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Wild boar paradise

What makes the Swedish wild boar reproduce more or less successfully?

Vildsvinsparadiset

Vilka faktorer gör det svenska vildsvinets reproduktion mera eller mindre framgångsrikt?

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FOREWORD

This thesis was created the spring of 2014 at the Swedish University of Agricultural Sciences in Umeå, Sweden.

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SUMMARY

Due to the growing wild boar (*Sus scrofa L.*) population in Sweden there has been an increase in wild boar related traffic accidents, damage on cropland, and conflicts regarding the management of the wild boar. Knowing what makes the wild boar reproduce and survive more or less successfully in different geographic areas is an important part of managing the population. According to previous studies the wild boars rate of increase varies from county to county. The aim of this study was to test, on the county scale level, if landscape composition and diversity as well as people and hunter densities might be the reason for this variation. The first hypothesis was that a big proportion of forests and cropland would increase the rate of increase. The second was that the more diverse the landscape, the higher the rate of increase. The third hypothesis was that a higher people and hunter density would mean a lower rate of increase. Analyses were done on the 14 counties where there is an established wild boar population. The programs used to carry out the analyses were ArcMap, FRAGSTATS and JMP. The results show that in terms of protected areas, the landscape composition might have an effect on the wild boar's rate of increase. When testing the factor "landscape diversity" the "landscape division index" was positively correlated with the rate of increase. People density did not have a significant correlation with the rate of increase, while hunter density did account for some of the variation in the rate of increase. We suggest that further studies should be made with the same kind of landscape metrics we tested for in this study, but on a finer scale of sub-landscapes within each county.

Keywords: landscape diversity, rate of increase, wild boar, sus scrofa

SAMMANFATTNING

På grund av den växande vildsvinspopulationen (*Sus Scrofa L.*) i Sverige har det skett en ökning av vildsvinsrelaterade trafikolyckor, skador på jordbruksmark samt konflikter angående skötseln av populationen. Kännedom om vad som påverkar vildsvinens reproduktion och överlevnad i olika geografiska områden är en viktig del av skötseln av populationen. Enligt tidigare studier varierar vildsvinpopulationens tillväxthastighet från län till län. Syftet med den här studien var att, på länsnivå, undersöka om landskapets sammansättning och diversitet samt befolknings- och jägartäthet kan förklara den variationen. Den första hypotesen var att en stor andel skogs- och jordbruksmark skulle gynna vildsvinens tillväxthastighet. Den andra hypotesen var att ju mera varierat landskapet är, desto högre är tillväxthastighet hos vildsvinen. Den tredje hypotesen var att höga befolknings- och jägartätheter skulle missgynna vildsvinets tillväxthastighet. Analyser gjordes på de 14 län där det finns en stabil vildsvinspopulation. Programmen som användes för analyserna var ArcMap, FRAGSTATS och JMP. Resultaten visade att i fråga om skyddade områden, kan landskapets sammansättning ha en effekt på vildsvinens tillväxthastighet.
När landskapsdiversiteten testades hade indexet "lanscape division" en positiv korrelation med tillväxthastigheten. Befolkningstäthet i sin tur, visade inget signifikant samband med tillväxthastigheten, medan jägartätheten stod för en del av variationen i tillväxthastighet. Vi föreslår att framtida studier görs med liknande mått som beskriver landskapet, men att det görs på en finare skala med "smålandskap" inom varje län.

