Swedish University of Agricultural Science
The Faculty of Natural Resources and Agricultural Science
Department of Ecology

Effects of wolf occurrence on the number of sheep farms in Värmland and Örebro, south central Sweden

Hur påverkar närheten till varg antalet fårgårdar i Värmland och Örebro?

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Key Words: Wolf (*Canis lupus*), Sweden, depredation, livestock, effects, sheep farms

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Abstract

With the increased wolf population around the world, conflicts between wolves and humans arise. One cause of conflict is predation on livestock, which has increased in Sweden the last decade. This has resulted in negative attitudes towards wolves and it is often claimed that sheep farmers are forced to close down their operations due to losses and injuries on their livestock. If grazing ceases, shrubs and trees will take over and biodiversity could be lost. The abandonment of pastures is today a major problem across Europe. As sheep is the type of livestock most often attacked, the objective of this study was to examine how the proximity of wolves affects the sheep farmers and thus the openness of the landscape and indirectly its biodiversity.

The two counties of Värmland and Örebro were included in this study, both located in the south central Sweden. To see if the presence of wolves affected the number of sheep farms, the proportions of newly established and closed down sheep farms were compared inside and outside wolf territories from 2001 to 2011. Any effects depending on how long the wolves had been present before sheep farms established or closed down were also examined as well as any delayed effects by wolves' presence.

No differences were found in the proportion of closed down sheep farms inside and outside wolf territories. Neither were there any differences in the proportion of closed down sheep farms before and after the establishment of wolves. When looking at the proportion of newly established sheep farms no differences were found when comparing inside and outside wolf territories. Areas where wolves had been present on and off even had a significantly larger proportion of newly established sheep farms.

The low observed effects of wolves on the number of sheep farms might be due to the fact that Värmland and Örebro contain few sheep farms, but also because of the high rates of wolves the two counties have received large amounts of subsidies for preventative actions, such as five stranded live wire fences. A method proven to be effective in reducing the risk of predation.

Keyword: Wolf (*Canis lupus*), Sweden, depredation, livestock, effects, sheep farms

Populärvetenskaplig sammanfattning

När vargstammen ökar runt om i världen ökar även konflikterna mellan varg och människa. En orsak till konflik är angrepp på boskap, vilka har ökat i Sverige det senaste decenniet. Detta har påverkat människors attityd mot vargen på ett negativt sätt och det hävdas ofta att fårägare tvingas lägga ner sin verksamhet på grund av skador och förluster orsakade av en ökad rovdjursstam. Med ett minskat betestryck kan buskar och träd enkelt ta över och värdefulla marker med hög biologisk mångfald kan gå förlorad. Detta är idag ett stort problem runt om i Europa. Då får är det boskap som oftast blir angripet av varg var syftet med denna studie att se hur vargens närhet påverkar fårbönderna och därigenom de öppna landskapen och dess biologiska mångfald.

Två län har studerats, Värmland och Örebro, både belägna i mellersta Sverige. För att se om närheten till varg hade någon påverkan jämfördes andelen etablerade och nerlagda fårgårdar i och utanför vargrevir från 2001 till 2011. Eventuell påverkan beroende på hur länge vargen förekommit innan gårdarna etablerats eller lagts ner undersöktes också, liksom eventuell fördröjd effekt av vargens närvaro.

Inga skillnader hittades i andelen nerlagda fårgårdar i och utanför vargrevir. Inte heller fanns det några skillnader i andelen nerlagda fårgårdar före och efter varg etablerats i området. Andelen nyetablerade fårgårdar var lika stor i som utanför vargrevir, medans områden där varg förekommit till och från hade en större andel nyetablerade fårgårdar.

Den låga påverkan av varg på antalet fårgårdar kan bero på att få fårgårdar är belägna i Värmland och Örebro, men även på grund utav att de två länen har höga tätheter av varg och därför får stora bidrag för förebyggande åtgärder, som till exempel viltstängsel. En metod som visat sig effektiv för att minska risken för angrepp.

Nyckelord: Varg (*Canis lupus*), Sverige, angrepp, får, påverkan, fårgårdar

Contents

1 Introduction

In many parts of North America and Europe, wolves (*Canis lupus*) and other large carnivores are recovering due to legal protection and changed public attitudes (Pyare et al. 2004; Bangs et al. 2001). From being almost extinct in the mid 1900´s wolves have increased manifold (Mech 1995; Wabakken et al. 2001). As the population increase conflicts between wolves and humans arise (Treves and Karanth 2003). Conflicts may arise for several reasons such as frequent encounter, due to wolves' large home ranges, as well as predation on livestock (Treves and Karanth 2003). Even though wolves mainly feed on wild ungulates they occasionally kill livestock where it is abundant (Meriggi and Lovari 1996). Since the wolf population started to recover the number of killed livestock has steadily increased (Treves et al. 2002). The traditional way of keeping livestock in Europe is by free ranging herds guarded by shepherds and livestock guarding dogs (Kaczensky 1999). In Sweden, this tradition has never been widespread and livestock is often kept within enclosures. Predation by wolves and other large carnivores is hence lower than in the rest of Europe (Kaczensky 1996, J. Karlsson pers. com.[1]), but still considered to be a problem as the number of attacks is increasing (Karlsson et al. 2013).

Not many studies have been carried out assessing how sheep farmers are affected by wolf depredation on livestock. What has been shown, however, is a shift in attitudes towards more negative the last decade. In a survey by Andersson et al. (1977) attitudes towards wolf recovery were mainly positive among people in Sweden. Twenty years later a survey by Karlsson et al. (1999) showed that people could even accept wolves in the vicinity of their homes and no differences in attitudes were found between people living outside and inside wolf areas. But as the wolf population increased and the presence of wolves became reality rater than a

[1] Swedish Wildlife Damage Center, 5 February 2013

made up scenario, attitudes started to change (Ericsson and Heberlein 2003). People living in areas where wolves had been restored now showed a more negative attitude towards wolves than the general public. From valuing wolves' ecological role they now emphasized wolves' more negative effects (Treves et al. 2012). One of the factors affecting the shifting attitude was the experience of depredation on livestock (Naughton-Treves et al. 2003).

As human activities are the main threat to the existence of wolves, attitudes are of great importance for conservation (Woodroffe 2000). Karlsson and Sjöström (2007) noticed that attitudes towards wolf conservation are associated with distance to nearest wolf territory. The further away from the territory the respondent lived the more positive were the attitudes towards wolves. This was even shown on micro-level as people living just outside wolf territories were more positive than those living inside it. As wolves expand and colonize new areas, attitudes of people living inside the new wolf territories could thus be expected to change in a more negative direction.

As the wolf population increases it is often claimed that sheep farmers are forced to close down their business due to losses and injuries on their livestock (A. Wetterin[2] and P. Wedholm[3] pers. com.). When sheep farms are closed down and livestock removed, grazing ceases and shrubs and trees encroach. The abandonment of pastures is today a major problem across Europe (Tallowin et al. 2005; Metera et al. 2010). Without grazing herbivores, biodiversity could decrease as disturbance regimes like treading, that otherwise creates gaps in the sward and gives annual and biannual species a chance to establish, ceases as well as the natural fertilization and seed dispersal (Van Braeckel and Bokdam 2002; Fischer et al. 1996). The effects of grazing are, however, not always positive and largely dependent on several factors like grazing intensity and local conditions like topography and soil fertility (Peco et al. 2006; Olff and Ritchie 1998). But with proper management, grazing could conserve and increase biodiversity on grasslands and pastures (Metera 2010).

1.1 Aim

As sheep is the type of livestock most often attacked by wolves (Sand et al. 2010; Karlsson et al. 2013) the objective of this study was to examine how the proximity

[2] The Federation of Swedish Farmers, 1 February 2013
[3] Örebro County Administration Board, 21 January 2013

of wolves in the two counties of Värmland and Örebro affects the number of sheep farms and thus the openness of the landscape and its biodiversity. The questions addressed and investigated were:

- Where do new sheep farms establish? Outside wolf territories?
- Where do sheep farms close down? Inside wolf territories?
- Are closed sheep farms located in areas with high biodiversity?
- Which sheep farms are closed down? Small, medium or large farms?

2 Background

After the protection in 1966, wolves slowly started to recover on the Scandinavian Peninsula (Sand et al. 2010). In 1978 the first reproduction in 14 years was confirmed in northern Sweden (Wabakken et al. 2001). From 1983 to 1990 wolves reproduced each year (except 1986), but only in one territory located in the north of Värmland (Aronson and Sand 2004). Still, the population did not grow and between 1983 and 1990 it never exceeded 10 animals (Wabakken et al. 2001). The breeding territory in Värmland was the only breeding one until 1991 when a second reproducing pair in a neighboring county was recorded. After that multiple reproductions were reported each year and the population started to grow. Today the estimated number of animals is between 200 and 270 in Sweden and additionally 30 animals in Norway and 30 on the border between Sweden and Norway (Svensson et al. 2012). Still, one third of the wolf population is located in Värmland (L. Svensson[4] pers. com., Svensson et al. 2012).

