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Swedish University of Agricultural Sciences, SLU
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Abstract

Management and conservation of wildlife populations are generally based on scientific knowledge (SK) and monitoring to establish reliable information. The information gathered and presented from SK is interpreted by individuals who can have different ways of interpreting the same type of information. To increase the validity and range of opinions, other types of knowledge can be incorporated with SK. There are a variety of non-scientific types of knowledge that can be used depending on the research question, such as local ecological knowledge (LEK), local knowledge (LK), traditional ecological knowledge (TEK) and indigenous local-, and traditional knowledge (ILK/ITK).

Wildlife management in Sweden already uses alternative knowledge systems incorporated with SK in monitoring of ungulates. This monitoring is predominantly used for spatial distribution and population indices. In management of multi-ungulate systems, it can be beneficial to have monitoring and management measures done on a smaller and more local scale. This can be done with a combination of SK and LEK from hunters, who have an accumulated knowledge based on experience and observations over a lifetime.

In this thesis, I investigate if LEK and SK can successfully be incorporated in management of multi-ungulate systems. First, I conduct a systematic review to explore how many studies have been analysing the overlap between LEK and SK regarding terrestrial mammals. Then I carried out a pilot study on Järnäs peninsula located in northern Sweden, where four different ungulate species are present, moose *Alces alces*, roe deer *Capreolus capreolus*, fallow deer *Dama dama* and red deer *Cervus elaphus*. For this, I use three different data sets: a questionnaire survey to establish LEK and for SK, camera traps for distribution, and DNA metabarcoding for diet data. I found that experience or age of hunters did not influence the LEK/SK overlap. The hunter estimates predict 30% of the DNA data, the diet deviated most for birch, *Vaccinium*, graminoids and "other". Fallow deer had the lowest diet deviation score between LEK and SK of all species. An overlap could be seen regarding spatial distribution for the introduced species, red deer and fallow deer. Also, a tendency of even distribution for moose and roe deer could be seen which indicates that a combination of LEK/SK could be used for spatial monitoring and management.

Keywords: local ecological knowledge, LEK, scientific knowledge, SK, wildlife management, ungulate management, multi-ungulate systems

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Abbreviations and Swedish terminology

ILK	Indigenous local knowledge
ITK	Indigenous traditional knowledge
LEK	Local ecological knowledge
LK	Local knowledge
SK	Scientific knowledge
TEK	Traditional ecological knowledge

Avskjutningsstatistik	Bag statistics
Flyginventering	Aerial surveys
Foderprognoser	Forage availability estimates
Kalvviktsinsamling	Calf weights
Spillningsinventering	Dung pellet counts
Älgobservationer (älgobs/viltobs)	Moose observations
Älgbetesinventering (ÄBIN)	Moose browsing damage monitoring

1. Introduction

Management and conservation of wildlife populations are generally based on scientific knowledge and monitoring. This is used to establish reliable information of the species to then be able to set a suitable harvest quota or ensure a viable population for conservation (Lebreton et al. 1992). This type of scientific data is globally scarce for many wildlife populations and can be due to factors like areas being remote, difficult or too costly to monitor. This may lead to insufficient information, which may prevent sustainable management or conservation planning (Ludwig et al. 1993).

Scientific knowledge (SK) is usually referred to as explicit knowledge derived from formal methods both from natural science and social science, with high reliability and validity (Raymond et al. 2010). The information gathered and presented from scientific knowledge is interpreted by individuals who can have different ways of interpreting the same type of information. This can influence what questions are asked and which might be ignored, how the data is described and what type of frameworks that are accepted or not.

To increase the validity and range of opinions, other types of knowledge can be incorporated with SK. There is a variety of non-scientific knowledge that can be used depending on the research question, such as local ecological knowledge (LEK) which refers to knowledge held by local people about their local ecosystems (Olsson & Folke 2001). This differs from local knowledge (LK) since it contains “ecological” and therefore concerns interplay among organisms and their habitat. Another type of ecological knowledge is traditional ecological knowledge (TEK) that contains an accumulated knowledge that has been handed down through generations and usually has a historical and cultural connection. Then there can be local or traditional indigenous knowledge (ILK/ITK) that refers to knowledge from indigenous people that is unique for a given culture and often spiritual (Raymond et al. 2010)

Wildlife management in Sweden already uses a mixture of different knowledge systems in the monitoring of both ungulates and bears (Flerartsförvaltning, viltdata n.d; Bellemain et al. 2005). This monitoring is predominantly used for distribution, pedigree predictions and population indices. For the different ungulate species in Sweden systems called “Älgobs” (moose observation), “Kronobs” (red deer observations) and “Klövviltsobs” (ungulate observation) is used by hunters to document observations of ungulates during the beginning of the hunting season (Ericsson & Kindberg 2019). It is conducted in Moose Management Units (Älgskötselområde) and Moose management Areas (Älgförvaltningsområde) and requires a minimum of 5000 man-hours to give a good estimate. This type of monitoring gives an index value that estimates fluctuations and composition in the population and is used for those that plan and decide the management. It is a cost-effective way to estimate population densities and population composition in an adaptive management framework, but it does not give the whole picture. Some aspects that is not included in this type of monitoring is seasonal differences in distribution which can differ between the species due to migration habits and food choice (Cretois et al. 2020).

On the Järnäs peninsula south of Umeå (Figure 1), four of the wild ungulate species present in Scandinavia can be found: moose (*Alces alces),* roe deer *(Capreolus capreolus),* red deer (*Cervus elaphus)* and fallow deer (*Dama dama).* All except fallow deer are native to Sweden but in Järnäs both fallow deer and red deer are introduced species that came to the peninsula in the 1970s (Järnäshalvöns Kronhjortsskötselområde n.d.; Apollonio et al. 2010). They were first kept in enclosures for hunting but later some individuals escaped and formed the source of the populations found on Järnäs today (Fahlgren & Lodestål 2011)

In management of multi-ungulate systems, it can be beneficial to have monitoring and management measures done on a smaller and more local scale. This can be done with a combination of SK and LEK from hunters, who have an accumulated knowledge based on experience and observations over a lifetime regarding species distribution (Gilchrist et al. 2005; Anadón et al. 2009). Hunters usually have good experience about the different ungulate behaviours in a specific area and carry more knowledge on the specific area than the general public (Morales-Reyes et al. 2019; Webb et al. 2019).

1.1. Aim

Given the stated limitation of SK in multi-ungulate systems the aim of this thesis is to explore if LEK and SK can be incorporated in management of multi-ungulate systems. To answer this broad question, I will conduct a systematic literature review and analyse a pilot study on LEK/SK overlap. In the literature review I will explore how many articles that has studied the overlap between the two knowledge types regarding terrestrial mammals and their ecology. My aim is to answer following research questions (RQ):

RQ 1. Is there a difference in the number of studies on LEK done between management and conservation?

RQ 2. Are there more studies done on game species?

RQ 3. Are some combinations of LEK and SK more successful?

For the pilot study on Järnäs I will use three different data types: a survey on LEK from hunters and two data sets of SK, from camera traps regarding spatial distribution and DNA data on diet to analyse in which areas there is an overlap between the different datasets. My aim is to find in which areas of expertise hunters' knowledge can be combined with scientific knowledge to create a sustainable management with finer resolution than current methods in multi-ungulate systems by answering the following questions:

RQ 4. Is there an alignment between hunters estimates and scientific data from camera traps and DNA metabarcoding?

RQ 5. Can any hunter attributes or self-assessed knowledge explain the potential alignment?

RQ 6. Are there differences between the four species in the LEK/SK alignment?

RQ 7. Are there differences between the four seasons in the LEK/SK alignment?

RQ 8. Are there significant differences in hunters self-assessed knowledge towards the different ungulate species?

RQ 9. Are there significant differences in hunters self-assessed knowledge between diet and distribution?

Answering these questions can hopefully contribute to potential future improvements of existing monitoring methods and hunters trust and participation.

Methods

The method contains two different sections, the first with the systematic review and in the second part the pilot study. The pilot study is divided into three subcategories, one for each of the different data types.

1.2. Systematic literature review

I initiated my work with searching for relative search words and synonyms in previous studies done in combining LEK and SK. I came up with three different Boolean search strings covering non-scientific knowledge, scientific knowledge and management.

Table 1. Boolean search strings combined with OR within the categories and AND between them.

Non-scientific knowledge	***Scientific knowledge***	***Management***
"Local knowledge"	"Scientific knowledge"	"Wildlife management"
"Local ecological knowledge"	"Local scientific knowledge"	"Wildlife monitoring"
LK	SK	"Environmental management"
LEK	LSK	"Biodiversity monitoring"
"Social learning"	"Scientific monitoring"	Conservation
"Knowledge integration"	"Scientific based monitoring"	"Biodiversity conservation"
"Participatory research"	"Scientific data"	"Wildlife research"
"Citizen science"		"Carnivore management"
		"Carnivore monitoring"
		"Ungulate management"
		"Ungulate monitoring"

I decided to use Web of Science (WoS) and Scopus as search engines for my review and used the PRISMA framework in conducting and structuring the review (Liberati et al. 2009; Moher et al. 2009). I limited my search to articles, reviews, and books, hereafter collectively referred to as articles, between 1945 until 2020. In WoS, I further limited my search to only the core collection. I exported all hits from both search engines to Zotero where I removed all the duplicates and did my first scan of title and abstract removing all that did not concern terrestrial wildlife and some combination of LEK and SK. I categorized the removed articles in different folders depending on what type of subject it was addressing, fish, marine, reptiles or insects, environmental, forest, agriculture or other plants. I then did a full text screening excluding those that did not look at the overlap between the different types of knowledge. The articles left were then further analysed and documented by country, species, management or conservation and what method was used to establish the LK and SK. I also summarized the major aspects in the studies such as conclusions, deficiencies, positive outcomes and what was highlighted as important when combining LEK and SK.

1.3. Pilot study

1.3.1. Study area

The pilot study is conducted on the Järnäs peninsula (Figure 1), which is located in the south-eastern part of Västerbotten county in northern Sweden (63°32´N, 19°41´E). The area is approximately 200km^2 and cut off in the north by both a fenced highway and a railroad. The remaining sides of the peninsula are enclosed to the Bothnian bay, which obstructs migration behaviours for the different ungulates present in the area. The peninsula is covered by boreal forest, mires, agricultural land and two towns at each side of the northern barrier, Hörnefors and Nordmaling. It is a unique area in Västerbotten since it inhabits all four ungulate species (Järnäshalvöns Kronhjortsskötselområde n.d.; Apollonio et al. 2010)

Figure 1. Overview of study area Järnäs peninsula

1.3.2. Data collection

Data regarding both diet and movement patterns for the different ungulates originated from previously conducted studies in Järnäs (Spitzer et al. 2019; Hofmeester et al. 2020). Both used the same sample grid (Figure 2). The hunter´s knowledge is quantified by a questionnaire survey (Appendix 1) that were distributed to 12 hunting teams on the peninsula in 2018. The hunting teams included have their hunting ground completely or partially located on the peninsula south of the highway and railroad.

Figure 2. Transects used for sampling of faecal pellets and locations for camera traps.

1.3.3. Survey

The local ecological knowledge (LEK) is assessed through a survey sent out to 12 hunting teams in the area (Appendix 1). No sample frame exists containing all hunters on Järnäs, therefore hunting team leaders were contacted during their annual hunting meeting in August 2018 and asked to give their contact information and an estimate of the number of hunters in their team. The membership records were provided by the leaders of each hunting team and indicated a total of 163 active members. In September each leader received a package with a cover letter, instructions, and surveys for all team members, plus a few additional copies. Survey packages also contained postage-paid return envelopes. After three weeks, the team leaders received a post card reminder to encourage their members to reply to the survey.

The survey included questions concerning ecology, movement patterns and diet of the four ungulate species that are found in the area (i.e., moose, roe deer, fallow deer, and red deer) (see Appendix 1 for all the questions). Regarding spatial distribution the respondents were asked *'Where is the hunting ground that you mostly hunt on'* and *'Several of the ungulate species migrate during the year. Can you please indicate where they live mainly during the different seasons on Järnäs Peninsula?'* Answers were given by referring to 2x2km grid cells within the attached map of Järnäs and for 4 seasons: spring (May-June), summer (July-August), autumn (September-October) and winter (November-April). The four questions concerning diet were divided into the same four seasons as for distribution. The questions were *'Which of the following food resources are most utilized by ungulates during spring, summer, autumn and winter?'* The respondents were asked to assess what percentage of different food items are eaten by the four ungulate species. Ten food items were listed in the survey, pine, spruce, juniper, birch, broadleaf, *Vaccinium*, shrubs, forb, graminoid and other. For hunters' attributes I used questions that asked the respondents *'How many years have you been hunting on Järnäs Peninsula?', 'How often do you visit the hunting ground?', 'How* *many days have you been hunting ungulates the last 12 months?', 'Do you live on Järnäs Peninsula?'* and the age and gender of the hunter. I also used two questions concerning self-assessed knowledge on both distribution and diet *'How would you describe your local knowledge on ungulates and their ecology?'* and *'How would you describe your local knowledge regarding following ungulate species and their ecology?'.* The last question is divided into the four different species and both questions are graded in seven steps from limited knowledge to high knowledge.