Nyckelord: landskap, diversitet, tillväxthastighet, vildsvin, sus scrofa

INTRODUCTION

Background

After being absent from the fauna for over 200 years, a number of wild boar (*sus scrofa L.)* escaped from enclosures in the 1970's and now the species has once again established it self in Southern and Central Sweden (Tham 2001). Since then the Swedish wild boar population has been both growing and spreading rapidly (Lemel 2003). In the beginning of the 1990's there were approximately 500 animals, by the end of the year 2001 they had increased to 15 000 (Markström 2002) and by 2010 the population was thought to be around 150 000 animals (Jansson et al. 2010).
The steady increase of the population means an increase in human-wildlife conflicts due to the damage the wild boars cause on crops (Lindblom 2011). According to one study, one in five farmers who grow oats and wheat could loose almost a fifth of their harvest due to damage by wild boar (Schön & Ball 2013). Car accidents involving wild boar have also increased a lot with the increasing wild boar population, from 755 in 2003 to 3551 accidents in 2013 (Nationella viltolycksrådet).
One of the cornerstones in good management is knowing what causes the changes in the population. Therefore it is a good idea to learn as much as possible about the population and the factors that affect the reproduction and distribution of the wild boar. In a former paper Magnusson & Sandahl (2013) showed that the rate of increase in the wild boar population varies between the different counties of Sweden. In this paper we test some of the factors, on county level, that could influence the variation in the rate of increase among counties.

The rate of increase "r"

The speed at which a population changes in size is called the rate of increase "r" (Sinclair et al. 2006). This is defined as the net change in number divided by the number of animals present at the start. For example if a population consisted of 200 animals in year one, and 300 a year later, the calculation would be r = (300-200)/200 = (100/200) = 0,5. Thus the growth for each year is determined by the rate of growth and by the number of animals there are to start with (Sinclair et al. 2006). The reason why we use "r" is that it controls for the year since the wild boar arrived in a given county and directly measures how quickly the pig population increased after it got there. There are many ways to estimate the size of a population, both through direct and indirect methods (Sinclair et al. 2006). Traditional methods for census of ungulates include registering tracks and droppings. Both of them are difficult to use accurately for the wild boar since the flock leaves a jumble of tracks plus their diet is so diverse it makes their droppings vary greatly in appearance (Markström 2002). In this study however we are not interested in the absolute numbers of the wild boar population but in the changes in size within it. Therefore we use reported traffic accidents involving wild boar as an index for the changes in the wild boar population. Indexes are very useful for observing changes in rates of increase (Sinclair et al. 2006) and reporting traffic accidents involving wild boar is mandatory in Sweden (Jaktförordning 2012). This should make the data reliable and consistent over the years, compared to voluntary reporting of wild boar killed by hunters. If the accidents increase in number it is reasonable to believe the wild boar population has increased by the same factor.

Previous studies have found that road-kill data can provide a substitute for other wildlife census methods (Case 1978) and that it can serve as an index of trends in populations on a large regional scale (Mallick et al. 1998).

Habitat selection

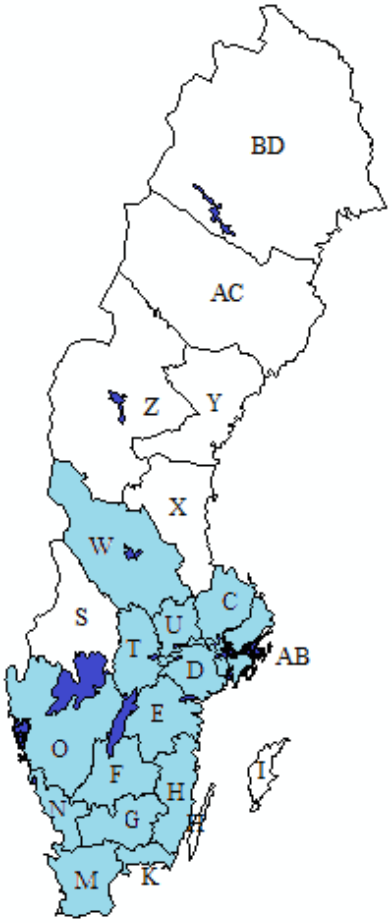
In the book Vildsvin by Tham (2001) the author lists three important factors that make for a successful establishment of the wild boar population. One is cover, such as forests, reeds, and thickets, another is big enough supply of food all year around (Tham 2001). And the third is water, such as streams, lakes and puddles (Tham 2001).
It has been suggested that the wild boar survives well in cultural landscapes of varying kind as long as they can find shelter in forests or reeds (Bjärvall 1985). Crop fields are exposed but rewarding habitats, and these are mostly used by the wild boar in close proximity to safe areas such as forests, ditches and hedges (Thurfjell et al. 2009). Furthermore wild boar abundance is known to be positively associated with landscape diversity (Acevedo et al. 2006). Thus we decided to test whether the composition and diversity of the landscape might predict the variation in the population growth. Habitat selection is also affected by traffic and hunting (Thurfjell 2011). Therefore we also tested to see if human or hunter density would reduce the rate of increase.