Whereas wolves primarily occur in the central parts of Sweden, sheep farms are mainly located in the south (Figure 1). In this report the two counties of Värmland and Örebro are studied, both located in the south-central Sweden (Figure 2). In 2010, only 8 % of all sheep farms were located within Värmland and Örebro (Swedish Board of Agriculture, 2012). Even though the number of sheep farms is increasing in Sweden (Figure 3), it is limited by poor profitability and small farms (Lukkarinen and Jirskog, 2012). With an increased wolf population as well as number of sheep farms, the number of attacked sheep has increased (Karlsson et al. 2013). The number of attacked sheep has however been limited in Värmland and Örebro and no increase over time has been recorded (Karlsson et al. 2013).

[4] Swedish Wildlife Damage Center, 11 April 2013

1. 2.

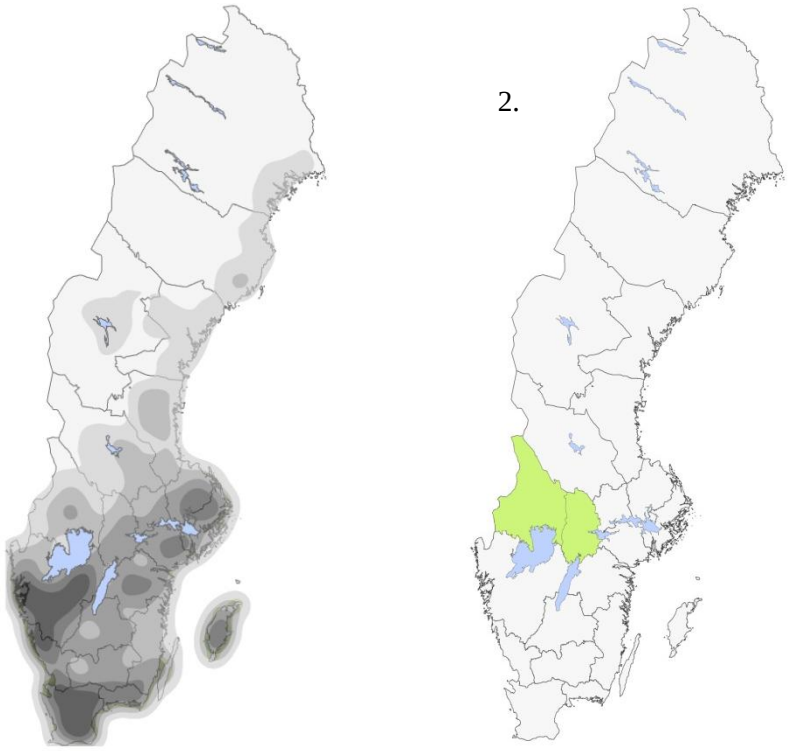

Figure 1 and 2. The distribution of sheep farms in Sweden (2012) to the left and the study area to the right.

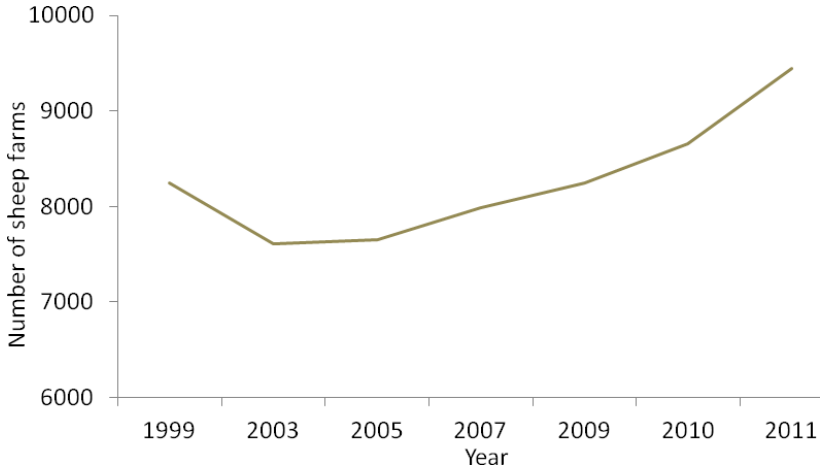

Figure 3. The number of sheep farms is increasing in Sweden. Source Swedish Board of Agriculture (2012) and www.scb.se (20 of June 2013).

3 Methods

3.1 Data collection and analysis

Data on sheep farms was obtained from the Swedish Board of Agriculture. The dataset is based on farmers reporting their business themselves and hence not all sheep farms are registered. Throughout the studied period (2001- 2011) a total of 1 354 sheep farms were included. During 2005 farmers also started to report the number of sheep in their operations. From this data the size of the active sheep farms was calculated to find changes over time. The size of the closed down sheep farms was also analyzed to see if there was a difference depending on where the sheep farms were located, outside or inside wolf territories.

Polygons on wolf territories were obtained from the Swedish Wildlife Damage Center. In total 59 territories were included, only two of them consistent throughout the whole studied period. The polygons are based on data from snow tracking, GPS positions from collared wolves and DNA analysis from scats. Every year data is collected from the 1st of October to the 29th of February (Svensson et al. 2012). The GPS positions from radio collared wolves give a good estimation of the territories while snow tracking and DNA only give an idea of where the territories are located. To standardize the territories polygons for each territory were merged in ArcGIS 10.0. The standardized territory represents the total area of a territory throughout its existing time. As an average wolf territory in Scandinavia is between 900 - 1200 km^2 (Sand et al. 2010), a buffer zone (End type Round) was added to each standardized territory until it reached 1000 km^2 $\pm$ 100 km^2. With the polygons of the standardized territories the proportion of active sheep farms located inside and outside wolf territories was calculated for each year. By tracing the farmers over time and record any newly established or closed down sheep farms, the proportions of newly established and closed down sheep farms inside and out-

side wolf territories were also calculated. To test for significance a Chi square test was used. Any effects depending on how long the wolves had been present before sheep farms established or closed down were also tested, as well as any delayed effects of wolf presence. How long the sheep farms had been active before they closed down was also recorded and a T-test (two-sample equal variance) was used to test for significance. Further explanations on calculations are described below (3.2 Calculations).

Data on pastures with high biodiversity could not be obtained from the County administration board. Hence no analysis could be made to see if closed down sheep farms were located in areas with high biodiversity.

3.2 Calculations

Active sheep farms

To calculate the proportion of active sheep farms the number of active sheep farms in each area category (*Outside wolf territories* and *Inside wolf territories + Mixed*, respectively) year X was divided by the total number of active sheep farms the same year.

Newly established sheep farms

The proportion of newly established sheep farms was calculated by dividing the number of newly established sheep farms in each area category (*Outside wolf territories*, *Inside wolf territories* and *Mixed* respectively) year X with the number of active sheep farms in each area category the same year.

Effects of how long the wolves had been present before sheep farms established

In order to assess if the number of newly established sheep farms was affected by how long the wolves had been present in the area, sheep farms where divided into 10 groups based on the number of years (1-10) that wolves had been present before the sheep farms established. The mean value for the number of newly established sheep farms in each group was then calculated as well as the standard deviation. The expected number of newly established sheep farms was also calculated and compared with the observed number.

Delayed effects

To analyze any delayed effects by wolf presence, areas were identified based on when wolves established in the area. The proportion of newly established sheep farms before and after the establishment of wolves was then calculated by dividing the number of newly established sheep farms year X with the total number of active sheep farms the same year. Data was then compiled based on when wolves established in the area and mean values and standard deviations were calculated. The same method was used when looking at any delayed effects on closed down sheep farms. Due to the relatively few closed down sheep farms (n = 88) data was grouped in periods of three years to get more accurate results.

Closed down sheep farms

When calculating the proportion of closed down sheep farms the number of closed down sheep farms in each area category (*Outside wolf territories, Inside wolf territories* and *Mixed* respectively) year X was divided by the number of active sheep farms in each area category the year before (year X-1).

Effects of how long the wolves had been present before sheep farms closed down

To test if the proportion of closed down sheep farms was affected by how long the wolves had been present, areas where wolves had been present on and off (*Mixed*) were divided into two groups: (1) areas where wolves had been present less than 50 % of the farmers active time (*Mix < 50 %*) and (2) areas where wolves had been present 50 % of the farmers active time, or more (*Mix $\geq$ 50 %*). Only two groups were used due to the relatively small sample size (n = 58). To calculate the proportion of closed down sheep farms, the number of closed down sheep farms in each group (*Mix < 50 %* and *Mix $\geq$ 50 %*) year X was divided by the number of active sheep farms in each group the year before (year X-1).