I further used a question asking, *'Where does your knowledge come from?'* that includes four subcategories *'Own observations', 'Participated in scientific census', 'Learned from another person'* and *'Learned from other sources'.* These were graded from 0= none to 3=a lot. I also asked, *'To what extent do you share your knowledge regarding ungulates to these following groups?'.* The groups to choose from were, family/relatives, friends, members of the hunting team, local people and others. It was graded in four steps as previous question from none to a lot.

To evaluate the usefulness of census methods I used two different questions. The first was *'Which of the following census methods of ungulates are used in your hunting area?'.* The different methods were bag statistics, aerial surveys, forage availability estimates, calf weights, dung pellet counts, moose observations and moose browsing damage monitoring. It was graded from every year, every second year, every third year, every fifth year to never. The second question used was *'How do you assess the benefit of the census methods in ungulate management?'.* The categories were the same as previous question and was graded from 1=small to 3=great.

1.3.4. Diet data

Diet composition for the four different ungulate species has been determined by a DNA metabarcoding study from collected faecal pellets (Spitzer 2019). The pellets were collected monthly from 11 transects of 1x1 km, spread over the study area from September 2016 to November 2017 (Figure 2). They aimed to collect five samples from each species per transect and visit. For the analysis approximately 2g of faeces was used to determine the diet composition and species. I categorized the samples into different seasons based on seasons defined by SMHI for northern Sweden, 1 May – 1 July (Spring), 1 July – 1 September (Summer), 1 September – 1 November (Autumn) and 1 November – 1 May (Winter) (*Årstider | SMHI*). This was to get the same resolution in seasons as used in the survey.

1.3.5. Spatial distribution

The movement and distribution for the different species was determined with camera traps placed in the 11 grids from January 2017 to February 2018 (Hofmeester et al. 2020). On each of the 11 transects, 18 locations for cameras were selected which yielded 198 locations. Out of those, 193 locations were successfully sampled and further analysed. Three cameras were placed on each transect and then moved after 6-10 weeks to new locations, this occurred six times to be able to cover all sampling spots. The cameras were set to take a series of photographs when activated to be able to track animal presence. For this thesis maps were created by extrapolating the visitation frequency from the camera traps and using a 2x2km grid covering the peninsula. The visitation frequency was calculated as the total number of visits at a camera trap location divided by the number of days the camera trap was active, resulting in a number of visits per day. The same definitions of seasons as in the diet data and survey are used.

1.4. Analysis

All statistical analyses have been carried out in RStudio (R Core Team, 2020)
at a significance level of alpha = 0.05 for hypothesis testing. Tidyverse package (Wickham et al. 2019) was used both to conduct the statistical analyses and produce figures.

1.4.1. Survey

I initiated my work with transcribing the paper surveys into Excel and structure them. To analyse the questions within the survey relating if hunter attributes influenced their estimations on food choice and occurrence, I used a multiple linear regression. I checked the assumptions for the regression and collinearity of the explanatory variables before conducting the regression. I further analysed if there were differences in the hunters self-assessed knowledge between the species and between diet and occurrence. For this, I used a one-way repeated measures ANOVA because the observations are not independent since the same individual has answered for all four species questions.

1.4.2. Diet data

For the comparisons between DNA data and survey data, the DNA data had to be converted to match the taxonomic resolution of the 10 food items in the survey. Fallow deer for summer were excluded due to missing DNA data for all statistical analyses. To deal with the differences in answering frequency between the hunters I assigned each hunter a score. The score is based on the deviation between the specific hunters answer for each food item and season and the mean values from the DNA data. If the estimates are within 10% from the DNA a score of 1 is assigned. If the deviation is greater than 10% or there is no answer a 0 is assigned. The maximum score for each respondent can therefore be 150 (4 species x 4 seasons x 10 food items = 160; minus 10 due to missing DNA data for fallow deer in summer). Respondents that got a total score of 0 were filtered away since they had chosen to not answer any of the food questions and were therefore not applicable for the analysis. These scores should not be interpreted as measures of "right" or "wrong" regarding the true deer diets but as quantitative measures of congruence between local knowledge and DNA results, i.e., the higher a respondent's score, the more similar this person's diet estimate was to the DNA diet results.

For analysing how well the hunters' estimates explain the DNA data I used a linear regression. To test the effects of how different hunter attributes influence their answers the total score was used as the response variable in linear multiple regression. The assumptions for linear regression, linearity, normal distribution, multicollinearity, and residuals were checked by plotting them in R. As explanatory variables I used the same as in the comparison within the survey. For analysing if there are difference in the deviation between species or season, I used a two-way ANOVA with a Tukey HSD post hoc test. The post hoc test was used to compare the pairwise group means to get a better understanding for the interaction. Assumptions for normality, equal variances and independence were checked visually with histogram, Q-Q plots and boxplots.

1.4.3. Spatial distribution

For the camera trap data together with the answers from the survey I used a combination of QGIS 3.14 and RStudio with rgdal package (Keitt et al. 2010) to create overview maps for the spatial distribution of the different ungulates. The data from the survey were first structured in Excel by assigning each raster square a score of 0 or 1 (Appendix 1, p 53.). If the hunter said that the ungulate species were evenly distributed a 1 were given all squares covering the peninsula. If they answered specifically which squares were more used, they were assigned a 1 and the others 0. Those that left the question blank were removed. The data were further processed in RStudio where the average for each species were calculated and transferred to a raster map over Järnäs. This map with all scores were then finalized in QGIS displaying the hunters estimates for abundance. Too few participants gave specific distribution data for the different seasons to be able to statistically compare the two datasets.

2. Results

2.1. Systematic literature review

The WoS search using the Boolean search strings (Table 1) initially yielded 308 hits which were reduced to 263 when the search was restricted to the WoS core collection, (see Figure 3). It was further reduced to 256 papers when only selecting for articles, reviews, and books. I entered the same search strings in Scopus and combined them which gave 167 hits. After selecting for only articles, reviews, and books it ended up with 155 papers. I exported all the hits to Zotero and checked for duplicates and removed them which narrowed it down from 411 to 271. I scanned through all the titles and abstract and removed all that did not address terrestrial mammals, LEK or synonyms to it. I found out that a big proportion was about fish or marine wildlife, over 30%. 11 articles were about birds and 13 about other types of animals like insects and amphibians. The rest of the articles were about environmental aspects, forestry, agriculture, or pure citizen science projects. There were 38 that had both terrestrial mammals and LEK involved that I saved for a full text assessment. While reading the articles I added one to the collection which resulted in 39 full text. After scanning trough these I discarded 30 that did not fulfil all the criteria of comparison between LEK and SK which left 8 for final analyses.

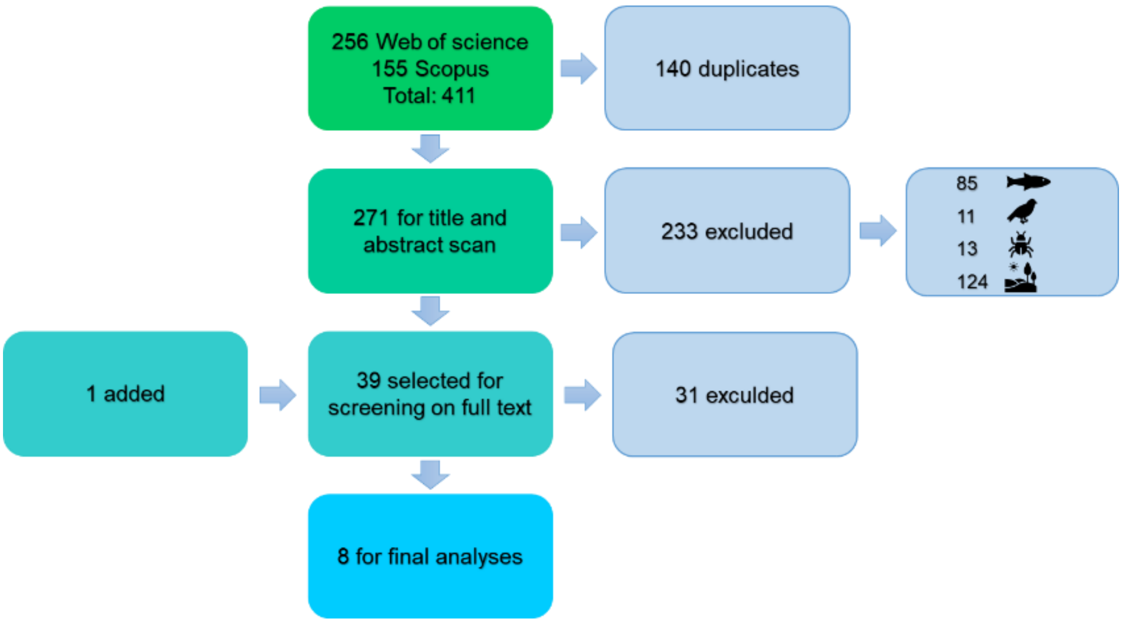

Figure 3. Flow diagram for systematic review, light blue boxes indicate how many articles were excluded in each screening step.

The studies were carried out in South America, North America, Africa, and Europe, none in Scandinavia (Table 2). To answer RQ1 I listed the number of studies concerning management or conservation. Five of them involved management and three for conservation, those regarding conservation are conclusively on poached species. The oldest article is from 2003 and the newest 2019. To answer RQ2, all species were hunted in some way, half as game species and half were previously hunted or currently poached. Four of the studies used camera traps and 2 used different kinds of DNA sampling.

Table 2. Summary of the 8 final articles in the review.

Article	*Country*	*Animal*	*Management/ conservation*	*Hunted*	*Interview/ survey*	*Scientific data*	*Conclusion*
(Dolrenry et al. 2016)	Kenya	African lion *Panthera leo*	Conservation	Yes/No	Interview	Scientist monitoring and validating	By incorporating traditional ecological knowledge from locals with modern wildlife monitoring, reliable data can be obtained. With the help of local hunters both the data quality and efficiency improved.
(Irvine et al. 2009)	Scotland	Red deer *Cervus elaphus*	Management	Yes	Interview	GIS-based habitat model	The ability for the GIS-model to predict red deer distribution improved significantly when incorporating managers knowledge and scientific knowledge. This will give better distribution predictions without time consuming and expensive counting methods.
(Jacqmain et al. 2008)	Canada	Moose *Alces alces*	Management	Yes	Interview	GPS, aerial photographs, and field survey	Integrated knowledge, both local and scientific, developed in black spruce forest is scientifically solid and culturally adapted, and therefore appropriate to create guidelines in a co-management process.
(McPherson et al. 2016)	Ghana	Sitatunga *Tragelaphus spekii*	Conservation	Yes/No	Interview	Camera	When combining local ecological knowledge and scientific knowledge it puts local knowledge into a broader perspective. It provides opportunities to build shared trust and respect between hunters and scientists.
(Morales-Reyes et al. 2019)	Spain	Mammalian scavengers	Conservation	Yes/No	Face to face questionnaire survey	Camera	A multi evidence-based approach where you bring different knowledge systems together is important in the understanding of biodiversity and ecosystem services. Especially the role of indigenous local knowledge integrated with scientific knowledge when it comes to management and conservation strategies.
Prado et al. 2014	Brazil	Mammals	Management	Yes	Interview	Camera	Local ecological knowledge is different and unique when it comes to the anthropogenic portion of the landscape which makes the combination of knowledge systems needed. In aspects of species life habitats, local knowledge and scientific knowledge had a high correlation, but there was a higher divergence regarding habitat use.
(Service et al. 2014)	Canada	Grizzly bears *Ursus arctos horribilis*	Management	Yes	Interview	Camera, genetic hair sampling and mortality data	Local knowledge and scientific knowledge predominately supported one another in the areas where they overlapped. This increased the confidence in patterns noted only by local knowledge. Local knowledge alone can be used in regards of distribution, but with careful consideration and when used for more specific details such as absolute abundance a calibration with scientific knowledge is needed.
Zuercher et al. 2003	Paraguay	Mammalian carnivores	Management	Yes/No	Identification survey	DNA sequencing	The results showed a high correlation between the two types of local knowledge used and the scientific data. A combination of the different types of knowledge can help improve the scientific knowledge regarding wildlife, habitat, and the interaction between them. First the credibility of the local

knowledge must be validated and when that is done this approach can save resources or relocate them to research or management.

Table 3. Summary of the major aspects from the final articles in the review.