Hypothesis

Two former studies have investigated the rate of increase in the Swedish wild boar population (Svensk Naturförvaltning 2011 and Magnusson & Sandahl 2013). The purpose of this study is to test which factors that might predict the different rates of increase at the county level. Firstly we tested for the landscape composition, hypothesizing that a higher proportion of forest and cropland would result in a higher rate of increase. Secondly we tested whether a higher degree of landscape diversity resulted in a higher rate of increase. Finally we hypothesized that higher people and hunter densities would result in a lower rate of increase.

MATERIAL AND METHODS

Study area



Länsnamn	*Länsbokstav*
Blekinge	K
Dalarna	W
Gotland	I
Gävleborg	X
Halland	N
Jämtland	Z
Jönköping	F
Kalmar	H
Kronoberg	G
Norrbotten	BD
Skåne	M
Stockholm	AB
Södermanland	D
Uppsala	C
Värmland	S
Västerbotten	AC
Västernorrland	Y
Västmanland	U
Västra Götaland	O
Örebro	T
Östergötland	E

Figure 1. Map of the 21 counties of Sweden, the 14 colored counties are the ones included in our study.

Data collection

Data used in this study includes number of hunters, traffic accident data, areas and people densities of the counties. Landscape data such as the amounts of forests and cropland was also used. Naturvårdsverket (Anon. 2014a) provides the data on the number of hunters in each county. Data on road accidents, 2003-2013, is available on the web page of Nationella Viltolycksrådet (Anon. 2014b). Data on the people densities in the counties was collected from Statistiska centralbyrån (Anon. 2014c). Lantmäteriet (Anon. 2014d) has the digital topographic map over the landscape and terrain (Terrängkartan) which was collected together with the GIS-data from the SLU data servers (Anon. 2014e).
Areas of the counties were collected from the SLU web pages (Anon. 2014f). We wanted to analyze the rate of increase of a given county, and exclude a few wild boar that may have wandered in from a neighboring county. Therefore only counties with more than 0 observations and observations for at least 10 years in a row were included in the analyses.

Data analysis

To organize the data about hunters, traffic accidents, land area, people densities and landscape composition Microsoft Excel was used. The calculations for ”r” were done in JMP 10.0.2. (Anon. 2012b) by fitting a regression line to the natural logarithm of road kills for each year and county (Sinclair et al. 2006). The slope of the line equals the rate of increase “r”, so the steeper the slope is, the higher the rate of increase will be (Sinclair et al. 2006). For example when “r” equals 0.24 it means that a population of 100 animals will increase to 124 animals the following year (Sinclair et al. 2006).
Our first index for landscape composition, i.e. a measure for what the land consist of was created by summarizing areas for forests and cropland in each county and dividing the sum by the total areas of the respective counties, we call this measure “proportion of forests and cropland”. The other way we measure landscape composition in this study is the proportion of protected areas. Protected areas include national parks, nature reserves and conservation areas. These kinds of areas have, to different extent, limitations on human activities such as forestry, motorized traffic and hunting. This data was collected from the SLU GIS-data (Anon. 2014e).
In ArcMap 10.1 (Anon. 2012a) the topographic map was converted to raster format (feature to raster tool) and the cells were set to the size of 100 x 100 m each (copy to raster tool). From that map the different counties were exported as individual layers in geotiff format (export data). To generate indexes for landscape diversity and fragmentation FRAGSTATS 4.2 (Anon. 2013) was used. The geotiff county layers were imported, the level was set to landscape and landscape metrics Shannon’s diversity index (SHDI) and Landscape Division Index (DIVISION) were chosen. Shannon’s diversity index is a measure of diversity which is widely used in community ecology (Acevedo et al. 2006) and it is one of the most popular indexes for comparing different landscapes (Mcgarigal & Marks 1995). For example when searching the Internet for Shannon’s Diversity Index the Web of Science gives us 967 hits (2014-04-24). The index measures the proportional distribution of area among patch types and increases with increasing heterogeneity (de Beer 2008). Landscape Division Index is another kind of measure for landscape diversity, which is defined as the probability that two randomly chosen places in the landscape are not situated in the same, undissected patch (McGarigal 1995). When the index equals zero the landscape consists of one single patch and when it reaches it’s maximum value (e.g. 1) the landscape is maximally subdivided (Bonaccorso et al. 2006). Analyses were run one by one on each county layer. People densities were taken directly from Statistiska centralbyrån (Anon. 2014c). The number of hunters in each county was collected from Naturvårdsverket (Anon. 2014a).
All the statistical analyses were done in JMP and we used the non-parametric statistical test called the Spearman rank order correlation. Non-parametric methods make no assumptions about normality are preferable when the sample size is small (Siegel & Castellan 1988). The Spearman rank order correlation is probably the best known among statistics based on ranks (Siegel & Castellan 1988).

