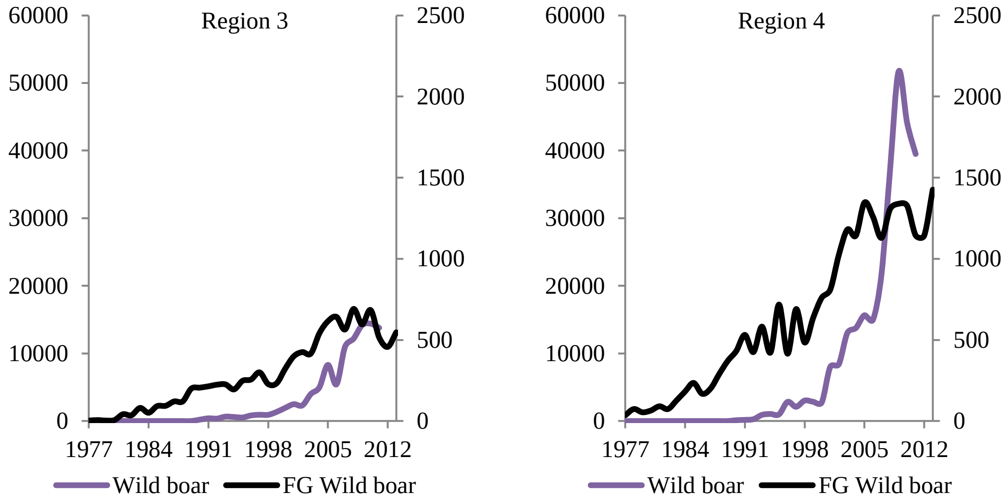

Figure 11. Comparison between yearly number of harvest wild boar and yearly number of registered wild boar hounds (FG Wild boar) from Region 3 and 4, during the time period 1977-2013. The left Y-axis shows the number of harvest for wild boar, while the right Y-axis shows the number of wild boar hounds (FG Wild boar). The R^2-value for Region 3: 0.76 and slope +0.03 and Region 4: 0.64 and slope +0.017.

Here follows a comparison between the yearly number of harvest deer (Deer) and yearly number of registered deer hounds (FG Deer), during the time period 1977-2013 (*Figure 12*). None of the four regions show following trends between the deer and the deer hounds. For Region 3 and 4 are opposite trends shown, when the number of harvest deer is decreasing is the number of registered deer hounds is increasing, during the time period of 1981-1994. For Region 3 is there a shift year 1994 when the number of harvest deer is increasing, but the number of registered deer hounds is decreasing. The same pattern is shown for Region 4, but there are high increases of harvest of deer in fluctuations during the time period 1994-2013, while the number of registered deer hounds is constantly decreasing after 2004.

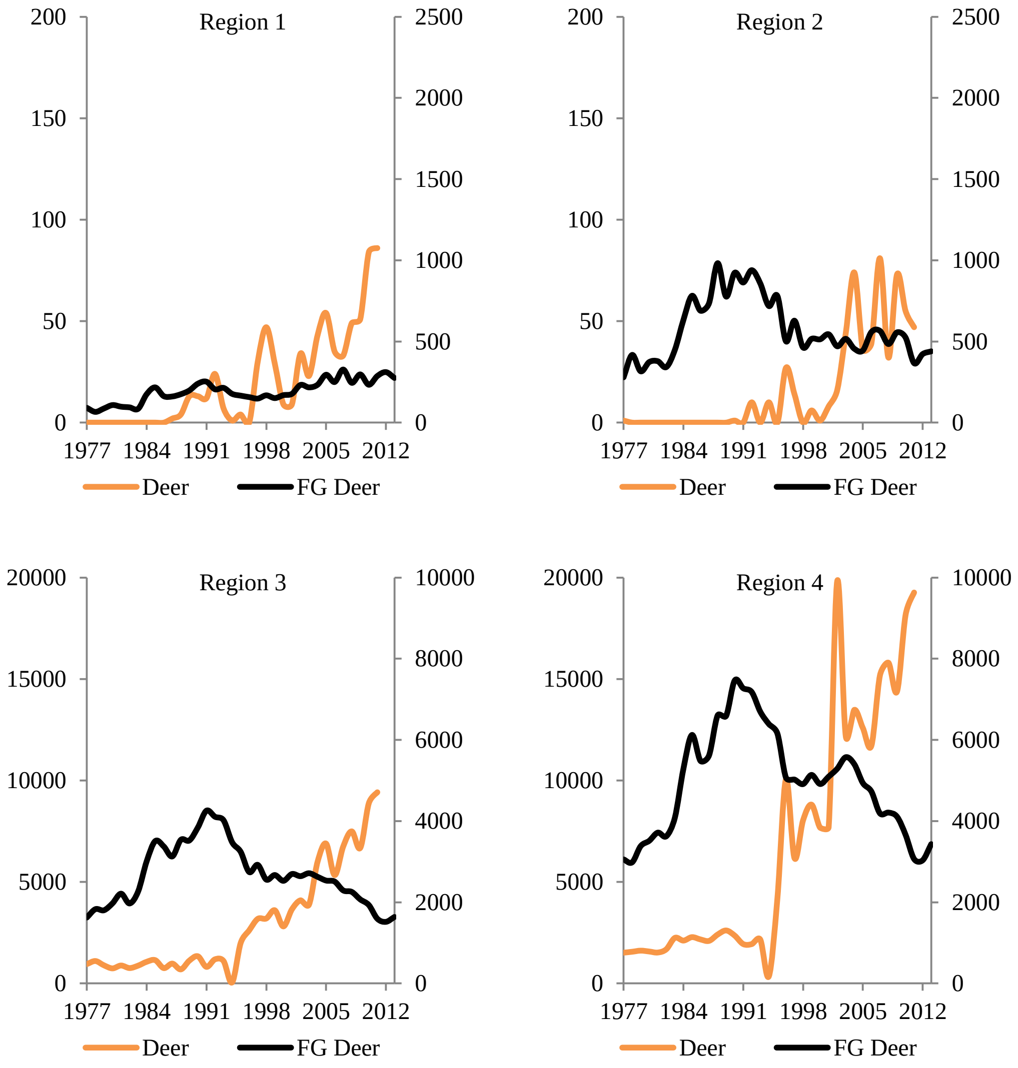

Figure 12. Comparison between yearly number of harvest deer and yearly number of registered deer hounds (FG Deer) from Region 1 to 4, during the time period 1977-2013. The left Y-axis shows the number of harvest for deer, while the right Y-axis shows the number of deer hounds (FG Deer). The R^2-value for Region 1: 0.44 and slope +1.84, Region 2: 0.05 and slope -1.8, Region 3: 0.20 and slope -0.12 and Region 4: 0.08 and slope -0.06.