4 Results

From 2001-2011 the number of sheep farms in the study area increased from 803 to 1288. Due to this, as well as the increased proportion of sheep farms with exact location available (56,9 % had an exact location in 2001 and 2011 the proportion had increased to 84,3 %), the results are mainly given as proportions instead of absolute numbers in order to allow for comparisons between years.

4.1 Active sheep farms

4.1.1 Comparing the number of active sheep farms outside and inside wolf territories

With the increased wolf population, more land has become occupied by wolf territories. As shown in Figure 4, the proportion of active sheep farms located inside wolf territories and in areas where wolves had been present on and off (*Mixed*) has increased as the area covered by wolf territories has increased. If sheep farms were evenly spread across the study area the proportion of active sheep farms inside wolf territories would be equal to the proportion of area covered by wolves. Sheep farms were however not evenly distributed, as only 30 % of the active sheep farms were located inside wolf territories when 50% of the area was covered by wolf territories (Figure 4). More sheep farms were thus located outside wolf territories than inside. Wolves and sheep farms were separated in the landscape as shown by Appendix 1 (for changes over time see Appendix 2).

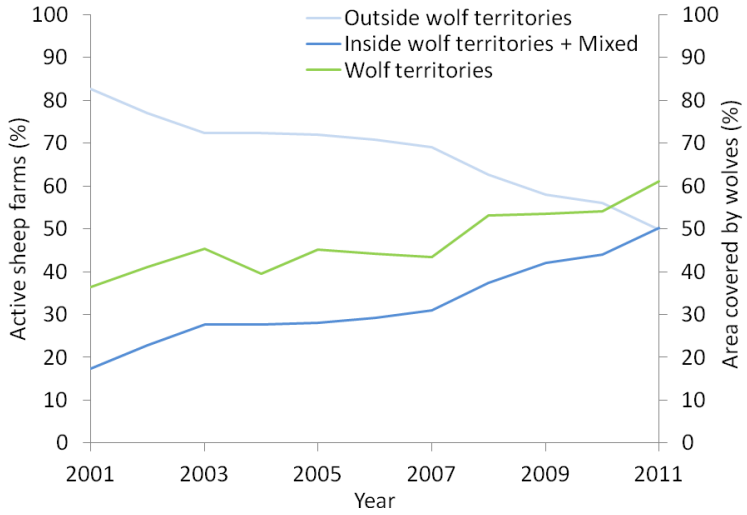

Figure 4. The proportion of active sheep farms inside (dark blue line) and outside (light blue line) wolf territories, 2001- 2011. The mixed group represents active sheep farms in areas where wolves had been present on and off.

4.2 Newly established sheep farms

The rate of newly established sheep farms inside and outside wolf territories followed the same pattern throughout the studied period (Figure 5). No significant differences were found between the proportion of newly established sheep farms inside and outside wolf territories except for 2011, when the proportion of newly established sheep farms was significantly larger outside wolf territories compared to inside (Table 1.). A larger proportion of newly established sheep farms was also found in areas where wolves had been present on and off (*Mixed*) the last five years, except for 2008 (Table 1).

When looking at the effects of how long the wolves had been present before sheep farms established, no differences were found in the number of newly established sheep farms regardless of how long the wolves had been present (Figure 6). The mean number of newly established sheep farms varied between 3,12 to 6,67 per year. Neither were there any significant differences in the proportion of newly established sheep farms before and after the establishment of wolves, as the gradient of the line was not significantly different from zero (p=0,867, Figure 7). Hence no delayed effects by wolf presence were found.

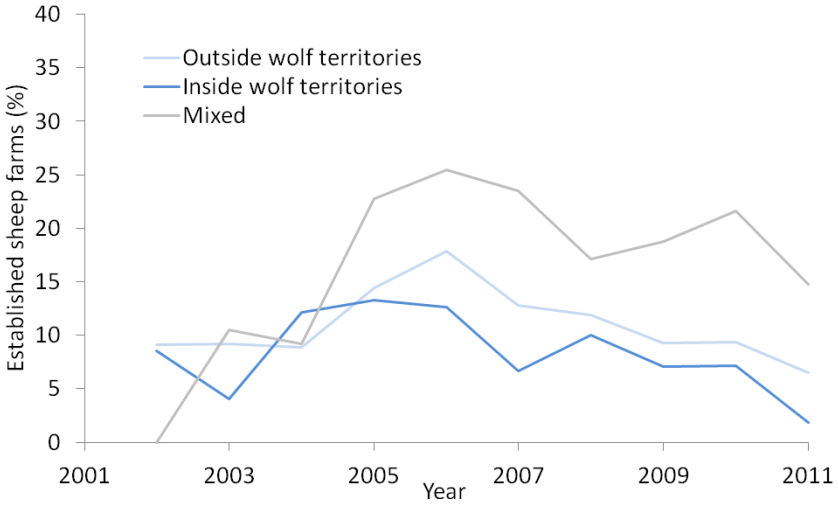

Figure 5. The proportion of newly established sheep farms *Inside wolf territories*, *Outside wolf territories* and in areas where wolves had been present on and off (*Mixed*), 2002- 2011. N_{tot} = Outside wolf territories: 558, Inside wolf territories: 95, Mixed: 287. Note that the scale only reaches 40 %.

Table 1. Chi^2 and P-values when comparing the proportion of newly established sheep farms Outside wolf territories, Inside wolf territories and in areas where wolves had been present on and off (Mixed), 2002- 2011. Tested values are presented to the right (% newly established sheep farms).

	Outside vs. Inside wolf territory		Outside vs. Mixed		Inside vs. Mixed		% newly established sheep farms		
Year	Chi^2	p-value	Chi^2	p-value	Chi^2	p-value	Outside	Inside	Mixed
2002	0,04	0,95	1,848	0,17	1,423	0,23	9,1	8,5	0
2003	1,287	0,26	0,014	0,9	1,212	0,27	9,2	4,1	10,5
2004	0,288	0,59	0,012	0,91	0,081	0,78	8,9	12,1	9,2
2005	0,004	0,95	2,542	0,11	1,419	0,23	14,4	13,3	22.8
2006	1,023	0,31	1,841	0,17	3,39	0,07	17,9	12,6	25,5
2007	2,409	0,12	6,41	0,01	9,115	0,003	12,8	6,7	23,5
2008	0,181	0,67	2,188	0,14	2,101	0,15	11,9	10	17,1
2009	0,447	0,5	10,312	0,001	8	0,005	9,3	7,1	18,8
2010	0,55	0,46	17,091	< 0,001	12,674	< 0,001	9,4	7,1	21,6
2011	5,42	0,02	12,19	< 0,001	20,006	< 0,001	6,5	1,8	14,8

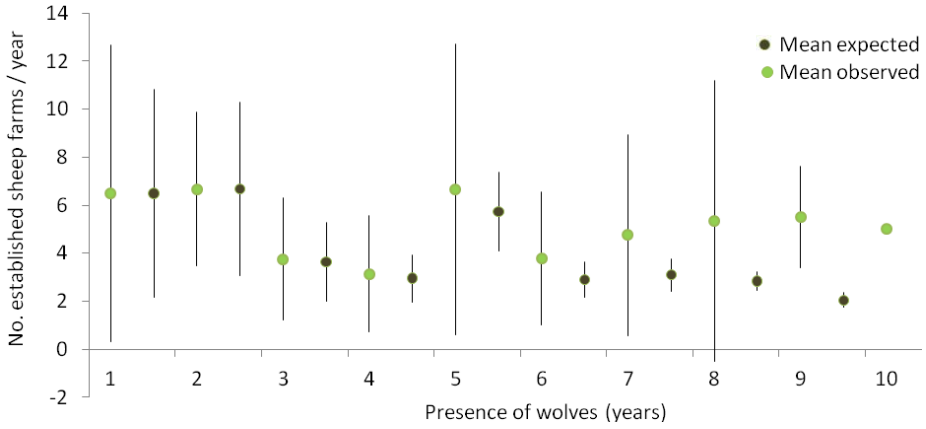

Figure 6. The number of newly established sheep farms where wolves had been present 1 to 10 years before the farms established. Mean values and standard deviations are presented in the figure. N_{tot} = 287.

