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Fakulteten för veterinärmedicin och husdjursvetenskap

The impact of Swedish game species on livestock feed production

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Abstract

Game related crop damage is a complex issue depending on several different factors and the current knowledge of how ungulate and crop damage are linked is scarce. This study aims to view if it is possible to connect ungulate densities of a study area with a new method for estimating grazing pressure and damage. If so, the current methodology could be used as a template for future estimation on ungulate impact, both concerning actual yield losses and economic losses. Vegetation height and damaged area was measured on 37 fields within the county of Södermanland. The farmers for each of the fields were sent questionnaires concerning farming, game and hunting. The results from the survey were analysed separately and compared with a survey conducted in 2014 where the same questions were sent to other Swedish farmers. Farmers in the current study experienced a higher mean damage and higher risk of economic losses due to game damage, than the Swedish average. A higher proportion of the farmers in the current study found the damage and the grazing pressure of the crops as unacceptable. The farmers which saw the crop damage as unacceptable were significantly more negative towards occurrence of fallow deer and wild boars. Farmers with fields in areas with high density of fallow deer were more likely to be involved in conflicts concerning game management. There was a significantly negative connection between fallow deer density of the field areas and vegetation height, which probably would result in reduced harvest yields of forage. The methodology of the study could be used to estimate grazing pressure, but could be improved by adding protected areas for comparison, as well as nutritional measurements and economic impact estimates.

Sammanfattning

Viltskador i gröda är en komplex fråga där kunskap om skadeuppkomsten i nuläget är begränsat. Syftet med denna studie är att undersöka om det finns ett samband mellan ett områdes klövviltsdensiteter och vegetationshöjder på åkrar. Om ett samband skulle förekomma skulle denna metod framöver kunna användas vid bedömning av klövdjurens inverkan på foderproduktion, både de faktiska förlusterna och den ekonomiska inverkan. Vegetationshöjder och skadeförekomst mättes på 37 åkrar i Södermanland. Brukarna av dessa åkrar fick frågeformulär med frågor om jordbruk, vilt och jakt. Brukarna i den nuvarande studien upplevde högre medelskador och större risk för ekonomiska förluster i samband med viltskador än övriga svenska brukare. Fler brukare upplevde även en oacceptabelt hög förekomst av viltskador och betesförluster i åkergrödor. De brukare som ansåg att skadorna var oacceptabla var signifikant mer negativt inställda till förekomst av dovhjort och vildsvin. Brukare i områden med högre förekomst av dovhjort var oftare involverade i konflikter gällande viltfrågor än övriga brukare i studien. Det fanns ett signifikant negativt samband mellan hög förekomst av dovhjort och åkrarnas vegetationshöjd, vilket bör kunna förorsaka lägre grovfoderskördar. Svaren analyserades separat, men jämfördes även med svar från en tidigare svensk undersökning från 2014 vilken innehöll samma frågor. Försöksupplägget kan användas för att estimera betestryck, men komplettering med betesskyddade områden, ekonomiska aspekter och mätningar av fodrets näringsvärde, skulle ge en mer komplett bild av de faktiska förlusterna.

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Introduction

Despite the fact that crop losses caused by game are a great concern for many farmers, this issue has gained quite little attention (Austin & Urness, 1995; Wretling Clarin & Karlsson, 2010). The damage arises as the game is grazing, rooting or trampling (Schley & Roper, 2003) the crops. Wild boar is the game which causes the largest crop losses in Sweden (Jordbruksverket & SCB, 2015). Thus, this is the ungulate which have gained most attention. The other Swedish ungulates, consists of moose, red deer, fallow deer and roe deer, which for most part are more known to cause damage to the forest sector (Ingemarsson. et al., 2007).

One reason for the low attention to agricultural damage is that there are several ways of reducing crop damage, thus, the farmer is expected to practice these methods. Among these methods are fencing, hunting and changing into a crop less desirable to game, which can be used alone or be combined. However, these commitments are time consuming, costly and might not be efficient enough to be worth the extra effort (Geisser and Reyer, 2004).

Until today the general knowledge of how game densities and the composition of different species affects the land use is limited. The actual game damage is often believed to be exaggerated since the damage mostly covers a small part of the field in relation to its full area. At a local scale, however, game damage may be comprehensive (Ericsson & Widemo, 2014a; Jordbruksverket & SCB, 2015). Swedish farmers may be compensated for crop damage caused by species protected from hunting, but not for damage caused by game (NFS 2008:16). In order to be able to compensate these losses, field inspections practices of crop losses have been developed regarding losses caused by protected animals. To which extent the different game animals causes losses are however quite unexplored (Månsson et al., 2010), thus, this is a question of debate. Grazing losses to leys and grasslands, as well as cereals in early stages of growth, has gained quite little attention, possibly since the exact amount of these losses are hard to measure (Putman & Moore, 1998).

The aim of this study was to see if it is possible to connect ungulate densities of a study area with a new method for estimating grazing pressure and damage. If so, the current methodology could be used as a template for future estimation of ungulate impact. The literature study was expected to provide a background of the need for a functional routine to evaluate damage and thus create a common benchmark to discuss the problem. This study will: 1. examine what type of crops that are sown; 2. examine ungulate related damage on different crops; 3. relate damage to ungulate density in the area; and 4. analyse farmer attitudes to crop damage. The hypothesis was that negative attitudes towards one or more of the ungulates would correspond to a high grazing or browsing pressure on the crops, as well as high density of the ungulate in the area. The grazing losses on grasslands will be measured by decreased vegetation heights on the fields, since this will be the result of extensive grazing. These effects would probably only reflect losses from red deer and fallow deer grazing of grasslands, and will not cover the more selective grazing by moose, roe deer, and to some extent also wild boar. On other crops, in which more selective grazing or browsing losses are expected, ungulate impact will be graded on a scale from ungrazed to high grazing pressure.

Literature study

The linkage between farm animals and game

Animal husbandry is a dominant production type in Swedish agriculture, with the exception of the central parts and southern county of Sweden where cropping farms are more common. Barley and leys are two important Swedish crops, and the majority of the leys, as well as considerable amount of the produced cereals, are included in the feed of our livestock. The number of farm animals in Sweden is currently decreasing (Statistics Sweden, *Agricultural statistics* 2015), and since joining the European Union, Swedish agricultural products have been competing on an international market. In many cases the increased economic competition has led to a lower profitability of Swedish farms (SOU 2014:38). This development has increased the need for efficient production, and a keystone to achieve this in animal husbandry is the ability to produce high quality feed to a low price (Växa Sverige, 2014). A problem with producing crops for feed is that they also will attract ungulates (Cerkal et al., 2009; Morellet et al., 2011). In a recent survey, 37.5% of the Swedish farmers growing cereals, legume seeds or oil plants reported some extent of game damage to their crops. In a majority of these cases, the effects on the crops were not noticeable, or resulted in losses of only a few percentages of the total crop yield. There were however some instances where the damage was extensive (Jordbruksverket & SCB, 2015).

Game related crop damage is a complex issue depending on several factors, but the current knowledge of how ungulate and crop damage are linked are scarce (Cerkal et al., 2009). This leads to conflicts worldwide (Bleier et al., 2012), and are thus not a local problem only seen in Sweden. Swedish farmers may receive compensation for crop damage caused by species preserved from hunting, such as some of the large birds (Månsson et al., 2011). The former law (SFS 1980:400) that allowed farmers compensation for damage caused by ungulates was abolished in 1995. This may force farmers to carry much of the costs related to a large ungulate population themselves, which may add to the ongoing conflict.

A high occurrence of game species may not entirely be detrimental for Swedish farm economy since it opens up the possibility for hunting, and thus provides a possible income for the area (Marchiori et al., 2012). Extensive pastures and marginal farmlands, which in traditional farming provide low economical returns, offer excellent feed for an increasing population of deer (Claesson, 1991). Grazing keeps the lands open, without the management practices needed in animal husbandry. More fertile farmlands can be rented by a neighbouring farmer or used for production of winterfeed for game, at the same time as hunting can be arranged on these lands. Hunting may then act as a population regulator, and this is the recommended praxis by the Swedish Association for Hunting and Wildlife Management (SOU 2014:38). Moreover, several studies have addressed hunting as one of the most important methods for reducing damage (Geisser and Reyer, 2004; Côte et al., 2004). A tenant farmer holds the hunting rights if nothing else is stated in the contract (SFS 1987:259), and can therefore regulate crop damage on the sown crops by hunting. It is, however, quite common that the landowner retains the hunting rights for him- or herself or leases it to another party. In a recent study by Ericsson & Widemo (2014b), only 12% of the Swedish tenants participating in the study owned the full hunting rights on their tilled land. This restrains the tenants' ability to regulate crop damage, which could make the tenants less positive towards game in general. However, no such connection was seen when comparing farmer's opinion on game populations (Ericsson & Widemo, 2014b). Conversely, a study performed in Södermanland found that tenants experienced a higher proportion of crop damage then landowners (Wretling Clarin & Karlsson, 2010).

Wild boars are known to causes the majority of the ungulate related crop damage in Sweden, and therefore a great part of the studies concerning game related crop damage in Sweden has focused on wild boars (Wretling Clarin & Karlsson, 2010; Jordbruksverket & SCB, 2015). But, according to the Federation of Swedish Farmers (Lantbrukarnas riksförbund, LRF) in Södermanland, which represent many of the active farmers in the area, local farmers experienced severe crop losses caused by other ungulates as well (Malmquist & Erjeby, 2014). These types of damage seem to be less well documented.