Article	*Deficiencies*	*Positive outcomes from stakeholder involvement*	*Importance of combining LK and SK*	*Highlight cost efficiency*
(Dolrenry et al. 2016)	They only selected promising candidates from interviews which do not reflect a collective local knowledge but more specialist knowledge. This method might exclude promising knowledge keepers.	An increase in job opportunities for locals, from lion hunter to a lion conservationist. The engagement from locals changed their view on lions and increased their sense of responsibility and also pride in their work.	Wildlife that are difficult to monitor and study by using scientific models can be benefited by combining local knowledge with scientific knowledge. A combination of the different knowledge types can increase both the quality and quantity of data.	Yes
(Irvine et al. 2009)	Only one estate was used for deer counts which then was used to calibrate the GIS model. More counts could have been done in estates with a different type of landscape.	Engaging different stakeholders in monitoring increases the likelihood that new bottom-up management solutions gets accepted.	Local knowledge and scientific knowledge can complement each other and increase the accuracy of distribution predictions from 50% only using GIS models to 80% when combined with local knowledge.	Yes
(Jacqmain et al. 2008)	According to the indigenous people some of the routs taken by moose were too narrow to be seen in the map. The interviews were from a previous study written in French which made it hard to evaluate the different interview questions asked. The correspondence found in this study could be less evident with other animals, especially those that might not have an economic or cultural value.	It can increase the mutual understanding amongst managers, both natives and non-natives. This can eventually lead to a more accepted management strategy.	A socioecological adapted management with a combination of different types of knowledges can help share the vision of moose-habitat relationships. Especially in an area with many stakeholders where management is based solely on science.	No
(McPherson et al. 2016)	The local knowledge might be inaccurate in areas that are restricted for various reasons. Another limitation of local knowledge may be people's capability to track change, it is often better at capturing dramatic changes. Bad camera positions might decrease the capturing events.	Involvement of stakeholders in monitoring can improve both their trust in authorities and their sense of inclusion. It can also increase the positive attitudes towards wildlife conservation.	The first reports that indicated presence of sitatunga in the area came from locals which lead to the discovery that they were not extinct. Local knowledge was more efficient in data gathering than camera traps. Local knowledge can be used to read secondary signs of animal presence to find suitable camera locations.	No
(Morales-Reyes et al. 2019)	Scientists and local people may have different views regarding timescales, in this case what is considered "total consumption" of carcasses. Camera traps only gives a snapshot while local knowledge can contribute with a longer temporal perspective.	It can help change the attitudes towards scavengers and create a more positive view for their conservation.	Since the local knowledge and scientific knowledge were highly correlated the locals can be used for seasonal monitoring and complementary data to identify species that might have a higher risk of for example poisoning.	Yes
(Prado et al. 2014)	Local knowledge may vary between different species or habitat use and it can be easier to detect change in rare species. Only interviewed men over 40, due to their higher involvement in local hunting activities. Contradicts the result (Morales-Reyes et al. 2019) got in their assessment of expertise and age. (Prado et al. 2014) found that their age, 40+, had no influence on their agreement and convergence. And as already mentioned does camera traps have its limitations.	X	A high correlation between the two knowledge types regarding species life habitats highlights the local ecological knowledge particular focus on the anthropogenic part of the landscape. This makes local ecological knowledge different from scientific knowledge.	No
Service et al. 2014	The interviewer's answers regarding abundance, local use and coverage probably differ due to their different use of the area, hunting, fishing etc. Black bears can have been mistaken for grizzly bears. The snowball sampling method may have excluded some promising participants. Cameras and hair snagging have its limitations, both on annual basis and over longer time frames since they are static and can be impacted	The engagement of local people may facilitate collaborative conservation efforts rather than antagonistic approach.	Co-affirmation of the different data sources in where they overlap increases the confidence in patterns noted only by local knowledge	No

	by poor placement. Local ecological data is not systematic in coverage.			
8. Zuercher et al. 2003	The most experienced ranger made a final examination and species identification of each sample. The same for indigenous where they collectively identified the species. This doesn´t reflect the collective local knowledge but more a specialist knowledge.	By involving both indigenous and local people can bridge the gap between their knowledge and scientific knowledge. It can increase the understanding of research goals and improve long-term relationships.	Indigenous and local knowledge can advance the scientific knowledge regarding animals, their habitats, and the interaction between them. First the local knowledge must vi validated and after that both finances and time can be reallocated to enhance management efforts.	Yes

None of the studies investigated LEK with regards to the diet of herbivores but six of them studied the habitat use in different aspects. Half of the studies highlighted that the use of LEK is a cost-efficient way of monitoring or information gathering but many of them also said that the LEK must be validated before used as a separate source of information (Table 3). All studies are conducted after 2000 and half of them after 2010. To answer RQ 3, most studies concluded that LEK could be a good complement to SK and that LEK can help improve current SK. Almost all the studies emphasized the importance of LEK in improving the trust, engagement and understanding of SK in both management and conservation and that it can help bridge the gap between the two types of knowledge. The method to perform face to face interviews is the most common way of acquiring LEK and to be successful in increasing the trust and participation (Table 2).

2.2. Pilot study

2.2.1. Survey

Out of the assumed 163 members, a total of 44 surveys were sent back from 11 of the 12 teams which yields a response rate of 27% with a range from 0-12 members answering per hunting team. This means that there is a high variation in response rate among the teams that leads to more answers from certain areas in the peninsula. There were 41 men, two women and one unknown amongst those who answered with an age span between 22 and 77 years. The mean age is 63 (SD=13.7) which means that there is a quite narrow age range that can influence the data and makes age an insufficient predictor. Thus the average age for hunters in Sweden is quite high, in 2016 it was 52.7 years (Eriksson et al. 2018). There was also a difference in the item response rate between species and between diet and distribution. Least answers on the diet questions were for fallow deer, but fallow deer had the highest frequency of answers of specific areas of distribution (see Table 4 and 5).

Table 4. How many out of 44 surveys that answered questions regarding food choice.

Diet	*Spring*	*Summer*	*Autumn*	*Winter*	*Item response rate*
Aa, moose	28	28	28	29	64%
Cc, roe deer	28	26	25	27	60%
Ce, red deer	27	26	27	27	61%
Dd, fallow deer	21	18	19	19	44%

Table 5. How many out of 44 surveys that answered questions regarding which areas that are most frequently used in different times of the year. Those in brackets have specified areas, others answered that they are evenly distributed over the whole area.

Distribution	*Spring*	*Summer*	*Autumn*	*Winter*	*Item response rate*
Aa, moose	30(4)	29(5)	30(6)	29(10)	67% (14%)
Cc, roe deer	22(2)	21(0)	22(1)	22(3)	49% (3%)
Ce, red deer	26(8)	26(5)	27(6)	25(11)	59% (17%)
Dd, fallow deer	21(11)	22(10)	22(10)	22(12)	49% (24%)

No significant relationship was found in the multiple regression on self-assessed knowledge on ungulate diet or distribution. Neither for the hunter attributes, such as age, years hunting in the area, time spent on the hunting ground or if the participant live in the area or not. I also could not find any significant correlation between those that answered the most questions and the hunter attributes. When looking at where the hunters have acquired their knowledge observations are the main source followed by other sources and other persons (Table 6). Least used source for knowledge is scientific census for all species both for food choice and occurrence.

Table 6. Where the participants required their knowledge. They were asked to rate the different sources from 0= none to 3=great.

	Own observations	*Scientific census*	*Another person*	*Other sources*
Score	1.7	0.3	1.1	1.2
Response rate	91%	73%	78%	82%

When analysing the answers regarding different census methods bag statistics seem to be most frequently used with 92% conducting it every year, followed by moose observations that 89% conduct every year. Both are highly rated in their usefulness, as well as for moose browsing damage monitoring which isn´t as frequently used, 55% never use and the rest use it more frequently (see Figure 4). Least used and least useful according to the hunters are aerial survey (69% never use), dung pellet count (67% never use) and in split last place forage availability estimates (86% never use) and calf weights (87% never use).

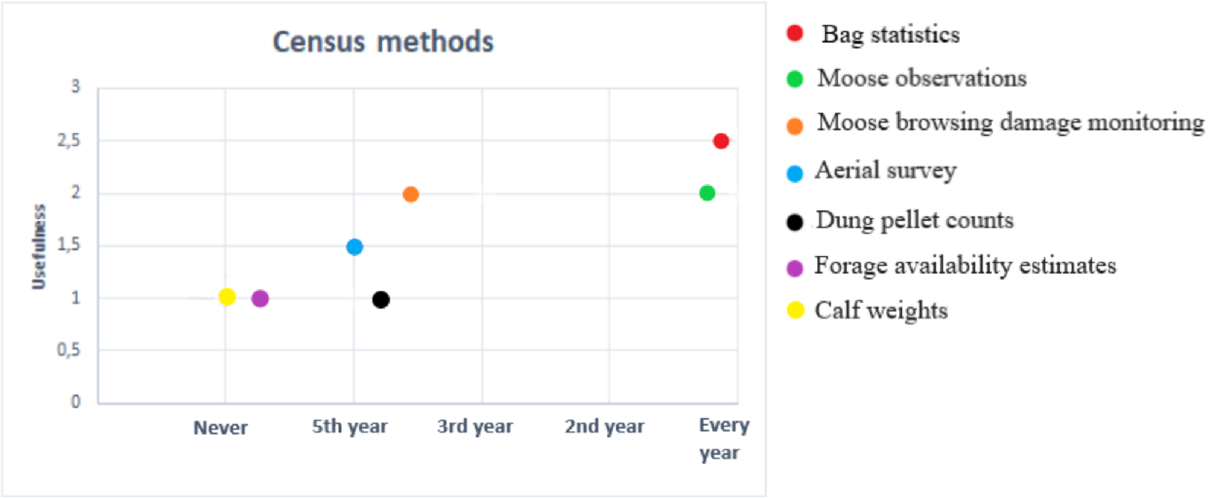

Figure 4. How often the different census methods are used on average in the area and how useful the hunters rate them from small (1) to great (3)

When looking at how willing the hunters are to share their knowledge to members of the hunting team and within the family is most common (Table 7). Sharing their knowledge on the internet seems to be least used with most answering they never do it.

Table 7. Willingness to share their knowledge on a scale from no share of 4 to high share of 16, four species and four answering categories.

	Family	*Friends*	*Members hunting team*	*Local people*	*Internet*
Distribution	11.12	9.78	11.6	8.36	4.49
Diet	11.75	10.58	12.14	8.72	4.63

To answer RQ 8 and 9 a one-way ANOVA analysis was done. The analysis on self-assessed knowledge towards the different species showed no significant difference between them (Appendix 2, Table 8). No significant difference was found between diet or spatial distribution either (Appendix 2, Table 9).

2.2.2. Diet data

I started by visually analysing the comparison between hunter estimates and DNA for the different species under different season and for all food items (Appendix 3, Figure 9). It shows a high deviation in both hunters' answers and in the DNA for some of the food items. Especially for pine, birch, *Vaccinium*, forb and graminoids. To better visualize the differences, I used the means for hunter estimates and DNA data (Figure 5) and the deviation between hunters estimates and DNA (Appendix 3, Figure 10). Some food items do differ a lot between the two data sets and these are also those that had a high variance in the boxplot. There are clear peaks in the DNA data for pine, birch, *Vaccinium* and forb while the peak in hunter estimated is for graminoids and other.

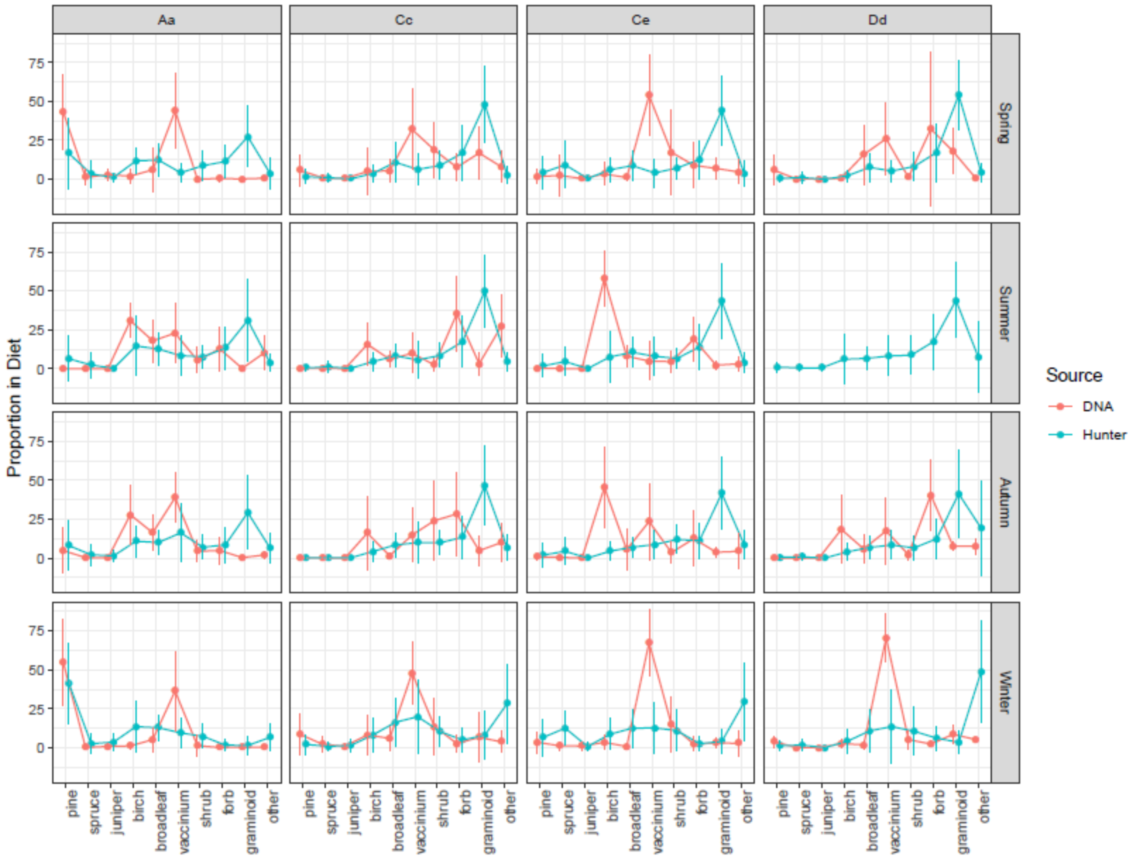

Figure 5. Mean values for DNA sample and hunters´ estimate on different food items for the four ungulates during different seasons with error bars included. Aa (moose, Cc (roe deer), Ce (red deer) and Dd (fallow deer).

