Student thesis series INES nr 478

Afforestation of open land in Sweden

A case study of Sjöbo Municipality

Josefin Svensson

2018
Department of
Physical Geography and Ecosystem Science
Lund University
Sölvegatan 12
S-223 62 Lund
Sweden

Josefin Svensson (2019).
Afforestation of Open Land in Sweden - A Case Study of Sjöbo Municipality
Skogsplantering på öppen mark i Sverige – en fältstudie av Sjöbo kommun

Bachelor degree thesis, 15 credits in *Physical Geography and Ecosystem Science*
Department of Physical Geography and Ecosystem Science, Lund University

Level: Bachelor of Science (BSc)

Course duration: *March* 2019 until *June* 2019

Afforestation of Open Land in Sweden
A Case Study of Sjöbo Municipality

Josefin Svensson

Bachelor thesis, 15 credits, in *Physical Geography and Ecosystem Science*

Hongxiao J
Dept. Physical Geography and Ecosystem Science

Thomas H
Dept. Physical Geography and Ecosystem Science

Acknowledgements

I would like to thank my supervisor Fredrik Lagergren at Lund's University for his great engagement and interest in this project. I would like to thank Karin Larsson at Lund's University for helping me with GIS and for directing me towards relevant data sources. I would like to thank my friends for all support and discussions regarding our thesis projects. Last I would also like to thank my family. Their support throughout my time here at Lund and during my thesis writing has been invaluable for me.

Abstract

Fast land use changes in the landscape can cause plenty of problems related to ecosystem services, especially when the changes concern sensitive land use types. This type of change has happened in Sweden during the last hundreds of years, where forests have been planted on abandoned pasture lands, as well as on crop lands.

This thesis looks at the afforestation in Sweden and some of the possible effects. This has been assessed by a case study as well as a literature study. The case study used aerial photographs over Sjöbo municipality for the years 1957 and 1975, as well as raster data from 2018 in order to analyse the afforestation in the area. In the literature study information on forests, cropland, pastures, and policies regarding land use change, as well as possible risks and effects were collected.

The result shows that the forest areas in Sweden increased not only due to afforestation, but also due to the forests becoming denser, increasing the standing tree volume. In the municipality of Sjöbo afforestation can be seen going on from 1957 to 2018. Of the two studied periods, most of the afforestation took place during 1975 – 2018, but the yearly afforestation rate was higher during 1957 – 1975. This happened at the expense of open areas in the municipality.

With increasing forests and decreasing open areas, especially pastures plenty of species risk becoming extinct in Sweden. Less grazing cattle animals might cause lower food production in Sweden, as well as a loss of various sites with high biological cultural heritages values in Sweden.

Key Words: *Afforestation, open land, pasture, biodiversity,*

Sammanfattning

Snabba förändringar i landskapet kan orsaka stora problem för olika ekosystemtjänster, speciellt när förändringarna sker i utsatta landskap. En sådan förändring har skett i Sverige de senaste hundra åren då skog har planterats på övergivna hagar, eller i vissa fall, även planterats på åkermark. Denna förändring beror på minskningen av djur ute på landsbygden, samt urbaniseringen som sker över hela landet.

Denna rapport tittar på skogsplantering i Sverige och vad några av effekterna av detta skulle kunna vara. Detta har gjorts dels genom en fallstudie av skogsplantering i Sjöbo kommun i Skåne under åren 1957, 1975, och 2018 med hjälp av gamla flygfoton och tolkningar av fotona, dels genom att studera samlad information om skogar, åkermark, och beteshagar i Sverige, samt hur ekosystemtjänster påverkas av förändringar från öppen mark till skogsmark.

Resultatet visar att skogsarealen har ökat dels genom skogsplantering, men också för att skogarna idag är mycket tätare och därmed en större volym skogsmassa. I Sjöbo kommun är skogsplanteringar synliga från 1957 till 2018. Den mesta planteringen skedde mellan 1975 – 2018, men planteringstakten var snabbare 1957 – 1975.