The Swedish ungulates

The ungulates described in this report are all considered part of Swedish fauna with their specific hunting seasons regulated in the Swedish hunting constitution (SFS 1987:905). Originally Sweden has five native ungulates, namely reindeer (*Rangifer tarandus*), moose (*Alces alces*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). Since the 15th and 16th century the domestication of reindeer intensified, and the Swedish reindeer are now considered domesticated (Bjørnstad et al., 2012). Fallow deer (*Dama dama*) was introduced into the Swedish fauna in late 1500, and the species is now well established in large parts of southern Sweden (Carlström, 2006). With the wild boar as an exception, all of the ungulates belong to the deer family (Christoffersson et al., 2010). Even though all deer are ruminants they have developed towards different ecological niches with different feed choices. Ruminants are commonly divided into two different groups, grazers and browsers, which fit these niches. Hofmann (1989) expanded this concept into three distinct groups; grass- and roughage eaters, concentrate selectors and intermediate ruminants. Grass- and roughage eaters are adapted towards a fibrous feed and graze with low selectivity; the domesticated cattle (*Bos taurus*) belongs to this group. The concentrate selectors are more adapted to digest plant cell contents derived from easily digestible forage, and do so with quite a high degree of selectivity. The intermediate ruminants are a combination of these two extremes as the intermediate ruminants prefer easily digested feed, but can also survive on more poorly digested fiber diets in contrast to concentrate selectors. Among the domestic animals, sheep (*Ovis aries*) belongs to this category (Hofmann, 1989).

The distinction between grass- and roughage eaters and concentrate selectors can be considered as a continuum where function and morphology of the digestive organs has adapted to maximize the needs of the different species. According to the classification by Hofmann (1989), both moose and roe deer are concentrate selectors whereas the moose is somewhat closer to the intermediate ruminants. The diet of moose mostly contains leaves and herbs. Red deer and fallow deer belong to the intermediate ruminants, with fallow deer closer to the grass- and roughage eaters. These species combine grazing of grasslands with occasional consumption of leaves, herbs and in some cases bark. Even if red deer and fallow deer do graze, they are far more selective than the grass- and roughage feeders (Hofmann, 1989).

The wild boar is a monogastric omnivore with plants as its main diet. The wild boar is also highly adaptive to its environment, and alters its diet according to availability. Agricultural crops are preferred feeds (Schley & Roper, 2003; Herrero et al., 2006; Ballari et al., 2015), but they may also perform their feed search on pastures. Wild boar effects on its surroundings have gained much attention, as it may cause extensive damage which leads to large costs (Geisser & Reyer, 2004; Bleiber et al., 2012). According to a report from the Swedish board of agriculture (Wretling Clarin & Karlsson, 2010), dairy producers are the group of farmers who suffer the most crop damage by wild boars. One explanation for this could be that dairy farms often lie close to forests, providing the wild boars a higher access to the crops (Bleier et al., 2012).

Population dynamics of Swedish ungulates

Since 1939, the Swedish Association for Hunting and Wildlife Management is responsible for wildlife surveillance and game population estimates are mainly based on Swedish hunting statistics (Kindberg, 2013). As a complement to this, data on number of observed animals, faecal pellet group counts, as well as numbers of game related road accidents (Geisser & Reyer, 2004; Milner et al., 2006) can be used for more reliable estimates (Johansson et al., 2013).

Through the years all Swedish ungulate population numbers have fluctuated, but are currently at high numbers and thus provide a valuable resource of game. Factors which may have been advantageous for ungulates are: changes in agriculture practices (Conover & Decker, 1991; Hewison et al., 2009), warmer winters, feeding of wildlife and low occurrence of natural predators (Massei et al., 2015). Historically, all Swedish ungulates have suffered an extremely high hunting pressure which in the case of wild boar once led to complete extinction. The species was however reintroduced by wild boars escaping enclosures in the 1970-80's (Thurfjell et al., 2009). Since the reintroduction, the wild boar population has recovered remarkably fast and is now considered established in all southern parts of Sweden (Viltövervakningen, 2016). A high fertility in combination with a large ability to adapt to new environments (Rosell et al., 2012) are two of the key factors which have made wild boars so successful. It also explains the fact that wild boars are expanding their geographical distribution. Despite the initially high population increase, the total numbers of wild boars now remains relatively stable in Sweden (Viltövervakningen, 2016).

Both moose and roe deer populations are well established in the main parts of Sweden, with the exception of roe deer in the northern mountain areas and moose on the Island of Gotland (Viltövervakningen, 2016). These species had their population peak in the early 80's and 90's, and the peak was partly caused by altered forestry and agricultural practices accompanied by an increase in available browse (Cederlund & Markgren, 1987). In parallel with this, the population of red foxes suffered an outbreak of Sarcoptic mange (*Canine scabies*) which led to increased roe deer fawn survival due to a lower predator occurrence (Jarnemo & Liberg, 2005). Changes in hunting practices also led to an increased survival of reproductive moose cows causing an increase in born calves and a rise in moose population (Cederlund & Bergström, 1996).

In contrast to the other ungulates, the populations of fallow deer and red deer are mainly concentrated to specific areas in southern Sweden (Viltövervakningen, 2016) and the dispersal of the home range is quite slow (Carlström, 2006) compared to the other ungulates. Despite this, the populations have increased in Södermanland. This is also true for the population of wild boars (Viltövervakningen, 2016), while the population of roe deer and moose seem to remain stable or has decreased in Södermanland over the last years (Viltövervakningen, 2016).

Effect on feed production

Impact on cereals

Of the game damage seen on agricultural crops, damage to cereals has gained the most attention (Conover & Decker, 1991). The ability of cereals to recover from grazing losses is reduced towards the end of the growing season. Therefore, game damage which occurs late in season will lower the harvest as well as reduce economical returns for the farmer. Despite this, only a few scientific studies concern the effect that big game may have on cereal grains (Austin & Urness, 1995).

Ungulate species composition, as well as population density, has a great impact on the damage seen in an area. Bleier et al. (2012) compared the extent of crop damage with different bag densities (number of shot game per area) of wild boar, red deer and roe deer in Hungary. The correlation between crop damage and bag density was positive for wild boar and red deer, but no connection was seen with roe deer. An increased forest edge length to field ratio, as well as a higher proportion of forest to field area also increased the amount of damage. Similarly, Novosel et al. (2012) found that an increased game density and reduced length to forest edge ratio increased the occurrence of crop damage in Croatia. Crop type has an effect on the amount of damage, as most of the damage in a Hungarian study was related to corn (*Zea mays*) and sunflower fields (Bleier et al., 2012). The fact that wild boars have a preference for corn corresponds with several other papers that have investigated the diet preference of wild boars by looking at stomach content (Schley & Roper, 2003; Herrero et al., 2006; Ballari et al., 2015). When corn is not available, other agricultural crops became the primary choice of feed (Schley & Roper, 2003; Herrero et al., 2006). In general, wild boar is the game species which causes the largest crop losses in Sweden, and the highest losses are found in corn, wheat, cereals grown for silage, oats and peas. Wild boars also cause substantial losses in leys. In Södermanland the largest losses caused by wild boars were those concerning cereals grown for silage, peas, faba beans and oats (Jordbruksverket & SCB, 2015). In a study by the Swedish board of agriculture, Wretling Clarin and Karlsson (2010) interviewed farmers in Södermanland and found that the wild boars caused the largest damage in wheat, oats and peas.

The impact of grazing of cereals is influenced by a number of factors, one of them being the developmental stage of the plant (Putman & Moore, 1998). Obrtel and Holisova (1983) identified two main periods of herbivore damage to crops; firstly the early stages of growth where leaves are grazed and secondly the maturing stages where the spikes are browsed. A Croatian study, supporting this thesis, found wild boar, red deer and fallow deer to be responsible for most of the crop damage. Damage mainly arose between May and October, with a peak seen at seed maturation (Novosel et al., 2012). Another study tested plant recovery and quality after grazing in an early growth state with simulated grazing intensities. A grazing pressure of 0, 25, 50 and 75% leaf area removal was performed on winter wheat, corn and spring barley. The crops in the trial were selected due to a documented high attractiveness of game, and the trial was conducted in the Czech Republic. Corn was the only crop that showed any effect on grain yield following simulated grazing. The reduction was 4 - 14% and was restricted to one of three years of trials. Thousand grain weight was not effected by simulated grazing pressure, but it increased the Falling Number in wheat (Cerkal et al., 2009).

In an earlier study, Austin & Urness (1995) evaluated the actual grazing impact on winter wheat by estimating grazing by mule deer, pronghorn and Rocky Mountain elk in Utah, USA. Twelve field trials were conducted; each with a set of 1-m^2 plots. In each trial, 1 - 2 of the plots were totally protected against grazing by wire cages (PWC). The different fields were either grazed during fall, spring, summer, or grazed from fall to summer and additionally cut during fall and spring in order to simulate maximum utilization. At the end of each period, all plots were hand clipped and the air dry weight was measured as well as the grain weight. The results showed that biomass production was low in fall, increased rapidly during spring and summer and declined in mid-June. The highest grazing pressure was seen during fall (9 - 60%), it decreased during spring (0 - 28%) and even further during early summer (-4 - 10%). The study could not show any difference in grain yield among trials due to treatment, except between unprotected grazed plots and the maximum utilization plots. The authors also noticed some grain losses due to trampling of trails, even if losses were not significant. Deer were also seen browsing weeds on the fields, therefore grazing could have a positive impact as well. A similar experimental design using PWC was later performed in the same area. In this study, grazing losses due to mule deer were evaluated in an alfalfa field. Significant losses of DM were found in 8 of 24 trials and the losses ranged from 0 to 40%. However, no nutritional parameters (e.g. protein, metabolizable energy, neutral detergent fiber or minerals) differed between the grazed and protected plots. In these fields, the estimated losses per deer and night were 2.2-2.6 kg DM (Austin et al., 1998).

