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Change in surface area of semi-natural grassland in the Osby municipality, Scania and potential consequences for plant diversity

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Bachelor thesis, 15 credits, in Physical Geography and Ecosystem Analysis

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Abstract

During the past, land use has changed and still is. It has been recognized that land use changes affect biodiversity all over the world. In Sweden semi-natural grasslands are a habitat with high biodiversity. The topic of this thesis is how land use change has affected the habitat of semi-natural grasslands in the area around Osby, Scania. For that purpose, semi-natural grasslands in a historical map from 1926-34 were digitalised and compared with the latest data to see if the size of the grassland has changed and if there was a loss of the previous semi-natural grasslands.

Even though there is a larger area of grasslands found in the area today, there was a decrease of continuous grasslands by 84.8% between 1926-34 and the latest data. Similar result of area loss for semi-natural grasslands have been found in other studies.

Former land use has an influence on the appearance of the landscape today. The type and timing of management, both historically and today, influences the species present in the semi-natural grasslands. Land use change has not automatically led to a loss of species, but it is affecting certain species, especially the ones which established before the 1700s and the ones which are grazing dependent. The effect is not fully clear, but a shift of plant species within semi-natural grasslands is suspected. Recently established grasslands could differ in composition to the old ones but still contribute to biodiversity. The importance of semi-natural grasslands as an ecosystem is better understood today. To protect and remain the remaining grasslands, governmental programs are put in place.

Keywords: Land use change, Semi-natural grasslands, Biodiversity, Scania, Historical land use

Popular Summary

During recent years, the loss of biodiversity has been a subject for many discussions. It has become clear that the way humans influence nature, influences both plants and animals. The loss of nature types has been named to be a problem in many cases. The conservation and protection of biodiversity is important. Among all the different types of nature the semi-natural grasslands found in Sweden are home to many different species, some of them found only there. When talking about biodiversity it refers to the variance between all living organisms and the diversity within species, between species and between ecosystems. Semi-natural grasslands are not natural, they are a result of humans and the way they have used the landscape. When humans started deforestation and used the ground for farming and cattle, this is when semi-natural grasslands stared to develop. As the land was used differently for example for hay making or for grazing, different types of semi-natural grasslands developed. As the need for fields grew, semi-natural grasslands were turned into arable fields and later, they were turned into forest for economic reasons. These are some of the reasons behind the loss of semi-natural grasslands.

To investigate if there has been a loss of semi-natural grassland in Osby, Scania, a historic map for 1926-1934 was compared to data from today. Maps and graphs were created to show the change in area over time. The comparison showed that there was a decrease for old semi-natural grasslands but an increase of new established grasslands.

The diversity of species had not changed drastically but some species had declined. The way land is used influences which species will be found. As it is important to keep a high diversity in the semi-natural grassland, old management strategies and the right timing of management must be considered. Today there are programs and plans to favour the creation and maintenance of semi-natural grasslands.

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1 Introduction

Today's threat on biodiversity due to loss of species is a well-known problem. Around 25% of animal and plant groups are threatened to become endangered and it is suggested that around 1 million species are already endangered (at risk at becoming extinct) (IPBES 2019). It has been acknowledged that land use changes are a big threat to biodiversity (Naturvårdsverket 2021a). But what is meant with biodiversity? Biodiversity could be described as the following: the variance of living organisms from any origin, including terrestrial, maritime, and other water ecosystems. It can refer to diversity within a specie, between species and between ecosystems (Naturvårdsverket 2021a).

Many ecosystems have been under great pressure during the last century and a loss of habitat for them has been reported (Silva et al). One of these ecosystems are semi-natural grasslands. (Cousins and Eriksson 2002; Naturvårdsverket 2020d). Due to the threat on habitat loss, they need protection, conservation, and restoration.

Semi-natural grasslands are also a habitat to many of the red-listed species in Sweden (Eriksson and Cousins 2014). In this report semi-natural grasslands will be defined to as open landscapes, which have been grazed or mowed, used as hay meadows or pastures under a longer time period and which have not been fertilized with artificial fertiliser to increase their productivity. Semi-natural grasslands are not naturally occurring, they originate from previous land use and human culture which has resulted in their high biodiversity (Emanuelsson 2009). Since the time semi-natural grasslands started to appear, land use has undergone many changes. Their origin could be dated back as long as 3200 BC in Sweden (Nielsen et al. 2012). They became relatively stable somewhere between 800BC-1000AC (Pedersen and Widgren 2011) and remained like that until the 18th century (Widgren 1983). A significant decrease in semi-natural grasslands has been recognised and was connected to the agricultural revolution (Gadd 2011).

Today both national and international goals are in place to recreate, conserve and enhance biodiversity. The problem of decreasing biodiversity was already recognized in the beginning of the 1990s. In 1992, at the United Nations (UN) conference in Rio de Janeiro, Brazil, the Convention on Biological Diversity (CBD) and an agreement was reached and become applicable in 1993, the same year Sweden signed the agreement. The aim of the CBD agreement is to protect biodiversity and make sure that natural resources are responsibly used (Naturvårdsverket 2021b). Besides that, in Sweden there are 16 environmental goals (so called miljömål) (Naturvårdsverket 2020b), which aim to promote a good development in consideration of the environment. The goal is to preserve a healthy ecosystem for the next generation. Two of the goals fit more specific to the aim of biodiversity, one called "a rich plant and animal life" and the other one called "a rich agricultural landscape" (Naturvårdsverket 2020c). A way to achieve the mentioned goal is to conserve and protect different kinds of species-rich and culturally important landscapes like semi-natural grasslands.

1.1 Aim and research questions

The aim of the study is to examine how the area of semi-natural grasslands have been affected by land use changes between 1926 -34 compared with data from 2020 and 2021 and what consequences that could have on the vascular plant diversity within them.

The following hypothesis will be considered:

- There has been a decrease of area for continuously used grasslands since 1926-34.
- Grassland left today are smaller in size and less connected to other grasslands.
- Due to the change in land use, biodiversity in semi-natural grasslands has been negatively affected due to the loss of areas.

With those hypotheses in mind the following research question are formulated:

- How much has the total area of semi-natural grasslands changed between the two periods?
- What have former semi-natural grassland areas changed into?
- Has the biodiversity changed within the grasslands?
- Does the management of grasslands affect the species that are found today?
- If there is a decrease in semi-natural grasslands, are there any management plans how one could counteract the effects on grasslands and their diversity?

2 Background

Land use changes and their effect on biodiversity is a much-researched topic (Naturvårdsverket 2020c; UNDP Sverige 2020). Lately the importance of grasslands for biodiversity and vascular plants has been highlighted (Naturvårdsverket 2020d).