Here follows the comparison between the yearly number of harvest deer and wild boar (Deer and Wild boar), and yearly number of registered blood tracking hounds (FG Blood tracking) during the time period 1977-2013 (*Figure 13*). For Region 1 and 2 there are no clear following trend between the deer and wild boar and the blood tracking hounds. For Region 3 there is a weak following trend shown. A following trend is clearly shown in Region 4, during the time period 1994-2013, especially from 2002-2013

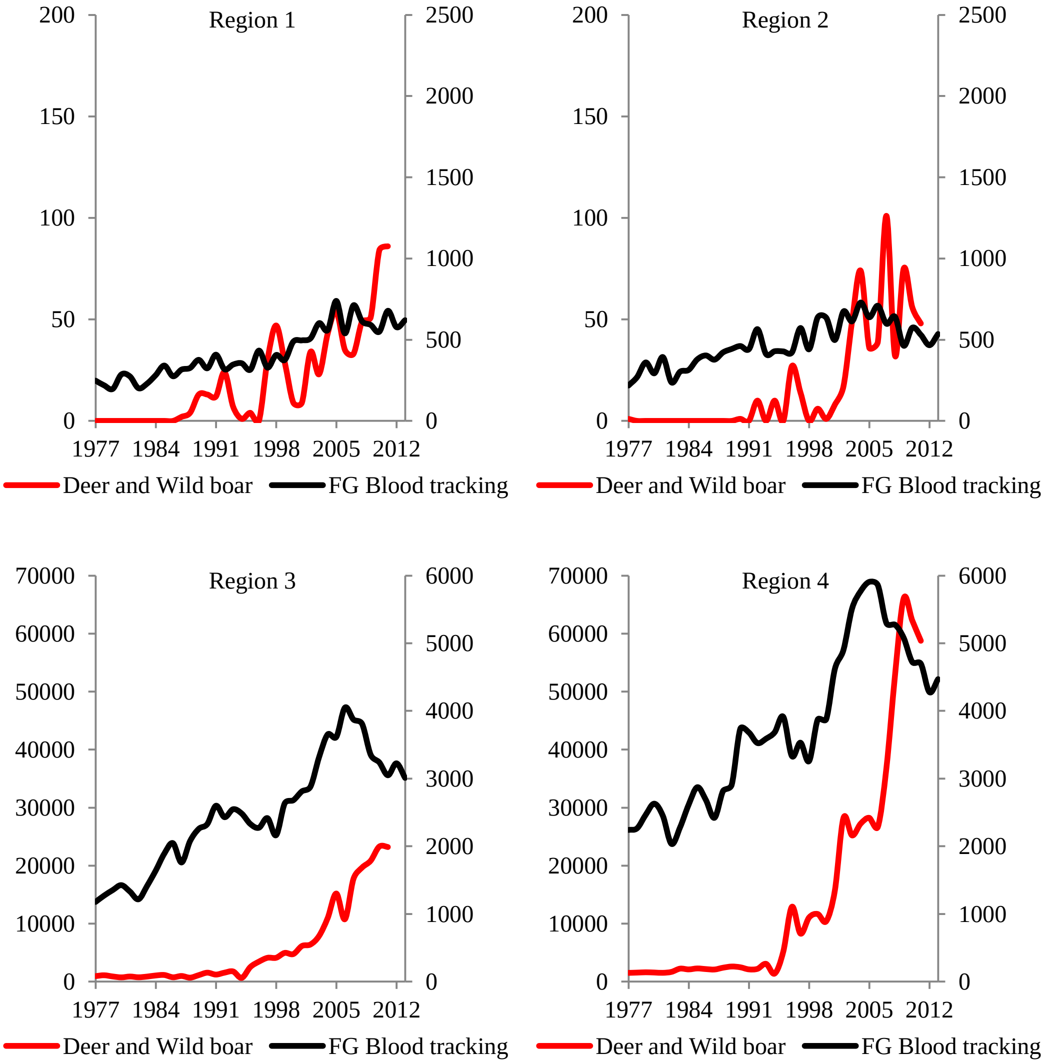

Figure 13. Comparison between yearly number of harvest deer and wild boar and yearly number of registered blood tracking hounds (FG Blood tracking) from Region 1 to 4, during the time period 1977-2013. The left Y-axis shows the number of harvest for deer and wild boar, while the right Y-axis shows the number of blood tracking hounds (FG Blood tracking). The R^2-value for Region 1: 0.59 and slope +4.83, Region 2: 0.34 and slope +3.00, Region 3: 0.59 and slope +0.089 and Region 4: 0.55 and slope +0.046.

Here follows the comparison between the yearly number of harvest bear (Bear) and yearly number of registered bear hounds (FG Bear), during the time period 2004-2013 (*Figure 14*). For Region 1 is a following trend shown during the time period 2004-2010. For Region 2 is no following trend detected. For Region 3 is a weak following trend shown for the time period 2004-2013.