Med växande skogar och minskande öppna ytor, speciellt hag- och betesmarker, finns det risk att vissa utsatta arter dör ut i Sverige. Minskat bete kan orsaka lägre matproduktion i Sverige, och att det biologiska kulturarvet i Sverige minskar.

Nyckelord: *Skogsplantering, öppen mark, hag- och betesmark, biodiversitet,*

Table of content

1. Introduction

1.1 Background

Sweden is a forested country, around 69% of the total land area is covered by forest today (Riksskogstaxeringen 2018). Sweden, together with Finland are the two countries with the largest forest cover in Europe (Forest Europe 2015). In 2016 Swedish news outlets released articles about how Sweden is becoming more and more forested. In these articles they claimed that the area of the Swedish forests during the last 90 years has doubled (SVT 2016; Ottosson 2016). These articles are based on a report ordered by the European Union and executed by Forest Europe in 2015 called "State of the European forests".

This report focuses on forest trends within the European forests, what the current statues are and how to work with policies regarding forests. Another important aspect the report takes up is the concept of sustainable forest management, especially as the European forests are vast and can be a significant key for climate adaption and migration (Forest Europe 2015).

In Sweden some of this data have been analysed by the Swedish Agricultural University (SLU). Göran Ericsson, a professor at SLU claims that one of the reasons for the forest expansion is due to the current urbanisation trend - with a majority of the people leaving the countryside for the cities. He thinks that another reason is the loss of animals in the landscapes, as grazing animals helps the landscape to stay open. Without them, previously forested areas may become overgrown (Ericsson 2016). Göran continues in an interview with the Swedish radio to explain that most of these forests are just reclaiming land that previously used to be forested and that the development is going along the plans of the UN meeting in Rio 1992[1] and the European agreement for forests in 1990[2]. Ericsson concludes by saying it is to be seen whether this expansion is good or bad (Klarin 2016; SVT 2016).

[1] The earth summit meeting in Rio in 1992 created the "the Statement of Forest Principles", which ensures protection of the world's forests as well as regulations for sustainable forest management (United Nations 1992)

[2] Also known as the Strasbourg General Declaration. Compliments the "Forest Principles" and says that the management of the forests should not be at the expense of the well-being of the forests (Forest Europe 1990)

In Sweden forests are the most common land use, around 28.1 million hectares, accounting for nearly 69 % of Sweden's total area. Of these 28.1 million - around 22 million hectares are considered productive forest and the rest 6 million hectares non-productive forest. According to national forests statistics, the amount of lumber in Sweden has increased since the statistics started in 1923 Until the 1970s the most common afforestation species was spruce. After the 70's spruce continued to be most commonly used but other forest types such as pine, and broadleaved forests started to increase (Riksskogstaxeringen 2018).

As stated above, two of the most possible reasons why the forests have grown is due to urbanisation and loss of animal husbandry (Ericsson 2016). Going back 100 – 200 years, natural meadows and mows were common with almost 1.4 million hectares. These areas were used for securing food for the animals during the winters. The animals themselves grazed in areas further out from the farm during the summers. Today the area of mows is only 8 000 ha and the total amount of pastures and meadows in 2013 reached 440 000 ha (Karlsson 2013).

The total amount of animals in Sweden has seen a downward trend for all species, except sheep, which has had a small increase. Many farms have been aggregated into larger farms leaving less people working with agriculture, furthering the movement of people towards the cities (SCB 2019). With less animals and less people on the countryside many previously open areas risk to become overgrown or afforested (Sandström 2015).

1.2 Problem

The Swedish forest area has increased over the last hundreds of years as a possible effect of urbanisation and loss of grazing cattle. This has caused previously open areas to disappear in the landscape. The urbanisation and animal reduction is still on-going – risking the few open areas remaining today to also become abandoned and therefore overgrown, or afforested. This will impact ecosystem services connected to open areas as well as forests, such as changing the local biodiversity.