For moose and pine the hunter's estimates follow the DNA well during summer (deviation of 6%) and autumn (deviation of 3%) but still lower than the DNA for winter (deviation of 13%) and spring (deviation of 27%). In winter, hunters have given quite a high portion of the diet as "other" for all species except moose. Especially fallow deer which have an estimation of 50% other food items. There is also a difference, albeit a small one, for red deer and spruce. The hunter's estimates are notably higher than DNA at all seasons for spruce for red deer although within the 10% range except for winter where the deviation is just over at 11%.

When analysing the means for hunter estimates with the DNA results by using a regression, showed a high significance, $p<0.001$ [$3.009e^{-13}$] indicating that the hunter data predicts the DNA results (Appendix 4, Table 10) quite well. To answer RQ 4 on diet, the R^2 of 0.30 shows that the hunter data explains 30% of the variation in the DNA data. For this model, the data had to be transformed by using double square root for the data to meet the model assumptions of normal distribution. When further analysing if any hunters' attributes can explain their answers, RQ 5, by using a multiple regression, none of the attributes could explain if they are within the 10% deviation or not, $p>0.001$ [0.658] (Appendix 4, Table 11).

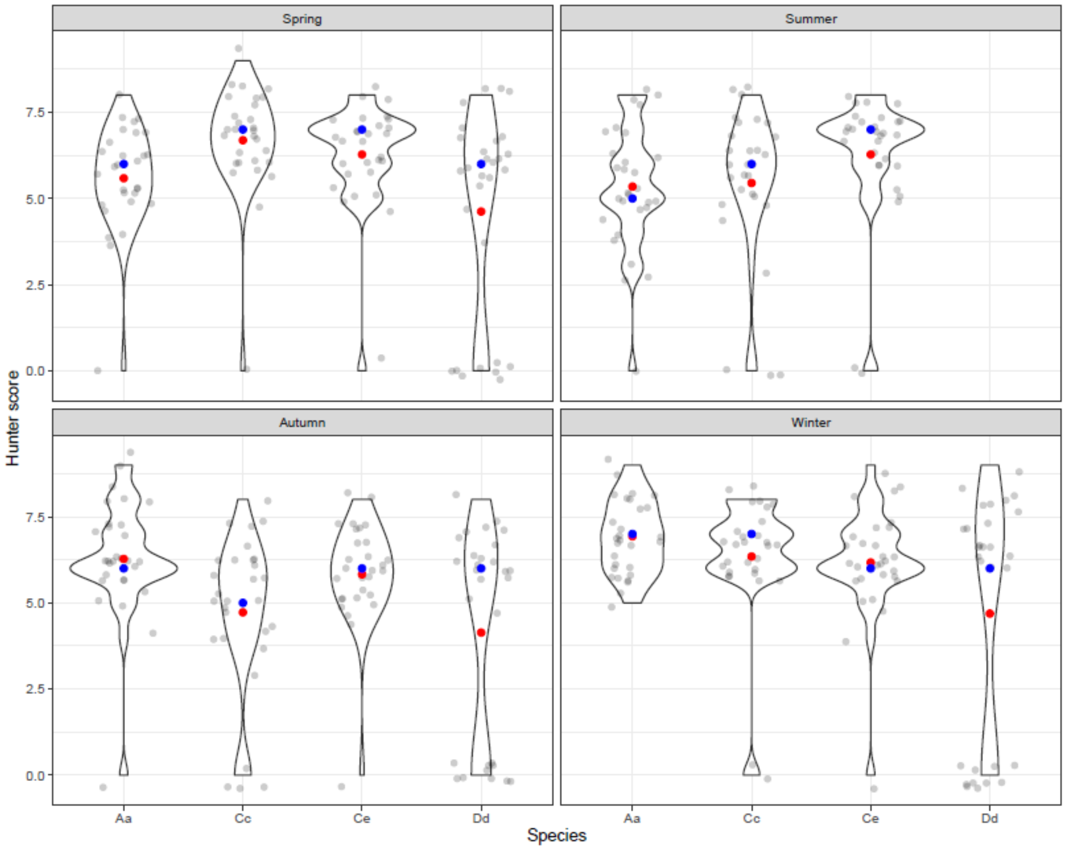

Figure 6. Hunter score from 0 - 10 from the similarity between LEK&SK for the four ungulates and different seasons. Mean value is displayed by a red dot and median by a blue dot for all species and seasons. Each dot represents one respondent. Higher scores indicate higher similarity between hunter estimated diet composition and DNA derived diet composition. Aa (moose, Cc (roe deer), Ce (red deer) and Dd (fallow deer)

When visually looking at the deviation with a violin plot it seems that there is a lower deviation score for fallow deer than the other ungulates (Figure 6). To test this, I first conducted a multiple regression between the deviation and species together with seasons and looked at the interaction between them. I then used a 2-way ANOVA which showed that both species and season are statistically significant, and species are the most significant explanatory variable (Appendix 4, Table 12). When looking at the interaction between species and season is also significant indicating that the relationship between the deviation and season depends on the species. To answer RQ 6 and 7 on diet I used a post-hoc test. The Tukey HSD showed a significant difference between fallow deer and the other ungulates, $p < 0.001$

(Appendix 4, Table 13). There was also a significant difference between the seasons winter and autumn, $p < 0.001$ (Appendix 4, Table 14). Fallow deer have a much lower mean value than the other ungulates and there is a big difference between the mean for winter which have the highest and autumn which have the lowest.

2.2.3. Spatial distribution

To answer RQ 4, 6 and 7 on spatial distribution I did a visual analysis. When examining the spatial distribution for moose and roe deer I saw no clear patterns (Figure 7) (see Appendix 5 for maps in higher resolution). For red deer and especially fallow deer on the other hand a clear pattern can be detected (Figure 8). Camera data for moose show that they are occurring in all parts of the peninsula but in a higher abundance in the north eastern parts while hunters estimate show that they are occurring all over the peninsula in all seasons while some have answered that they are more frequently seen in the central parts of the peninsula. For roe deer most respondents answered that they are evenly distributed, just a couple that answered for specific areas (Table 5). The camera trap data show that roe deer are occurring all over the peninsula but as for moose, roe deer are also more abundant in the north east parts for most of the year.

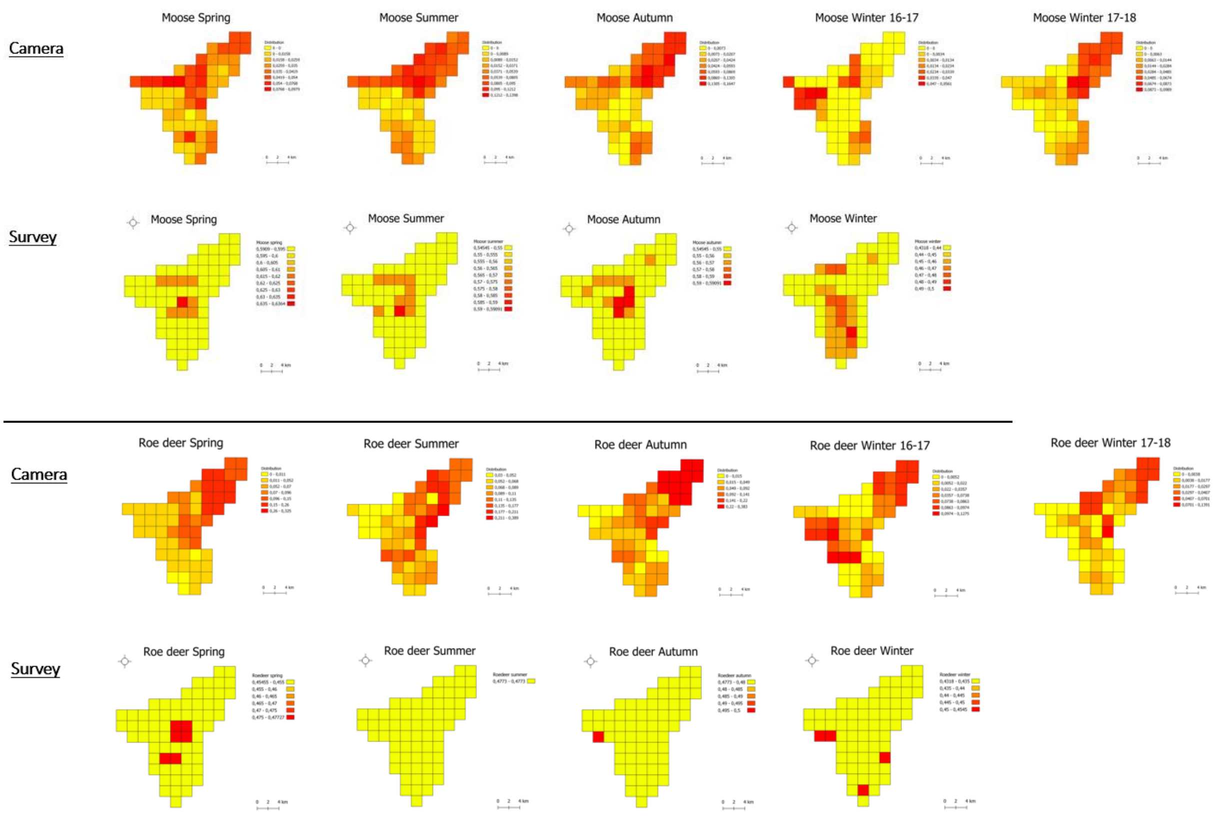

Figure 7. Occurrence of moose and roe deer from camera traps and hunters´ estimates. Camera trap data are graded from non or few observations (bright yellow) while survey data have evenly distributed (bright yellow).

The distribution of red deer shows from both camera traps and hunters´ estimates that they are more abundant in the central parts of the peninsula but are occurring in all parts of the peninsula (Figure 8). Both data types indicate that they are less abundant in the north eastern part on the peninsula. For fallow deer there is a clear pattern of overlap between the two data types. Both camera and hunters´ estimates show that fallow deer is occurring in the most southern parts of the peninsula. There are no camera trap records in the bright yellow areas for fallow deer while some hunters answered that fallow deer were evenly distributed over the peninsula (Table 5).

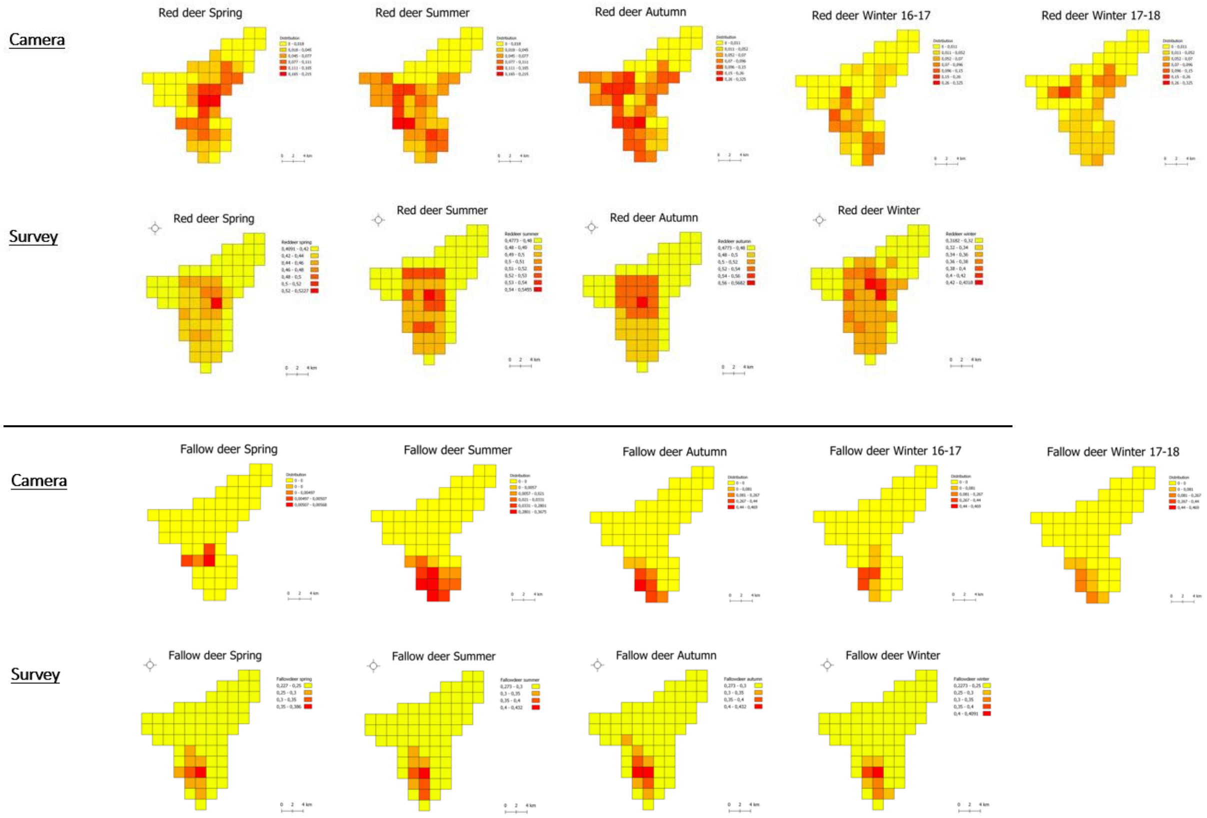

Figure 8. Occurrence of red deer and fallow deer from both camera traps and hunters´ estimates. Camera trap data are graded from non or few observations (bright yellow) while survey data have evenly distributed (bright yellow).