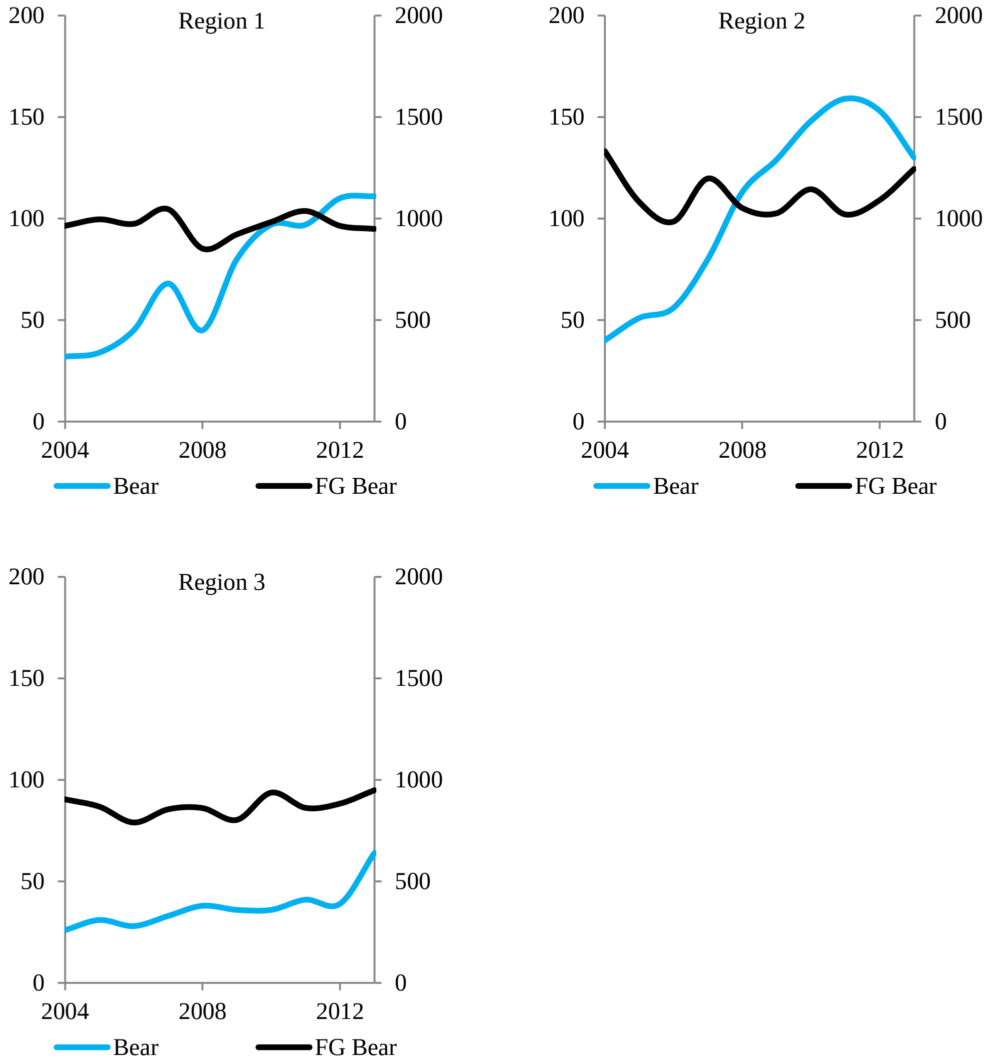

Figure 14. Comparison between yearly number of harvest bear and yearly number of registered bear hounds (FG Blood tracking) from Region 1 to 3, during the time period 2004-2013. The left Y-axis shows the number of harvest for bear, while the right Y-axis shows the number of bear hounds (FG Bear). The R^2-value for Region 1: 0.03 and slope +0.29, Region 2: 0.08 and slope -0.67 and Region 3: 0.27 and slope +2.52.

Here follows the between the yearly number of harvest forest grouse (Forest grouse) and yearly number of registered forest grouse spitz (FG Forest grouse), during the time period 1977-2013 (*Figure 15*). Following trends are shown in Region 1, 3 and 4, during the time period 1977-2013. For Region 2 is there no following trend detected. Common for all regions is that the yearly number of harvest forest grouse (Forest grouse) and yearly number of registered forest grouse spitz are highly fluctuating.

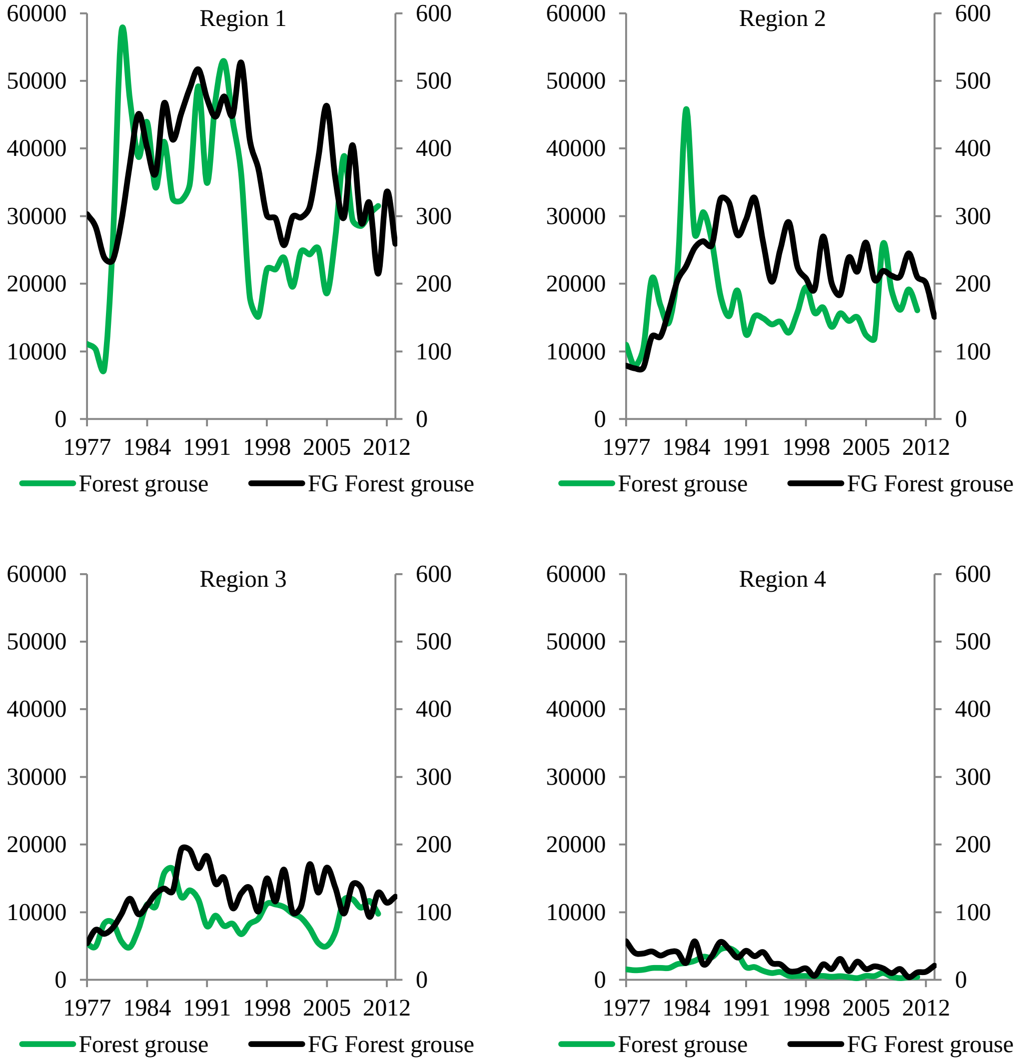

Figure 15. Comparison between yearly number of harvest forest grouse and yearly number of registered forest grouse spitz (FG Forest grouse) from Region 1 to 4, during the time period 1977-2013. The left Y-axis shows the number of harvest for forest grouse, while the right Y-axis shows the number of forest grouse spitz (FG Forest grouse). The R^2-value for Region 1: 0.23 and slope +0.003, Region 2: 0.05 and slope +0.002, Region 3: 0.09 and slope +0.004 and Region 4: 0.45 and slope +0.008.

Relation between the hunting dog breeds and the game species

The statistical analyses test the third prediction (C) of how the hunting dogs are affected of the game species in Sweden. The relations between the six functional groups of hunting dogs and the game species populations show different results in all the four regions.