RESULTS

The rate of increase “r”

To begin with, we calculated the rate of increase “r” for the 14 counties that fulfilled the requirements of more than 0 observations and observations for at least 10 years in a row. When calculating “r” based on road kills during the time period 2003-2013 the rate of increase showed a wide variation between counties ranging from 0.14 to 0.36.

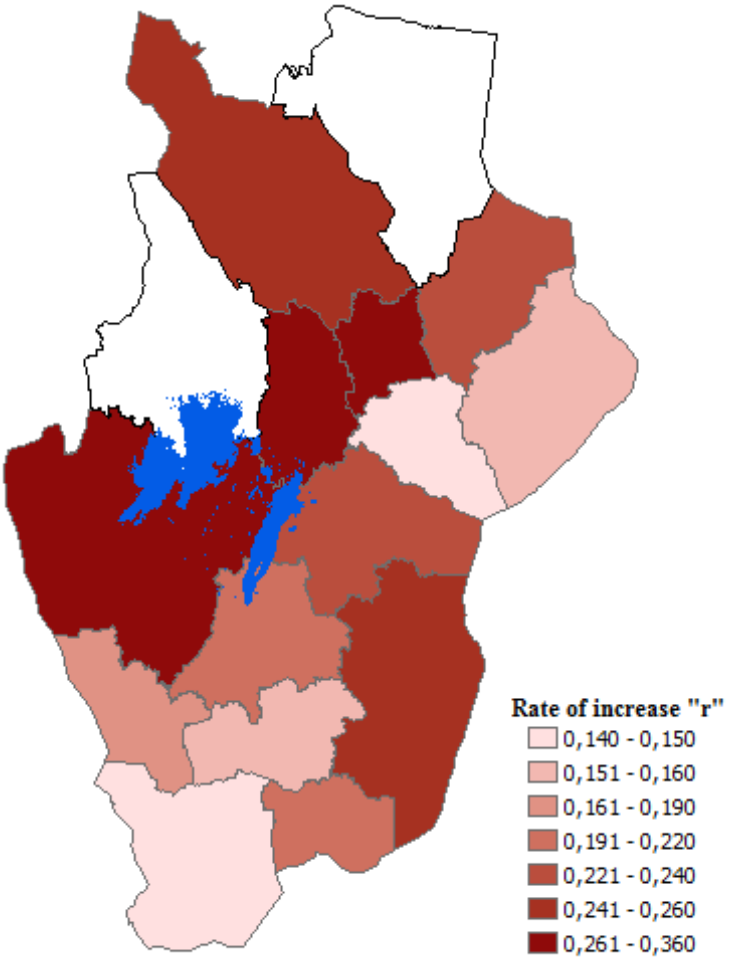


Figure 2. The 14 counties (n=14) in our study and their respective rates of increase. Calculations for “r” based on the annual road kills (which have to be reported by law) in each county.