An alternative to the use of PWC is establishment of transects across a field. This method was used by Putman (1986) who evaluated the crop losses caused by roe deer in spring barley and winter wheat fields by establishing fixed transects. These transects were placed to cover as much of the field as possible. Every damage seen along a transect was measured and total damaged area was calculated. A square meter plot was established within every damage to monitor crop recovery until harvest. Prior to harvest, each plot was clipped and the harvests of these areas were compared with the rest of the field. The total damaged area never exceeded 5% of the field area, and the locations of damage were quite variable, both within and between fields. Roe deer primarily grazed the field from March to May, and this early grazing did not reduce grain yields. Wilson et al. (2009) used a similar method to evaluate crop damage caused by red deer and fallow deer. A field was monitored for three succeeding years in which winter wheat (2 years) and winter barley (1 year) were sown. The crops were inspected from crop emergence until harvest; during this period, all signs of grazing were noted and then removed in order to avoid duplications. Before harvest, 10 sections untouched by deer and 10 sections with varying levels of damage were randomly selected for analysis. Yield within each section was estimated and the yield in ungrazed areas was compared with the grazed areas. The analysis showed that grazing caused a harvest loss of 7.1% in a year with winter wheat, and the main part of these losses could be attributed to areas most heavily used by deer. No significant losses were seen during the other two years. A significant variation in yield across the field was seen during two of the years (first and second year of study).

The fact that cereals are a great source of energy, in combination with its availability, may even attract ungulates that are not usually associated with grazing farmed fields. This is especially true for areas including forest patches, which are used as a refuge for ungulates (Godvik et al., 2009; Wilson et al., 2009; Bleier et al., 2012), within close contact to crop field. The fields located in such areas are often the areas that have the highest occurrence of damage (Jordbruksverket & SCB, 2015). Similarly, Swedish farmers with fields in forest regions (‘skogsbygd’) were more negative towards game than farmers in partially wooded landscapes (‘mellanbygd’). Farmers in a more open landscape (‘slättbygd’) were the most positive towards game (Ericsson & Widemo, 2014b).

Moose is one of the species that is commonly known as a forest habitat species and which is not adapted to a starch rich diet, e.g. cereals (Butler et al., 2008), but have a preference for oats and in some areas they can consume a great part of the crop (Jordbruksverket & SCB, 2015). Another species that foremost will be found in forests are roe deer as they seem to actively select against cereal fields during the major part of the year (Putman, 1986; Morellet et al., 2011). However, there may be some advantages with cereal fields. In a study by Hewison et al. (2009), the hypothesis of a nutritional advantage of roe deer in a more agriculture dominated area was tested. This was done by comparing the body mass of roe deer caught in an open landscape compared to ones caught in a forest dominated area. The deer caught in open landscapes were heavier than the others; this correlation was especially pronounced in juveniles. Faecal samples from open landscape roe deer also had a higher content of both nitrogen and phosphorus, indicating that their diet had been of a higher quality.

Skåne was the county in Sweden where fallow deer caused the largest damage to cereal crops, and of these, the damage to oats was the most pronounced. As much as 60.2% of the losses in oats were caused by fallow deer, which can be compared to the Swedish average of 9.8%. The county of Södermanland had the second largest losses caused by fallow deer, covering 26.2% of the total losses in oats. Red deer caused the largest crop losses in winter wheat, triticale and rapeseed, and the highest losses in these crops were found in Södermanland (Jordbruksverket & SCB 2015; table 1).

Table 1. *Total crop losses (%) caused by red deer. When data were gathered from less than three farms, no numbers were available and therefore replaced by *. Modified from Jordbruksverket & SCB, 2015.*

Type of crop	**Total crop losses caused by red deer (%)**		
	County of Skåne	County of Södermanland	Swedish average
Winter wheat	7.2	27.8	8.8
Triticale	*	38.6	11.6
Winter rape	17.8	25.6	13.0
Summer rape	*	30.8	15.6

Grazing and damage on leys

Ungulate grazing on leys and pasture may led to yield losses as well as more pronounced damage, and therefore concerns many farmers. These losses also seem to be the ones that are the hardest to measure (Putman & Moore, 1998). In Sweden, game damage are not covered by any compensation system (Månsson et al., 2011), making it harder to view the actual damage and change of incidence over time (Trdan & Vidrih, 2008). The common picture is however that ungulate grazing of grasslands has a quite low economic impact (Côte et al., 2004), and for most part has a positive effect on grass growth (Hilbert et al., 1981). Instead, the wild boar is the ungulate which causes 70% of losses on Swedish leys. In excess of actual crop losses, wild boars can reduce farmers' incomes by rooting in extensive pastures which would otherwise receive state grants for having unique floras (Wretling Clarin & Karlsson, 2010; Jordbruksverket & SCB, 2015). Pastures can also be seen as the only permanent crop, thus, these damage might be harder to restore (Novosel et al., 2012). In a recent Swedish study (Jordbruksverket & SCB, 2015), the largest yield losses of leys caused by ungulates were 5.9% of the total expected yield and were found in the county of Kalmar. A majority of these, 73.8% could be related to damage by wild boar. The second largest losses of ley were found in the counties of Kronoberg and Södermanland (3.7% of the total expected yield). As in Kalmar, the majority of the damage seen in Kronoberg were caused by wild boar (92%), in Södermanland on the other hand, the losses were caused by red deer (38.8 %), wild boar (29.5%) and fallow deer (15.8%). Therefore, the remainder of this section will mainly focus on losses caused by deer.

Only a couple of studies deal with the impact that deer might have on forage production. In a Slovenian study, red deer were perceived as the game which caused largest losses in leys. In three different areas, with reportedly high densities of red deer, the assumed grass yield losses in ley were tested by using PWC. At each location, plots were assessed and equally distributed to one of three treatments: protection from onset of the experimental period until sampling; unprotected until 2-3 weeks before sampling; and unprotected areas which were freely grazed until sampling. Over the experimental period, which lasted from the end of March until beginning of October, the highest total mean yield was found in the totally protected plots. The plots which were grazed for 2-3 weeks before sampling yielded, 70-73% of the yield in protected plots, whilst the totally unprotected plots yielded 32-62 %. The grazing pressure was increased with decreased forest edge distance (Trdan & Vidrih, 2008). The grazing impact of red deer in pasture (one area), and fallow deer in leys for forage production (two areas) was assessed in an English study. In the pasture, PWCs were placed and the DM grass yield was evaluated within and outside the cages just prior to turn out of stock (1 March). The same procedure was applied in the leys, and the DM grass yield was evaluated just prior to harvest. In each of the areas, the grass yield was lower outside, than inside the cages, this difference was however not significant for both leys. The authors found the losses to be about 15% of the yield gathered in the protected cages, but since the yield variations within a field would at some locations reach 70%, they found the grazing effects to be modest in comparison (Wilson et al., 2009). Wilson et al. (2009) estimated the deer red deer densities (15-20 deer/km^2) to be about the same in their study, as in the study by Trdan & Vidrih (2008). The authors argued that a high occurrence of forest in Slovenia (60% of the area; Trdan & Vidrih, 2008) would possibly increase the losses due to an increased access of grasslands to deer.

A more recent study, which tried to estimate forage yield losses due to red deer grazing, was performed by Marchiori et al. (2012). The study area was located in the Italian Alps, an area which hosted a high density of red deer protected from hunting. During two years, PWCs were placed on meadows of four different farmlands. Prior to harvest, the grass inside the cages were harvested, the DM yield was evaluated, and the nutritional value of the grass examined. The same analysis was performed on the grass of a 1 m^2 plot 1-2 m from each PWC. The values inside and outside the cages was then compared. DM yield and crude protein content (CP) was highly affected by cut, sampling position and farm. Still, the DM yield was significantly higher inside than outside the PWC in all cuts and years. The difference accounted for approximately 15-20% of the DM yield during the first cut, and 25-40% during the second cut. As there was a positive correlation between deer index and production losses, these yield losses were confirmed to be a consequence of deer grazing. There were no significant differences in CP inside and outside the PWC when the CP content inside PWC was 12-13% DM, but when the CP content reached 20-25% DM, the CP content outside the PWC was significantly reduced. According to the authors, this can most likely be explained by an increased selective feeding by the deer as they may select plants or parts of plants with a higher CP when possible. Distance to forest edge only had a limited impact on yield losses, which could be an effect of the reduced risk of being shot (Marchiori et al., 2012).

Regardless of the exact quantitative losses, the prediction of when damage mainly occurs might be a helpful tool for reducing it. Red deer grazing on leys were seen during the entire vegetative period (Trdan & Vidrih, 2008), but mostly during fall and spring, and sightings were reduced during winter and summer months (Godvik et al., 2009). Roe deer also grazed grasslands during fall, but grazing was more pronounced in the spring, as they mainly feed on grasslands during this period. Throughout summer, fall and winter, roe deer showed a greater preference for woodlands (Putman & Moore, 1998). The same pattern was seen with red deer, which could be explained by an increased woodland forage production in the summer in combination with shelter (Putman, 1986; Godvik et al., 2009). The extent of the losses may also depend on grazing period as Trdan & Vidrih (2008) found that grass regeneration was highest in summer, moderate in spring and smallest in fall.