Exactly how this change will affect the Swedish landscape is still not quite understood, and as Eriksson said to SR is it still too early to know if this change is for the better or for the worse

(SR 2016) . It is therefore important to investigate if there is, still, a continued afforestation in Sweden, and to evaluate the risk of a continuation of afforesting the Swedish landscape.

In this thesis afforestation is defined as the act of establishing or planting a forest on a previously non-forested area (Clement et al. 2009).

1.3 Case study

In order to investigate if there has been any afforestation in the recent years, this project is a case study through time, which use old aerial photographs taken in 1957 and 1975 from the open source data on Lantmäteriet.se, to create afforestation and land use maps between 1957 and 2018.

Mapping possible afforestation for the whole country of Sweden would be too extensive for a bachelor thesis. Instead a smaller area was chosen to work with, in this case the study area was chosen to be the municipality of Sjöbo in Scania. The reason for this choice is that Sjöbo is a municipality with strong agricultural activity as well as having a large amount of forests, creating a mosaic landscape where the problem of afforestation could potentially be common.

1.4 Literature study

This project is also a literature study. Information and data for the entirety of Sweden have been gathered from various sources, both from official sites and published articles.

These parts reviews published information regarding forests, open areas, afforestation, biodiversity and ecological aspects, and cultural impact.

1.5 Aim

With the historical and ongoing afforestation in Sweden in mind, the aim of this thesis is to study and evaluate the afforestation of the Swedish landscape, and in particular in Sjöbo Municipality.

This will be done by answering the following questions:

- What are the land use changes in the municipality of Sjöbo through time?
- What are the major reasons for afforestation in Sweden?
- What are the possible effects of afforestation in Sweden?
- What are the policies regarding change in land use in Sweden?

The first question relates to the case study of Sjöbo municipality, whilst the other three are covered by the literature study.

2. Study area – Sjöbo municipality

Sjöbo is situated in the middle of southern Scania and has an area of around 500 km^2. The municipality holds around 18 500 residents, with most of the residents living in the town of Sjöbo. Sjöbo has a large variation in the landscape, containing broadleaved forests, pastures, and lakes (Svedin 2018). Historically it has been an important place for cattle, leading to a lot of pastures and meadows in the area. In recent years more cultivation and forestry have started to make way. Due to the long tradition of agriculture in the area, there are 14 nature reserves in the municipality, many of which holds deciduous forests or areas that have been grazed for long time leading to rich nature and wildlife. Some of these reserves are a part of the Natura 2000 initiative (Wallström; Nielsen Osterman 2016).

In 2016 the municipality released a program "Natur i Sjöbo Grönstruktur- och naturvårdsprogram för Sjöbo kommun" (Osterman 2016) to increase the nature values in the area, the program was ordered by the municipality back in 2001. This program focuses on five goals – ensuring the rights and needs for green areas, conserve and evolve the natural values in these areas, conserve and evolve the cultural aspects of the green areas, increase knowledge and understanding of protected areas, and ensuring a good management of parks and green areas close to the villages and towns. They have also commented on which areas that are deemed extremely valuable for the municipality and what the risks for those areas are, including old forested pastures, broadleaved forests, and meadows, amongst others (Osterman 2016).

3. Methodology

The flow of data and methods are summarized in figure 5.

3.1 Data sources

Naturvårdsverket – Marktäcketdata – from a collaboration between different Swedish agencies to create a large land use raster data, open source. The data used here are forest data, pasture data, and over all land use data. Compiled in 2018, 10 x 10 m large raster cells. (https://www.naturvardsverket.se/Sa-mar-miljon/Kartor/Nationella-Marktackedata-NMD/Ladda-ned/)

Lantmäteriet – Lantmäteriet provides many different open source data for use. In this project their historical aerial photographs from 1957 and 1975 over Sjöbo municipality have been used, their size is 5 x 5 kilometres, with a resolution of 10 m.
(ftp://download-opendata.lantmateriet.se/)

SLU – the Swedish Agricultural University has an open source raster data on forests, which in combination with the Marktäckedata from Naturvårdsverket have been used to create the necessary maps for this project, last updated in 2018. Resolution - 25 x 25 m.
(https://www.slu.se/centrumbildningar-och-projekt/riksskogstaxeringen/statistik-om-skog/slu-skogskarta/)
SLU also makes yearly forests inventories which has been used as background data.