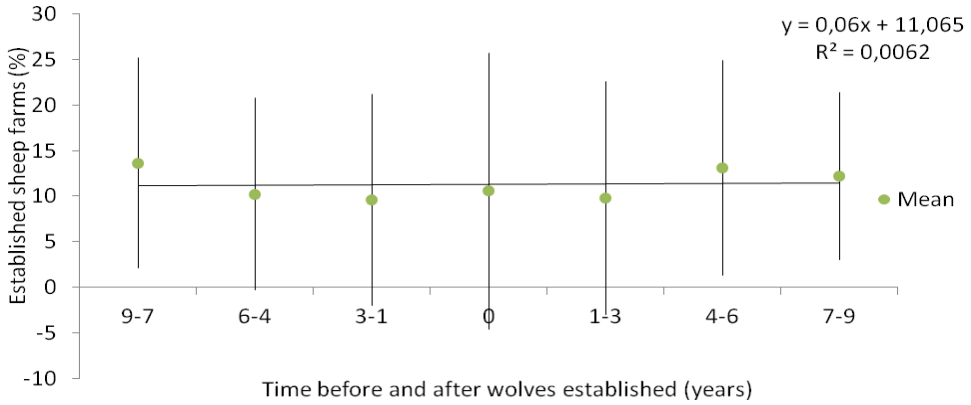

Figure 7. The proportion of newly established sheep farms before and after the establishment of wolves (year 0). The gradient of the line was not significantly different from zero (p=0,867). Mean values and standard deviations are presented in the figure. N_{tot} = 235. Not that the scale only reaches 30 %.

4.3 Closed down sheep farms

The proportion of sheep farms that closed down varied over time but all three areas (*Outside wolf territories*, *Inside wolf territories* and *Mixed*) followed the same pattern and no significant differences were found between them (Figure 8, Table 2). How long (less or more than 50 % of the farmers active time) the wolves had been present before sheep farms closed down did not affect the proportion of closed down sheep farms (Table 2). Neither were there any significant differences in the proportion of closed down sheep farms before nor after the establishment of

wolves, as the gradient of the line was not significantly different from zero (p=0,176). Hence no delayed effects by wolf presence were found (Figure 9).

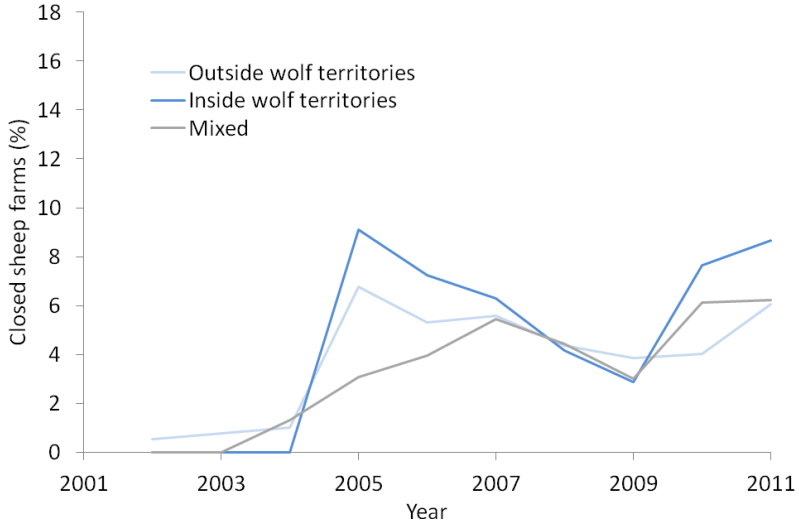

Figure 8. The proportion of sheep farms that closed down *Outside wolf territories, Inside wolf territories* and in areas where wolves had been present on and off (*Mixed*), 2002- 2011. N_{tot} = Outside wolf territories: 199, Inside wolf territories: 58, Mixed: 58. Note that the scale only reaches 18 %.

Table 2. Chi² and p-values when comparing the proportion of closed down sheep farms Outside wolf territories, Inside wolf territories and in areas where wolves had been present on and off (Mixed), 2002- 2011. The Mixed group was divided into two groups: (1) areas where wolves had been present less than 50 % of the sheep farmers' active time (Mix < 50 %) and (2) areas where wolves had been present 50 % of the sheep farmers' active time, or more (Mix ≥ 50 %), to test if the proportion of closed sheep farms was affected by how long the wolves had been present. Tested values are presented to the right (% closed sheep farms).

	Outside vs. Inside wolf territory		Outside vs. Mixed		Inside vs. Mixed		Mix < 50 % vs. Mix ≥ 50 %		% closed sheep farms		
Year	Chi²	p-value	Chi²	p-value	Chi²	p-value	Chi²	p-value	Outside	Inside	Mix
2002	0,086	0,77	-	-	-	-	-	-	0,5	0	-
2003	0,001	0,97	0,349	0,55	0	0	-	-	0,8	0	0
2004	0,032	0,86	0,146	0,7	0	0,98	0,066	0,8	1,0	0	1,3
2005	0,141	0,71	1,175	0,28	1,485	0,22	0,229	0,632	6,8	9,1	3,1
2006	0,166	0,68	0,078	0,78	0,353	0,55	0,302	0,58	5,3	7,2	4,0
2007	0,003	0,95	0,031	0,86	0,001	0,97	0,037	0,85	5,6	6,3	5,5
2008	0,023	0,88	0,045	0,83	0,047	0,83	0,664	0,41	4,4	4,2	4,4
2009	0,087	0,77	0,095	0,76	0,095	0,76	0,182	0,67	3,9	2,9	3,0
2010	2,632	0,1	1,128	0,29	0,137	0,711	0,046	0,83	4,0	7,6	6,1
2011	1,053	0,3	0,003	0,96	0,571	0,45	1,839	0,17	6,0	8,7	6,2

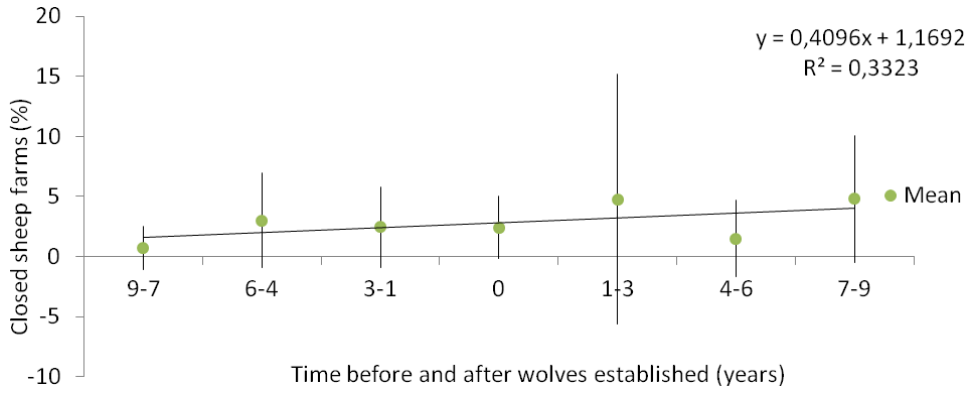

Figure 9. The proportion of sheep farms that closed down before and after the establishment of wolves (year 0). The gradient of the line was not significantly different from zero (p=0,176). Mean values and standard deviations are presented in the figure. N_{tot} = 88. Note that the scale only reached 20 %.

4.3.1 The average active time of sheep farms before closing down

Only sheep farms that started and closed down within the period 2001-2011 were included when analyzing how long the sheep farms had been active before they closed down. These were chosen to know exactly how long they had been active. Two groups were tested: (1) sheep farms located outside wolf territories (2) and sheep farms located inside wolf territories. On average, sheep farms located outside wolf territories were active 2,82 years before closing down, while sheep farmers located inside wolf territories were active 2,70 years (Figure 10). No significant difference was hence found between the two groups (p=0,72; T-test two sample equal variance).

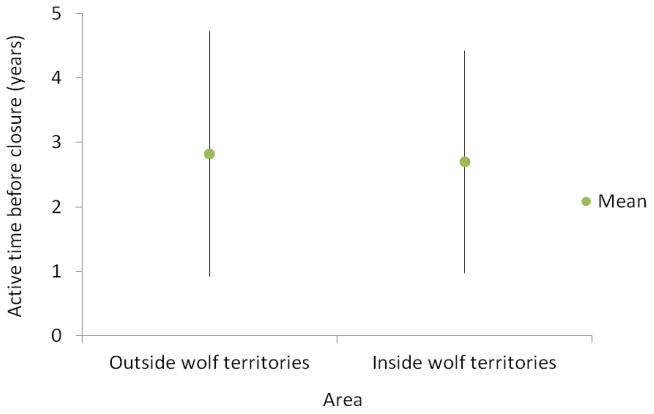

Figure 10. The number of active years for sheep farms located *Outside wolf territories* and *Inside wolf territories* before closing down. Mean values and standard deviations are presented in the figure. Data from 2004- 2011. N = Outside wolf territories: 114, Inside wolf territories: 43.