Preventing ungulate impact

There are several ways to prevent crop damage, among them hunting, baiting and the use of electrical fences. Geisser and Reyer (2004) evaluated the efficiency of these methods to reduce crop damage by wild boars in a Swiss area. In this study, hunting was the only method which significantly reduced damage, while an increased baiting and fencing were linked to an increased occurrence of crop damage. Baiting may change the location of the damage by redirecting the spatial distribution of boars, and it has also been discussed that increased baiting can lead to improved fertility, followed by a higher occurrence of damage (Schley & Roper, 2003; Ballari et al., 2015). However, it has recently been discussed that in order to evaluate the true effect of baiting, a broader study is needed in which several other effects, such as occurrence of other feedstuff, are monitored in parallel (Ericsson & Widemo, 2014a). Fencing did reduce damage in wheat, but had no effect on damage in corn fields and even increased damage in grasslands. This indicates that fencing is not sufficient to reduce damage, but only shifts the damage to unfenced areas (Geisser and Reyer, 2004).

A common practice of reducing crop damage is the use of alternative crops which are less desirable for game species. In a study by the Swedish board of agriculture, 50% of the farmers in Södermanland adapted the choice of crop after occurrence of game, compared to the Swedish average of 26%. Of the farmers who had no game damage, there were also more farmers in Södermanland than the Swedish average which stated that they had adapted the choice of crop after the occurrence of game (22% and 12%, respectively; Jordbruksverket & SCB, 2015). Among the preventative methods that farmers applied to prevent damage were hunting; fencing; use of different types of scaring devices; and delayed seeding. Without these preventative methods, the crop damage would probably have been considerably larger. Farmers may also reduce game related crop losses by early re-seeding of damaged crop, or by using leys for grazing instead of intended harvest. As there are no available data from these practices, crop losses related to game damage may be underestimated (Jordbruksverket & SCB, 2015).

Materials and methods

Field tract selection

The gathering of data was made in the county of Södermanland, Sweden (58°6′N, 17°1′E), and all field data was gathered between 21th of August and 9th of September 2015. Since all of the native ungulates are established in the area, with some local variations, it represents an ideal area to study the ungulates' effect on crops. All data gathered in this study were collected from arable fields within a FOMA ('Fortlöpande miljöanalys') reference area in Södermanland, Sweden (Edenius 2012, 2013, 2014). This area comprised of fifty smaller tracts, each 1 km^2 large and set 3 km apart in a grid system. The arable fields within the closest range of the tract centre and which received funds from the Single Payment Scheme (gårdsstöd) 2014, were chosen as candidate tract fields (TF below) for data gathering. Thus, the candidate fields were selected independent of crop type. Data on the closest field and owner or tenant, hereafter referred to as farmers, of each field were acquired from the Country Administrative Board. Initially, all farmers were contacted in order to get permission to inspect their fields. Some farmers were responsible for more than one TF within the study; subsequently 40 unique farmers were included in the study. Among the farmers, 37 could be contacted and approved the inspection. Correspondingly, all field data were gathered from these fields.

Monitoring procedure and definition of grazing and browsing

Leys

This category includes grasslands for forage production, fallows and pastures on arable land, which was all inspected with the same approach.

On leys, a minimum of ten points were randomly distributed alongside the field. From these points a GPS mark was made perpendicularly from the field margin, twenty-five meters into the field. At the GPS marks, the grass height was measured and grazing pressure from wild ungulates was evaluated according to the scale: ungrazed (UG), signs of grazing (G), medium grazed (MG) and high grazing pressure (HG). The area was defined as UG if there were no visible signs of grazing and as G if grass with fresh cut surface, likely to have been caused by grazing, were found. If the area included both sections that had a clear impact of grazing and sections that were more or less untouched, it was classified as MG. An area was defined with HG if the vegetation was grazed to a uniform low height. The classification of grazing pressure was made directly on the GPS mark and within a range of 10 m^2 around it. Another twenty-five meters into the field a new GPS mark was made, the grass height and the browsing pressure was evaluated in the same way as described above. An example on a TF and the distribution of GPS marks can be found in Appendix. 2.

A great proportion of the TF in the study were grasslands and in most cases one or more harvests of grass had already been collected from the fields. The harvest could be seen as a dried cut surface on the grass at the same height all over the field. The date of most recent harvest of the ley was obtained from the farmers and noted, in order to make it possible to correct for the effect of harvest on the vegetation height. Grazing was seen as a deviation in form of shorter tussocks of grass and fresh cut surface on leafs. Therefore, earlier cut fields allowed a clear distinction between ungrazed areas, and grazed areas. In cases of newly cut fields, where the cut surface was still fresh, a distinction between cut and newly grazed grass was not possible. Therefore the GPS marks on these fields were mostly classified as ungrazed, regardless of possible additional grazing.

Unfortunately, the grazing evaluation would not allow any distinction between grazing of ungulates or by livestock such as cattle, sheep or horses. Therefore, the evaluation of grazing pressure in pastures will describe the combined grazing pressure of livestock and the grazing of wild ungulates, without making it possible to determine their relative importance.

In addition, vegetation height was measured using a grass ruler (Appendix 3.) where a plastic sheet (A4) was held 5 cm over the highest vegetation on each measurement point and then dropped so that the combined height of the vegetation could be measured. The vegetation height was measured at all GPS marks in all leys and pastures.

Cereals and salix

In fields with cereals, the evaluation of grazing pressure was be made by following old tracks from tractors and sprayers to avoid trampling of the crops. GPS marks were made at about fifty meter intervals and grazing pressure was evaluated at the GPS mark and 10 m^2 around it. Grazing of grass differs from grazing of relatively ripe cereals, thus, the definition of grazing intensity had to be modified. Most of the cereals also had a ground layer of complementary vegetation that could be attractive to game. If neither cereals, nor complementary vegetation had any visible signs of grazing, the area was classified as UG. The area was classified as G if the vegetation had fresh cut surface on the straws, and MG if grazing was extensive. If the absolute main part of the plants were grazed, the area was classified as HG. If an area had a high occurrence of trampling or droppings in combination with scare vegetation compared to the rest of the field, the area was also classified as HG.

Any game related damage on the fields was noted and the extent of damage was measured and marked with a GPS mark, if damage exceeded an area of 1 m^2. These measurements were made even though the damage did not fall inside the 50 m plots. Areas that had several smaller damage which fell below the 1 m^2 threshold but were in close contact, were grouped into one large damage. Since these areas contained parts that were undamaged, they received a lower severity on the browsing scale than the damage within it.

On TF with Salix, old furrows were followed to ease the inspection of the field. The grazing scale could not be used on this type of crop. Instead, browsing pressure was evaluated according to the scale; unbrowsed (UB), signs of browsing (B), medium browsed (MB) and high browsing pressure (HB). An area was considered UB if there were no signs of browsing, or if browsing were of an earlier date with a grey cut surfaces. If there were a couple of freshly browsed branches and shoots the area was classified as B, and MB if more was browsed. If every Salix bush within the area of 10 m^2, and within reach for browsing, had several freshly made cuts it was considered HB. The maximum browsing height was set to 3 m which was a height that had been used in an earlier study by Edenius & Ericsson (2015). The browsing pressure was evaluated every 50 m and was marked by a GPS point.

Questionnaire

The farmers' from all fifty tracts were sent questionnaires with questions concerning farming, game and hunting. Since the questionnaire sent to the farmers was meant to be a pilot questionnaire for further studies, it also included game related questions which were not relevant for this study. Therefore, the analyses were restricted to a relatively small part of the questions related to ungulates and of interest for this study (Appendix 1.). The farmers were asked how they thought game affected their farming management. The farmers which were responsible for more than one TF only received one questionnaire and were asked to answer this with all TFs in mind.

The questionnaire used in this study was based on a questionnaire that was sent to Swedish farmers in an earlier survey concerning game impact on Swedish agriculture which was conducted in 2014 by Ericsson & Widemo (2014b). The results from the current study, with farmers from Södermanland, were compared with the results from 2014. Thus, the attitudes to game distribution and numbers, as well as the farmers' attitude towards game could be compared between Södermanland and the national figures for all of Sweden. For some questions, printing mistakes were detected after the questionnaires had been sent out. These inaccurate questions were discarded and each farmer was contacted so that the original questions could be asked over the phone. In those cases where farmers had returned a questionnaire, but could not be contacted by phone, the faulty questions were left empty when analysing the data. Thirty-two of the farmers returned their questionnaires, and of those, 29 could be reached for asking complementary questions. This gives an answer frequency of 80% and 72.5%, respectively.

Data analysis

All statistical tests were performed in Statistica 13 (Dell Inc. 2015. Tulsa, USA). Some variables were not normally distributed and were analysed using non-parametric tests. The statistical method used was the Mann-Whitney test, which is the non-parametric equivalent to the t-test and the Spearman rank correlation which is the nonparametric equivalent to linear regression. The sample sizes did not allow for multivariable analysis. The analyses included survey results as well as inventory data such as mean vegetation height and crop type.

The farmer's choices of crops inside the study area were compared to the choices of crops in all of Sweden and in Södermanland (Statistics Sweden, *Agricultural statistics* 2015) using G-tests (Sokal & Rohlf 1995). The ungulate densities and the ungulate species composition for every TF and its surrounding area were based on dung counts performed in the areas, and were taken from FOMA data from previous years (Edenius 2012, 2013, 2014). The grazing index from leys and pastures proved difficult to analyse. First, it often was impossible to tell whether the vegetation had been cut or grazed. Second, it was not possible to tell grazing from game apart from grazing from livestock in pastures. Third, the leys and pastures either appeared to hardly have been grazed at all or to be heavily grazed, yielding low or high but no intermediate indices. As a result, mean grass height was used as the only measure of grazing pressure and no further analysis was done on the estimated grazing pressure. This decision was made prior to any analysis.