2.1 Origin and historical background of semi-natural grasslands

Semi-natural grasslands are not naturally existing in Sweden, as they originate from previous land use (Emanuelsson 2009). Lately it has been pointed out that to fully understand the current landscape one has to consider the history of it (Antrop 2005; Eriksson and Cousins 2014). It is assumed that the origin of semi-natural grasslands could be dated back to the Neolithic period (Eriksson and Cousins 2014), mostly because of the deforestation known as slash and burn occurring during that time (Emanuelsson 2009). A more open landscape was described in Sweden from 3200 BC (Nielsen et al. 2012), which might be linked to the start of human agricultural activity (Nielsen et al. 2012). With a second deforestation occurring from late bronze to early iron age, here referred to 800 BC until 1000 AD, a more stable livestock was developed. Here a mosaic landscape with fields, meadows, pastures, and managed semi-open woodlands were created (Pedersen and Widgren 2011). A certain type of land use was developed with inner fields used as arable areas and for haymaking and outfields often containing semi-woodlands used for grazing (Dahlström et al. 2006). This mosaic landscape remained relatively stable from the medieval time until the 18th century, and it has been proposed that it could even have been stable since the iron age (Widgren 1983). Where fields were used mostly as arable land, meadows were used for hay making and pasture to have cattle on. The different uses led to different development of their plant community.

During the time from 1700-1870, agriculture and land use changed dramatically, also known as the agricultural revolution in Sweden (Gadd 2011). During that time period, lakes and wetlands were drained and forests were cut down to create more arable land. At the same time new techniques like crop rotation and new seeds for winter fodder became more important for agriculture activity. As modernisation took place, the grazing particularly in forests declined and land was more often used to grow winter fodder (Eriksson and Cousins 2014). At this point a clear decrease in grasslands was observed. Between 1750 and 1827, different redistributions of the land were initiated, the so called "skiften". This meant that farmers got fewer but bigger parcels of land and led to that they relocated their farms from the villages to the outside of the village and closer to the farmland (Gadd 2011). During the first half of the 20th century artificial fertiliser were introduced and traditional fertilisers became more effectively used. Artificial fertilisers became more commonly used after the Second World War (Morell 2011) and occurred together with other modernisations. This modernisation led to a decreasing number of farms and abandonment of low producing fields and pasture, which often were turned into forests as timber became more important to Sweden (Eriksson and Cousins 2014).

To examine the effect this evolution has had on grasslands, a couple of studies have been done (Johansson et al. 2008; Cousins et al. 2015; Aune et al. 2018). It can be stated that through the changes in agriculture and land use, grasslands have been affected twice: first when clay and silty soils were turned into fields, likely around the end of the first agricultural revolution (1700-

1870), and a second time when the grasslands on soils with a lower quality became forests or were abandoned after the second World War which both led to a decline of grasslands (Eriksson and Cousins 2014).

2.2 Land use changes and the decrease of semi-natural grasslands

Since the first agricultural revolution a decrease in semi-natural grasslands in Sweden has been noticed, where they first were changed into arable land (Cousins 2009). Later they were either abandoned, which led to gradually transforming into forest, or they were actively turned into forest (Eriksson and Cousins 2014). Cousins et al. (2015) have carried out a study in the Swedish region of Södermanland where they examined an area of 1652 km^2 to estimate the areal loss of old grasslands and the effects on biodiversity. For that, a total of 16 cadastral maps from 1897-1901were digitalised manually, creating polygons to represent different land uses. For the present-day data, a terrain map from 2013 was used and simplified to fit the purpose. Furthermore, to include the known semi-natural grasslands Cousin et al. used data from an inventory from 2002-2004. The data are provided by the Swedish Board of Agriculture and their database TUVA. After analysing the data, they found that on a regional scale, only a few percent of the area found in 1897-1901 was left, approximately less than 4 %. Cousins et al. (2015) found a trend that pastures were likely to become forest, but meadows were more likely to became arable fields or modern grasslands. Regarding biodiversity, they found that if a certain size of grasslands is lost, the positive effect they have on biodiversity may vanish. So, today´s biodiversity is still influenced by the biodiversity of historical landscapes.

Aune et al. (2018) performed a study on area loss for semi-natural grasslands in the region of Mostasmarka south of Trondheim Fjord in Norway. In their study they examined an area of 6.2 km^2 with parts being grasslands. To estimate the change in area for semi-natural grasslands they analysed two sets of arial photographs and did field mapping. The field mapping occurred during the summers 2014/2015 and for the historical date, panchromatic black/white arial photographs from 1963 were used. Their findings were that between 1963 and 2014/2015, 49.1% of the semi-natural grasslands changed into other land use types.

Johansson et al. (2008) conducted a study where they observed the change of area and fragmentation of old semi-grasslands. The study site was located on the island of Öland, Sweden, in the Baltic Sea. A time series of 274 years were examined between 1723 to 1997 which were divided in to 6 time periods. The area size was 22.5 km^2.

For the interpretation, different historical maps and arial photographs were used. They found that over the 274 years, 82% of the semi-natural grasslands were lost. Johansson et al. (2008) also stated that the number of grazing dependant species were different for areas with different historical use. Areas of former arable land will host a significant lower number of grazing-dependant species.

2.3 The importance of appropriate timing of management

Species composition of grassland is strongly determined by the type of management (Dahlström et al. 2008). Dahlström et al. (2008) have done a more detailed study to show the importance of management strategies and timing. To understand the connection between traditional management and the effects, they used cadastral maps from the eighteenth century over an area of 16,700 ha within 4 different landscapes in Sweden and with 6 types of land use. To include the management perspective, data from the Nordic Museum about peasant culture from the 1930 was used. Current data for management came from the national records of semi-natural grasslands recorded in 2005. One of the differences between the management in pastures and hay meadows is the onset of management. The traditional management of pastures has been grazed between late May/early June and October, while hay meadows could be left untouched until the end of July sometimes even until September.

This created two different landscapes, with one having permanent disturbance and one having minor disturbance. In the hay meadows the plants could grow undisturbed longer in the summer, which led to a bigger production of seeds and more seeds in the following seasons. It has been proven that late management from early July will lead to that 20-95% of all vascular plants had completed their reproduction process. For the present situation it was observed that between 97-99 % of the former grasslands (meadows and pastures) have been lost. In the area left today, the dominating management strategy is grazing. Grazing is occurring between May to September and only 4 hectares of the investigated 16,700 ha are still mowed. As the biggest part of the remaining grassland are managed with early management strategies like grazing, species which were favoured by late onset management like mowing were negatively affected. The traditionally late management or between management was totally absent today compared to a proportion of 20-45% in the historical records. It was also stated that semi-natural grasslands had a historical extent of between 67-95% of the whole area compared to 0.6-2.2% in the data over the area from 2005.