4.4 Size of sheep farms

When analyzing the size of the sheep farms the categories 1-9 sheep, 10-24 sheep, 25-49 sheep and 50 sheep or more were used. These categories were chosen to be comparable with the Swedish Board of Agriculture statistics. Since sheep farmers only started to report the number of sheep in their operations 2005, results are only provided from 2005 to 2011. Most sheep farms were small-scaled with 1-9 or 10-24 sheep (36 % respectively 34 %). The proportion of active sheep farms within each category (1-9, 10-24, 25-49 and 50 sheep or more) was more or less the same throughout the studied period (Figure 11). When looking at the size of closed down sheep farms, small farms with 1-9 sheep followed by farms with 10- 24 sheep were the most frequently closed down (Figure 12). This trend was found for all studied areas (*Outside wolf territory*, *Inside wolf territory* and *Mixed*) and no significant differences were found between them (Table 3).

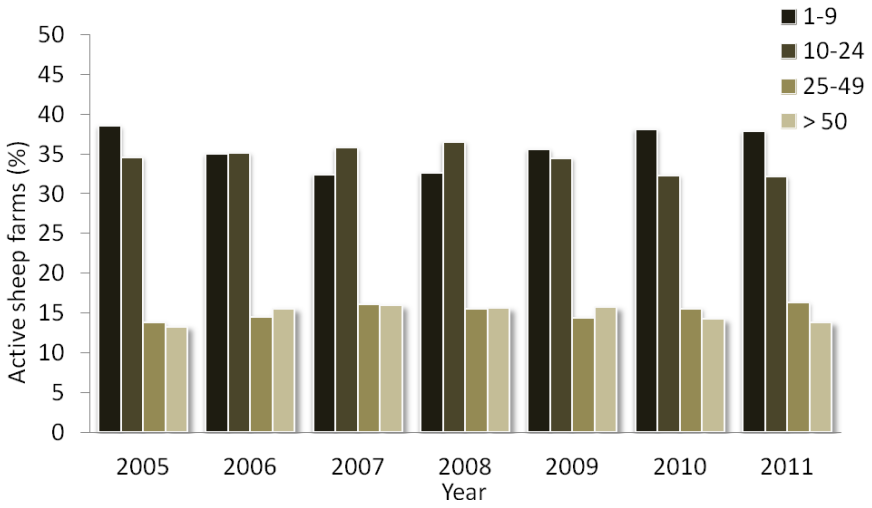

Figure 11. The proportion of active sheep farms with 1-9 sheep, 10- 24 sheep, 25- 49 sheep and 50 sheep or more, 2005- 2011. Note that the scale only reaches 50 %.

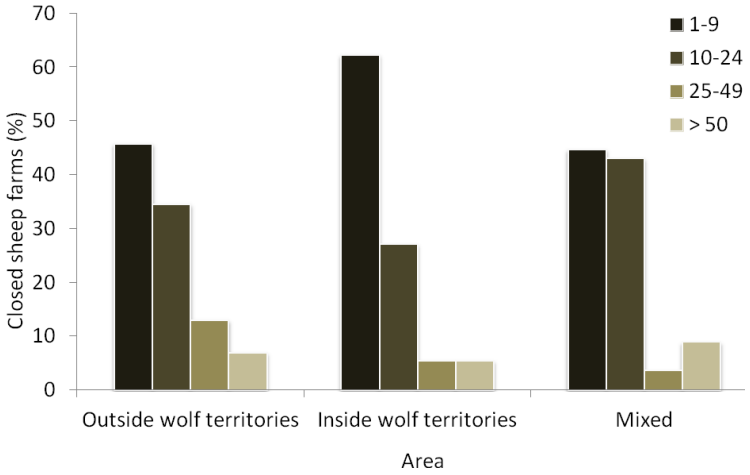

Figure 12. The proportion of closed down sheep farms in each size category; 1-9 sheep, 10-24 sheep, 25-49 sheep and 50 sheep or more for the three tested areas; *Outside wolf territories*, *Inside wolf territories* and in areas where wolves had been present on and off (*Mixed*). Data from 2006 - 2011. N= Outside wolf territories: 116, Inside wolf territories: 37, Mixed: 48. Note that the scale only reaches 80 %.

Table 3. Chi^2 and p-values when comparing the proportion of closed down sheep farms for each size category (1-9 sheep, 10-24 sheep, 25-49 sheep and 50 sheep or more) and area; Outside wolf territories, Inside wolf territories and in areas where wolves had been present on and off (Mixed), 2002-2011. Tested values are presented to the right in the table (% closed sheep farms).

	Outside vs. Inside wolf territory		Outside vs. mixed		Inside vs. mix		% closed down sheep farms		
No. sheep	Chi^2	p-value	Chi^2	p-value	Chi^2	p-value	Outside	Inside	Mixed
1-9	0,682	0,41	0,02	0,89	0,41	0,52	45,7	62,2	44,6
10-24	0,173	0,68	0,178	0,67	0,579	0,45	34,5	27,0	42,9
25-49	0,725	0,39	1,566	0,21	0,068	0,79	12,9	5,4	3,6
≥ 50	0,007	0,93	0,001	0,98	0,04	0,95	6,9	5,4	8,8

5 Discussion

5.1 Active sheep farms

The proportion of sheep farms located inside wolf territories increased with the increased area covered by wolf territories (Figure 4). No "drop off" in the proportion of active sheep farms was detected, suggesting no upper limit where wolves start to negatively affect the proportion of active sheep farms. As shown by figure 4, sheep farms are not evenly distributed over the studied area and a larger proportion of sheep farms are located outside wolf territories compared to inside. Most wolf territories are located in the northeast of Värmland and in the northwest of Örebro (Appendix 1), an area mainly covered by forest. Sheep farms on the other hand are mainly located in the south of Värmland and southeast of Örebro where the land is more open and suitable for agriculture.

5.2 Newly established sheep farms

No differences in the proportion of newly established sheep farms inside and outside wolf territories were recorded, except for 2011 when the proportion of newly established sheep farms was larger outside wolf territories than inside (Table 1). This could be due to random effects such as fewer sheep farms being located inside wolf territories. In 2011, 540 sheep farms were active outside wolf territories while only 218 sheep farms were active inside wolf territories. A smaller sample is more sensitive to changes, and even a small change can cause large fluctuations. The difference could also reflect an actual change in trends. But as we do not have data from many years after the year 2011 it is hard to tell at the moment.

Areas where wolves had been present on and off had a significantly larger proportion of newly established sheep farms the last five years (except for 2008)

compared to both the proportion of newly established farms inside and outside wolf territories (Figure 5, Table 1). These sheep farms were located between the continuous forest in the north and the more open agricultural land in the south. In a Polish study by Jedrzejewski et al. (2004), they showed that the number of killed domestic animals was higher in areas like this, where wolves were abundant but forest cover low. It is also in these areas that most subsidies for wildlife fences are given (www.lansstyrelsen.se/varmland 3rd of May 2013). Wedholm (2009) showed that most farmers (92 %) that received subsidies for wildlife fences (5 wired electric fences) were pleased and would even recommend it to others. The subsidies for fencing could be a contributing factor for the high proportion of newly established sheep farms in these areas. But it might even more be depending on the fact that sheep farmers that applied and received subsidies to a larger extent are represented in the Swedish board of Agricultures register and thus available for this analysis.

5.3 Closed down sheep farms

No differences in the proportion of closed down sheep farms inside and outside wolf territories were recorded. Neither were there any delayed effects of wolves' presence on the proportion of closed down sheep farms, or any effects depending on how long the wolves had been present before sheep farms closed down. Other factors, such as production costs and market prices are more likely to affect the number of sheep farms (Berger 2005). As mentioned before the profitability within the Swedish sheep industry is poor and the market price has more or less remained unchanged the last decade (Lukkarinen and Jirskog 2012; www.jordbruksverket.se 3rd of May 2013). Another possible factor affecting is urbanization. As people move from remote areas to live closer to larger cities, a reduced number of farms in remote areas could be expected. Last year, 2012, the number of inhabitants in Karlstad, Hammarö and Kil, three larger municipalities in the south of Värmland, increased while smaller municipalities in the north decreased or had a small increase (less than 100 people). The same trend is found in Örebro, where the municipality itself increased with 1831 inhabitants 2012. Kumla, another big municipality close by increased as well while smaller municipalities farther away decline in number of inhabitants (www.scb.se 3rd of May 2013).

5.4 Size of sheep farms

According to the Swedish Board of Agriculture (2012) one third of the sheep farms in Sweden have 9 sheep or less and only 15 % of the sheep farms have more than 50 sheep. This matches the results obtained by this study as, in average, 36 % of the active sheep farms had 1-9 sheep and 15 % had 50 sheep or more (Figure 11). Due to the low profitability within the Swedish sheep industry, sheep farms are mainly small scaled and often an avocation to other work (Lukkarinen and Jirskog, 2012).

Regardless of where the sheep farms were located, no differences in size of closed down sheep farms were found. When comparing the proportion of active sheep farms with the proportion of closed down sheep farms, smaller farms were more often closed down. Farms with 1-9 sheep represented 36 % of the active sheep farms but 45-62 % of the closed sheep farms. Larger farms, on the other hand, with 25 sheep or more represented 30 % of the active sheep farms but only 9-22 % of the closed sheep farms (Figure 12). A proportional correlation between active and closed sheep farms was only found within sheep farms with 10- 24 sheep.