There were no significant differences in the corrected vegetation height of leys within fields 25 and 50 m from the edge of the field (paired t-test, $n= 24$, $t= 0.61$, $p= 0.55$). Thus, the measurements at 25 and 50 metres from the field edges were combined for each transect within fields, to yield averages based on more measurements. As there was a clear positive correlation between mean grass heights of leys and time since last harvest, all mean grass heights were corrected for time since last harvest using residuals from the regression of vegetation height on days since harvest ($n= 26$, $r^2= 13.7$, $p= 0.035$).

Landowners and tenants may not be affected in the same way by game species, thus, it would be preferable to analyse these different attitudes separately. However, Ericsson & Widemo (2014b) could only detect small differences in damage and attitudes between farmers that were landowners and tenants. Also, many farmed both land they owned themselves and land they leased. These findings, in combination with the small sample size in the study, resulted in an overall analysis of the attitudes of all farmers included in the current study. In order to see if these attitudes differed from other Swedish farmers, the data was tested against the data of Ericsson & Widemo's (2014b). When analysing the perceived mean damage on crops caused by game and the perceived economic impact the answers were graded on a scale from 1; negligible, to 5; severe. Quantitative attitudes (such as negligible-small-medium-large-severe) were ranked in order using numbers and analysed using non-parametric methods.

Results from the survey were analysed separately and compared with the survey of 2014. The answers from the farmers were also related to the corresponding ungulate density of the TFs.

Results

Study area properties

A large majority of inspected fields were leys. This category represented 70% of the fields within the study area. Only 14% of the fields were cereal fields of different types (wheat, barley, oats and mixed grains). The choice of crops differed between the study area and all of Sweden (G-test, I= 19.1, df= 2, p< 0. 001) and the county of Södermanland, as farmers grew less cereal and more leys in the study area (Fig. 1.).

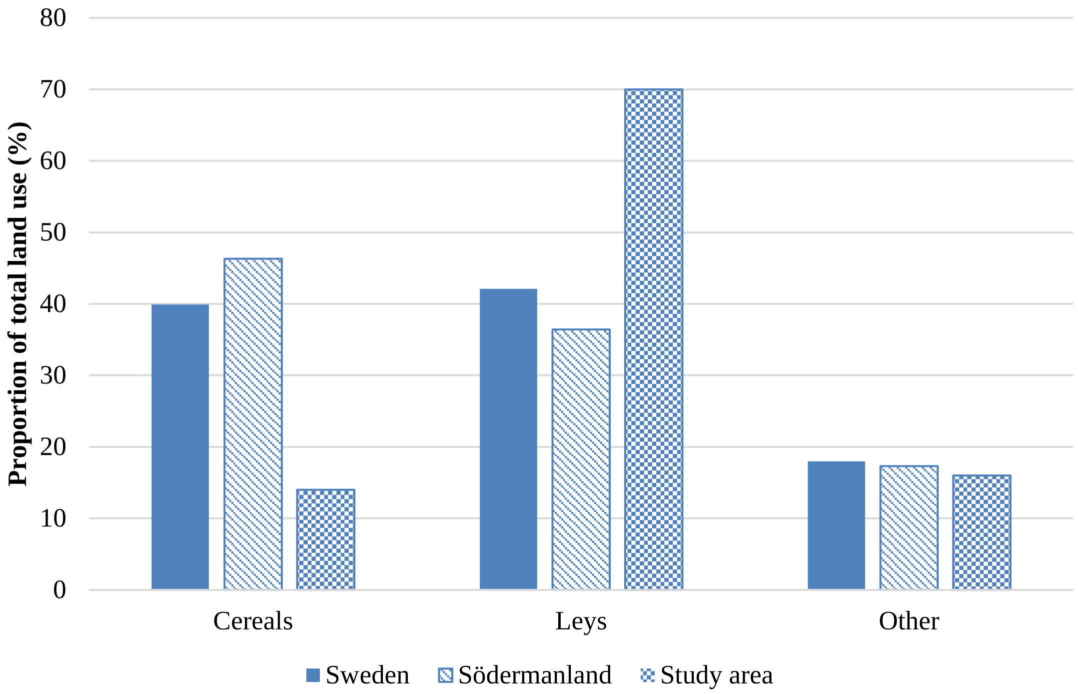

Figure 1. Field use in the study area (proportion of all fields), the county of Södermanland and nation level (area land use). Data modified from Statistics Sweden, Agricultural statistics 2015.

The majority of the tract fields (81%) were located in partly wooded areas with similar occurrence of forest areas as farmland areas, whilst the remaining tract fields were located in forest dominated areas (19%).

According to the farmers of the study, populations of fallow deer and wild boar were established in the majority of the TFs (Figure 2.), while roe deer and red deer were less prevalent and moose were established in one third of the areas.

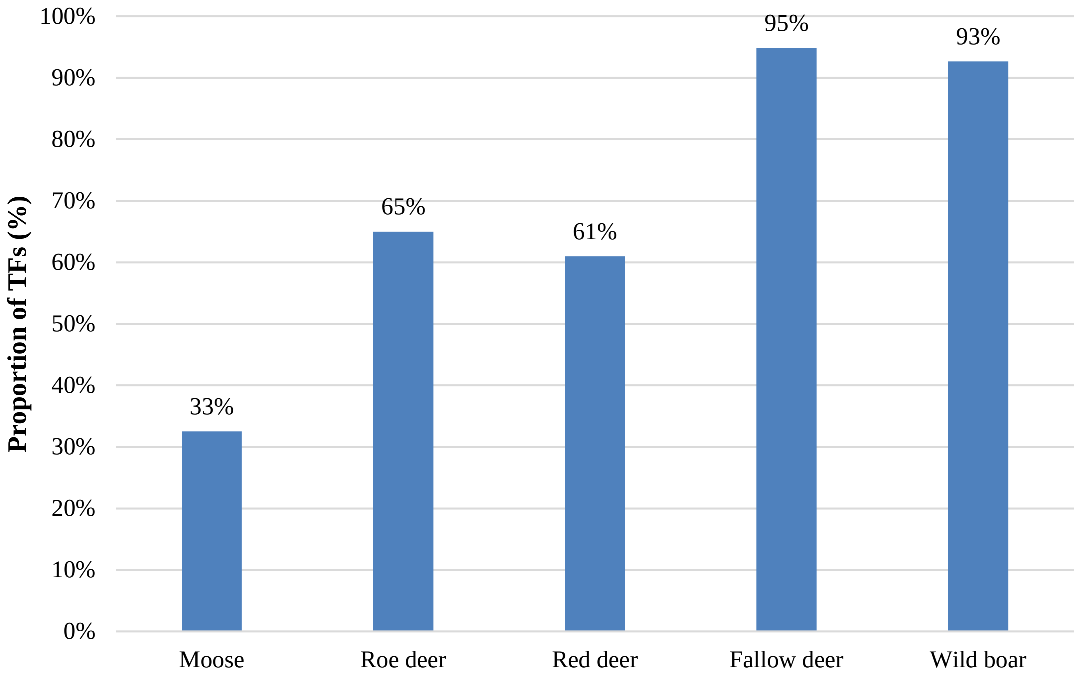

Figure 2. Proportions of the TFs where populations of the different ungulates were established.

Damage to crops

On average, 57% of the total area of inspected cereal fields was judged to be affected by game grazing, but of these, only 1.41% of the total field area suffered complete crop losses which could be linked to game. There was however a large area of the fields which had poor establishment of vegetation, but where effect of game could not be confirmed as the single factor. There were too few cereal fields to compare statistically different cereal crops, and too few cereal fields to look att effects of ungulate densities on levels of damage.

There was a significant negative correlation between grass height and occurrence of fallow deer, but no significant correlations was seen with the other deer species (Table 2).

*Table 2. Spearman rank correlation tests of mean grass height, corrected for days since last harvest, tested against the deer densities. Significant correlations ($P<0.05$) are marked with *.*

Independent variables	n	r_s
Moose	26	0.11
Red deer	26	0.28
Roe deer	26	0.06
Fallow deer	26	-0.50*

Questionnaires

Impact of damage

Farmers in the current study perceived a significantly higher damage than the average Swedish farmer in 2014 (Mann-Whitney; n= 570 & 29, p= 0. 000008).