If an area is not managed at all in the early summer, the result would be decay of the grassland where shrubs and trees could establish in a greater degree and missing late management leads to a decline of certain species in the grasslands. It is becoming clear that how and when grasslands are managed has a major effect on the ecological processes in grasslands such as change from mowing to grazing and from late to early disturbances. To conserve that kind of environments, management timing and the historical management practises should be more often considered.

2.4 Effects on biodiversity: what has been found

It is a known fact that a decrease in biodiversity is observed over the last decades. There are both a loss in number of species and a decline in numbers for certain species (IPBES 2019). Some habitats have been found to be in greater danger, among them semi-natural grasslands, which are hosting many species. They have got some attention during the last years and their importance for biodiversity and species richness has been pointed out (Naturvårdsverket 2020d). As example Cousins (2009) carried out a study where it was found that semi-natural grasslands which are still grazed had around 23 different species per m^2. With a decline of grazing, the number of species decrease to 19 and on abandoned semi-natural grassland the number decreased to 13 species per m^2 (Cousins 2009).

Tyler et al. (2018) carried out a study to find out what the main drivers are for the change in biodiversity under the 20th century. They chose to observe the following factors: climate change, land use change, drainage, acidification, nitrogen deposition and eutrophication, pollinator decline and changes in CO_2 concentration. The study site was in Swedish region Scania which has a total area of about 11000 km^2. For that data from two vascular plant surveys were analysed, one from 1989-2006 and one from 2008-2015. The surveys covered 200 randomly selected 2.5 by 2.5 km grids distributed over the whole of Scania. Among their findings were that species established before 1700 had declined while species established after that had increased. For grassland species, they found that species which were depending on mowing and grazing decreased while newly established species increased. They suggested that the main drivers for south Sweden are climate change and land use changes.

Tyler et al. (2020) performed another study to investigate the effect of different drivers on individual species level. They based the divers on a previous study done by Tyler et al. (2018). For that, changes in the frequency and the decrease or increase of species and different vegetation types were examined. Three data sets were used to compare: the first from 1938-1971, 1987-2006 and 2008-2015. The data was collected by the Lund Botanical Society. To analyse changes for different vegetation types, all species were put in one of 30 vegetation groups. There were both increases and decreases in species between all the surveys, although it was in both times more decreasing than increasing species. Vegetation types with the biggest average decrease during the last decades are all treeless as in opposition to wooded vegetation types that are performing better.

2.5 Why is it important?

It can seem like losing some areas or some species would not have a high impact, and one could replace them or just create new similar areas to compensate. But it is not that easy. The problem is more complex and to compensate with other areas could not always solve the problem as the prerequisites are not the same and areas probably will be different in species composition. It can also not be stated that it is just loss of one specie, or a couple, or a habitat, as plant species are often connected to certain insects and they are connected to certain birds so to lose a certain grass may not seem so bad in the first place, but a snowball effect could be started and end up with a loss off many different species (Gamfeldt et al. 2008).

There are a lot of other reasons why biodiversity is important. Such as the possibility of ecosystems to react on changing conditions and keep ecosystem functioning (Cleland 2011).

3 Method

3.1 Study site

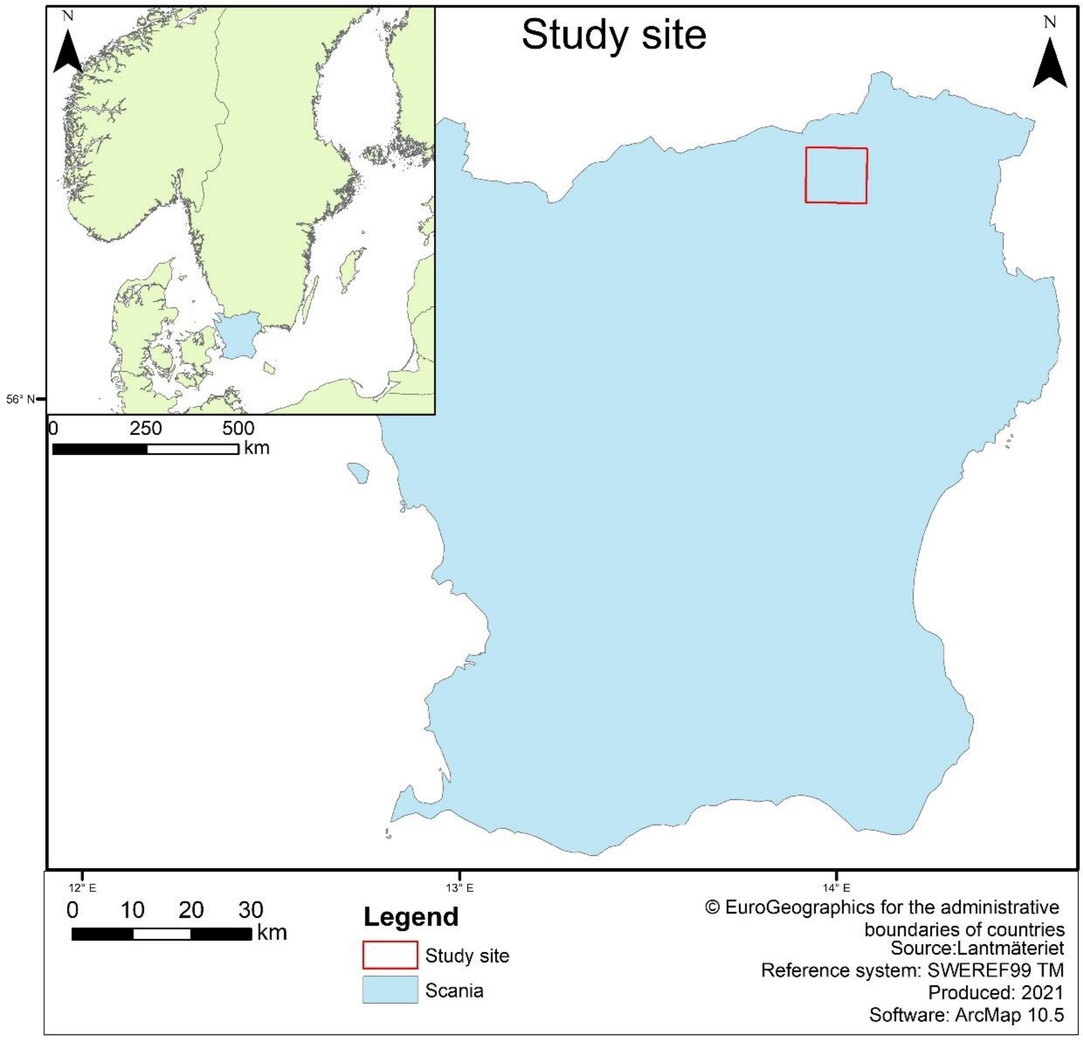

Figure 1. Overview of the study site's location.