In Region 1 (*Table 4*) FG Moose is affected by the harvest data of moose: when moose harvest is increasing in number the FG Moose is also increasing. The strongest relation explains 33% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 2.7% per year, with a time delay of 1 year. The same pattern follows for FG Deer, there is a significant relation that explains 50% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 198% per year. For FG Blood tracking the result is similar to FG Moose and FG Deer, but with the difference that the strongest relation that explains 59% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 531% per year, with a time delay of 3 years. FG Bear has no significant result. FG Forest grouse is affected by the harvest data of forest grouse, there is a significant relation that explains 45% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 0.5% per year, with a time delay of 2 years.

In Region 2 (*Table 4*) FG Moose has no significant result. FG Deer has a significant result, but a negative slope, which indicates that the relation between the FG Deer and the harvest of deer does not follow each other. There is a significant relation that explains 19% of variation in the hunting dog use between years, and on average, the number of hunting dogs decreased with 332% per year.When the harvest of deer increases the abundance of FG deer decreases. FG Blood tracking has a significant relation that explains 34% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 300% per year. When the harvest of wild boar and deer increases the abundance of blood tracking hounds also increases. FG Bear has no significant result. FG Forest grouse is affected by the harvest data of forest grouse, there is a significant relation that explains 33% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 0.35% per year, with a time delay of 5 years.

Table 4. *Relation table between the functional groups (FGs): FG Moose, FG Deer, FG Wild boar, FG Blood tracking, and FG Forest grouse and the harvest data, of Region 1 and Region 2. Covering the time period for FG Moose 1977-2012, FG Deer 1977-2011, FG Wild boar 1977-2011, FG Bear 2004-2013 and FG Forest grouse 1977-2011. n/a representing that no harvest data were available. TD is representing which time delay which had the highest R^2-value that was significant. Level of significance * = p≤ 0.05, **= p≤ 0.01, ***= p≤ 0.001, ****= p≤ 0.0001*

	Region 1				Region2			
FG:	R^2	p-value	Slope	TD	R^2	p-value	Slope	TD
Moose	0.33	0.0003***	+0.027	1	0.013	0.50	+0.004	0
Deer	0.50	0.0001***	+1.98	1	0.19	0.01*	-3.32	4
Wild boar	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Blood tracking	0.59	0.0001***	+5.31	3	0.34	0.0003***	+3.00	0
Bear	0.03	0.65	+0.29	0	0.16	0.33	+0.79	2
Forest grouse	0.45	0.0001***	+0.005	2	0.33	0.0006***	+0.0035	5

In Region 3 (*Table 5*) FG Moose is not following the trend of harvested moose, there is a significant relation that explains 35% of variation in the hunting dog use between years, and on average, the number of hunting dogs decreased with 1.4% per year. FG Deer has the same patterns as FG Moose, there is a significant relation that explains 55% of variation in the hunting dog use between years, and on average, the number of hunting dogs decreased with 2.6% per year. FG Wild boar has the highest relation to the harvest game of all results, there is a significant relation that explains 76% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 3% per year. FG Blood tracking show similar pattern, there is a significant relation that explains 59% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 9% per year. FG Bear has no significant result. FG Forest grouse has a significant relation that explains 38% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 0.7% per year, with a time delay of 2 years.

In Region 4 (*Table 5*) FG Moose is not following the trend of harvested moose, there is a significant relation that explains 34% of variation in the hunting dog use between years, and on average, the number of hunting dogs decreased with 1.5% per year. FG Deer has a significant relation that explains 14% of variation in the hunting dog use between years, and on average, the number of hunting dogs decreased with 14% per year. FG Wild boar has the highest relation to the harvest game of all results, there is a significant relation that explains 64% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with1.8% per year. FG Blood tracking show similar pattern, there is a significant relation that explains 55% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 4.6% per year. FG Bear has no significant result. FG Forest grouse has a significant relation that explains 48% of variation in the hunting dog use between years, and on average, the number of hunting dogs increased with 0.8% per year, with a time delay of 2 years.

Table 5. *Relation table between the functional groups (FGs): FG Moose, FG Deer, FG Wild boar, FG Blood tracking, and FG Forest grouse and the harvest data, of Region 1 and Region 2. Covering the time period for FG Moose 1977-2012, FG Deer 1977-2011, FG Wild boar 1977-2011, FG Bear 2004-2013 and FG Forest grouse 1977-2011. n/a representing that no harvest data were available. TD is representing which time delay which had the highest R^2-value that was significant. Level of significance * = p≤ 0.05, **= p≤ 0.01, ***= p≤ 0.001, ****= p≤ 0.0001*

	Region 3				Region 4			
FG:	R^2	p-value	Slope	TD	R^2	p-value	Slope	TD
Moose	0.35	0.0004***	-0.014	5	0.34	0.0006***	-0.015	5
Deer	0.55	0.0001****	-0.26	5	0.14	0.0001****	-0.14	5
Wild boar	0.76	0.0001***	+0.03	0	0.64	0.0001***	+0.018	0
Blood tracking	0.59	0.0001****	+0.09	0	0.55	0.0001***	+0.046	0
Bear	0.27	0.12	+2.52	0	n/a	n/a	n/a	n/a
Forest grouse	0.38	0.0001***	+0.007	2	0.48	0.0001***	+0.008	2

The correlation between the FG Forest grouse and the harvest data of forest grouse (*Table 6*) are computed with a MA of 1-10 year. The results from the 5 in Region 1 shows in sections an increase with a peak of 0.72 at year 4, and decline after the peak to 0.56 at year 10. Region 2 does not have a peak, instead a continuous increase from 0.22 year 1 to 0.73 year 10, with the highest correlation at year 10. Region 3 has the highest correlation with 0.61 year 7, with an increase from 0.30 year 1 to 0.59 year 5. After the peak year 7 there is a decrease to 0.29 year 10. Region 4 has all the results in diffusion from 0.65 to 0.74 at year 5, which is the highest correlation in the whole table.

Table 6. *Correlations between FG Forest grouse and the harvest data of forest grouse for Region 1, Region 2, Region 3 and Region 4. With a moving average (MA) of ten years, showing that the highest correlation for Region 1 is four years, Region 2 is ten years, Region 3 is seven years and Region 4 is five years.*

MA years	Region 1	Region 2	Region 3	Region 4
1	0.48	0.22	0.30	0.67
2	0.62	0.28	0.40	0.71
3	0.72	0.35	0.50	0.72
4	**0.72**	0.39	0.53	0.73
5	0.67	0.46	0.57	**0.74**
6	0.65	0.57	0.59	0.73
7	0.64	0.67	**0.61**	0.71
8	0.63	0.73	0.50	0.69
9	0.59	0.73	0.38	0.65
10	0.56	**0.73**	0.29	0.65

Summary of my results

In short, my study shows that the numbers of hunting dogs and the hunting dog breeds have changed during the time period. In general, there are more dogs and more hunting dog breeds in Sweden today compared to thirty years ago. The number of hunting dogs, including the six FGs consisting of 48 breeds, matches prediction A; there has been an increase during the time period from 1977 to 2013 (*Table 2*) and prediction B; more dogs in the south than in the north of Sweden.