Landscape composition

We tested the factor landscape composition in two ways. One was summarizing the land areas of forests plus cropland and dividing by the total land area of the county. The Spearman correlation showed that the proportion of forest and cropland in each county could explain about 16% of the variation of "r". The probability of finding this correlation between "r" and proportion of forest and cropland by chance alone was 0.57.
The other way we tested for landscape composition was the proportion of protected areas per km^2. Protected areas include national parks, nature reserves and conservation areas. These kinds of areas have, to different extent, limitations on human activities such as forestry, motorized traffic and hunting. According to Spearman's correlation the proportions of protected area explained 54% of the variation of "r" and the probability to get this correlation by chance alone was less than 0.05.

Table 1. The variables we tested for. Spearman correlations and probabilities. Sample size n = 14.

Variable	**Spearman ρ**	**Probability > ρ**
Proportion of Forest and Cropland	0,17	0,57
Hectares Protected area per km2	0,55	0,04*
Shannon's Diversity Index	0,33	0,25
Landscape Division Index	0,5	0,07
Humans per km2	- 0,28	0,34
Hunters per km2	- 0,48	0,08

Landscape Diversity

When fitting a line of relationship between Shannon's diversity index and the rate of increase it looks like there is a slightly positive correlation. Though the non-parametric test shows a Spearman correlation that explains 33% of the variation p = 0.25. So the statistical evidence for this is weak.