The chosen study site was the area around Osby, Scania in the most southern part of Sweden, see Figure 1. The area is located between 56˚20´N-56˚25´N and 13˚53´E-14 ˚40´E. The site was chosen due to the accessible historical map and the appearance of meadows or semi-natural grasslands in the area. The size of the studied area was determined in consideration to the size of the historical map. Osby is a small town in the northern part of Scania at the lake Osbysjö and a small river. The average January temperature is between -2˚C – 0 ˚C and the average temperature in July is 15˚C- 17˚C. The average precipitation is depending on the location and varies between 500mm/y up to 1000mm/y (SMHI 2009a). According to the Köppen system the most southern part of Sweden is in the warm/mild temperate zone C (SMHI 2009b).

3.2 Digitalisation of a historical map with a R-Script

The digital map was retrieved from the Swedish mapping, cadastral and land registration authority (Lantmäteriet). The so-called Häradsekonomiska kartan (Lantmäteriet 2021a) was available as a raster file. The map is a description of the land use between 1859-1934. The type of map was not available for all of Sweden just for parts of Götaland and Svealand and some small parts of Norrland. They give a good overview over land uses, vegetation, settlements, trails, and borders in the south. They were produced in a scale of 1:20.000 (Lantmäteriet n.d.) The new classification into the three classes of the map was carried out in R 64 4.0.5 (R foundation for statistical computing, Vienna, Austria 2021), with the help of a script from (Auffret et al. 2017) written in R. The R-script was chosen for several reasons, first as it has shown to have an accuracy over 80%, which meet the standard requirements for landscape classification (Auffret 2017) and manual digitalisation is time consuming. At first the colours were evened out, to account for uncertainties due to the variation which could occur within a group. Within this process the script is using the average value of the RGB-bands in an area to even out the colour for that section. Colour difference could occur due to the quality of the map. This was followed by the choosing of three classes in my case: fields, semi-natural grasslands and other. The classes were defined due to the colour the areas were symbolized with in the historical map. Ten points were chosen in the map to create colour scales. After that, a colour panel was suggested and had to be confirmed, be adjusted manually or the process of choosing points had to be redone. The proposed colour scales were cross checked with the original map to make sure that it fits the chosen regions. When the result was satisfying, thereby representing the colour within the different classes, and confirmed, the raster was created by the script.

3.3 Analyse of different datasets in ArcMap

Spatial analyses were done in ArcMap 10.5.1 (Esri, Redlands, California). As the old map was missing correct georeferencing and as that was needed for later comparison it was georeferenced with help of the corresponding terrain map from the land registration authority (Lantmäteriet 2021c) and the projection was changed into SWEREF 99 TM (Lantmäteriet 2021b). Beside that the datasets seen in Table 1 were used.

Table 1. The different datasets used to perform the different types of analyses.

Dataset	From where
TUVA database meadows and pasture inventorying 2020	Jordbruksverket (2021a)
Agricultural Block (Jordbruksblocket) 2021	Jordbruksverket (2021b)
Swedish national land cover data (nationella marktäckedata; nmd) 2020	Naturvårdsverket (2020a)

The Agricultural Block (Jordbruksblocket) from 2021 was chosen to get an overview over all meadows and grasslands which are found in the area today. The data was retrieved as a shapefile. The Agricultural Block is data which contains information about agricultural land which has full right of founding according to the EU-definitions (Jordbruksverket n.d.).

The data from TUVA were chosen to find areas which have important values for nature (species, shrubs, trees, flora and fauna, nature types according to the EU habitats directive historical land use among others) it also includes data from a previous inventories, areas which are founded with environmental compensation and other areas of natural or cultural importance which are known by the country administrative board (Nordberg 2013). It was created after an inventory of all the meadows and pastures and their individual significant natural or cultural values. The inventory started 2002 and the latest data is from 2020 (Jordbruksverket 2021a).

The Swedish national land cover data from 2020 was chosen for its resolution, 10m by 10m with smallest object included of 0.01 ha and the overview it gives over the present-day land use.

All layers were downloaded in SWEREF 99 TM, which is the Swedish standard projection. Even if there are regional variations in Sweden (Lantmäteriet 2021b), it was chosen to keep SWEREF 99TM instead of SWEREF99 13˚ 30´to ensure inter-comparability. Data which were received as raster were converted into polygon layers to be able to calculate the area of the semi-natural grassland and all datasets were clipped after the historical map over Osby as it was the area of interest.

The produced raster from the historical map was compared to the original RGB raster. Some areas have been misinterpreted or could be identified not to be semi-natural grasslands like the graveyard in Osby. To correct the misreading's two polygon layers were created to add or remove areas. These layers were merged with the polygon layer from historical map to get the best possible outcome.

To be able to calculate the areas of semi-natural grasslands today, the meadows were extracted from the Agricultural Block (Jordbruksblocket) and merged with the layer from the TUVA database. An analysis was made to see which areas were semi-natural grasslands 1926-34 and in the latest data. This was done by cutting the layer produced over today's semi-natural grasslands after the polygon layer presenting grassland in 1926-34.

There was also an interest to know what the areas would have changed to if they were not semi-natural grasslands anymore. For that, the Swedish national land cover data was cut after the polygon layer over semi-natural grasslands from 1926-34 and areas which were classified earlier to be semi-natural grasslands today were erased. The results of those steps gave a layer showing the areas which have been meadows or grassland in the historical map but are not anymore, and what land use they have today.

3.4 Statistical analysis

First the total area for grasslands and meadows from the historical and the present-day meadows and grasslands were calculated. The loss of area from meadows and grasslands were calculated both in ha and in percentage. In addition to that the areas which have changed since 1926-34 were analysed. It was examined what areas changed into and the size in hectare and percentage were calculated. All areas were included in the calculations and maps, but for the graphs about the change in grassland, areas smaller than 1 ha were excluded.

4 Results

After digitizing the historical map of the area around Osby, Scania with the help of the R script, the area which has been grassland or meadow in the time between 1926-34 could be calculated. Calculations carried out in MS Excel resulted in a total area of all grasslands of 408 ha as seen in Figure 2.