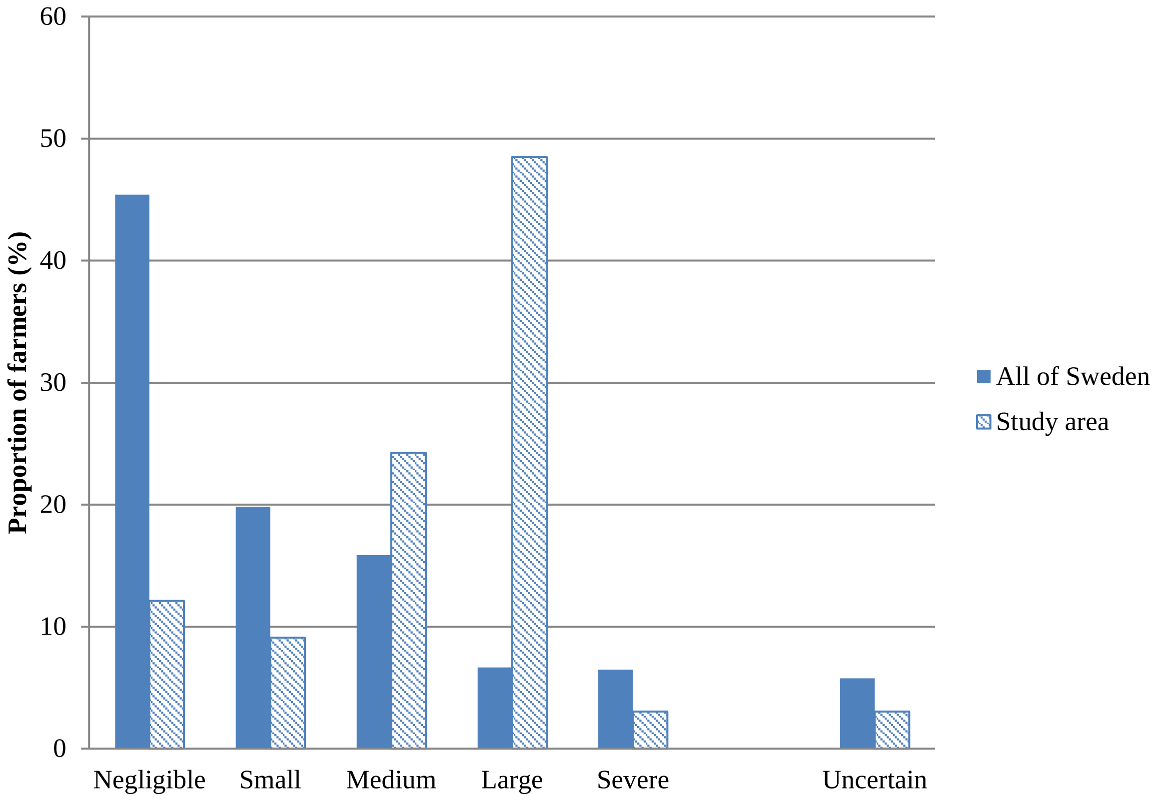

Figure 3. Farmers' perceived mean field damage; answers of farmers from all of Sweden and answers from the study area.

Farmers in the current study perceived a risk of a negative economic impact of ungulate grazing for all crops, to be larger than the average Swedish farmer (Mann-Whitney; n= 667 & 29, p= 0. 003; figure 3). There were no significant correlations between vegetation height on leys and perceived damage (Spearman rank correlation; n= 24, r_s= -0.16, p> 0.05) or vegetation height and perceived risk of economic impact (Spearman rank correlation; n= 24, r_s= 0.05, p> 0.05).

Factors affecting farmers attitudes

In the current survey, 69% of the farmers thought that one or more of the ungulate species caused unacceptably large damage on their crops, which was significantly more than the farmers from the earlier survey perceived (Mann-Whitney; n= 649 & 29, p= 0.008). When this question was narrowed down to include only the grazing of leys, there were still more farmers in the current study than the average which perceived this as unacceptable (Mann-Whitney; n= 653 & 29, p= 0.007).

The ungulate densities did not differ significantly between tract fields of farmers who perceived vegetation height as unacceptably low and those who saw them as acceptable (Mann-Whitney; n= 24; 9, all U< 62.5, all p> 0.065).

No significant correlations could be seen between perceived crop damage and negative attitudes to moose (Spearman rank correlation; n= 24, r_s= -0.38, p> 0.05), nor to red deer (Spearman rank correlation; n= 24, r_s= 0.26, p> 0.05) or to roe deer (Spearman rank correlation; n= 24, r_s= -0.20, p> 0.05). There were, however, significant negative correlations between perceived crop damage and farmers' attitudes to wild boars (Spearman rank correlation; n= 24, r_s= 0.54, p< 0.05) and fallow deer (Spearman rank correlation; n= 24, r_s= 0.61, p< 0.05). When comparing farmers' attitudes towards wild boars and fallow deer, there were no significant difference between their attitudes (Mann-Whitney; n= 29 & 25, p= 0.72).

The majority of the farmers in this study did not experience any conflicts related to game management, but 24% of the farmers in the current study did. This was significantly more than the average Swedish farmer (Mann-Whitney; n= 718 & 28, p= 0.003; Figure 4). Farmers that had experienced conflicts with respect to game management had higher fallow deer densities in the areas in their tract fields, as compared to farmers who didn't experience any (Mann-Whitney; n= 20 & 7, p= 0.03). There were no corresponding relationships for other ungulates (Mann-Whitney; n= 20 or 19; 7, all U< 37.5 all p> 0.07).

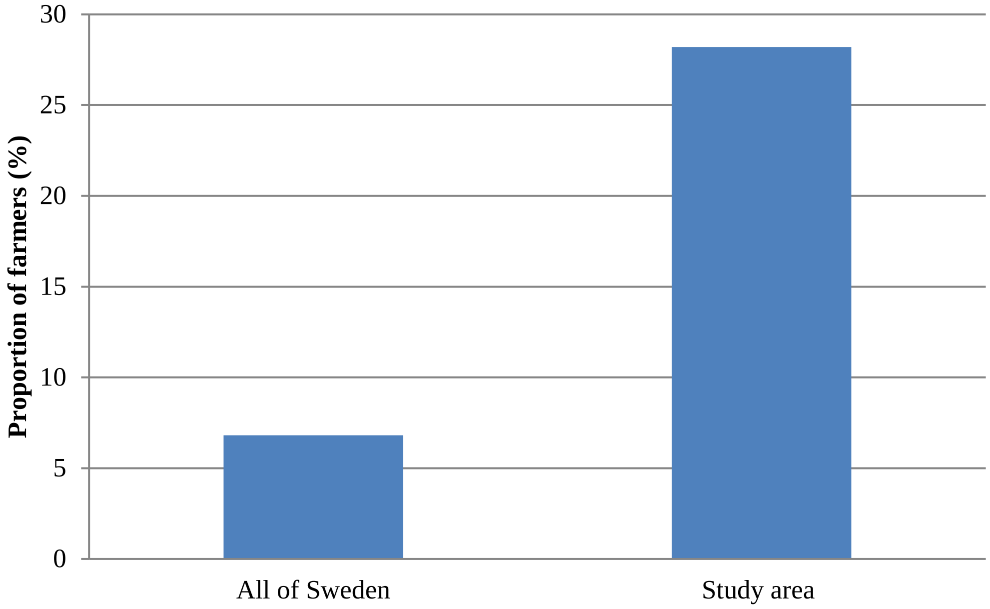

Figure 4. Percentage of farmers from all of Sweden (7%) and the study area (24%) which experienced a conflict related to game damage.

Prevention of game damage

In total, 70% of the farmers in the study area specified that they had used one or more method for preventing game damage to crops. The most common way of preventing damage was extended hunting during hunting season; this method was used by 62% of the farmers. The second most used method was to change to a crop less attractive to game; this was done by 52% of the farmers. The farmers were also asked to specify which crops they avoided planting in order to reduce crop damage, and what crops they used as substitutes (Figure 5). Fewer farmers used diversionary feeding (33%), fencing of crops (19%) and different types of scaring devices (5%) as methods for preventing crop damage by game.

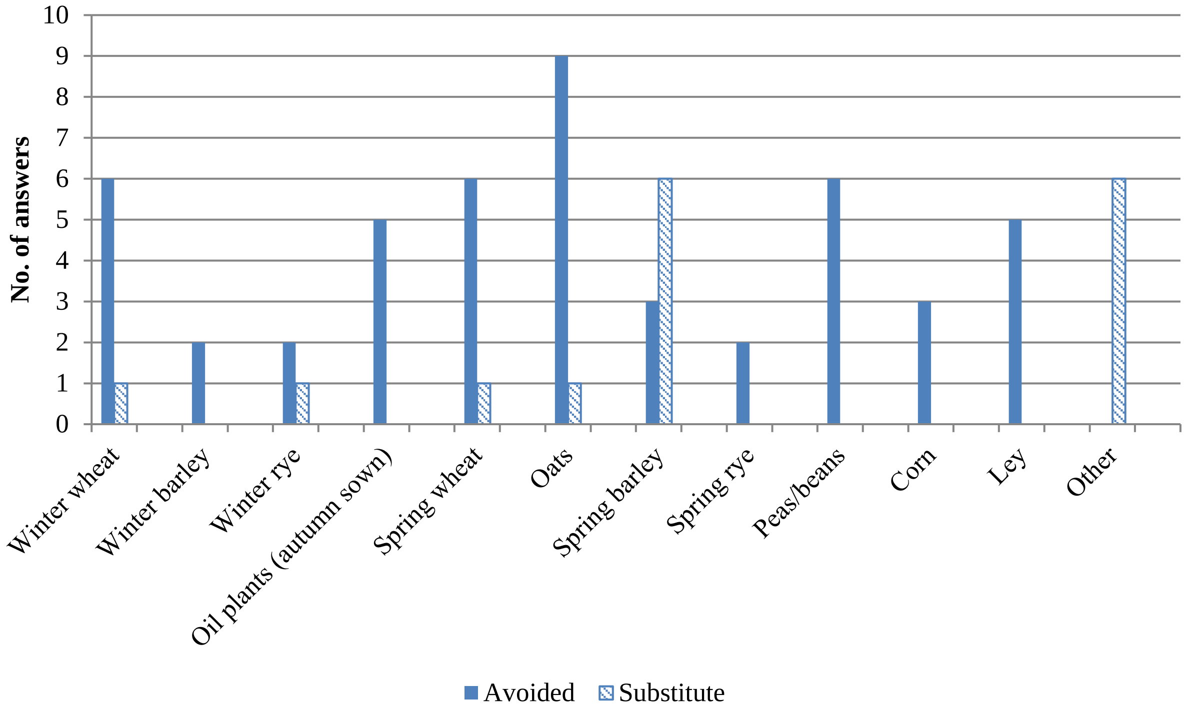

Figure 5. Crop usage; which type of crops which farmers avoided in order to reduce game damage and which type of crops which are used as substitutes for these.