Jordbruksverket – The Swedish Agricultural Agency is responsible for the statistics covering agriculture in Sweden. Long term studies and yearly inventories have been used for background information, mainly regarding open land in Sweden.

SCB – Swedish statistical Agency. Statistics gathered for information on land use, forests, open land, and animals - both in Sweden and in Scania.

Skogsstyrelsen – Swedish forest agency. Together with SLU they gather data on the Swedish forests.

3.2 Remote sensing

For this project two digital images over the municipality of Sjöbo were created using 33 5 x 5 km black and white aerial photos from lantmäteriet, and official forest and land use raster data from SLU and naturvårdsverket over the area covering the year 2018.

Interpreting black and white photos is more difficult than interpreting coloured images since different colour tones and hues can be good indicators for different land use types. Black and white photographs are more difficult to interpret as texture, shades, and other visible clues becomes harder to evaluate (Lillesand et al 2015).

An identification key was used to discern different types of land use in the 1957 and 1975 images. For this project a premade key from the Marktäckedata was used, which made it easier to relate information from 2018 to 1957 and 1975.

Three raster sets over Sweden, clipped to the size of Sjöbo were used in reference to interpretation. The first was a raster set over land use in Sweden. The other raster set was forest cover, and the last data set used was open pasture land (Naturvårdsverket 2018; Lantmäteriet 2019; SLU 2018).

The main focus during the interpretation of the 1957 and 1975 images was on areas where there had been open land, as seen on the aerial images, but are currently forested, shown by overlaying current forest data.

3.3 Digitizing

Digitizing is a spatial analyst feature in Esri ArcMap. To be able to digitize first an empty vector layer containing polygons was created. The aim of creating the maps were to differentiate between forests and open land, which are the two major land use types indicated on the maps, as well as how the presence of deciduous, coniferous, and mixed forests has evolved throughout the years.