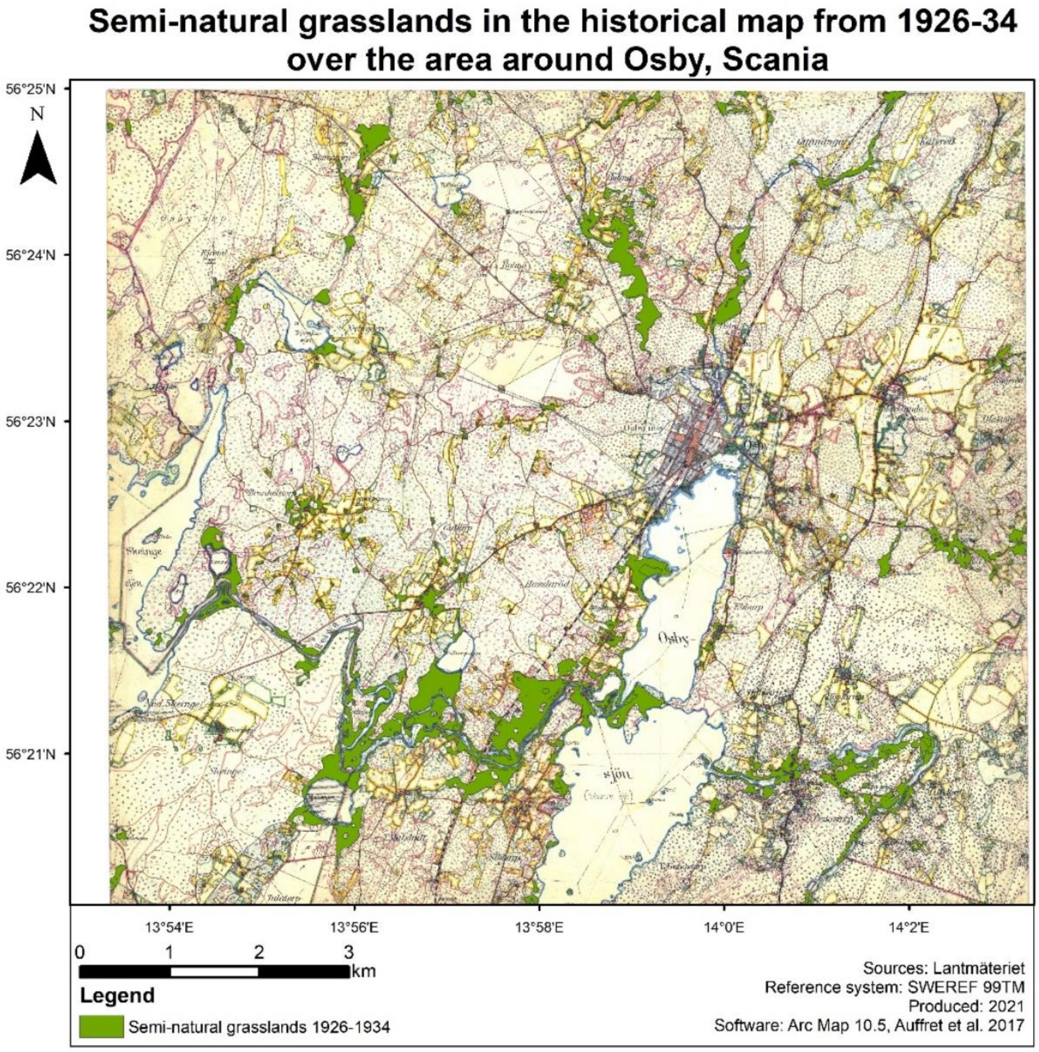

Figure 2. The historical map over the area around Osby from 1926-34 was used as background and the identified semi-natural grasslands were highlighted in light green.

Furthermore, maps were produced to display the current situation in the area and how much semi-natural grasslands are in the area today. Two datasets from the Swedish Board of Agriculture, the agriculture block and the dataset from TUVA, were used to estimate semi-natural grasslands today and their combined total area was calculated to 490 ha. Of the area, 140 ha were of ecological or cultural importance according to an inventory done by the Swedish Agency for Agriculture found in the data base TUVA (Jordbruksverket 2021a). The results are seen in Figure 3.

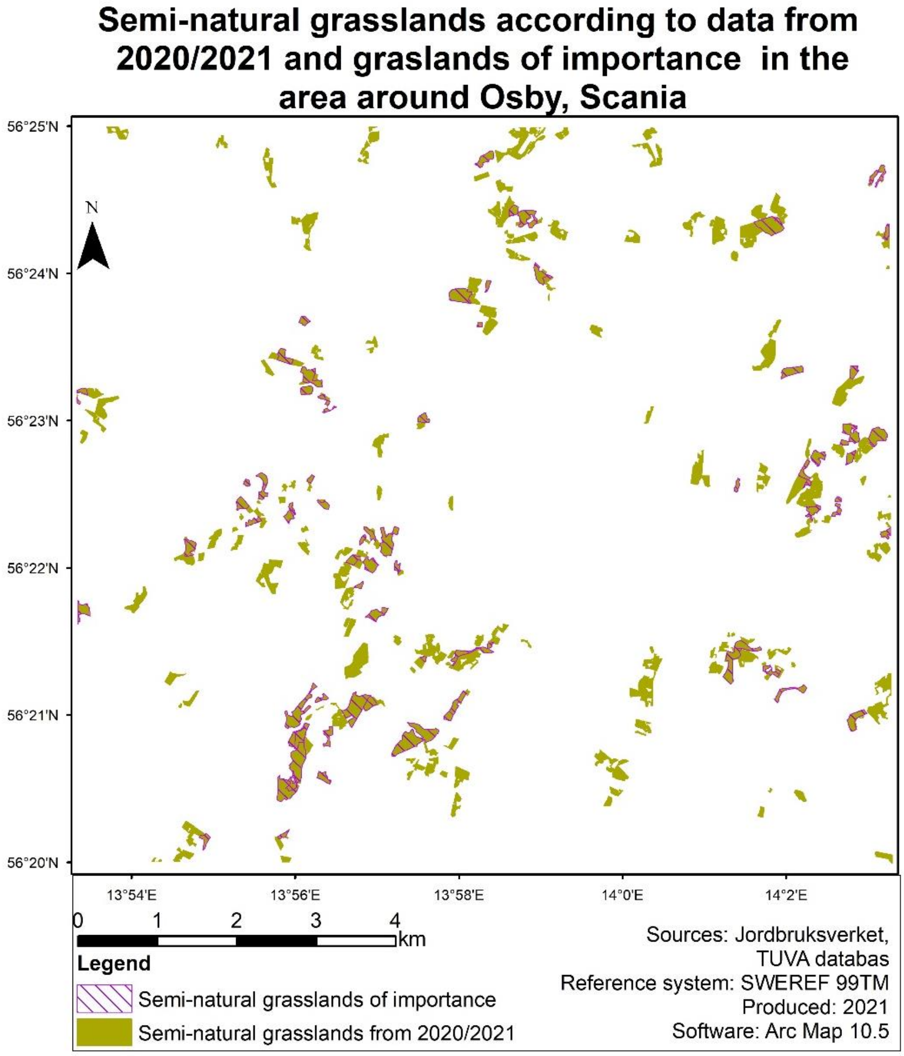

Figure 3. The green area represents semi-natural grasslands from 2020-2021. The stuctured areas in purple over the green are representing the semi-natural grasslands which have been classified of significance for nature or culture.