The development of the game species are showing similar pattern throughout the whole country. Region 1 to 4 has local changes of the number of harvest for each of the game species (*Figure 6, 7, 8 and 9*).

The results indicate that there are connections between the functional groups of hunting dogs and the studied game species populations. Different results are shown in the different regions and there are different levels of significance (*Figure 10, 11, 12, 13, 14 and 15*).

The summarised results of the relation table (*Table 7*) show that there are significant relations between the FG and the game species (*Table 4 and Table 5*). And some are matching prediction C; that there is a relation between the hunting dogs and the game species populations.

FG blood tracking, FG Wild boar and FG forest grouse have the highest positive relation through the country. The development pattern for the FG Moose, FG Bear, FG Wild boar and FG Blood tracking, compared to the connected game species populations shows that every functional group and region has different relationships for the factors.

The highest correlation between the FG Forest grouse and the harvest data of forest grouse had a time lag of four to ten years, depending on which region that is studied (*Table 6*).

Table 7. *Summary and comments from the relation results (Table 4 and Table 5) of how the FG is following the pattern of the game species. ↑Positive relation, ↓ Negative relation,# no significant relation found, n/a data not available.*

FG	Region 1	Region 2	Region 3	Region 4	Comments
Moose	↑	#	↓	↓	Following trend for Region 1
Deer	↑	↓	↓	↓	Do not follow, except of Region 1
Wild boar	n/a	n/a	↑	↑	Following trend in Region 3 and Region 4
Blood tracking	↑	↑	↑	↑	Following trend in all the Regions
Bear	#	#	#	n/a	No significant relation found
Forest grouse	↑	↑	↑	↑	Following trend in all the regions

Discussion

There has been an increase in the abundance of hunting dog breeds

Today there are more hunting dogs and hunting dog breeds in Sweden than thirty years ago. The functional groups included in my study have all increased in number of dogs and number of breeds. In the whole country the number of hunting dogs has more than doubled. There number of hunting dogs is higher in the southern regions compared to the northern regions from 1977 to 2013. This also applies to the number of hunting dog breeds. The group of hunting dogs which are hunting deer (FG Deer) has the highest number of dogs, whereas the functional group of hunting dog breeds that are used for blood tracking hounds (FG Blood tracking) has the highest number of breeds throughout the country.

The breed composition is highest for the functional group of blood tracking hounds (FG Blood tracking) with 21 different breeds, with a variety from Bavarian Mountain Scenthound to Jack Russell Terrier. Traditionally the blood tracking hounds consisted of hunting dog breeds with roots in the German hunting culture (Tham, 2004). Today the education and the personality of the individual dog is more important than the breed (Tham, 2004), which may explain the variety and the large number of breeds in this functional group.

My assumption that the elkhounds (FG Moose) would have the highest density in number of hunting dogs, compared to the other functional groups, was based on that the Swedish elkhound is the second most popular dog breed and most popular hunting dog breed in Sweden (SKC, 2014b). The tradition of hunting moose is also highly appreciated by the Swedish hunters (Pedersen, 2006, Boman et al., 2011, Lindqvist et al., 2014) and the different abilities the elkhounds have, for example hunting bear and wild boar (Christoffersson, 2004).

The hunting dog breeds are influenced by the game species populations

This study compared the abundance of hunting dogs and the population sizes of game species. The results of my study show that the hunting dog breeds are connected to the game species populations and confirm the third prediction. The strongest correlations are found for the hunting dog breeds hunting wild boar (FG Wild boar) and the blood tracking hounds (FG Blood tracking). The two groups have positive relations with game numbers in the whole country.

The functional group of elkhounds (FG Moose) significant positive relation to the harvest of moose is shown in the Region 1 (*Table 4*), but opposite in the southern regions (Region 3 and 4) with negative relations (*Table 5*). For Region 1, the abundance of elkhounds follows the development of the moose harvest (*Figure 10*), with stronger relation with the time delay of one year. In the northern counties of Sweden the harvest of moose affects the abundance of elkhounds positively and in the southern counties the harvest of moose does not affect or affects the abundance of elkhounds negative. The results can be explained by the strong tradition of using the elkhounds in the north of Sweden (Pedersen, 2006) and that the moose still is the ungulate species in largest population size in Region 1 (*Figure 6*) compared to the other studied ungulate species. In the southern counties, the populations of red deer, fallow deer and wild boar have increased in large proportions and the hunt for those game species is today popular among hunters (Magnusson, 2010, Ezebilo et al., 2012, Månsson & Jarnemo, 2013, Wallgren et al., 2013, SAHWM, 2014). This may be the explanation that the elkhounds have negative relations to the harvest of moose in Region 3 and 4 and no significant result for Region 2. The results of the relations in Region 2, 3 and 4 show that the presence of other ungulate species than moose affects the moose hunt and then also the use of elkhounds (Magnusson, 2010, Boman et al, 2011, SAHWM, 2012 a, SAHWM, 2012 c, SAHWM, 2012 d, SAHWM, 2012 h, Swedish EPA, 2013).

The functional group of deer hounds (FG Deer) a positive relation to the harvest of deer is shown in Region 1 with a time delay of 1 year (*Table 4*). For Region 2, 3, 4 are all relations negative (*Table 4*, *Table 5*). The population of deer is increasing in Sweden (*Figure 6, Figure 7, Figure 8*, *Figure 9*), but it does not lead to a corresponding increase of the number hunting dogs (FG Deer) (*Figure 12*). One explanation of this result can be the hunting method to control the population of deer in southern Sweden where the population is in high density (Grignolio et al., 2011, SAHWM, 2012c, SAHWM, 2012d). Deer hounds then often are used for an effective hunt, but not always the best hunting method according to disturbances of the deer and other wildlife (SAHWM, 2012c, SAHWM, 2012d, Jarnemo & Wikenros, 2013). An effective drive can include a high number of hunters and a low number of deer hounds and still get a successful outcome with a high harvest of deer. There is also a possibility that a talented hunting dog can compensate for a larger number of hunting dogs. If this reasoning applies to reality it would be interesting to investigate the efficiency of the hunting dogs for further research.