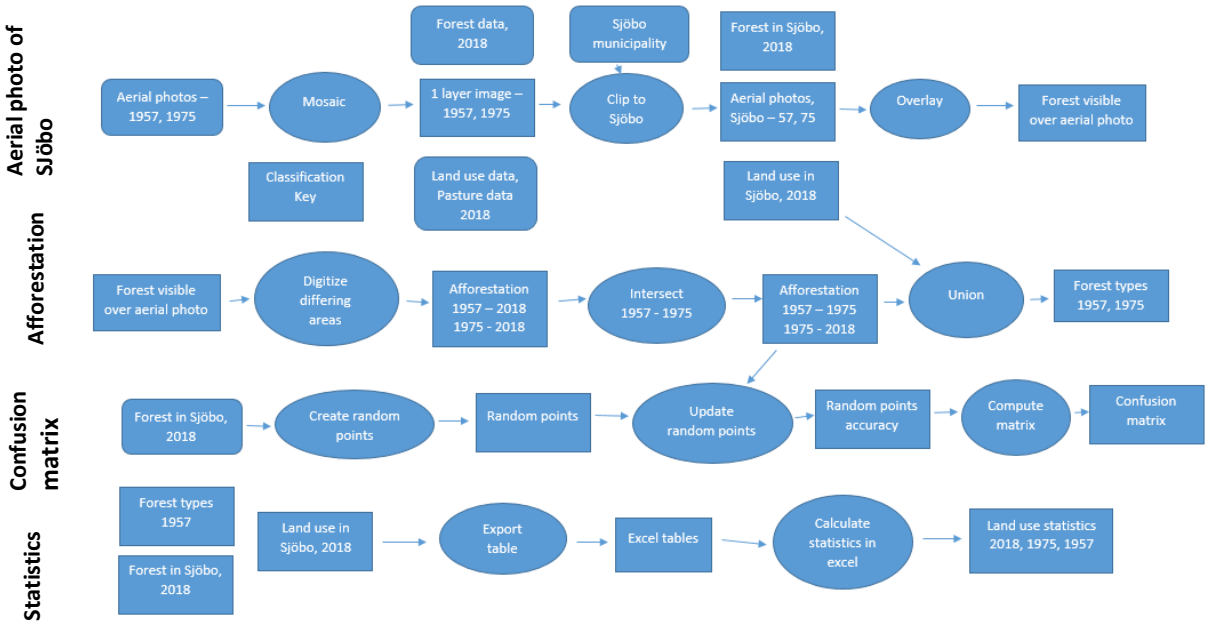

Figure 5 Flowchart of the image interpretation, digitizing, and analysis process of the 1957 and 1975 images

In order to create the maps, first the 5 x 5 km aerial images needed to be merged into one layer by using the mosaic feature in ArcMap. This created one layer for 1957 and one for 1975. Then the aerial photos as well as the land use raster and forest raster were clipped to the extent of Sjöbo municipality, creating historical photographs, forest extent, and land use in Sjöbo. These three layers were then laid over each other, with the aerial photo at the bottom. The two overlaying areas visibility were lowered to 50 % causing see through (figure 6). This caused the areas which differed in land use to be visible through the forest and land use layer. The areas were then digitised to the polygon layer created in the beginning. From the digitizing two data sets containing afforestation 1957 - 2018, and afforestation 1975 – 2018 polygons were created. In order to make a timeline, the data set based on 1957 was subtracted with the 1975 data layer with the function intersect. This created a timeline from 1957 – 1975, and 1975 – 2018.

Figure 6 Aerial photo layered with current forest data and pasture data.

To get the forest types for these two layers, the land use layer and forest layer were used and unionised with the afforestation layers. This resulted in information of the forest and land use layer to be "transferred" to the afforestation layers.

From these two sets three land use maps, apart from the two afforestation timeline maps over Sjöbo were created. Land use for 2018 used only relevant raster data – land use and forest use. These data layers were then reworked to fit the purpose of showing forests and open land, as seen in figure 4 – land use in Sjöbo, 2018. The 1957 map used data from 2018, 1957 and 1975, whereas land use for 1975 only used 2018, and 1975. In these maps, the afforested areas were shown as open land instead of forests, as they were open land at those times (figure 7; figure 11)

3.4 Statistics

The statistics were used from the attribute tables created in ArcMap, where they were transformed into excel documents (figure 5). In order to evaluate the maps a confusion matrix

over the digitized polygons for 1957 and 1975 was created using ArcMap as well. A function to create random stratified points for forest and open land with the ground truth being the forest cover in 2018 was created. These points were then updated with the classified points from the afforestation polygons. The number of random points were set to be 100.

This was then used to create confusion matrices for both 1957 and 1975. Important to note here is that the afforestation polygons do not take already forested areas into consideration, which creates a false matrix, and needs to be corrected for. This was done by overlaying the digitized polygons, the pasture raster, as well as the forest raster in order to exactly check how many points were in each category.

The finished confusion matrix (table 2; table 3) can be seen in the results section. The reference data is the ground truth, and the classification data is the digitized and classified areas. The table compare the two data sets against each other in order to visualise misclassifications. The producer's accuracy shows how well the pixels of the different land use types are classified. The user's accuracy shows commission of error – probability that a classified land use is classified to the correct land use. Overall accuracy shows the overall accuracy of the map, and Kappa indicates the extent of correctly classifications due to agreement, and not by chance agreement (Lillesand et al 2015).