5.5 Effects of wolves on sheep farms

The low effects of wolves on sheep farms found in this study might due to the limited number of attacked livestock within Värmland and Örebro. As the wolf population increases you might expect an increased predation on livestock. But the relationship between carnivore abundance and predation losses is not unequivocal (Knowlton et al. 1999; Conner et al. 1998). Karlsson et al. (2006) showed that the main factor affecting the number of attacked livestock was the abundance of sheep within wolf territories. As mentioned before, only 8 % of all sheep farms in Sweden are located within Värmland and Örebro (Swedish Board of Agriculture, 2012). The two counties also receive large amounts of subsidies for preventative management due to the high densities of wolves (Karlsson et al. 2013). One such management action is wildlife fences, which has been proven to be an effective method in reducing the risk of predation (Reinhardt et al. 2012, Karlsson et al. 2006).

5.6 Future studies

As data on pastures with high biodiversity could not be obtained, the question if closed down sheep farms were located in areas with high biodiversity could not be looked into. This would however be an interesting aspect to follow up.

It would also be interesting to interview the farmers that closed down, to see if there is a difference in reason for closing down depending on where the farms were located. Interviewing farmers that experienced an attack to see how it affected them and how many of them are still active, would be another interesting aspect.

5.7 Conclusion

Even though it is often claimed that sheep farmers are forced to close down their business due to an increased wolf population, no differences were found in the proportion of closed down sheep farms inside and outside wolf territories. Neither was there a difference in the proportion of closed down sheep farms before nor after the establishment of wolves. Other factors are more likely to impact the number of sheep farms, such as production cost and market prices. When looking at the proportion of newly established sheep farms no differences were found when comparing inside and outside wolf territories. Areas where wolves had been present on and off even had a significantly larger proportion of newly established sheep farms. The low effects of wolves on sheep farms might be due to the relatively few attacks within Värmland and Örebro. This in turn might be due to the fact that few sheep farms are located within the two counties, and the many preventative actions that have been taken against predation on livestock, such as subsidies for wildlife fences.

Acknowledgement

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Litterature citet

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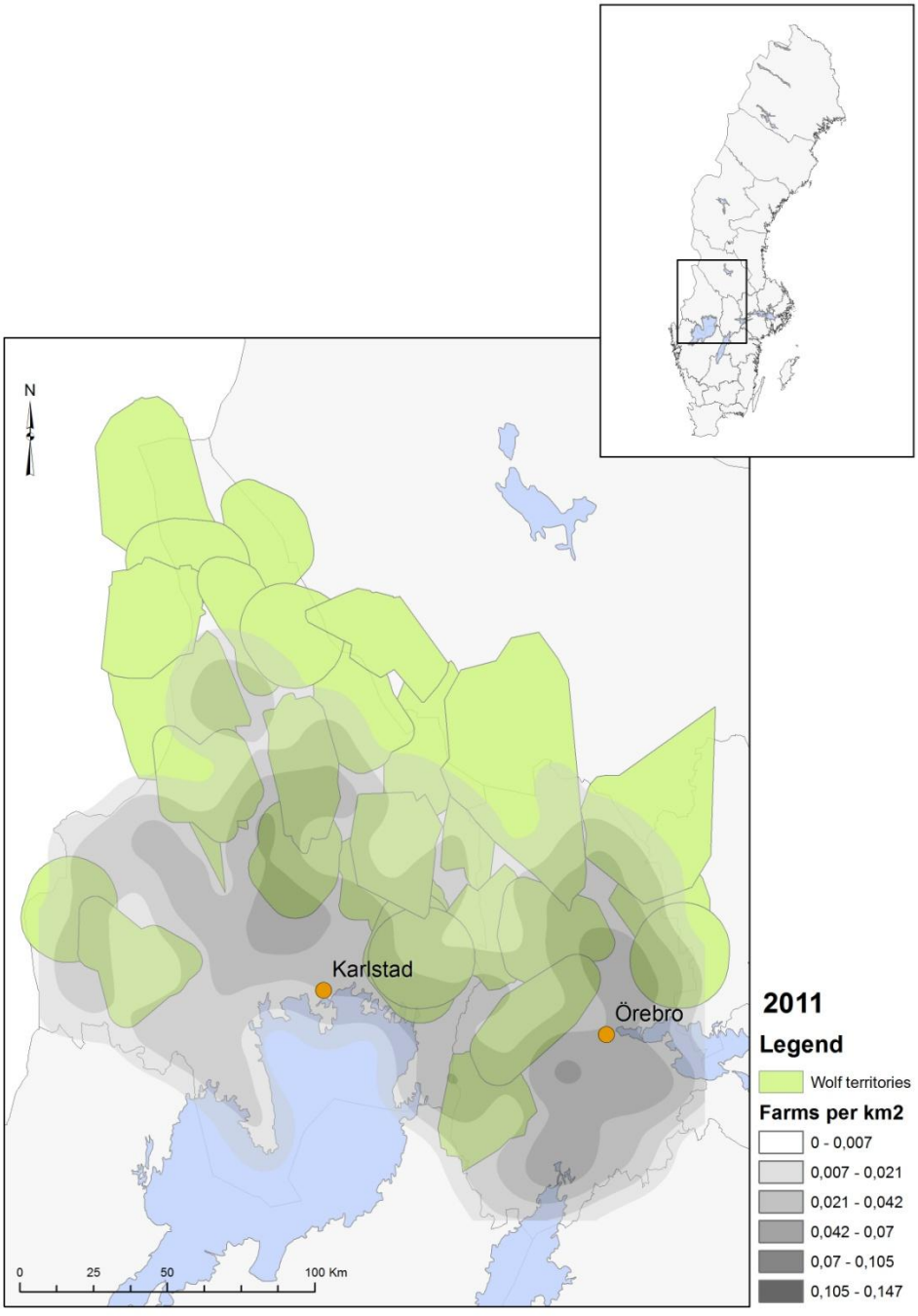
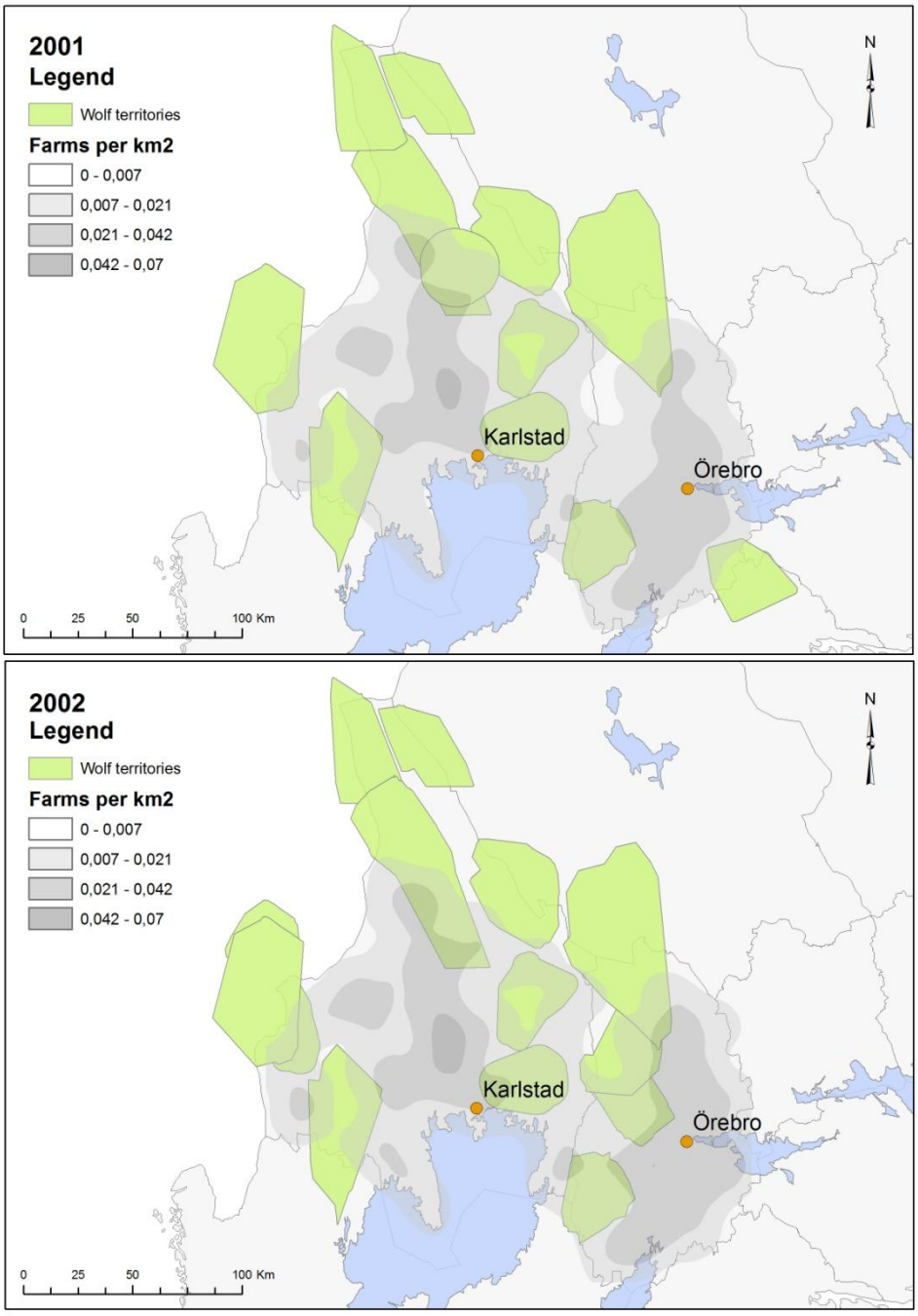
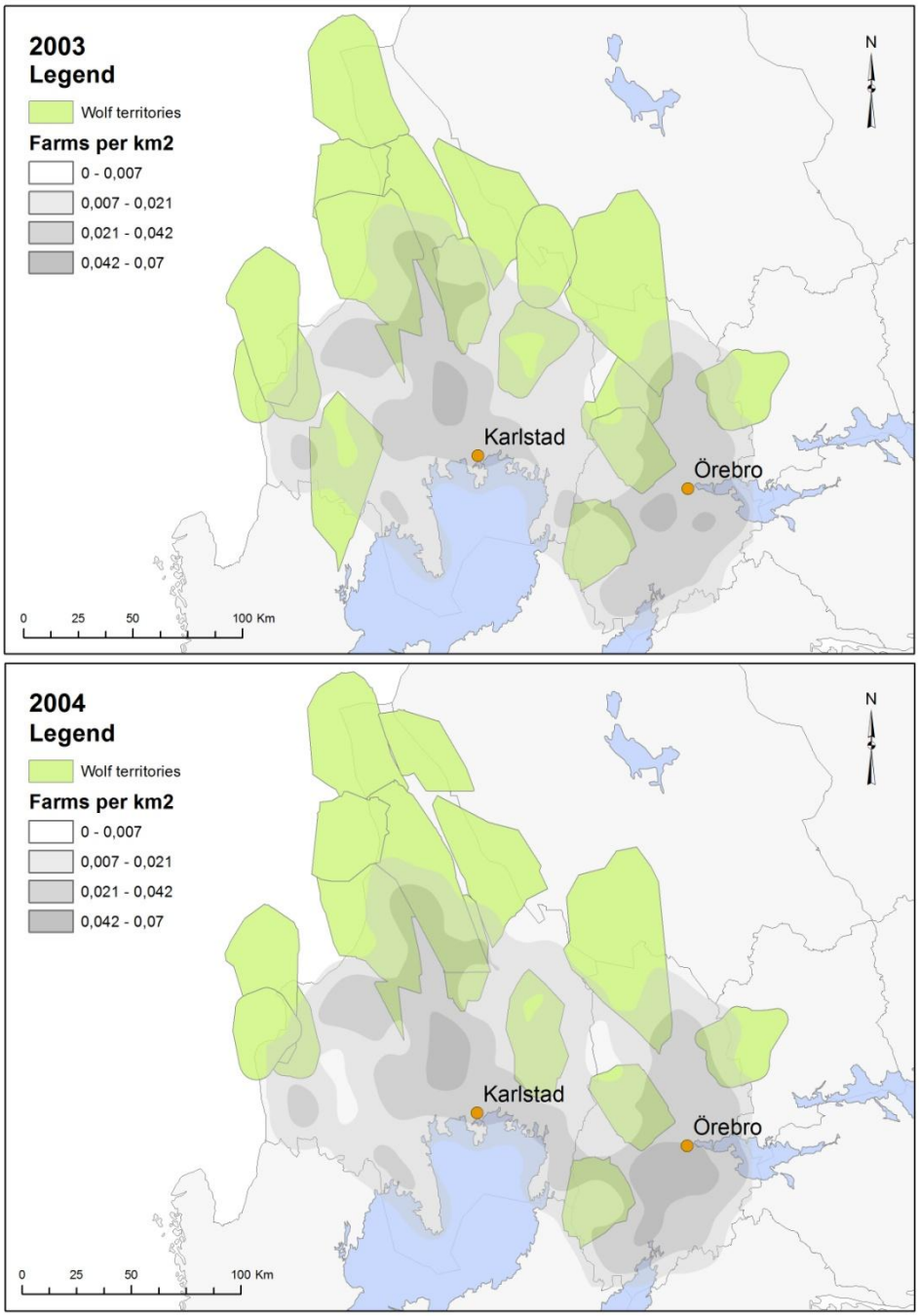
Appendices