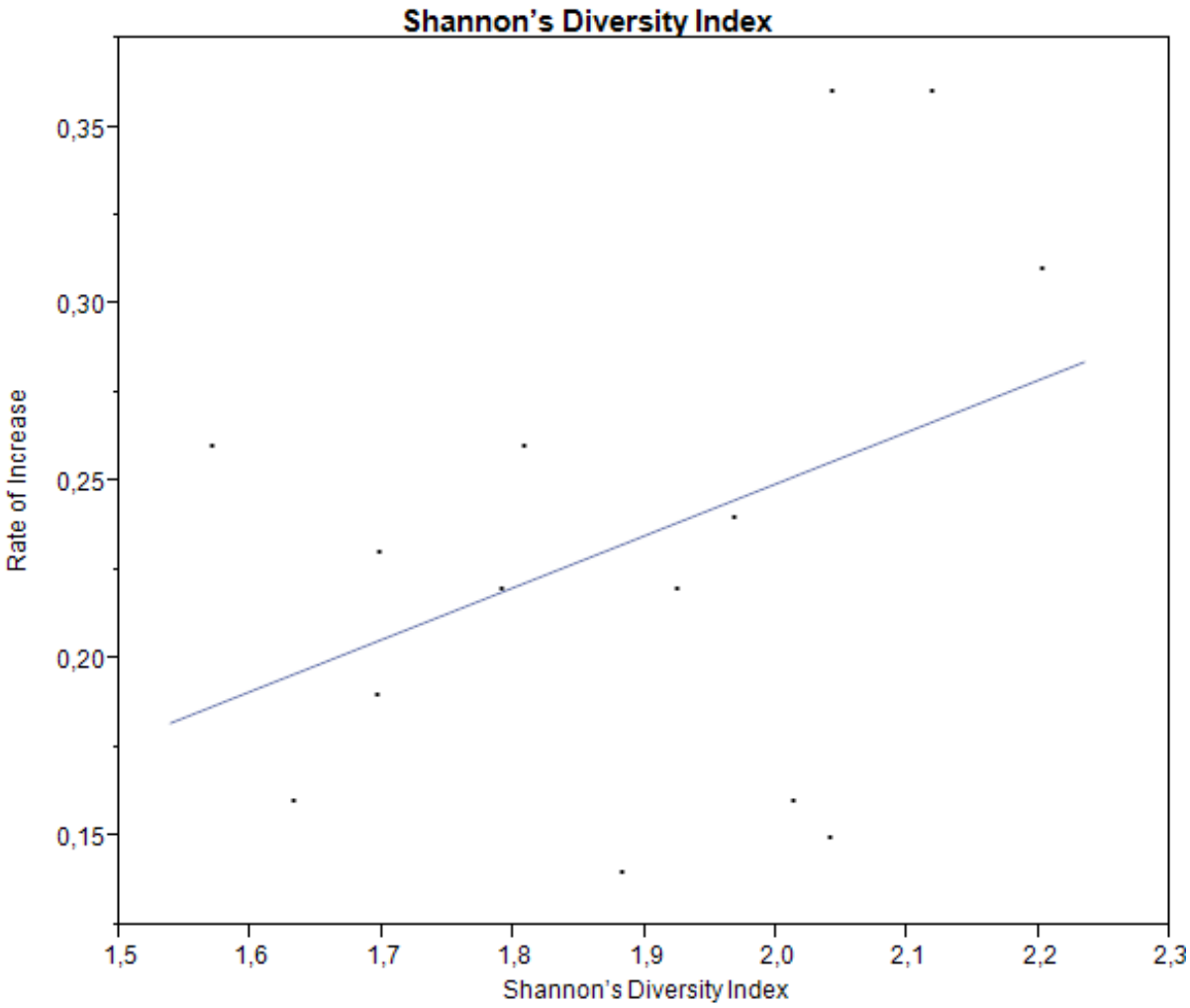


Figure 3. Graph showing the relationship between the rate of increase and Shannon's diversity index. (n=14, R^2=0.33, p=0.25).

The relationship between the landscape diversity index and the rate of increase also suggests that there is a positive correlation. The non-parametric test shows a Spearman correlation that explains 49% of the variation and p = 0.07, which strongly suggests that this is worth more examination in future studies.