The functional group of wild boar (FG Wild boar) strong positive relations are shown to the harvest of wild boar in Region 3 and 4. The results indicate that the harvests of wild boar are affecting the abundance of wild boar hounds (*Table 5*) in those counties where the wild boar population is well-established (SAHWM, 2013, Schön, 2013) and where the harvest of wild boar is high (*Figure 8* and *Figure 9*). The positive relation between the wild boar hounds and the population of wild boar can be explained because the hunt of wild boar demands an efficient wild boar hound (Christoffersson, 2004) and if the relation is the same in the future the abundance of wild boar hounds will increase even more.

For the functional group blood tracking hounds (FG Blood tracking) all regions have positive relations (*Table 4, Table 5*) for the studied game species: wild boar, red deer and fallow deer and I suggest that the underlying factor is the increase of the wild boar population. The increase of large game (Milner et al., 2006, Ezebilo et al., 2012, SAHWM, 2012e, SAHWM, 2013, Schön, 2013) and the influences of the continental hunting culture are explaining that the functional group of blood tracking hound hunting dogs had increased in abundance the last decade (Tham, 2004). The Swedish hunting system also explains the increase since blood tracking hounds are mandatory to find wounded game while hunting bear, moose, red deer, fallow deer, roe deer and wild boar (Jaktförordningen, 1987). In southern Sweden (Region 3 and 4) the population sizes of the ungulates are largest (*Figure 8, Figure 9*) which also apply on the hunting dog breeds (*Figure 4, Figure 5*). These relations support predictions B and C: an increase of the game species population results in an increase on the number of hunting dog breeds and in the abundance of hunting dogs. And these results are new knowledge about the hunting dog breeds and their connection to the game populations.

Significant relations are not detected between the bear hounds (FG Bear) and the harvest of bear in any of the studied regions (*Table 4 and Table 5*) those results also confirmed by studying the comparison graphs between the yearly numbers of harvest bear (Bear) and yearly number of registered bear hounds (FG Bear) (*Figure 14*). The results showed that the hunting dogs are not increasing at the same rate as the harvest of bear. One potential explanation of this result can be that hunters and hunting dogs have an effective hunting method and there is no need to have more hunting dogs to harvest more bear in the area (Dahlström, 2012). The short time period of six years makes the analyse weak and furthered studies is needed for this potential relation.

For the functional group of forest grouse spitz (FG Forest grouse) all regions have positive relations (*Table 4, Table 5*). The relation of FG Forest grouse and the harvest data are all positive, surprisingly, is the highest relation in Region 4, the explanation behind this result is the low number of hunting dogs and low number of harvested birds. The harvest data highly fluctuates from year to year and reflects not the population trend (de Jong, 2002). This deviation could be explained by the fact that harvest of forest grouse is not limited by the population size, instead of the hunting effort (Christoffersson, 2004, Willebrand, 2011). The fact to be considered is the choice of the hunter; good years of harvest are those years were the conditions for hunting forest grouse were good and many hunters have chosen to be out for many hunting days, whereas years with poor conditions resulted that the hunters chosen to not hunt that often. The study of Willebrand investigated how much of the variation in bag size (total number of harvested grouse km^{-2}) is explained by variation in willow grouse (*Lagopus lagopus*) density (adult and young grouse km^{-2}) and hunting effort (total number of hunting days km^{-2}). The result of the study indicated that the hunting effort and the total grouse density explained most of the variation in bag size. And that the bag size was twice as sensitive to changes in hunting effort compared to changes in grouse density (Willebrand, 2011) which is applicable to the forest grouse. The results of the analyse with moving average are showing that the FG Forest grouse is correlating different, depending on the time lag (MA) to the harvest data. For Region 1 the highest correlation is showed in the fourth year, while the tenth year is for Region 2, seventh year for Region 3 and the fifth year for Region 4. This can be explained by the theory of the hunters' choice; the decision of getting a hunting dog is most likely a response to the harvest data. The different correlation results are responding to the time of consideration the hunters spend, before they decide to buy a hunting dog.

A shift in the breed composition

Since Stone Age 9,000 BC until today (Pedersen, 2006) the moose hunt and therefore the elkhounds have played a central role in the Swedish hunting culture (Boman et al., 2011, Lindqvist et al., 2014). Compared to international population densities of moose (Ezebilo et al., 2012) the Swedish moose population has been and still is high since the 1980´s (*Figure 6, 7, 8, 9*). Due to this high population density of moose nine breeds of elkhounds originated from Sweden, Norway and Russia (Pedersen, 2006). In Region 1 and 2, where the harvest of moose is highest (*Figure 6, Figure 7*), are the elkhounds still the most numerous functional group (*Table 2*). In the south however, the functional groups of wild boar hounds, deer hounds and blood tracking hounds have outcompeted the functional group of elkhounds in Region 3 and 4 (*Table 2*). This shift in the breed composition from elkhounds to wild boar hounds, deer hounds and blood tracking hounds can be explained by an increased population density of red deer, fallow deer and wild boar in those areas (*Figure 8, Figure 9*, Milner et al., 2006, SAHWM, 2013, Schön, 2013). The increased population density of wild boar caused a higher interest of hunting wild boar, which led to the fact that breeds that traditionally hunted moose specialized to also hunt wild boar (Kerbs, 1965, von Oehsen, 1996, Tham, 2004).

Another possible explanation for the shift is the institutional change in the Swedish hunting law that legalized annual hunt of bear in 2004 (Jaktförordningen, 1987, Swedish EPA, 2014a, Swedish EPA 2014d, CAB, 2015). Bear is one game species that has enriched the hunting opportunities and also introduced new hunting dog breeds (Christoffersson, 2004, Dahlström, 2012, SKC, 2014a). The results of my study showed that the number of bear hound breeds have increased after the approval of bear hunt (*Table 3*). As for the wild boar hunting dog breeds that traditionally were specialized on moose (Pedersen, 2006) are today also classified as bear hounds (Christoffersson, 2004). Examples of those breeds are Swedish Elkhound and different types of Laikas (Christoffersson, 2004). An example of an introduced breed that is relatively new in Sweden is the Plott hound, a hunting dog breed which is preferable for hunting bear (Christoffersson, 2004, Dahlström, 2012).

The importance of having the hunting dog breeds

The hunting dog breeds are bred to fulfil the task of delivering the game to the hunter, with different methods depending on which game species is hunted. Today the tasks of a hunting dog are to hunt efficiently and also reduce the time in which a wounded game is suffering.

One example of a management situation where there is a need for an efficient hunting dog is the hunt for wild boar. The wild boar is one of the game species that shows a big increase in population size where they are already established in Sweden (*Figure 7-9)* but also shows high dispersal north along the east coast (SAHWM, 2013, Schön, 2013).