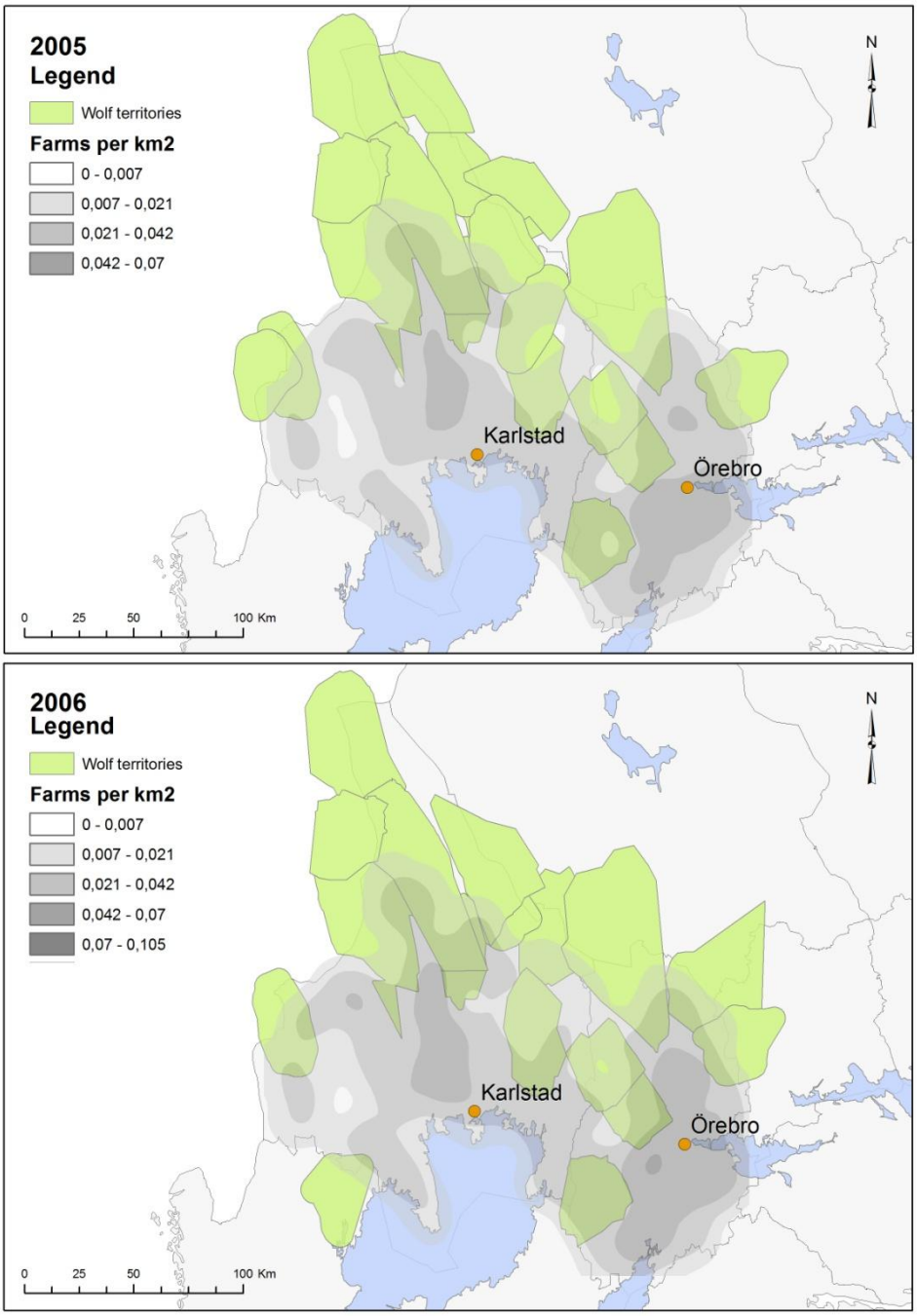
Appendix 1. The distribution of wolves and sheep farms in Värmland and Örebro 2011. Kernel density analysis of sheep farms made in ArcGIS 10.0.