3. Discussion

The aim of the thesis was to explore if LEK and SK can be incorporated in management of multi-ungulate systems and to investigate how many similar studies have previously been done. The systematic literature review shows the small number of studies done combining LEK and SK in management and conservation for terrestrial mammals. The oldest study was from 2003 and half of them were conducted after 2010. This shows the method of combining these knowledge types in management of mammals is relatively new and unexplored. Most of the studies found concerned fish and marine wildlife or were more environmental, forest or agriculturally related. Those few remaining articles were quite evenly divided between management and conservation and related to if they were hunted or not. Half were concerning game species, but because of the issue with the rest being exposed to poaching all can be considered hunted in some way.

The pilot study shows that none of the hunter attributes such as age or experience could explain the alignment of diet choice. Local ecological knowledge is defined as accumulated knowledge based on experience and observations over a lifetime (Gilchrist et al. 2005; Anadón et al. 2009). This implies that both age and experience could explain potential overlaps between LEK and SK. One explanation for this pilot to not be able to use these factors is probably because of the small sample size and narrow age span. Possible effects of gender could not be assessed due to the very male-biased sample of respondents. Neither did their self-assessed knowledge explain their answers towards different species, diet, or spatial distribution within the survey. Nor could the LEK/SK overlap on diet be explained by any of the hunter's attributes. Prado et al. (2014) assumed, based on previous studies that younger generations, up to 40 years old, are educated in a different and more social and cultural way than older generations who are more likely to have gathered more knowledge regarding their environment. The study was done in Brazil and therefore not fully transferable to Sweden, but this might influence from which sources they get their knowledge. In opposite, Morales-Reyes et al. (2019) found no difference in levels of consistency between ILK/SK in relation to their age or experience. This means that older participants did not have greater knowledge at the species level. They say that the younger participants may be more likely to use external sources of information like the internet, which was the least favourable media to share their knowledge in this study. The relatively low use and confidence in some of the census methods are most likely linked to the very low use of census methods as sources for knowledge. In the next part I will discuss the combination of LEK from these hunters and the SK from the pilot study, starting with the diet.

The hunters estimate and DNA data aligned well for many of the food items but with a large difference for a few, such as pine, birch, Vaccinium and graminoids. Since I used the mean value from the DNA in my analyses, the spectra on differences in diet between ungulate individuals is removed. When looking at (Figure 9, Appendix 3*)* there is a high range in the diet amongst the species especially for some main food items. When looking at the mean from both datasets in (Figure 5*)*, the DNA data show that *Vaccinium* is the main food source in winter with the exception of for moose that has pine as main food item. The hunter estimates for winter is highest for "other" for all species except for moose. One explanation for this can be that many stated in the survey that they supplementary feed in the winter and therefore may believe that the supplementary feeding is the main food source in winter. The LEK/SK alignment for moose and pine in summer and autumn are within 10% and just above (13%) for the two datatypes in winter. This can probably be explained by the ongoing discussion on moose damage on pine and how the damages can be reduced (Kardell 2016). There seems to be an overall trend in hunters' estimates being high for graminoids for all species from spring to autumn when the DNA peaks for *Vaccinium* and birch. This can be due to experience of seeing ungulates in the fields and assuming their diet consist of most graminoids, while *Vaccinium* and birch browsing might not be noticed in the same way. Both *Vaccinium* and birch do not have an economic value for the landowner as pine and crops which might explain why they are passed unnoticed.

The differences in the overlap between species and that there was a significant difference for fallow deer seems to be caused by the item response rate between the different ungulates. I interpret it as for those that chose to answer for the other species and not for fallow deer did so because they feel they did not have the knowledge. Many of the hunting teams included in the survey do not have fallow deer on their hunting ground and therefore might not be as interested in their diet. For the difference between seasons it is surprising that autumn had the lowest mean since the hunting season is initiated in mid-August and beginning of September (Jägareförbundet)(Appendix 4). Next, I will discuss the overlap on LEK/SK for spatial distribution.

In the LEK/SK overlap for spatial distribution, a clear pattern could be seen for red deer and especially for fallow deer. For moose and roe deer no clear pattern of overlap on higher distribution in certain areas can be seen, this can be because they are distributed over the whole peninsula. Since the sample size from the survey is so small, it is hard to draw any final conclusions, but inclinations of good overlap can be found. Fallow deer had the highest response rate on specific areas of distribution but still some answered that they were evenly distributed over the whole area. This can be caused by misinterpretation of the question, believing it was asked only for their hunting area, or they believe they truly are distributed over the whole peninsula. This bias can be transferred to all species, but it is most noticeable for fallow deer. No clear differences can be seen for the occurrence between the seasons from either knowledge type. Another limitation in this pilot study is that the response rate differed quite a lot between the hunting teams, resulting in many answers for some areas and few in others. This can influence the data since the distribution of different ungulates varies a lot between the hunting areas.

When only looking at the camera trap data it seems like moose and roe deer are more abundant in the north eastern part while fallow deer and red deer are absent in that area. This can indicate inter specific competition between the native species and the introduced (Gordon & Illius 1989). Prado et al. (2014) suggested that species who are more frequently occurring in an area are not directly related to more consensual local knowledge regarding the animal´s pattern of habitat use. This can be compared to the frequency of answers regarding roe deer on the Järnäs peninsula, which had both lower answering rate and lowest specialization on exact areas of distribution. They also saw that rare species had higher levels of internal agreement of LEK which also can be seen for the distribution of fallow deer. In the next section I will reflect over both the review and pilot study.

Most studies from the review used interviews to establish LEK which appears to be a successful way of establishing this type of knowledge. This allowed the participants to be more interactive in both questions regarding distribution or habitat choice and to address aspects that the scientists had not thought of. Half of the studies used camera traps to establish SK which seems to be a effective way of combining LEK and SK for both spatial distribution and for establishing other ecological aspects. Morales-Reyes et al. (2019) used this combination for monitoring scavenger's consumption time of carcasses and establish which species visited in the area. Camera traps do have some deficiencies that needs to be addressed, they are static and can be influenced by poor placement (Prado et al. 2014; McPherson et al. 2016). They also just show a snapshot of the reality while LEK can give a longer temporal perspective (Service et al. 2014; Morales-Reyes et al. 2019). In the pilot study the detection of juveniles suffered from inadequate detection of the cameras but to correct for potential detection bias, the cameras was moved to increase the sample size and cover more area (Hofmeester et al. 2020). The DNA metabarcoding approach also has its limitations. For example, different plant taxa may have differences in digestibility and even varying concentrations of chlorophyll that can affect the quantity of DNA of each plant taxa in the faecal samples (Spitzer 2019). But by using DNA metabarcoding, misidentification of faecal samples in multi-ungulate systems can be avoided and the method is free from observer bias. I also need to address bias in me doing the review alone, I can have excluded or missed articles of interest. This risk could have been reduced by being two or more to go through the same studies and cross check which were included or not and discuss why.

All articles from the review show good overlap between LEK and SK or that LEK can contribute to increase the efficiency and reliability of SK. A combination of the two seems to be a good way to both improve monitoring and management and increase the acceptance for management strategies and improve long-term relationships between hunters and scientist.

3.1. Conclusions

All types of data sources have potential deficiencies, but by using different independent sources of information can increase the temporal and spatial details and reduces the bias (Service et al. 2014). This study shows that a combination of SK/LEK can be used for spatial distribution and to some extent for diet. The response scientists get from interviews or surveys from local people may vary due to many factors, the local culture may affect as do the familiarity with the interviewees, how the data is interpreted and which opportunities are given for interaction and feedback (Huntington & Fernandez-Gimenez 1999; Turner et al. 2000). Many of the studies from the literature review used different types of interviews instead of questionnaire surveys which might be a good idea for future comparisons on LEK/SK. That way the participants feel more involved and bias due to misinterpretation of questions can be reduced. It also opens for questions scientists have not thought of in terms of local experiences or including people that are locally known for their specific knowledge. The goal of studies that involves collection or use of LEK should contribute in a meaningful way to the community and be of local benefit (Berkes 2004). I believe that to be more successful in retaining a better participant commitment with a higher diversity, the cause of the study and the gain for hunters to participate needs to be stated in a clear way.

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Appendix 1- Survey with map included

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Institutionen för vilt, fisk och miljö

EN UNDERSÖKNING OM KLÖVVILT PÅ JÄRNÄSHALVÖN

En undersökning om klövvilt på Järnäshalvön

Undersökningen ingår i två forskningsprojekt, som syftar till att bättre förstå hur viltförvaltningen fungerar i praktiken och hur man kan anpassa den till framtidens utmaningar. Målet med undersökningen är att ta fram lokal kunskap om klövviltets ekologi, förekomst, beteende och foderresurser på Järnäshalvön. Till Järnäshalvön räknar vi allt söder om E4 mellan Nordmaling och Hörnefors.

Inom studien kommer vi att koppla insamlad lokal kunskap med existerande databaser om betesresurser (data från DNA analyser) och rörelsemönster (data från viltkameror och GPS-halsband). Resultaten kommer att fördjupa vår förståelse för överlappningar och hur man kan kombinera lokal och vetenskaplig kunskap och bidra till att förbättra inventeringsmetoder och flerartsförvaltning.

Vi ber dig att läsa texten noggrant och besvara alla frågor så gott det går. Just dina erfarenheter och upplevelser är viktiga för oss. Det är helt ok om man inte vet något eller om man är osäker, då är det bara att lämna frågan tom. Svaren är konfidentiella och kommer inte att kunna spåras till dig.

Om du har andra tankar som är viktiga i sammanhanget finns utrymme i slutet av formuläret.

Tack på förhand!

A. Frågor om dina erfarenheter

A1. Vilken roll har du på Järnäshalvön?

☐ Jag är enbart markägare (→ gå till A7 på sidan 2)

☐ Jag är enbart jägare

☐ Jag är både jägare och markägare

A2. Hur många år har du varit jägare?

☐ 1-5 år

☐ 6-10 år

☐ 11-15 år

☐ 16-20 år

☐ Mer än 20 år

A3. Hur många år har du jagat på Järnäshalvön?

☐ 1-5 år

☐ 6-10 år

☐ 11-15 år

☐ 16-20 år

☐ Mer än 20 år

A4. Hur ofta befinner du dig på din jaktmark?

☐ Bor där ☐ Dagligen ☐ Varje vecka ☐ Varje månad ☐ Några gånger per år

A5. Har du någon del av jägarexamen?

☐ Nej ☐ Ja

A6. Hur många dagar har du jagat följande arter de senaste 12 månaderna?

Då du jagat flera arter samtidigt räknar du dagarna för varje art, dvs. en jaktdag kan räknas för flera kategorier.

	Inte jagat	1 – 5 dagar	6 – 10 dagar	11 – 15 dagar	16 – 20 dagar	21 – 25 dagar	> 25 dagar
Klövvilt	☐	☐	☐	☐	☐	☐	☐
Björn, lo	☐	☐	☐	☐	☐	☐	☐
Sälar	☐	☐	☐	☐	☐	☐	☐
Andra däggdjur	☐	☐	☐	☐	☐	☐	☐
Änder och gäss	☐	☐	☐	☐	☐	☐	☐

Andra fåglar	☐	☐	☐	☐	☐	☐	☐

A7. Jagade din pappa när du växte upp?

☐ Nej ☐ Ja ☐ Vet inte

A8. Jagade din mamma när du växte upp?

☐ Nej ☐ Ja ☐ Vet inte

A9. Är det någon i ditt nuvarande hushåll som jagar?

☐ Nej ☐ Ja

A10. Hur många av dina närmaste vänner jagar?

☐ Så gott som alla

☐ Mer än hälften

☐ Hälften

☐ Ett fåtal av dem

☐ Ingen av dem

A11. Bor du på Järnäshalvön?

☐ Nej, jag har aldrig bott där ☐ Nej, men jag har bott där tidigare ☐ Ja, men bara ibland (t.ex. stuga) ☐ Ja

Hur länge har du bott på Järnäshalvön?

☐ Har alltid bott här

☐ Har alltid bott här bortsett från kortare perioder, t.ex. studier på annan ort

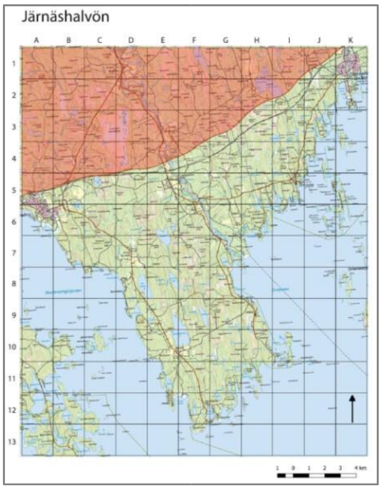
☐ Inflyttad, har bott här i mer än 10 år

☐ Inflyttad, har bott här i 1-10 år

☐ Inflyttad, har bott här mindre än ett år

B. Förekomst och rörelse av olika klövviltarter på Järnäshalvön

För att svara på följande frågor vill vi be dig använda kartan som medföljer detta frågeformulär. Kartan har ett raster system med bokstäver och siffror som gör att du kan ange konkreta platser. Vänligen svara genom att ange den relevanta rutan t.ex. "A4". Om du vill beskriva flera rutor, var vänlig och ange dem med kommatecken (t.ex. A4, A5, B4).