4. Land use in Sweden and Sjöbo

This study is focused on land use in Sweden, mainly on forests and open land in the agricultural landscape. First the land use will be discussed in relation to the entire country and then specifically for the situation in the municipality of Sjöbo.

4.1 Forests in Sweden

Forests are important to the landscape. They help with cleaning the air, cleans the waters, and if managed right they help sequester carbon. In Sweden, the forest are also a large part of the Swedish economy and one of the main exportation (Forsberg 2012). According to the red-listing in Sweden almost half of all known species are in one way or another connected to the forest as a biotope, around 1 800 species use it as a key biotope, most of which are found in

old, protected forests. More intense management, over-growth, denser forests, and planted coniferous trees in southern Sweden are all examples of actions that affect the biodiversity in a negative way (Sandström 2015). Most of the replanting and newly afforested forests are monoculture coniferous forests, mainly spruce. This has happened at the expense of other forest types, such as deciduous forest in southern Sweden (Felton 2019).

The definition of a forest in Sweden is defined in the Swedish forest law and equals the one defined by the United Nations Food and Agriculture Organisation (FAO), which says "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not exclude land that is predominately under agricultural or urban land use" (Riksskogstaxeringen 2018). Forests in Sweden can also be defined as productive forest or unproductive forest. "For a forest to be a productive forest it must be able to produce 1 cubic meter wood per hectare and year. Unproductive forest is any forest that is not a productive forest" (SCB 2019).

According to the 2018 forest inventory in Sweden by the Swedish Agricultural University, the most common forest type is coniferous forest. In these are spruce and pine the dominat species, covering around 40% each, with spruce being more common than pine (Riksskogstaxeringen 2018). Coniferous forests are prefered due to the high timber production, as well as their ability to be processed into timber, pulp wood, and other viable products. They also tend to grow with one domintating top and puts less energy on creating branches, which increases the value of the processed goods (Hallsby 2013).

Deciduous forests in Sweden are mostly located in the southern parts of the country which has warmer altitudes (Riksskogstaxeringen 2018). Due the preference of coniferous forests, the deciduous forests has not been a priority in the Swedish forestry (Hallsby 2013). This has lead to different initiatives focusing on the importance of deciduous forests. These initiatives have started to gain some traction, with more deciduous and mixed forests being planted during more recent years (Skogsstyrelsen 2017).

According to statistics created by SLU in 2018, there has historically been a slight change in the forest areas (Riksskogstaxeringen 2018). This goes against what the newspapers said, where they claimed that the forest area has doubled (SVT 2016; Ottosson 2016). For the productive forest, in the beginning of 1900 to 1950 there was a minimal decrease of the productive forest

area, after which there has been a slight increase from around 1950 until today. Most of that arial increase can be seen between 1955 – 1970. In 1955 the productive forest area was 21.5 million ha, in 2015 this has increased by 5% to 22.7 million ha (SCB 2019). Today, that number has further increased to 23.5 million ha (Riksskogstaxeringen 2018). The volume of timber has increased from 1 658 million m^3 (1926) to 3 328 million m^3 (2015) (Riksskogstaxeringen, 2019)

There are a few different reasons for the increased growth. First and foremost old and sparse forests has been cut down to make way for younger and more healthy forests, increasing the biomass. The trees themselves grow slightly larger today and the amount of trees with a diameter of 45 cm or larger has for the entire country gone from 1 tree/hectare in 1985 to 2 trees/hectare in 2018. In southern Sweden statistics shows up to 7 trees/ha with a diameter of 45 cm or more (Riksskogstaxeringen 2018; SCB 2019). This caused the total increment to increase in the period 1956 – 2014, from 80 million m^3 to 120 million m^3 per year. This increase exceeds the total harvest during the same time period, wich has increased from 45 million m^3 to 85 million m^3 per year (Riksskogstaxeringen 2018). In the inventory for 2016 the authors raised the question how the forests and the forestry potentially could look in the future. According to a model the total standind volume could increase to 4900 million m^3 by the year 2100 (Riksskogstaxeringen 2016).