The increase of the population is positive in some areas because it is a popular game among many hunters. A larger population of wild boar is associated with an increase in damages to the agriculture sector and traffic accidents (SAHWM, 2013). My study, which shows a positive relation between the population of wild boar and the wild boar hounds in Region 3 and Region 4 (*Table 5*), indicates that there is a need for wild boar hounds. To reduce the negative effects of wild boars a higher hunting pressure is needed and therefore a higher number of wild boar hounds.

Using dogs often increases hunting efficiency, the blood tracking hounds are needed to decrease the time of suffering to those animals that have been wounded during the hunt, by a traffic accident or natural reasons (Tham, 2004). They have an important role in the Swedish hunting culture, to maintain the positive opinion the Swedish people have towards hunting (Tham, 2004). According to the Swedish law (Jaktförordningen, 1987) the blood tracking hounds are required during the hunt of specific game species, earlier described, for accomplishing a high ethical standard (Swedish EPA, 2014a). Another motive is the economical aspect. The value of the game meat is high and the retrieval of a lost game can be necessary for a single hunter or a hunting team (Tham, 2004).

Method development

The geographic regions

The method that was used in this study, grouping the counties of Sweden into four geographic regions Norra Norrland, Södra Norrland, Svealand and Götaland, is used by the

Swedish Meteorological and Hydrological Institute (SMHI, 2015). Hence, this method of grouping the counties was motivated because it is commonly known in Sweden. The results were therefore showing a regional difference between the regions and it was possible to detect changes from north to south. Other possible methods of grouping the counties would be based on the population density and distribution of the game species, land use, population density of the hunters, since there are regional differences.

Grouping the counties based on the population density and distribution of the game species (Grubbström, 1989, Brännström, 1998, Hörnberg, 2001, Milner et al., 2006, Danell & Bergström, 2010, Magnusson, 2010, Ezebilo et al., 2012, Månsson & Jarnemo, 2013, SAHWM, 2013, Schön, 2013, Wallgren et al., 2013, Åhlen et al., 2013, IUCN, 2014, Swedish EPA, 2014b) would be feasibly and may show how the hunting dog breeds fastest are responding on the population density of game species. Connected with this method would it be possible to include the land use, for grouping the counties. There are large differences in land use through Sweden (Nilsson et al., 2014), earlier described in the method section, the land use could indicate different habitats and possibly the distribution range of several game species.

Grouping the counties based on the population density of the hunters (Swedish EPA, 2014c) mainly follow the same pattern of the population density of the Swedish citizens (SCB, 2015). The largest difference is that the densities of the hunters diverge from the population density of the Swedish citizens in the county of Norrbotten, which is on the 15th place ranked by the density of Swedish citizens but is ranked to the 3rd place by the density of the hunters. The proportion of the hunters is not equal trough Sweden and it would be interesting to follow the hunting dog use in those counties were the density of the hunters is highest.

The complication with those described potential method options of grouping the counties are that the density and locations of those characters not are following the borders of the counties. It would be complicated to do analysis with the available data that were collected for the study. Therefore, the data of hunting dog breeds and the data of game species populations are analysed by county and grouped into the four regions.

The categorizing of hunting dog breeds

The method used for categorizing the hunting dog breeds into the eleven functional groups has complications; several hunting dog breeds are included in more than one functional group. By this method are the result biased of the connections between the functional groups. To avoid the biased effects of the functional groups, one solution would be to only categorize the hunting dog breeds to one functional group, but it would lead to a large error. Because by using this method of categorizing to one functional group would the results would not correspond to the reality, some hunting dog breeds have the capacity of several hunting traits. An example is the breed Alpine Dachsbracke, which is categorized into four functional groups of Short running hounds, Bear hounds, Wild boar hounds and Blood tracking hounds. In this case would it be possible to “only” categorize this breed into the blood tracking hounds, based on is first hunting trait it was bred for (Tham, 2004). The limitation of this method would be that breeds, with a strong ability to adapt to new hunting methods and to develop new hunting traits, can be categorized into more than one functional group but would only be represented in one. The consequences of the method used in this study of categorizing the hunting dog breeds into several functional groups, which leads to that the border between the functional groups not are clearly distinguished, but by using this method the categorizing correspond to the reality.

A limitation of this study is that not all hunted game species were available to analyse cause of lacking harvest data on the county level, which leads to that the results not are showing a complete picture of the whole range of the hunting dog breeds used in Sweden today. There may be links between population sizes of different game species, for example roe deer and fallow deer, which are hunted by the same hunting method and are mainly using the same habitats (SAHWM, 2012c). Those ecological connections are factors that may affect the result of this study, but cannot be detected due to the limitations of the data of the game species. If all game species would be available, analyse of all functional groups would be possible and by that it would be possible to detect other trends between the game species populations and the functional groups of hunting dogs.

Future research

The hunting dog breeds are well studied in the hunting society in Sweden and also in the scientific room. In addition to the studied relationship, between the game species populations and the hunting dog breeds in Sweden, would other interesting factors to study even deeper the institutional factors in the hunting system per level (Jaktförordningen, 1987, Swedish EPA, 2014a, Swedish EPA 2014d, CAB, 2015) and also the behaviour of the hunter (Willebrand, 2011). The hunting dog is nowadays also an individual and a family member (Bendz, 2007), which put this study into a more social-science direction. The hunting dog is connected to the hunter and my study indicates that the influence of the game species populations is not the only factor that influencing the hunting dog breeds. And there is still more knowledge about the hunting dog and the hunter needed to be discovered.

Since the domestication of the dog, the human has developed the dog into many different breeds to increase theirs traits for an anthropogenic purpose (Udell et al., 2012). This study has focused on forty-eight breeds and how they are affected by the game species populations. Each breed has their specific traits and is different in a physical and psychological way. The trait of a breed is chosen by the breeders during the development of the breed, but is it possible to develop a perfect hunting dog breed? Several scientific articles are showing that there are pedigrees and processes ongoing to make breeds more efficient for their hunting methods (Lindberg et al., 2004, Brenøe et al., 2002, Leroy et al., 2009, Kropatsch et al., 2011, Leroy, 2011, Huson, 2012, Udell et al., 2012, Arvelius & Klemetsdal, 2013, Arvelius, 2013). Two examples are the Norwegian study of hunting performance of gundogs (Brenøe et al., 2002) and the Swedish study of the genetic analysis of hunting behaviour in Swedish Flatcoated Retrievers. These two studies indicate that the genetic knowledge of a breed is needed for future development of the hunting dog breeds, both for maintaining a healthy population without genetic diseases and individuals with traits that are refined and an appropriate hunting behaviour.