As there is an interest in knowing which areas has been semi-natural grasslands for a longer time, an analysis was done to compare the areas with semi-natural grasslands s from 1926-34 and data from 2020 and 2021. It was found that from the original 408 ha, 62 ha were still used as semi-natural grasslands today as illustrated in Figure 4. This leads to the conclusion that 84.8% of the original grasslands and meadows were lost. It can also be seen from the maps that the areas used as semi-natural grasslands today seem to be more fragmented and the area of the single semi-natural grasslands have decreased.

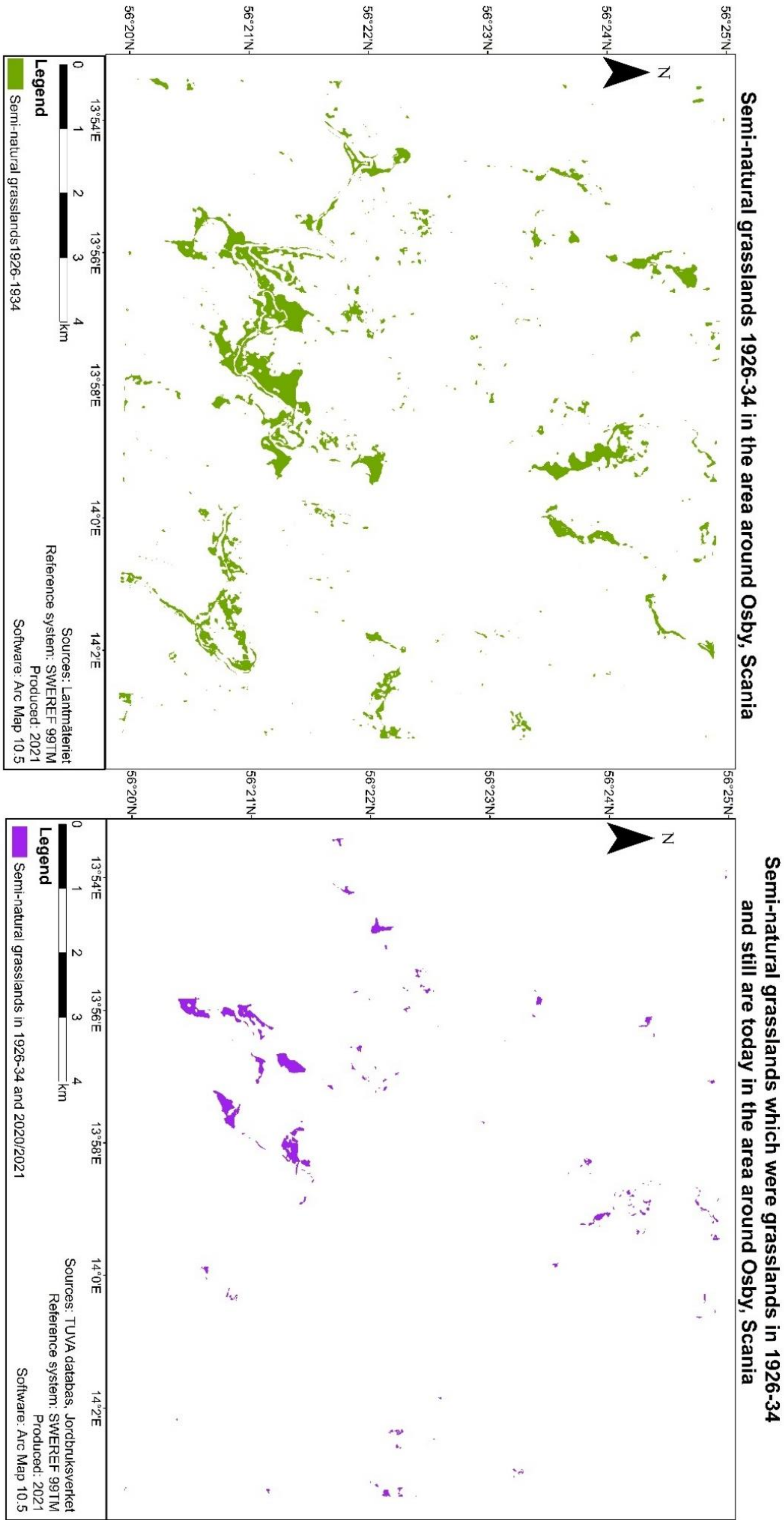

Figure 4. The green areas in the left map are representing semi-natural grasslands which were found in the histrorical map from 1926-34. The violet areas in the right map are representig the semi-natural grasslands left in the same area with data from 2020 and 2021.

Beside the interest in if there has been a change in the size of area it has also been of interest to know what the lost areas has been changed into. For that a dataset from the Swedish Environmental Protection Agency from 2020 was analysed. The biggest part of the lost semi-natural grasslands changed into open wetland (24.1%), followed by deciduous forests (12.7 %), mixed forest outside of wetlands (11.0%) and other open areas with vegetation (9.4%), see Figure 5. The size of the area for the changed land uses can also be seen in Figure 5.