Another reason for the increased volume is increased growth caused by climate change and a rise in CO_2, in combination with a positive feedback cycle of carbon and nitrogen (Barichivich 2013; Zak, 2011). There has been different reports claiming that the northern hemisphere has become much greener in the last two decades (Barichivich 2013). The most greening has been happening in the northern boreal forests, where 56 % of the forest has seen some greening. This greening can be explained by an increase in LAI[3] (Chen 2006), as well as longer growing seasons (Barichivich 2013).

4.2 Forest in Sjöbo

In the municipality of Sjöbo the most common forest type is deciduous forest. Most forests grow in the northern, southern, and western parts of the municipality (figure 1). There are some

[3] LAI (leaf area index) is defined as the total area of one-sided leaves in relation to the ground beneath (Chen 2006)

areas with coniferous forests, and even fewer are the areas of mixed forests, which seems to be rather uncommon in the municipality(SLU 2018; Naturvårdsverket 2018).

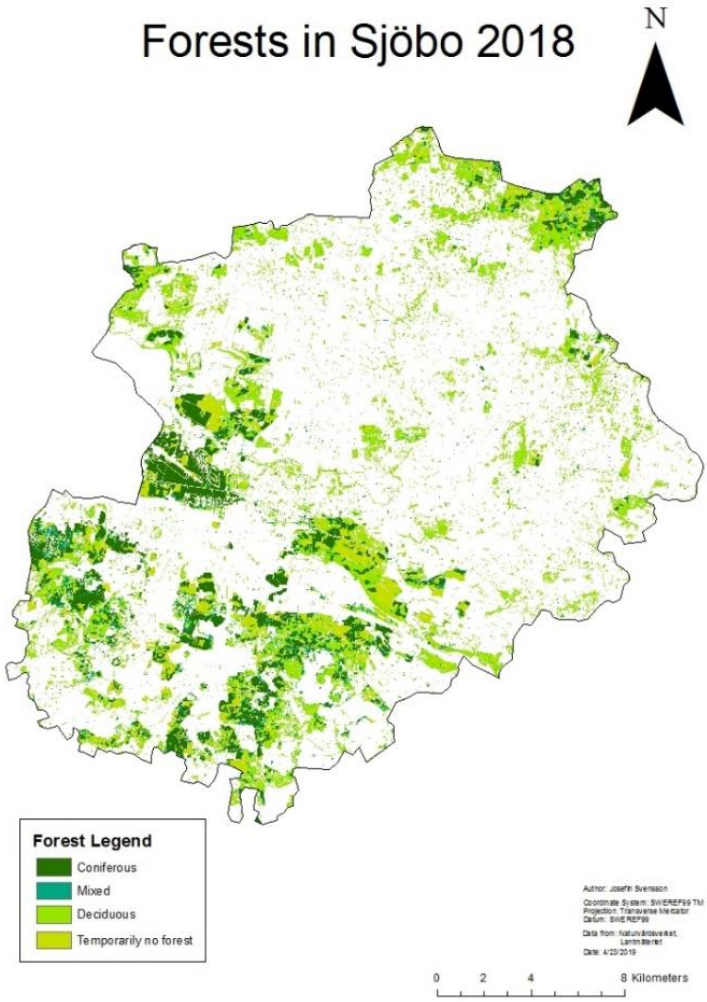

Figure 1 Map over the forest distribution in Sjöbo municipality 2018

Deciduous forests is by far the most common forest type in Sjöbo municipality in 2018 (7 000 ha), followed by coniferous forest (3 000 ha), and mixed forest (1 000 ha) (figure 2).