Conclusion

The conclusion of my study is that the hunting dog breeds are influenced by the abundance of game species population sizes in Sweden. There are today more hunting dogs and more different hunting dog breeds, compared to thirty years ago. There are higher abundances in the south than in the north, which follow the prediction. The functional groups of hunting dog breeds that are used for wild boar and blood tracking hounds follow the prediction and have significant relation between the hunting dogs and the game species populations. The results will be increasingly important for wildlife management, in the aspect that harvesting of increasing populations of game species will be a method for wildlife management in Sweden. Since the hunting dog breeds are a part of the hunting method, are knowledge of the breed composition important for the future management. I suggest that future research should focus on the hunters and their choices of hunting dogs. Factors as age, gender, social backgrounds, traditions, values or favouritism of a specific type of breed are important to monitor, to get a better understanding of the connection between the hunter and the hunting dog.

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Appendix

Table 8. *The functional groups of hunting dog used in Sweden, Swedish translation and the game species the method is hunting.*

ID Letter	Functional groups	Jakthundsgrupper (Svensk)	Game species
A	Elkhounds	Älghundar	Moose
B	Forest Grouse	Skällande fågelhundar	Capercallie, Black grouse and Marten
C	Retriever	Apporterande	Birds
D	Gun Dogs	Stötande	Birds
E	Pointing	Stående fågelhund	Birds
F	Burrow	Grythund	Badger and Fox
G	Hounds, Short Running	Kortdrivande	Fallow deer, Red deer, Roe deer
H	Hounds, Long Running	Drivande	Fox and Hare
I	Bear	Björn	Bear
J	Wild Boar	Vildsvin	Wild boar
K	Blood Tracking	Eftersökshundar	Wounded animals

Table 9. *The 95 studied hunting dog breeds categorized into the 11 functional groups. The functional groups described in Table 6.*

	A	B	C	D	E	F	G	H	I	J	K
1							X		X	X	X
2								X			
3							X	X			
4								X			
5							X	X		X	X
6											X
7							X			X	X
8							X	X			
9									X	X	
10									X	X	
11						X	X				X
12								X		X	
13					X						
14					X						
15					X						
16					X						
17					X						
18					X						
19					X						
20					X						
21							X	X		X	
22				X							
23											X
24					X						

25							X	X			
26								X			
27					X						
28			X	X							
29			X	X							
30	X	X									
31								X			
32			X								
33			X		X						X
34			X								
35								X		X	
36					X						
37								X			
38							X	X		X	
39							X			X	
40							X	X		X	
41			X		X					X	
42								X		X	
43										X	
44			X	X	X						X
45								X			
46	X										
47								X			
48							X				X
49					X						
50					X						
51								X			X
52								X			X
53						X	X				X
54	X	X							X	X	
55	X								X		
56			X		X		X				X
57			X		X						
58			X								X
59			X		X						
60	X	X									
61	X										
62	X										
63			X								
64	X	X							X	X	
65						X	X				X
66							X	X			
67								X			
68									X	X	
69					X						
70								X			X

71					X						
72	X	X							X	X	
73								X			
74								X			
75								X			
76								X			
77											
78								X			
79						X					X
80										X	
81								X			
82				X	X						
83			X	X	X						X
84			X		X						X
85	X								X		
86						X	X				
87						X	X				
88			X			X	X			X	X
89			X	X	X						X
90			X	X	X						X
91	X	X							X	X	
92			X				X			X	X
93			X		X						
94			X		X						
95			X	X							

Table 10. *Hunting dog breeds used in Sweden*

ID Number	Hunting dog breeds
1	Alpine Dachsbracke
2	Russian Spotted Hound
3	Basset Artésien Normand
4	Basset Bleu De Gascogne
5	Basset Fauve De Bretagne
6	Basset Hound
7	Bavarian Mountain Scenthound
8	Beagle
9	Black And Tan Coonhound
10	Bluetick Coonhound
11	Border Terrier
12	Bosnian Coarse-Haired Hound - Called Barak
13	Bracco Italiano
14	Auvergne Pointing Dog
15	Ariege Pointing Dog
16	Bourbonnais Pointing Dog
17	French Pointing Dog - Gascogne Type

18	French Pointing Dog - Pyrenean Type
19	St. Germain Pointing Dog
20	Brittany
21	Medium Griffon Vendeen
22	English Cocker Spaniel
23	Montenegrin Mountain Hound
24	Drentse Partridge Dog
25	Drever
26	Dunker Hound
27	English Setter
28	English Springer Spaniel
29	Field Spaniel
30	Finnish Spitz
31	Finnish Hound
32	Flat Coated Retriever
33	Old Danish Pointing Dog
34	Golden Retriever
35	Polish Hunting Dog
36	Gordon Setter
37	Gotland Hound
38	Grand Basset Griffon Vendéen
39	Grand Griffon Vendéen
40	Great Gascony Hound
41	French Wire-Haired Korthals Pointing Griffon
43	Fawn Brittany Griffon
44	Griffon Nivernais
45	Large Münsterlander
46	Halden Hound
47	Hamilton Hound
48	Hanoverian Scenthound
49	Irish Red And White Setter
50	Irish Red Setter
51	Istrian Short-Haired Hound
52	Istrian Coarse-Haired Hound
53	Jack Russell Terrier
54	Swedish Elkhound
55	Karelian Bear Dog
56	Small Münsterlander
57	German Short-Haired Pointing Dog
58	Labrador Retriever
59	German Long-Haired Pointing Dog
60	Norrbottenspitz
61	Norwegian Elkhound, Grey
62	Norwegian Elkhound, Black
63	Nova Scotia Duck Tolling Retriever
64	East Siberian Laïka

65	Parson Russell Terrier
66	Petit Basset Griffon Vendéen
67	Small Blue Gascony Hound
68	Plott hound
69	English Pointer
70	Posavaz Hound
71	Pudelpointer
72	Russian-European Laïka
73	Schiller Hound
74	Small Swiss Hound/Lucerne Hound
75	Swiss Hound/Lucerne Hound
76	Swiss Hound/Schwyz Hound
77	Serbian Hound
78	Serbian Tricolour Hound
79	Fox Terrier, Smooth
80	Slovakian Hound
81	Småland Hound
82	Italian Spinone
83	Stabyhoun
84	German Wire-Haired Pointer
85	Swedish White Elkhound
86	Dachshund Standard, Smooth-Haired
87	Dachshund Standard, Wire-Haired
88	German Hunting Terrier
89	Hungarian Vizsla. Short-Haired
90	Hungarian Vizsla, Wire-Haired
91	West Siberian Laïka
92	German Spaniel
93	Weimaraner, Short-Haired
94	Weimaraner, Long-Haired
95	Welsh Springer Spaniel

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