Discussion

The study area within Södermanland hosted all of the native ungulates and had the highest ungulate densities in Sweden, as suggested by bag statistics (Viltövervakningen, 2016). Since the ungulates have quite diverse feed preferences (Hofmann, 1989; Schley & Roper, 2003; Herrero et al., 2006; Ballari et al., 2015), this might give rise to damage in several of the different crops. This was also the impression of the farmers within the study as they perceived a higher mean damage, as well as a higher risk of economic losses due to damage than the average Swedish farmer. The proportion of farmers who saw the damage by one or more of the ungulates as unacceptable were also significantly higher than in average of Sweden. It should however be noted that the two surveys were conducted during different years, which may have had an impact on farmers' attitudes as the occurrence of damage varies between among years.

Similarly, Bleier et al. (2012) found increased densities of red deer and wild boar to coincide with a higher amount of crop damage. Likewise, Trdan och Vidrih (2008) found that high densities of red deer caused significant yield losses in leys. One of the issues with game damage, and which contributes to the complexity, is that density is not the single predictor for severity of damage. Wilson et al. (2009) estimated that the deer densities in their study was about the same as in the study by Trdan och Vidrih (2008). Despite this, the losses in this study were smaller, which the authors believed could be due to a lack of forest refuges which would allow ungulates a higher access to the fields. The fact that forests function as refuges for ungulates is quite well established (Wretling Clarin & Karlsson, 2010; Bleier et al., 2012; Novosel et al., 2012; Jordbruksverket & SCB, 2015). As the study area constitutes a quite variable landscape with a large proportion of fields in close contact to forest, this might be another explanation to the high damage pressure.

The study area had significantly fewer fields of cereals, but more fields of leys than the rest of the county of Södermanland. The geographical properties of the study area may have influenced the divergent crop choice, but it could also have been a way for the farmers to reduce the extent of crop damage. Fifty-two percent of the farmers in the study had chosen to use crops less vulnerable to game in an attempt to reduce crop damage. Cereals are highly attractive to game (Cerkal et al., 2009) while ley is a crop which many farmers use as a substitute to cereal production since leys are known to have a higher tolerance to grazing (Hilbert et al., 1981). Despite this, a higher proportion of farmers in the study, compared to the average Swedish farmer, experienced that the grazing losses on crops were unacceptably high. This corresponds with findings from the study by Jordbruksverket & SCB (2015) where the largest crop losses in winter wheat, triticale and rapeseed, were those in Södermanland, primarily caused by grazing of red deer.

Even if wild boars caused the majority of losses in leys in the rest of Sweden, red deer and fallow deer had a large impact on losses in Södermanland. The yield losses in leys were among the highest found in Sweden (3.7%). Red deer caused the highest losses, followed by wild boar and then fallow deer (Jordbruksverket & SCB, 2015). Roe deer and moose are more bound to forest areas (Butler et al., 2008; Putman, 1986; Morellet et al., 2011), and are therefore seldom involved in game related crop damage. This, in combination with low densities in the area, resulted in low damage in Södermanland (Jordbruksverket & SCB, 2015). This was also in agreement with the opinion of farmers in the current study since there was no connection between the opinion that ungulates caused an unacceptably high grazing, and negative attitudes towards the densities of either moose or roe deer. Neither was there any correlation between perceived unacceptable grazing and negative attitude towards red deer. This finding was contrary to the finding by Jordbruksverket & SCB (2015) that red deer caused the largest losses of leys. According to the farmers, red deer are not established in the entire study area, which could be part of the explanation. A quite low occurrence of crops favoured by red deer could also have led to less losses. It is, however, hard to know if the crops are avoided due to the risk of damage, or due to other reasons. Instead, wild boars and fallow deer seemed to be the ungulates which caused local farmers the greatest concern. It should be noted that both the study by Jordbruksverket & SCB (2015) and the current study base damage estimates on farmers' statements, in which farmers' judge both the severity of damage and the game species involved. Actual measurements of damage and confirmation of liable game species would probably have provided a more correct picture.

A high density of fallow deer in the area was associated with short vegetation on the leys, suggesting higher grazing pressure. Furthermore, high fallow deer densities seemed to increase the risk of farmers being involved in conflicts concerning game management. Fallow deer is the type of ungulate which shows the greatest preference for grazing and are also less selective in their grazing behaviour (Hofmann, 1989). This means that fallow deer has a wider range of preferred crops. Thus, it is not surprising that there was a connection between a high grazing pressure, seen as a low vegetation height of grass, and density of fallow deer. Red deer are also known to be a species which to a large extent consume grass. But, when using vegetation height as a measure on grazing pressure, the density of red deer did not seem to have any effect on grass height. Red deer are known to be more selective during grazing than fallow deer (Hofmann, 1989), and their grazing could therefore have had less impact on the vegetation height. Furthermore, fallow deer densities were higher and more variable than red deer densities (Edenius 2012, 2013, 2014), potentially making it more likely to pick up effects from fallow deer statistically.

Therefore, vegetation height does seem to give a reflection of grazing pressure, but may not be the most accurate way of measuring total grazing losses which also include quality losses due to selective grazing. Even if yield losses are of great concern for the farmer, reduced quality of the feed is often of even larger importance. The effect of ungulate grazing on both yield losses and different quality parameters are, however, inconsistent. Neither Cerkal et al. (2009), nor Austin et al. (1998) found grazing to have any impact on nutritional parameters. Marchiori et al. (2012) found that a high grazing pressure resulted in decreased CP content, but the losses were only significant at higher CP content when the crop allowed for a higher selectivity by the deer. Of the few studies which have been made on grazing effects on crops, in particularly grasslands, an even smaller number of these concern the grazing effect on nutritional parameters. It is therefore hard to evaluate the actual effect of ungulate grazing on feed production in general. But, since deer perform selective grazing (Hofmann, 1989), in which they prefer plants of high quality, a high grazing pressure most likely decreases overall feed quality. A common way to overcome nutritional shortage forage is to supplement with concentrates, such as cereals grown on the farm. This practice might not be possible within the study area since these crops are quite attractive to game, and thus, yield of these crops are expected to be low. In the worst case scenario, farmers in the area may have to purchase concentrate feeds, which will have a negative impact on the profit of the farm and may also providing a sub-optimal feed for the livestock. Furthermore, it could be argued as to which extent the farmers should be willing to tolerate a high grazing pressure by game.

The fact that feed quality is of great importance corresponds with the findings that farmers, which found that they had unacceptably large damage on their crops, had non-significantly lower vegetation heights on their fields. Neither were there any correlation between the perceived crop damage in general, nor leys exclusively, and the measured vegetation heights.

Another possibility is that yield losses were in fact the greatest concern for farmers, but that the data set in the current study was too small to yield significant results of this. In addition to this, farmers' attitudes may not exclusively have been affected by the conditions of their own tilled land, but may also have been influenced by other factors, such as conditions on neighbouring farms. These interactions may create more uniform attitudes, with less clear relationships between densities, damage and attitudes as a result.

Another concern for the accuracy of the methodology used is the different properties of the fields within the study. For example, plant composition and age of the leys may have differed between TFs, which could have impacted growth, and consequently, vegetation heights of the fields. One of the greatest concerns is that the fields in most cases had been exposed to one or more harvests, which should impact regrowth, and in many cases also prohibited evaluation of the true grazing pressure. Several studies (Novosel et al., 2012; Austin & Urness, 1995; Trdan & Vidrih, 2008; Godvik et al., 2009; Putman, 1989) found grazing to be most pronounced in spring and in fall. Since the practical parts of the study were performed in the late summer or beginning of the fall, the majority of damage may not have occurred. In order to reveal the total costs of grazing, monitoring would have had to be performed throughout the vegetation period, ideally using an enclosure design for comparison within each field.

Since grazing is known to increase tillering rate of grass (Hilbert et al., 1981), the usage of PWC, which has been performed in many studies (Austin & Urness, 1995; Austin et al., 1998; Trdan & Vidrih, 2008; Wilson et al., 2009; Marchiori et al., 2012), might give an underestimation of grazing losses. Putman (1986) and Wilson et al. (2009) instead used fixed transects in order to evaluate crop losses. This methodology might give a good predictor of losses in cereals and other crops which are mainly selectively grazed. But, it could be harder to distinguish totally ungrazed areas from those that were grazed in the beginning of the season. Therefore, the actual grazing losses might be underestimated using this approach as well.

Since the data set included too few cereal fields, it was not possible to perform any statistical analysis on either total grazing pressure or effect of different ungulate densities on this crop category. Therefore, it is not possible to evaluate the accuracy of the methodology either. As cereal field are known to attract game, the few that are sown will probably suffer a higher pressure than would be expected if the occurrence of cereal fields was not limited. Furthermore, in order to see the true effect of game grazing, which can be compared with other Swedish areas, more cereal fields have to be inspected and for that purpose, more have to be sown.