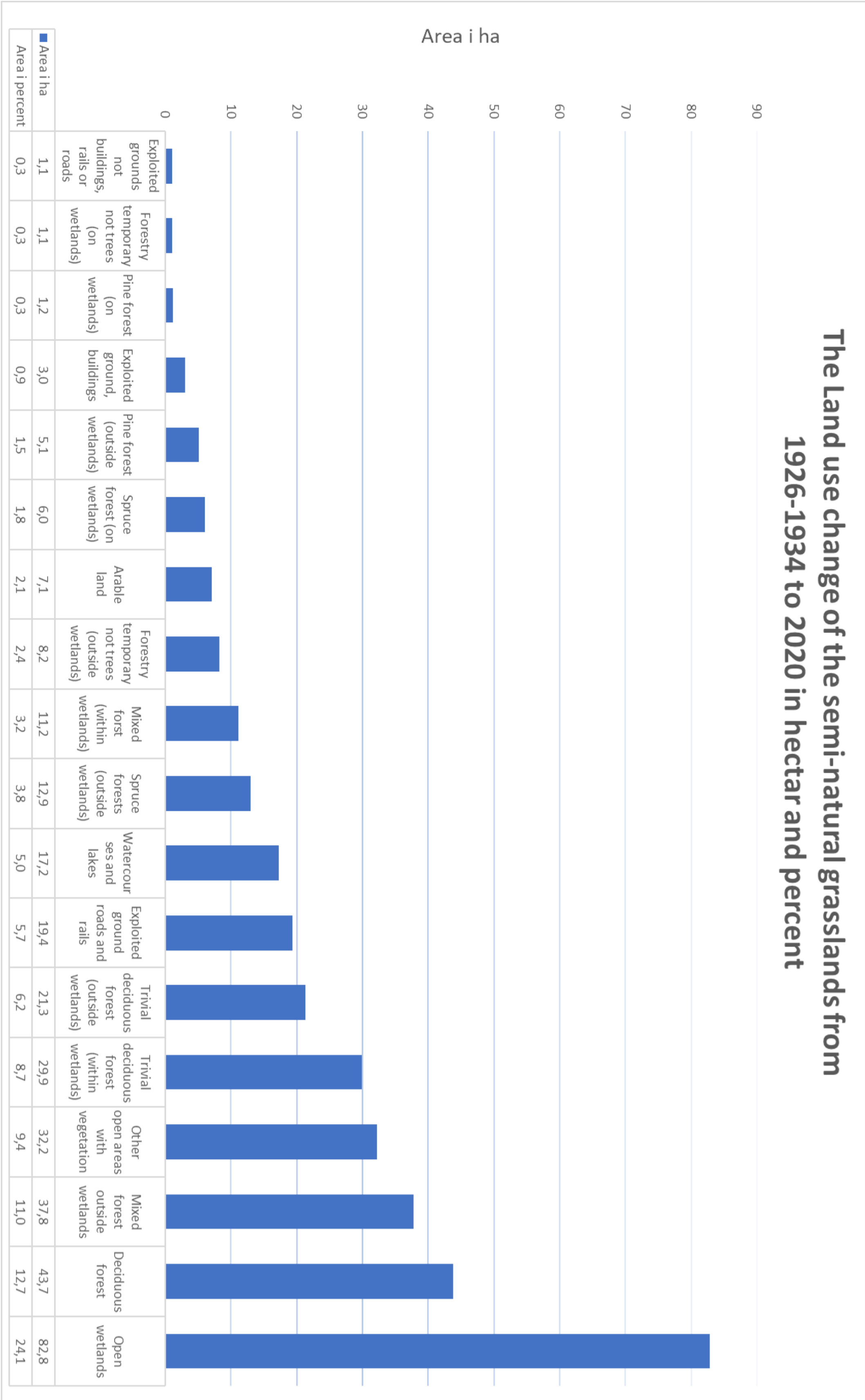

Figure 5. Graph showing the change in Land use in percent and hector for the semi-natural grasslands from 1926-34 to 2020.

5 Discussion

5.1 Decrease in area for the semi-natural grasslands for long time use.

The result is showing a decrease in area of semi-natural grasslands that has existed for both observed times. The traditional use of land under a long period created an environment that favoured the growth of certain plant species which are today known as grassland specialists (Auffret et al. 2018). A decrease and loss of those areas can influence species and the diversity of the grasslands and meadows. This will be discussed later in the thesis.

The decrease in area for continuous grassland found in the result corresponds to the findings of several other studies (Johansson et al. 2008; Aune et al. 2018).

Cousins et al. (2015) have carried out a similar study where they used old historical maps over an area in Sörmland. In their study they found the areas classed as semi-natural grasslands have reduced to less than 4% of the original areas found in the map from 1900.

Johansson et al. (2008) showed in a study performed on Öland a decrease of area from a total of 86% of the whole observed area in 1723/1733 to 8.7% in 1994/1997. The observed area had a size of 22.5 km^2. Besides the loss mentioned earlier they also found that it depends on the time what the land would be converted to, as was mentioned in section 2.

The study from Norway of Aune et al. (2018) found that for the observed time period 1960 to 2015, 49.1 % of the semi-natural grasslands were lost. They were the land type which had the highest degrees of change and loss during that period. Thus, the total number of semi-natural grasslands increased from 114 to 174 while the size of the individual grassland decreased from 1.02 to 0.37 ha. They observed two processes contributing to the change, where one was intensified management which resulted in arable land and the other was decreasing management where the result was a slow change from grassland to forest.

All these studies show the same trend as found in the results of this study for semi-natural grassland which have existed in the past, that their area is decreasing. From the numbers given by Cousins et al. (2015), the loss of area is about 0.83%, for the study done by Aune et al. (2018) this number is 0.89% and for the analyses done in this study, area loss per year is about 0,91%. They are all similar to each other though the loss is not actually happening in a linear fashion, there will be year with bigger loss and some without loss.

5.2 Modern grasslands

In the results it was seen that there were more meadows or grassland identified in the recent data than from the old map of 1926-34. The cause of that could be explained with different theories. In the map over the semi-natural grasslands today, figure 3, it is seen that not all the new grasslands and meadows are included in the database called TUVA, so they might not host grasslands specialist, species mostly found in grasslands depending on the management and environmental properties like soil quality. So, they might differ in their species composition to the old grasslands and give habitat to different species.

The chosen historical map is dated to 1926-34, a period where most open land was converted into agriculture fields (Eriksson and Cousins 2014). During the latest time the new established grassland in the area has increased, these ones could be classed as modern grasslands (Auffret and Cousins 2011; Marteinsdottir and Eriksson 2014). These modern grasslands could contribute to a positive development effects for the species richness (Cousins et al. 2015).

Lately meadows and grasslands also received more attention as an important habitat for many species and the contribution to biodiversity and species richness (Emanuelsson 2009; Naturvårdsverket 2020d) .With the knowledge of their importance to nature there are programs in place to make it more profitable for landowners and farmers to keep this type of land use (Jordbruksverket 2021c). This could be a reason of the increasing area of modern grasslands. Another explanation could be a more effective agriculture that has lowered the need for agricultural fields. This is not investigated in this study and for that interview with farmers which have been starting to have grasslands could have been done. Also, older dataset could have been compared to the latest data to see the change.

5.3 Why is it important that the areas have been used as meadows or grassland under a longer time and that they are managed a certain way like before?

It has been acknowledged that the historical management of grasslands has created a habitat where one finds a high species richness of vascular plants. To keep grasslands and meadows with a high biodiversity of grassland specific species, one must manage the areas like they have been in the past. In Dahlström et al. (2008) the importance of the management type and timing is highlighted. In the traditional land use, meadows and pastures were used for either grazing or hay making. The mowing often took place later in the summer, mid-July to September and was followed by grazing on the area. This management strategy led to many species that were able to build seeds, favouring certain species while grazing favoured low growing species and the demand of light.