B1. Var är den jaktmark du oftast jagar på?
Vänligen ange relevanta rutor via bokstav och nummerkombination.

____

B2. Enligt din egen uppfattning, ungefär hur många individer av de följande klövviltarterna finns det?

	Djur/1000ha på din jaktmark	Djur/1000ha på Järnäshalvön
Älg		
Kronhjort		
Dovhjort		
Rådjur		

B3. Flera av klövviltarterna vandrar under året. Kan du vänligen ange var de lever huvudsakligen under de olika årstiderna på Järnäshalvön?
Ange relevanta rutor via bokstav och nummerkombination. Om du tycker att det finns en jämn fördelning av en art över hela Järnäshalvön skriv "jämnt" istället för att ange rutor.

	Vår (maj-juni)	Sommar (juli-augusti)	Höst (september-oktober)	Vinter (november-april)
Älg				
Kronhjort				
Dovhjort				
Rådjur				

B4. Hur långt tror du att deras dagliga rörelse är i genomsnitt? *Vänligen uppge deras dagliga rörelse i kilometer för varje årstid.*

	Vår (maj-juni)	Sommar (juli-augusti)	Höst (september-oktober)	Vinter (november-april)
Älg				
Kronhjort				
Dovhjort				
Rådjur				

C. Foderval och betesresurser

Under detta avsnitt skulle vi vilja att du delar med dig av din kunskap om klövviltets foderval på Järnäshalvön. För varje säsong finns det en tabell att fylla i.

C1. Vilka av följande betesresurser är mest nyttjade av klövvilt på Järnäshalvön under våren (maj-juni)?

Ange i vilken andel du tror att betesresurserna äts av de fyra klövviltarterna på Järnäshalvön. Summan bör uppgå till 100% för varje viltart. Om du inte vet säkert kan du använda "Övriga", och skriv 0% om du är säker på att de undviker en art.

	Älg	Kronhjort	Dovhjort	Rådjur
Tall				
Gran				
En				
Björk				
Andra lövträdsarter				
Blåbär- & Lingonris				
Övriga buskar				
Örter				
Gräs				
Övriga				
Totalt	100%	100%	100%	100%

Av lövträd, buskar, örter, gräs och övriga finns det särskilda arter som är vanliga betesresurser under våren? *Ange nedan*

Betas ofta				
Betas mer sällan				

C2. Vilka av följande betesresurser är mest nyttjade av klövvilt på Järnäshalvön under sommaren (juli - augusti)?

Ange i vilken andel du tror att betesresurserna äts av de fyra klövviltarterna på Järnäshalvön. Summan bör uppgå till 100% för varje viltart. Om du inte vet säkert kan du använda "Övriga", och skriv 0% om du är säker på att de undviker en art.

	Älg	Kronhjort	Dovhjort	Rådjur
Tall				
Gran				
En				
Björk				
Andra lövträdsarter				
Blåbär- & Lingonris				
Övriga buskar				
Örter				
Gräs				
Övriga				
Totalt	100%	100%	100%	100%

Av lövträd, buskar, örter, gräs och övriga finns det särskilda arter som är vanliga betesresurser under sommaren? *Ange nedan*

Betas ofta				
Betas mer sällan				

C3. Vilka av följande betesresurser är mest nyttjade av klövvilt på Järnäshalvön under hösten (september - oktober)?

Ange i vilken andel du tror att betesresurserna äts av de fyra klövviltarterna på Järnäshalvön. Summan bör uppgå till 100% för varje viltart. Om du inte vet säkert kan du använda "Övriga", och skriv 0% om du är säker på att de undviker en art.

	Älg	Kronhjort	Dovhjort	Rådjur
Tall				
Gran				
En				
Björk				
Andra lövträdsarter				
Blåbär- & Lingonris				
Övriga buskar				
Örter				
Gräs				
Övriga				
Totalt	100%	100%	100%	100%

Av lövträd, buskar, örter, gräs och övriga finns det särskilda arter som är vanliga betesresurser under hösten? *Ange nedan*

Betas ofta				
Betas mer sällan				

C4. Vilka av följande betesresurser är mest nyttjade av klövvilt på Järnäshalvön under vintern (november - april)?

Ange i vilken andel du tror att betesresurserna äts av de fyra klövviltarterna på Järnäshalvön. Summan bör uppgå till 100% för varje viltart. Om du inte vet säkert kan du använda "Övriga", och skriv 0% om du är säker på att de undviker en art.

	Älg	Kronhjort	Dovhjort	Rådjur
Tall				
Gran				
En				
Björk				
Andra lövträdsarter				
Blåbär- & Lingonris				
Övriga buskar				
Örter				
Gräs				
Övriga (inkl. utfodring)				
Totalt	100%	100%	100%	100%

Om det finns utfodring under vintern, vad består den av?

Av lövträd, buskar, örter, gräs och övriga finns det särskilda arter som är vanliga betesresurser under vintern? *Ange nedan*

Betas ofta				
Betas mer sällan				

D. Kunskap och lärande

Efter att du har svarat på våra frågor om klövviltets förekomst, beteende och foderresurser på Järnäshalvön vill vi be dig att berätta hur du har inhämtat din kunskap.

D1. Hur skulle du beskriva din lokala kunskap om följande arter och deras ekologi?

		Begränsad			Måttlig			Hög
Klövvilt	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Rovdjur	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Fåglar	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Fisk	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐

D2. Hur skulle du beskriva din lokala kunskap om följande klövviltarter och deras ekologi?

		Begränsad			Måttlig			Hög
Älg	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Kronhjort	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Dovhjort	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐
Rådjur	förekomst	☐	☐	☐	☐	☐	☐	☐
	foderval	☐	☐	☐	☐	☐	☐	☐

D3. Varifrån kommer din kunskap?

Ange i vilken utsträckning din kunskap kommer från egna observationer, genom systematisk viltinventering, från en annan person eller någon annan källa.

0=Inte alls, 1=Lite, 2=Måttlig, 3=Mycket

		Egna observationer under fritid jag tillbringat i naturen (inkl. jakt)	Deltagit i vetenskapliga inventeringsmetoder	Lärt mig från en annan person (t.ex. vän, familj, lagmedlem)	Lärt mig från andra källor (t.ex. bok, jakttidning, kurs)
Älg	förekomst	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
	foderval	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
Kronhjort	förekomst	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
	foderval	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
Dovhjort	förekomst	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
	foderval	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
Rådjur	förekomst	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3
	foderval	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3	☐☐☐☐ 0 1 2 3

D4. Av det du lärt dig från andra personer, vänligen ange hur mycket du lärde dig av följande grupper.

	Inget	Lite	Måttlig	Mycket
Familj / släkt	☐	☐	☐	☐
Vänner	☐	☐	☐	☐
Medlemmar av jaktlag	☐	☐	☐	☐
Lokalbefolkning	☐	☐	☐	☐
Andra:_____________________________	☐	☐	☐	☐

D5. Av det du lärt dig från andra källor, vänligen ange hur mycket du lärde dig av följande alternativ

	Inget	Lite	Måttlig	Mycket
Kurs för jägarexamen	☐	☐	☐	☐
Böcker	☐	☐	☐	☐
Jakttidningar	☐	☐	☐	☐
Vetenskapliga publikationer	☐	☐	☐	☐
Internet	☐	☐	☐	☐
Andra:_______________________________	☐	☐	☐	☐

D6. I vilken utsträckning delar du med dig av din kunskap om klövvilt till följande grupper?

	Inget	Lite	Måttlig	Mycket
Familj / släkt	☐	☐	☐	☐
Vänner	☐	☐	☐	☐
Medlemmar av jaktlag	☐	☐	☐	☐
Lokalbefolkning	☐	☐	☐	☐
Andra:_____________________________	☐	☐	☐	☐

D7. Vilka av de följande metoderna för inventering av klövvilt används inom ditt jaktområde?

	Varje år	Vartannat år	Vart tredje år	Vart femte år	Inte alls
Avskjutningsstatistik	☐	☐	☐	☐	☐
Älgobservationer (älgobs / viltobs)	☐	☐	☐	☐	☐
Spillningsinventering	☐	☐	☐	☐	☐
Kalvviktsinsamling	☐	☐	☐	☐	☐
Flyginventering	☐	☐	☐	☐	☐
Älgbetesinventering (ÄBIN)	☐	☐	☐	☐	☐
Foderprognoser	☐	☐	☐	☐	☐

D8. Hur bedömer du nyttan av inventeringsmetoderna i klövviltförvaltningen?

	Liten	Måttlig	Stor
Avskjutningsstatistik	☐	☐	☐
Älgobservationer (älgobs / viltobs)	☐	☐	☐
Spillningsinventering	☐	☐	☐
Kalvviktsinsamling	☐	☐	☐
Flyginventering	☐	☐	☐
Älgbetesinventering (ÄBIN)	☐	☐	☐
Foderprognoser	☐	☐	☐

D9. Används andra inventeringsmetoder inom ditt jaktområde?

☐ Nej ☐ Ja, det används också……………………………………………………..

………………………………………………………………………………………..

D10. Vilka viltarter inventeras inom ditt jaktområde?

☐ Älg
☐ Kronhjort
☐ Dovhjort
☐ Rådjur
☐Andra: ____

E. Bakgrundsinformation

E1. Är du man eller kvinna?

☐ Man ☐ Kvinna

E2. Vilket år är du född?

Jag är född .... (Ange år)

E3. Vilken är din högsta avslutade utbildning?
Sätt ett kryss i rutan framför det alternativ du anser stämma bäst in på dig.

☐ Obligatorisk skola (t.ex. grundskola, folkskola)
☐ Yrkesutbildning (yrkesskola, fackskola, institut av olika slag)
☐ Gymnasieutbildning (även realexamen, folkhögskola)
☐ Universitet eller högskoleutbildning

ETT VARMT TACK FÖR DIN MEDVERKAN

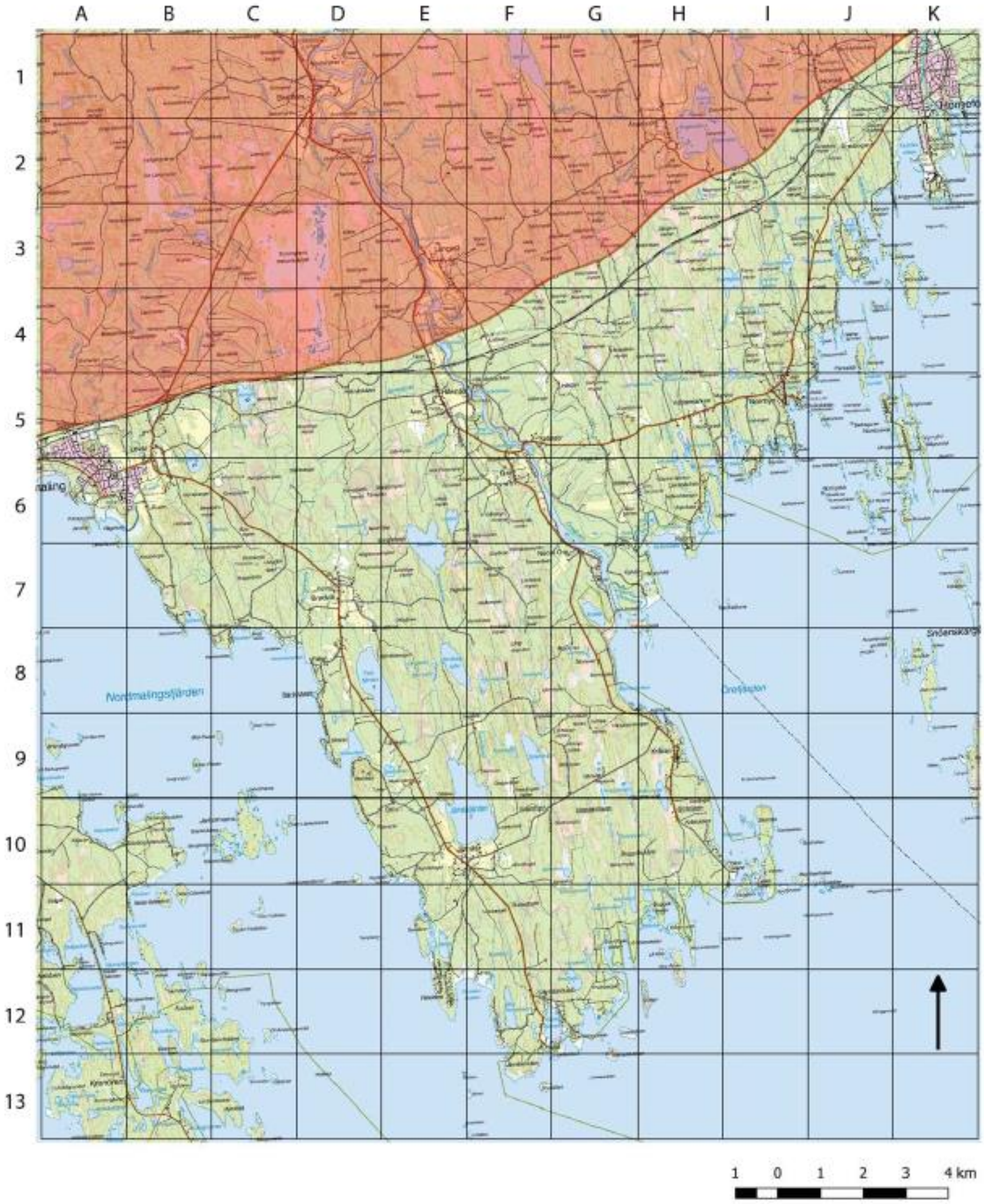
Vi är medvetna om att det har tagit tid för dig att svara på våra frågor. Finns det kanske någon specifik aspekt på klövviltets rörelse och/eller foderval som du vill dela med dig av?