To exclusively use vegetation heights of leys as a predictor of grazing losses seems to give a quite vague representation of total losses, including qualitative losses. Despite this, there was a significant correlation between high densities of fallow deer and TFs with low vegetation height. This could indicate that fallow deer are attracted to areas with low grass heights, but more likely, fallow deer exert a high grazing pressure on the leys in the study. Indeed, this would be a major source of conflicts between farming and game management in the area as many have claimed losses due to grazing to be quite negligible. With these high grazing losses, reduced harvest yields of forage would be expected. However, in order to get more reliable estimates on total grazing pressure, measurements of vegetation heights could be complemented with the use of PWCs in combination with assessing nutritional parameters of feeds in these areas. Samples collected inside PWCs could be used as a control for field DM yields, as well as for the expected nutritional composition without any selective grazing by deer.

Conclusion

Fallow deer seem to have generated a quite high grassing pressure on leys in the area, which probably has result in reduced yields. A more reliable estimate of actual grazing losses may be found by complementing the current methodology with the use of PWCs in combination with assessing nutritional parameters of feeds in these areas. In order investigate the full effect of game grazing in the area; more cereal fields must be available for inspection.

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Appendix

Appendix 1.

A5. Hur ser landskapet ut där ni bedrev jordbruk 2015?

- ❑ Slättbygd (huvudsakligen öppet odlingslandskap)
- ❑ Mellanbygd (ungefär jämnt fördelat mellan öppet landskap och skog)
- ❑ Skogsbygd (huvudsakligen skog)

B2. Hur stora var skadorna (bete-, tramp-, ligg- och bökskador) **av vilt i genomsnitt på** växande grödor **på fastigheten under 2015?**

	Obetydliga skador	Lätta skador	Måttliga skador	Medelsvåra skador	Svåra skador	Vet inte
På mark vi äger	❑	❑	❑	❑	❑	❑
På mark vi arrenderar	❑	❑	❑	❑	❑	❑

B3. Anser ni att några klövviltsarter orsakade oacceptabla skador på växande grödor (avsedda att skördas) **under 2015?**

	Nej, ingen art	Älg	Rådjur	Kronhjort	Dovhjort	Vildsvin
På mark vi äger	❑	❑	❑	❑	❑	❑
På mark vi arrenderar	❑	❑	❑	❑	❑	❑

B5. Hur anser ni att viltskador på växande grödor avsedda att skördas **påverkat** ert jordbruk **ekonomiskt?**

	Inte alls	Obetydligt	Delvis	Avsevärt	Vet inte
På mark vi äger	❑	❑	❑	❑	❑
På mark vi arrenderar	❑	❑	❑	❑	❑

B7. Anser ni att några klövviltarter **orsakade ett oacceptabelt betestryck på** odlad vall **under 2015?**

	Nej, ingen art	Älg	Rådjur	Kronhjort	Dovhjort	Vildsvin
På mark vi äger	❑	❑	❑	❑	❑	❑
På mark vi arrenderar	❑	❑	❑	❑	❑	❑

B18. Har du eller någon annan utfört någon av nedanstående åtgärder **för att begränsa skador av** vilt **på** gröda **eller** betesmark på fastigheten **under 2015?**
Här är det möjligt att fylla i flera olika svarsalternativ:

❑ Stängsling av gröda

❑ Utökad jakt under ordinarie jakttid

❑ Skrämsel, med

❑ Fast anordning, exempelvis fågelskrämma

❑ Ljud, exempelvis radio

❑ Mänsklig närvaro

❑ Hund

❑ Avledande utfodring

❑ Val av mindre skadekänslig gröda (flera grödor kan väljas):

	Har valts bort	Används istället
Höstvete	❑	❑
Höstkorn	❑	❑
Höstråg	❑	❑
Höstsådda oljeväxter	❑	❑
Vårvete	❑	❑
Havre	❑	❑
Vårkorn	❑	❑
Vårråg	❑	❑
Ärtor/bönor	❑	❑
Majs	❑	❑
Vårsådda oljeväxte	❑	❑
Vall	❑	❑
Annat (skriv ut)	❑	❑
Annat (skriv ut)	❑	❑

❑ Ingen av ovanstående åtgärder har tillämpats

C4. Vilka viltarter fanns på mark som ni brukade under växtsäsongen 2015?

	På ägd mark (sätt ett kryss per art)				Arrenderad mark (sätt ett kryss per art)			
	Saknas helt	Sporadisk, enstaka djur/spår	Etablerad, regelbunden förekomst	Vet inte om det finns	Saknas helt	Sporadisk, enstaka djur/spår	Etablerad, regelbunden förekomst	Vet inte om det finns
Älg	❑	❑	❑	❑	❑	❑	❑	❑
Rådjur	❑	❑	❑	❑	❑	❑	❑	❑
Kronhjort	❑	❑	❑	❑	❑	❑	❑	❑
Dovhjort	❑	❑	❑	❑	❑	❑	❑	❑
Vildsvin	❑	❑	❑	❑	❑	❑	❑	❑
Änder	❑	❑	❑	❑	❑	❑	❑	❑
Gäss	❑	❑	❑	❑	❑	❑	❑	❑
Tranor	❑	❑	❑	❑	❑	❑	❑	❑
Duvor	❑	❑	❑	❑	❑	❑	❑	❑
Svanar	❑	❑	❑	❑	❑	❑	❑	❑

C5. Är det någon eller några viltarter du tycker det finns för lite eller för mycket av på fastigheten du brukar?

	På ägd mark (sätt ett kryss per art)					Arrenderad mark (sätt ett kryss per art)				
	Alldeles för lite	Något för lite	Lagom	Något för mycket	Alldeles för mycket	Alldeles för lite	Något för lite	Lagom	Något för mycket	Alldeles för mycket
Älg	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Rådjur	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Kronhjort	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Dovhjort	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Vildsvin	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Änder	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Gäss	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Tranor	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Duvor	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Svanar	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

C7. Finns det en konflikt om viltskadorna på mark ni brukar? Här är det möjligt att fylla i flera olika svarsalternativ

❑ Nej ❑ Ja, ange nedan

❑ Mot markägaren på mark vi arrenderar

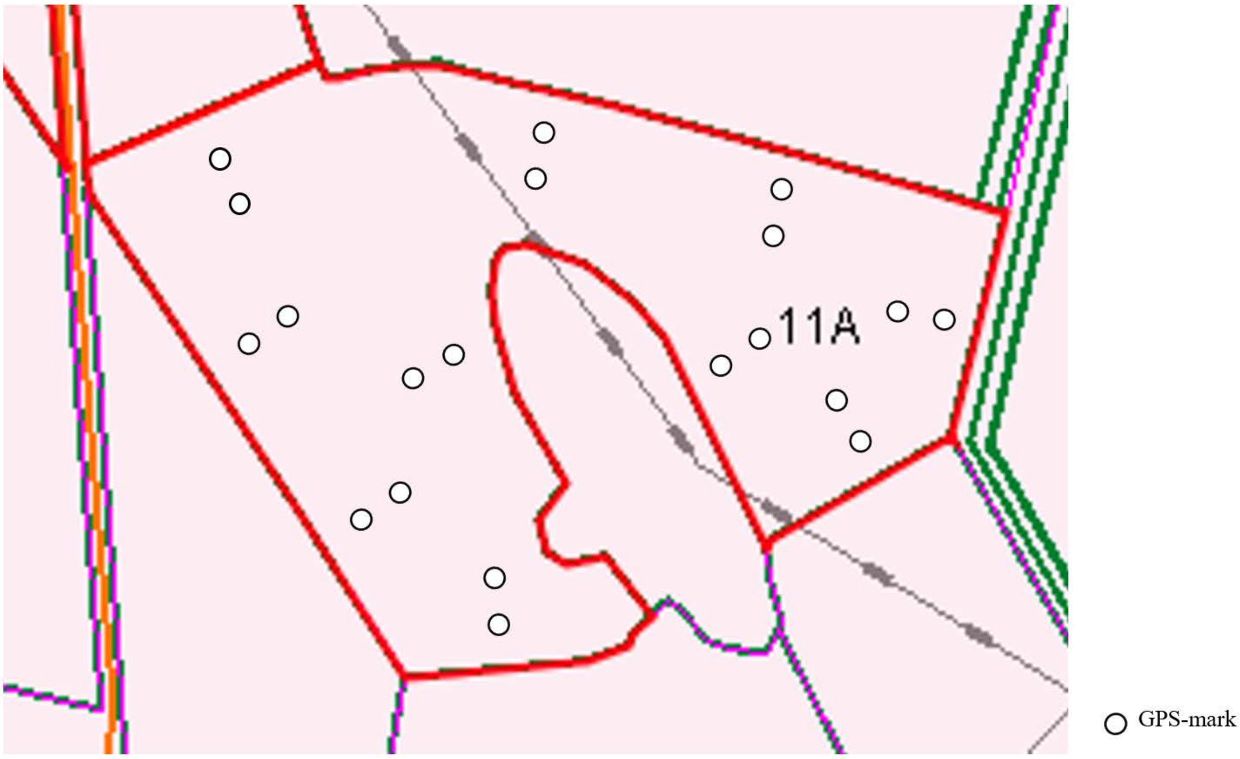
❑ Mot annan jakträttshavare på mark vi arrenderar

❑ Mot annan jakträttshavare på mark vi äger

❑ Mot markägare på angränsande fastighet till mark vi brukar

❑ Mot annan jakträttshavare på angränsande fastighet till mark vi brukar

Appendix 2.



Appendix 3.