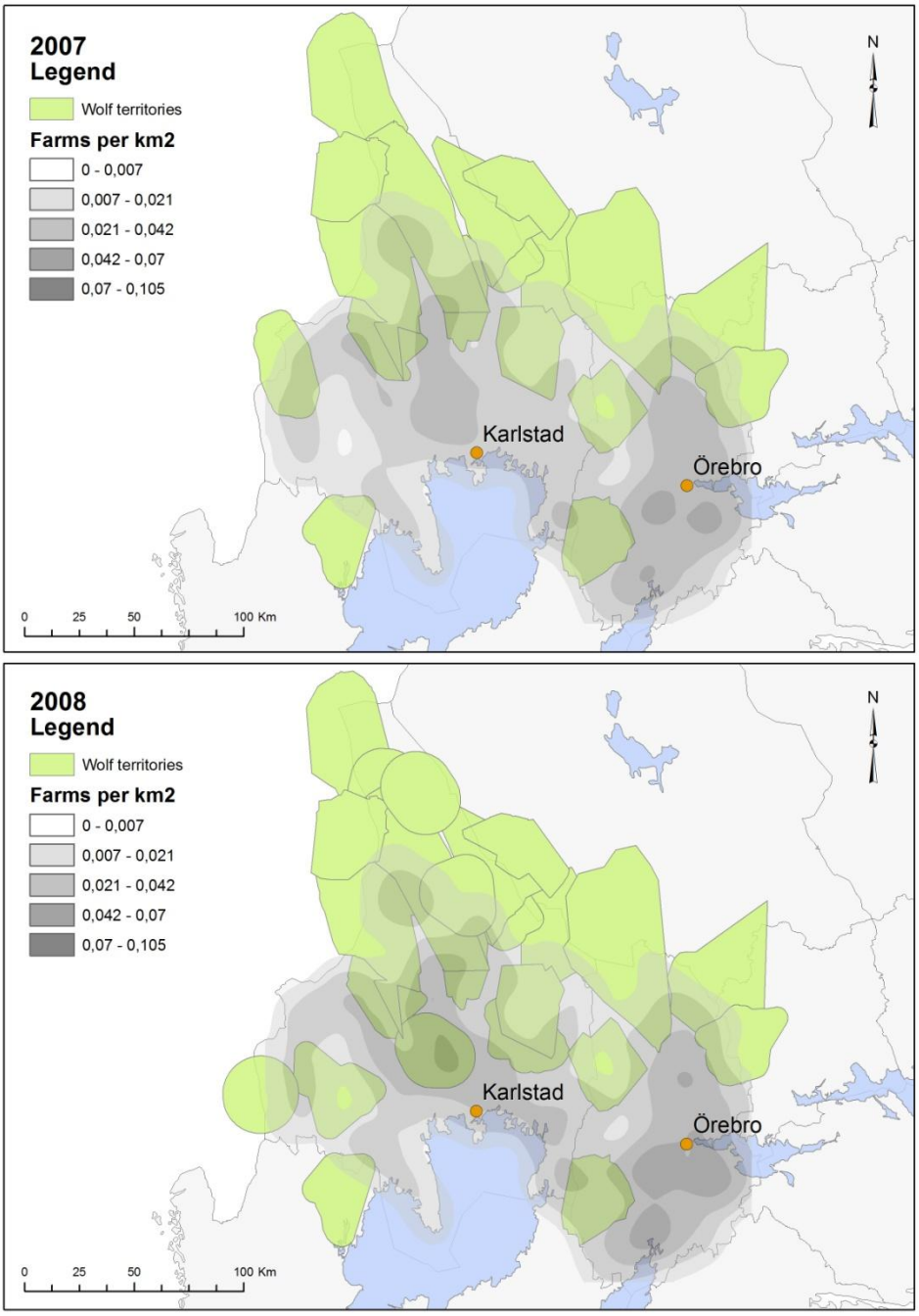


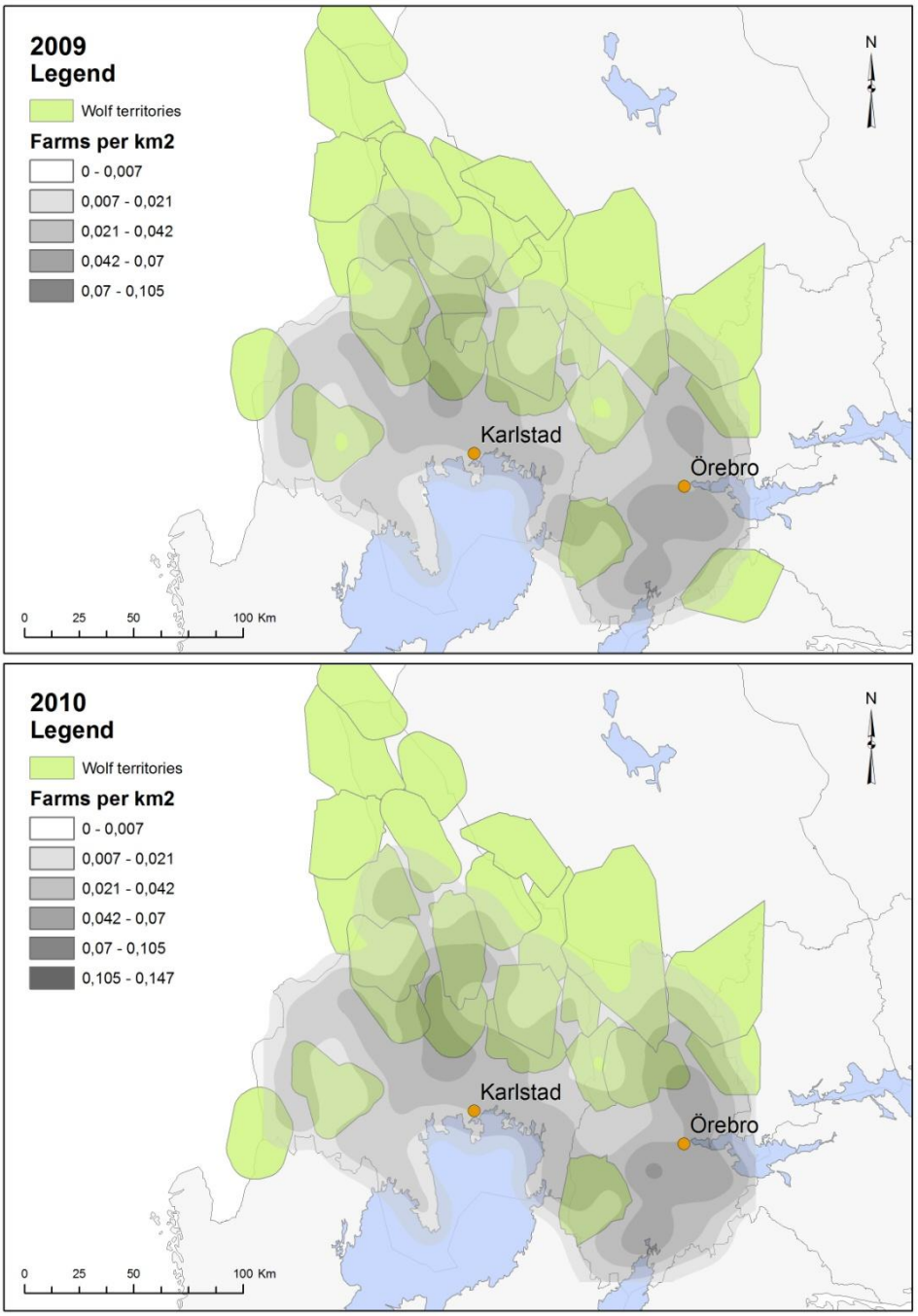
Appendix 2. The distribution of wolves and sheep farms in Värmland and Örebro over time, 2001-2010.




2003
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
N
Karlstad
Örebro
0
25
50
100 Km
2004
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
N
Karlstad
Örebro
0
25
50
100 Km


2005
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
N
Karlstad
Örebro
0
25
50
100 Km
2006
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
0,07 - 0,105
N
Karlstad
Örebro
0
25
50
100 Km


2007
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
0,07 - 0,105
N
Karlstad
Örebro
0
25
50
100 Km
2008
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
0,07 - 0,105
N
Karlstad
Örebro
0
25
50
100 Km


2009
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
0,07 - 0,105
N
Karlstad
Örebro
0
25
50
100 Km
2010
Legend
Wolf territories
Farms per km2
0 - 0,007
0,007 - 0,021
0,021 - 0,042
0,042 - 0,07
0,07 - 0,105
0,105 - 0,147
N
Karlstad
Örebro
0
25
50
100 Km