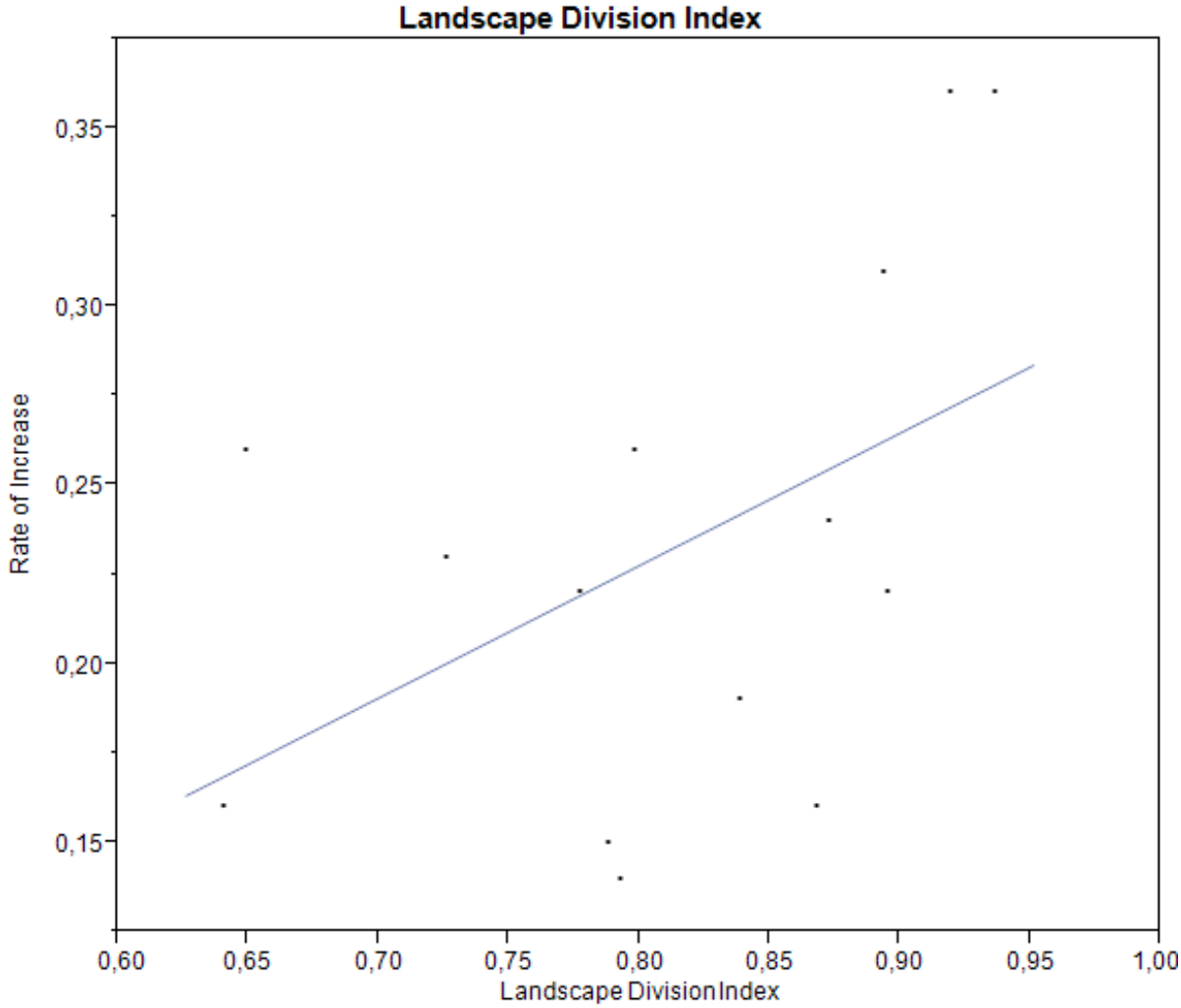


Figure 4. Graph showing the relationship between the rate of increase and landscape diversity index. (n=14, R^2=0.49, p=0.07).

Human and Hunter densities

Spearman's correlation for human density was negative 28% and p=0.33. The hunter density also had a negative correlation, but explained 48% of the variation in "r", p=0.08. Which suggests a relationship.

DISCUSSION

The rate of increase "r"

Our calculations for r, based on the annually road killed wild boar shows considerable variation between the different counties. This indicates that something makes the wild boar population grow at different pace in the different counties of Sweden. Since reporting of traffic accidents involving wild boar is mandatory in Sweden (Jaktförordningen 2012), using road kills, as an index for the wild boar should be a reliable method to estimate the population. Obviously variation in the number of road kills can occur due to human activity, like taking actions to reduce the number of game related traffic accidents by putting up game fences along the roads and highways. It is possible that future studies could calculate the amount of road kills in relation to road density or road length in order to create potentially better estimates of the wild boar population.

Landscape composition

The wild boar is a forest animal, which takes advantage of the abundance of resources offered by cropland. Still the proportion of forest and cropland on the county scale did not explain the variation in the rate of increase. The proportion of protected areas on the other hand does show a significant correlation with the variations in the rate of increase. This could indicate that areas where the wild boar can stay undisturbed from human activity, is of importance for the animals reproduction and survival on the county scale.

Landscape diversity

There was no significant correlation between Shannon's diversity index and the rate of increase on the county scale. The "landscape division index" on the other hand could explain almost half of the variation in the rate of increase, and was close to being significant at $p = 0.07$. It is possible that further testing on a smaller scale than the county scale might reveal stronger correlations between landscape diversity and the rate of increase in the Swedish wild boar population, and we suggest further research.

Human and hunter density

The factor "human density" showed no significant correlation with the rate of increase at the county scale. Hunter density did though; almost half of the variation in "r" could be explained with a probability close to being significant ($p=0.08$). There are many other ways of testing whether human activity has any effect on the wild boar's rate of increase, for example road density, proportion of populated areas and hunting intensity. The simple fact that our study showed that variations in "r" could be explained by the proportion of protected areas could indicate that the wild boar benefits from the absence of human activity.

CONCLUSION

The growing wild boar population in Sweden is causing damage on crops and an increasing number of traffic accidents. In the counties where there is an established wild boar population, the rate at which the population increases varies significantly. The aim of this study was to test factors that might be the reason for that variation, on the county scale level. The factors we tested were “landscape composition”, “landscape diversity” plus human and hunter density. The results suggest that there is a relationship between the population rate of increase and “landscape composition”, in this case protected areas. Also “landscape diversity” and the hunter density predicted a portion of the variation in the rate of increase. These relationships suggest that it might worth it to further investigate the same factors tested in this thesis. If investigated on a finer scale with e.g. “sub-landscapes” within the counties, the relationship between the rates of increase and “landscape diversity” might come out even stronger.

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