5.4 How the change of land use and the management strategies can have effects on biodiversity and what has been found about plant diversity changes in the semi-natural grasslands

Besides the interest to investigate the change of land use and how semi-natural grasslands have coped in comparison to other land use types there is also an interest to see if there has been an effect on biodiversity or plant richness.

The effects of land use changes on species diversity have been a much-discussed question in the later years.

Tyler et al. (2018) found a decrease of species established before 1700 and a decrease for species which was dependent on mowing or grazing. In contrast an increase of species which were established after 1700 was found. This finding could lead to the conclusion that the loss of old grassland leads to a decline in biodiversity for certain species. As the study also pointed at, the decrease of species favoured by grazing or mowing was highest on plants in grasslands habitats. The importance of the management was also pointed out. Another problem mentioned is the decreasing number of cows, especially on low productive semi-natural grasslands which is one of the drivers of the ongoing floristic changes found (Dahlström et al. 2008; Cousins et al. 2015). The most extreme result of lack of management and traditional land use would be overgrowth (Tyler et al. 2018). Tyler et al. (2018) conclude from their results that the main drivers for the found changes are climate change and changes in land use.

As mentioned before, Tyler et al. (2020) published a second study of the surveys including a third time period and compared time periods from 1938-1971,1987-2006 and 2008-2015 from the Lund Botanical Society. The focus of the studies was to find what effects the drivers from the Tyler et al. found in 2018 have on species and particular vegetation. Thirty vegetation types were defined. For that, frequency was compared. When comparing the different surveys, the number of decreasing vegetation groups were bigger than the increasing, both between the first survey (1938-1971) and the beginning of the second (1987-1995) and between the latest surveys (1987-2006) and (2008-2015).

During the last decades species like Matgrass (*Nardus stricta),* Prairie Sedge *(Carex prairie)* and Fen Bedstraw (*Galium uliginous)* are experiencing one of the greatest declines (Tyler et al. 2020). These are species which are typical to be found in mown and grazed semi-natural grasslands.

An overall trend was showing that species decline between the first two surveys will either continue to decline or stabilize between survey two and three. Species increasing between survey one and two did not always keep increasing.

It has been found that the overall biodiversity is not decreasing through the number of species which are declining is bigger than the number of species with an increase. Some species have shown to be favoured with the latest development in Scania. These are mostly wooden species.

With the issues discussed, one could reflect to one of the research questions: If there is a decrease in semi-natural grasslands and are there any plans how one could counteract the effects on grasslands and their diversity.

In Sweden there are different programs in place to favour semi-natural grasslands. One can apply for financial support to maintain grasslands. Another funding in place is that one can get financial support to restore a grassland, or one could get a onetime funding to clear an area to make it to a grassland (Jordbruksverket 2021c).

Recently a Life project call RestoRED has stared in Sweden (Länsstyrelsen Västra Götlanda 2020). It is an EU funded project in which 9 Swedish regions participate include Scania and Stockholm. The project is taking place between 2021-2027 and will get an amount of 150 million SEK. One program which is partly in cooperation with the EU is the Swedish Rural development program (Landbruksprogrammet).

So, there are programs in place to benefit the habitat of semi-natural grasslands. Some programs in place contribute to the new establishment of grassland while other help to protect the old ones and keep a continuous management in place. The new established semi-natural grasslands become what is earlier in the report called “modern grasslands” with a plant diversity that might differ from the plant diversity in the old semi-natural grasslands. The overall increase of semi-natural grasslands in the present day could be a result of the programs in place and contribute positively to achieve the environmental goals for “a rich plant and animal life” and the other one called “a rich agricultural landscape.

5.5 Limitation and uncertainties

As no field studies were done for this study, it cannot clearly be stated that there is a change and how in the plant composition or the biodiversity for the examined area. It can however be assumed that the trends found in other areas would be the same here. To get a clearer picture of that a longer field study is recommended. The focus of that study should be to absorb the frequency of grasslands specialist and the number of species in total. For the chosen map, the R-script had some difficulties with areas just marked with a border of colour. For that, manual corrections had to be performed. There is always a certain degree of miss readings when carried out due to interpretation differences. Some difficulties observed with R-script were that it could not read in areas with just boundaries they had to be filled with colour are the difficulty to distinguish between similar colour close to each other and not define as different classes like in this study the blue of the rivers. The accuracy of 80% could be teste by calculated with the sum of the areas for the correction and the total area of grasslands identify in the map.

A challenge with this study was the different use of words which could relate to the same issue, like semi-natural grassland, semi-natural pasture, hay meadows and more. When diffing something as semi-natural grassland it can include different types of grasslands. With a more specific definition like hay meadow, one must have a certain knowledge about the specific area and the use of it in a historical perspective. It is also more likely to find certain species in this area and the area to examine is probably smaller.

Lastly the result one gets are always depending on the data one chooses to include.

Due to the lack of time in this study no further data analyses were carried out. The TUVA database is providing a lot of information about the inventoried grasslands which could be used for further analyses. For example, information on which species are found provided as well as 2 inventories for some areas, with that one could examine the change over time for certain species. It also provides information on which type of grassland or openness.

6 Conclusion

It has been found that there is a decrease in area for old continuous semi-natural grassland. Although this was tested in a small area around Osby, a comparison with other studies in similar climate confirmed this. Studies are showing that species normally associated with grazing or mowing and species which have established before 1700 (Cousins et al. 2015; Tyler et al. 2018; Tyler et al. 2020) are showing a negative trend. It is assumed that there is a connection between the decrease in area for semi-natural grasslands shown in several studies (Johansson et al. 2008; Cousins et al. 2015; Aune et al. 2018) and the biodiversity of semi-natural grassland. It has not been found that there is a general trend for loss of biodiversity in semi-natural grassland. What has been found is a trend of decline for certain species and thus connected to biodiversity. It would be necessary to do more studies where continuous data from field inventories with detailed information on species composition are used as well as other techniques like pollen analysis to study the specific situation in the study area. To break the trend with certain species declining, it came also clear that it is not just a matter of protecting, conserving, and restoring grassland but also about taking in consideration of the former historical use so the type and time of management can be optimised to favour that specific semi-natural grassland.

From the analysis it was seen that semi-natural grasslands mainly changed into open wetlands. But no general statement for what they will change into can be made. This depends on whether the land use is changed actively or if they are abandoned. It has been shown that both the timing and the type of management will lead to different species compositions in semi-natural grasslands. Factors which must be considered are early or late management, grazing or mowing and which type of grazing. Although the area of grassland is increasing it is not clear what specie composition they will have.

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