Vi är tacksamma för dina synpunkter!

Kontakt:

Sabrina Dressel
Institutionen för vilt, fisk och miljö
901 83 Umeå
Tel. 090-786 85 58
E-post: survey@slu.se

Järnäshalvön



Appendix 2- Analyses within the survey

Table 8. One-way repeated measures ANOVA analysis if species significantly affects hunter self-assessed knowledge.

Knowledge	Df	Sum Square	Mean square	F value	Pr(>F)
Species	3	60.8	20.282	2.287	0.0805

Table 9. One-way repeated measures ANOVA analysing if there is a difference between the knowledge of diet or distribution, for the different species.

Knowledge	Df	Sum Square	Mean square	F value	Pr(>F)
Distribution and diet	1	66.4	66.45	2.268	0.136

Appendix 3- Figures diet

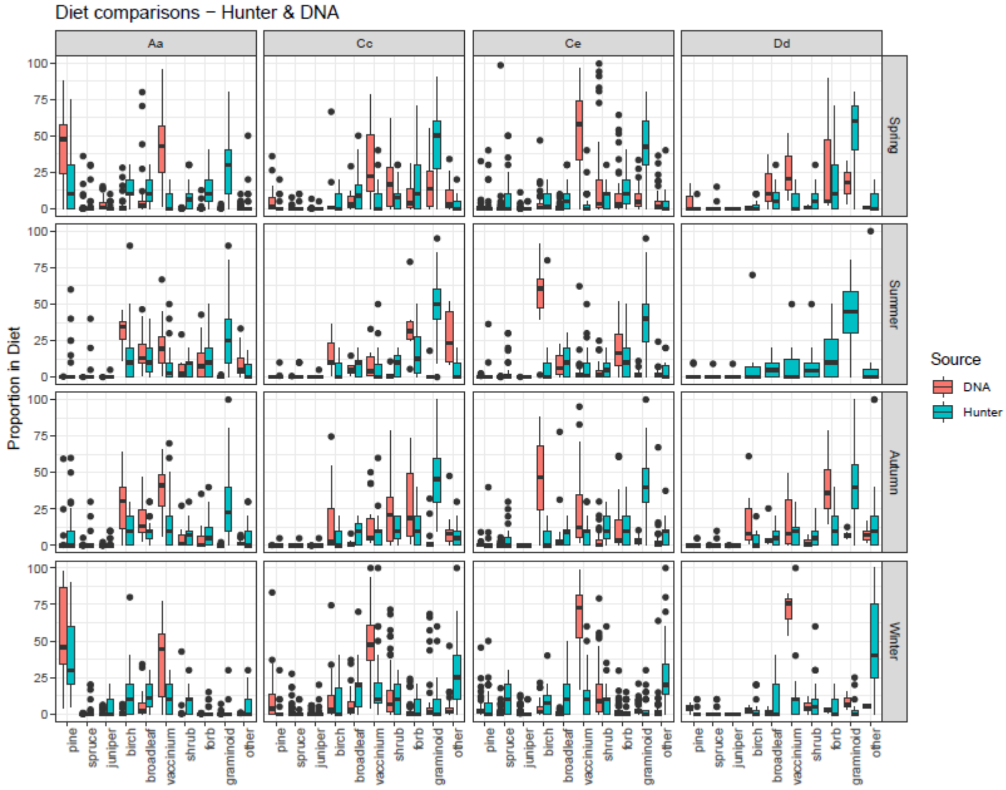


Figure 9. DNA sample and hunter estimate regarding different food items for the four ungulates during different seasons.

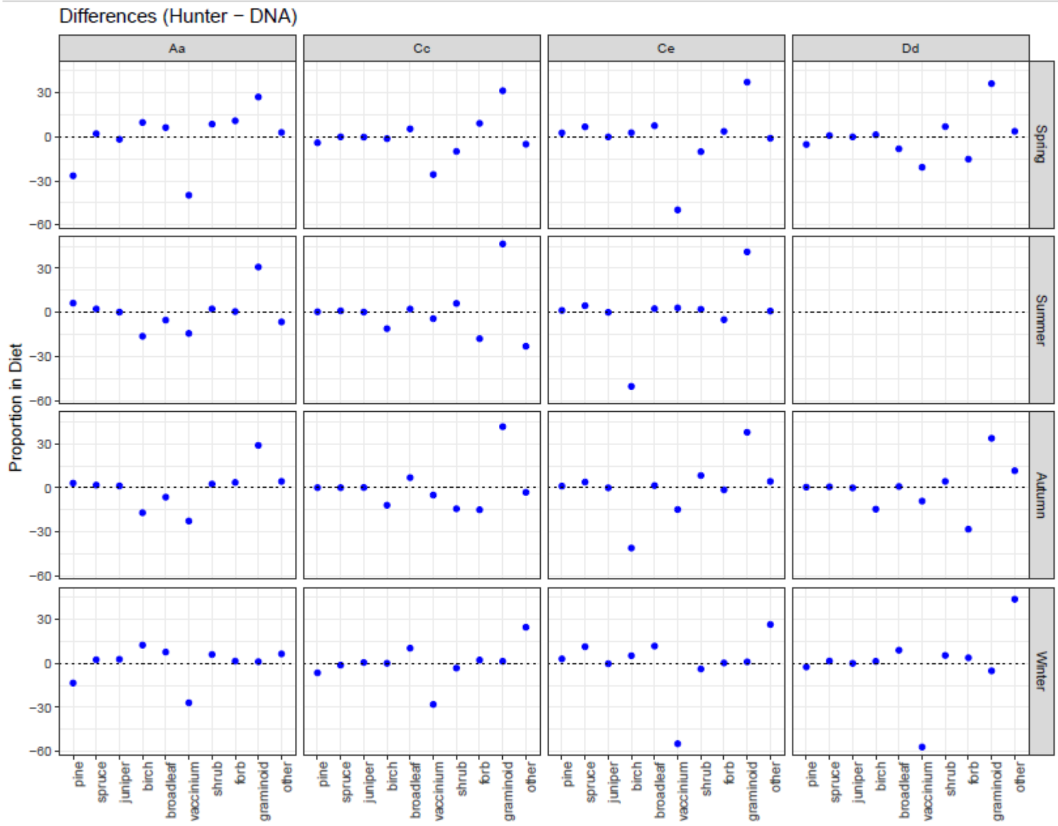


Figure 10. The differences between hunter estimates and DNA. The mean DNA is set as zero and the deviation for hunter's estimates is shown by the blue dots.

Appendix 4- Analyses diet and hunter estimates

Table 10. Regression on hunter mean estimates and DNA mean.

Hunter / DNA	Estimate	Std. Error	T value	Pr(>|t|)
Intercept	0.3120	0.144	2.166	0.0319
Hunter estimates	0.6990	0.087	8.017	$3.01e^{-13}$
R-squared: 0.3028	p-value: 3.009e-13			

Table 11. Regression without zero values on hunter score and attributes.

Hunter / DNA	Estimate	Std. Error	T value	Pr(>|t|)
Intercept	71.19349	15.91707	4.473	0.0001
A3	0.09355	2.00910	0.047	0.9633
A4	2.26607	2.45371	0.924	0.3653
A6_1	-1.32218	1.48815	-0.888	0.383484
A11	4.86421	3.31426	1.468	0.155740
R-squared: 0.09606	p-value: 0.6588			

Table 12. Two-way ANOVA on species and seasons for the hunter estimates and DNA.

2-way ANOVA	Df	Sum Square	Mean square	F value	Pr(>F)
Species	3	165.3	55.09	12.222	1.11e-07
Season	3	48.9	16.30	3.616	0.0133
Species:Season	8	73.6	9.20	2.041	0.0405
Residuals	420	1893.3	4.51		

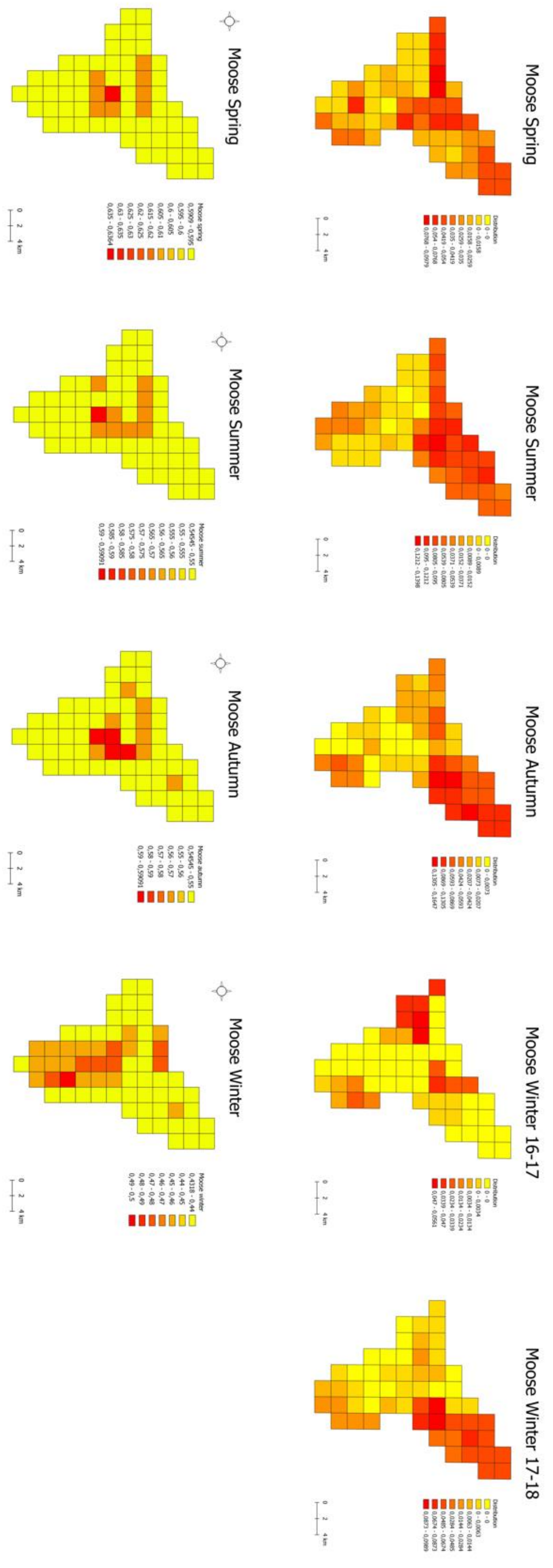
Table 13. Tukey post-hoc test for the different species and the deviation between hunter estimates and DNA, showing difference in means, confidence levels and the adjusted p-value.

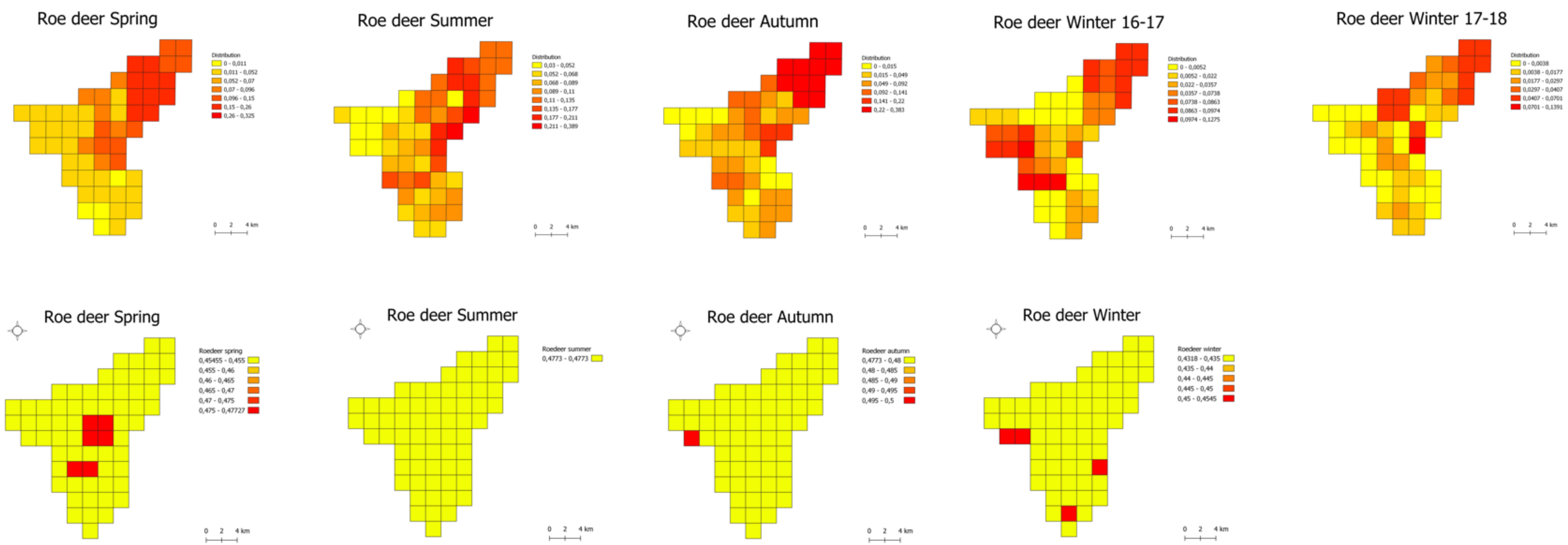
Species	Mean Difference	Lower	Upper	p adj
Cc-Aa	-0.2327586	-0.9518462	0.4863290	0.8378
Ce-Aa	0.1034483	-0.6156393	0.8225359	0.9825
Dd-Aa	-1.5517241	-2.3284275	-0.7750208	0.0000
Ce-Cc	0.3362069	-0.3828807	1.0552945	0.6234
Dd-Cc	-1.3189655	-2.0956689	-0.5422621	0.0001
Dd-Ce	-1.6551724	-2.4318758	-0.8784690	0.0000

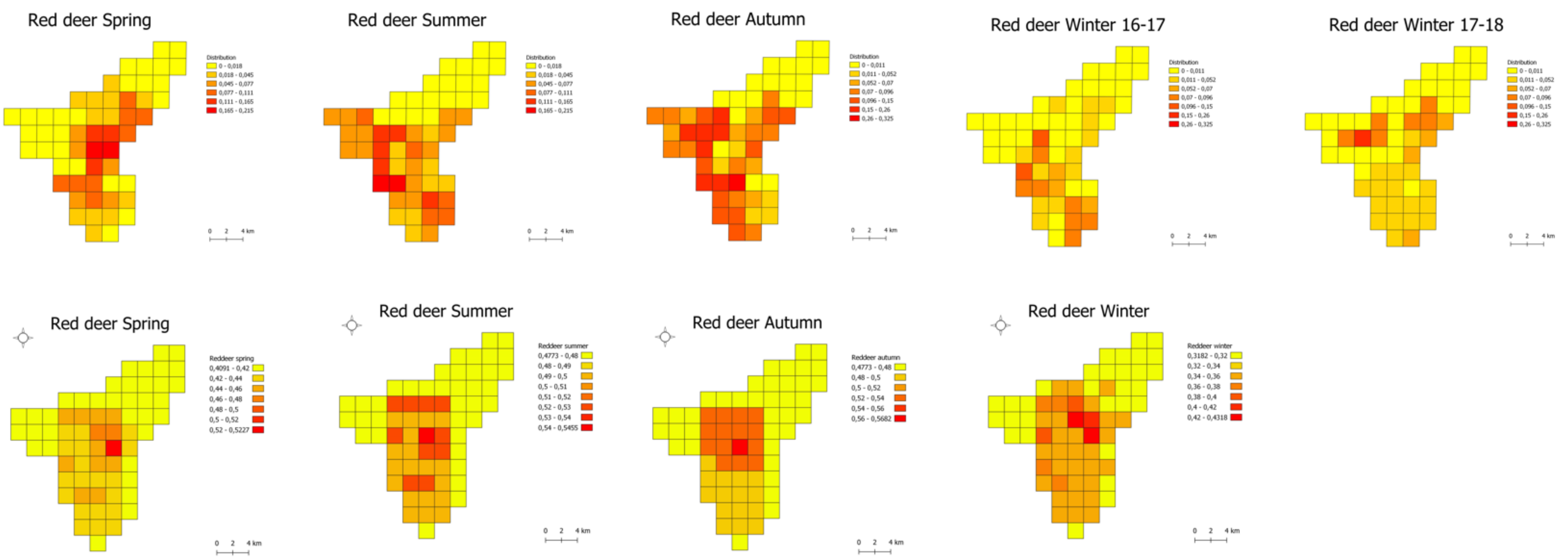
Table 14. Tukey post-hoc test for the different seasons and the deviation between hunter estimates and DNA, showing difference in means, confidence levels and the adjusted p-value.

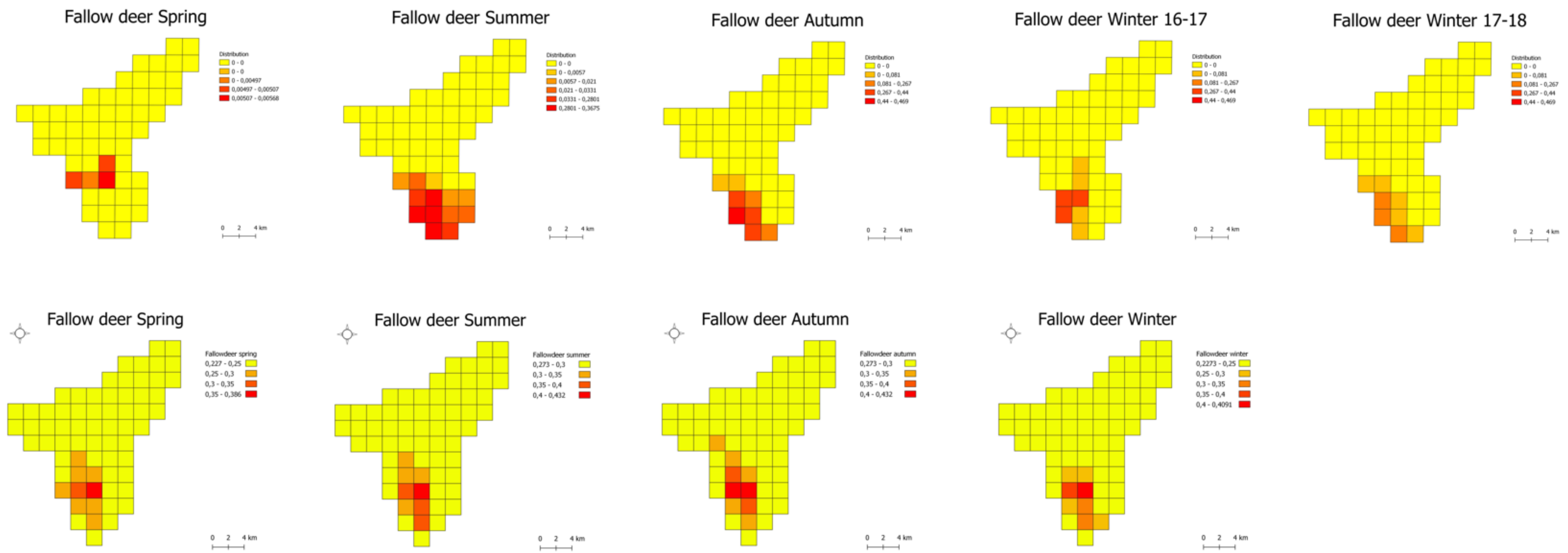
Season	Mean Difference	Lower	Upper	p adj
Spring-Autumn	0.55172414	-0.16736347	1.2708117	0.1976
Summer-Autumn	0.07112069	-0.70558269	0.8478241	0.9954
Winter-Autumn	0.79310345	0.07401584	1.5121911	0.0240
Summer-Spring	-0.48060345	-1.25730683	0.2960999	0.3820
Winter-Spring	0.24137931	-0.47770829	0.9604669	0.8225
Winter-Summer	0.72198276	-0.05472063	1.4986861	0.0791

Appendix 5- Maps spatial distribution




Roe deer Spring
Distribution
0 - 0,011
0,011 - 0,052
0,052 - 0,07
0,07 - 0,096
0,096 - 0,15
0,15 - 0,26
0,26 - 0,325
0 2 4 km
Roe deer Summer
Distribution
0,03 - 0,052
0,052 - 0,068
0,068 - 0,089
0,089 - 0,11
0,11 - 0,135
0,135 - 0,177
0,177 - 0,211
0,211 - 0,389
0 2 4 km
Roe deer Autumn
Distribution
0 - 0,015
0,015 - 0,049
0,049 - 0,092
0,092 - 0,141
0,141 - 0,22
0,22 - 0,383
0 2 4 km
Roe deer Winter 16-17
Distribution
0 - 0,0052
0,0052 - 0,022
0,022 - 0,0357
0,0357 - 0,0738
0,0738 - 0,0863
0,0863 - 0,0974
0,0974 - 0,1275
0 2 4 km
Roe deer Winter 17-18
Distribution
0 - 0,0038
0,0038 - 0,0177
0,0177 - 0,0297
0,0297 - 0,0407
0,0407 - 0,0701
0,0701 - 0,1391
0 2 4 km
Roe deer Spring
Roedeer spring
0,45455 - 0,455
0,455 - 0,46
0,46 - 0,465
0,465 - 0,47
0,47 - 0,475
0,475 - 0,47727
0 2 4 km
Roe deer Summer
Roedeer summer
0,4773 - 0,4773
0 2 4 km
Roe deer Autumn
Roedeer autumn
0,4773 - 0,48
0,48 - 0,485
0,485 - 0,49
0,49 - 0,495
0,495 - 0,5
0 2 4 km
Roe deer Winter
Roedeer winter
0,4318 - 0,435
0,435 - 0,44
0,44 - 0,445
0,445 - 0,45
0,45 - 0,4545
0 2 4 km


Red deer Spring
Distribution
0 - 0,018
0,018 - 0,045
0,045 - 0,077
0,077 - 0,111
0,111 - 0,165
0,165 - 0,215
0 2 4 km
Red deer Summer
Distribution
0 - 0,018
0,018 - 0,045
0,045 - 0,077
0,077 - 0,111
0,111 - 0,165
0,165 - 0,215
0 2 4 km
Red deer Autumn
Distribution
0 - 0,011
0,011 - 0,052
0,052 - 0,07
0,07 - 0,096
0,096 - 0,15
0,15 - 0,26
0,26 - 0,325
0 2 4 km
Red deer Winter 16-17
Distribution
0 - 0,011
0,011 - 0,052
0,052 - 0,07
0,07 - 0,096
0,096 - 0,15
0,15 - 0,26
0,26 - 0,325
0 2 4 km
Red deer Winter 17-18
Distribution
0 - 0,011
0,011 - 0,052
0,052 - 0,07
0,07 - 0,096
0,096 - 0,15
0,15 - 0,26
0,26 - 0,325
0 2 4 km
Red deer Spring
Reddeer spring
0,4091 - 0,42
0,42 - 0,44
0,44 - 0,46
0,46 - 0,48
0,48 - 0,5
0,5 - 0,52
0,52 - 0,5227
0 2 4 km
Red deer Summer
Reddeer summer
0,4773 - 0,48
0,48 - 0,49
0,49 - 0,5
0,5 - 0,51
0,51 - 0,52
0,52 - 0,53
0,53 - 0,54
0,54 - 0,5455
0 2 4 km
Red deer Autumn
Reddeer autumn
0,4773 - 0,48
0,48 - 0,5
0,5 - 0,52
0,52 - 0,54
0,54 - 0,56
0,56 - 0,5682
0 2 4 km
Red deer Winter
Reddeer winter
0,3182 - 0,32
0,32 - 0,34
0,34 - 0,36
0,36 - 0,38
0,38 - 0,4
0,4 - 0,42
0,42 - 0,4318
0 2 4 km



Fallow deer Spring
Distribution
0 - 0
0 - 0
0 - 0,00497
0,00497 - 0,00507
0,00507 - 0,00568
0 2 4 km
Fallow deer Summer
Distribution
0 - 0
0 - 0,0057
0,0057 - 0,021
0,021 - 0,0331
0,0331 - 0,2801
0,2801 - 0,3675
0 2 4 km
Fallow deer Autumn
Distribution
0 - 0
0 - 0,081
0,081 - 0,267
0,267 - 0,44
0,44 - 0,469
0 2 4 km
Fallow deer Winter 16-17
Distribution
0 - 0
0 - 0,081
0,081 - 0,267
0,267 - 0,44
0,44 - 0,469
0 2 4 km
Fallow deer Winter 17-18
Distribution
0 - 0
0 - 0,081
0,081 - 0,267
0,267 - 0,44
0,44 - 0,469
0 2 4 km
Fallow deer Spring
Fallowdeer spring
0,227 - 0,25
0,25 - 0,3
0,3 - 0,35
0,35 - 0,386
0 2 4 km
Fallow deer Summer
Fallowdeer summer
0,273 - 0,3
0,3 - 0,35
0,35 - 0,4
0,4 - 0,432
0 2 4 km
Fallow deer Autumn
Fallowdeer autumn
0,273 - 0,3
0,3 - 0,35
0,35 - 0,4
0,4 - 0,432
0 2 4 km
Fallow deer Winter
Fallowdeer winter
0,2273 - 0,25
0,25 - 0,3
0,3 - 0,35
0,35 - 0,4
0,4 - 0,4091
0 2 4 km

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