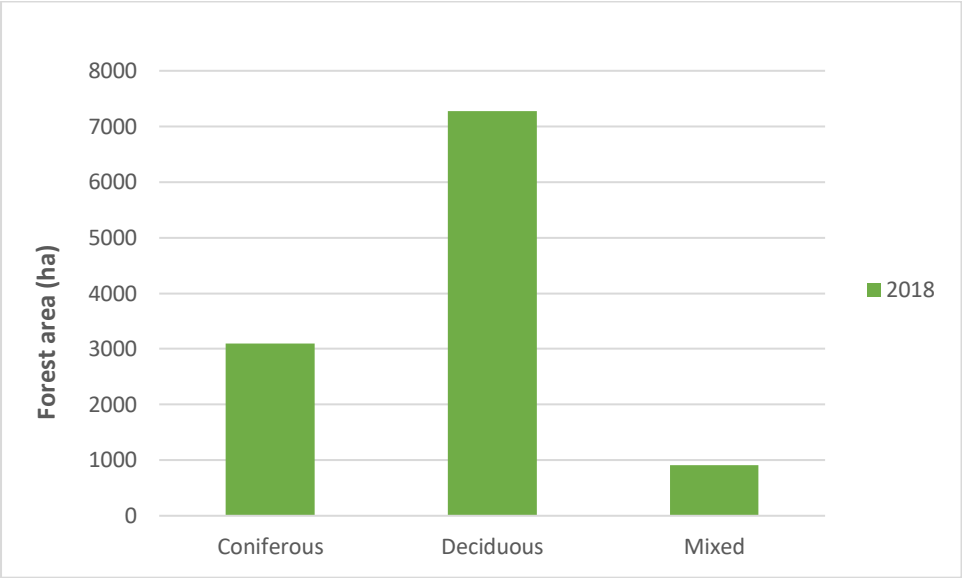

Figure 2 Distribution of forest type in Sjöbo municipality in 2018.

4.3 Open land

In this study open land is considered to be all areas that are not forests, or used for infrastructure. This includes arable land, pastures, meadows, and other types of open areas. The main focus will be on arable land and pastures/meadows.

4.3.1 Cropland

Categorised by the FAO as cropland and defined as "land used for cultivation of crops. The total of areas under "Arable land" and "Permanent crops". With "Arable land" they mean any type of cultivation where the lifespan of the crops are less than one year, with certain exceptions. These less-than one year lifespan are called "temporary" crops and includes cultivated land as well as land temporarily used for grazing or mowing. "Permanent crops" are crops with a long lifespan and do not need to be replanted that often, such as apple trees, or coffee beans (Keesstra et al. 2018).

In Sweden the amount of agricultural land is around 8% of the total area, 2.6 million hectares. Most of these areas are in the southern part of the country, with Scania having the largest fraction of agricultural land per county in Sweden (SCB 2019). According to a report done by

the Swedish agricultural agency, the area of fields and cultivation fields have decreased for a long period, at least since 1975 (Jordbruksverket 2018). On a nation-wide scale the loss is around 14% from 1975. The most common reason for loss of arable and agricultural land seems to be due to exploitation for building infrastructure, and expanding cities. Since 1951 until 2015 the amount of exploited cropland was 1 million hectares. The main reason being urbanization and the need for more houses, and various types of infrastructure (SCB 2019; Karlsson 2015).

Scania holds the best farmland in Sweden, and in 2015 17% of the total cropland in Sweden (Karlsson 2015). Even though the numbers are high in Scania the county has some of the largest loss of open land in the country with a loss of nearly 60 000 ha (10%) since 1975 (Karlsson, 2015).

4.3.2 Cropland in Sjöbo

In Sjöbo the area of agricultural land was 26 391 ha (53%) back in 2014 (SCB 2019). The major land use in the municipality is cropland. Most of the croplands are situated in the north and towards the east in the municipality. There are also cropland towards the south, but it is more of a mixed landscape with forests and pastures mixed in as well (figure 3) (Naturvårdsverket 2018; SLU 2018).

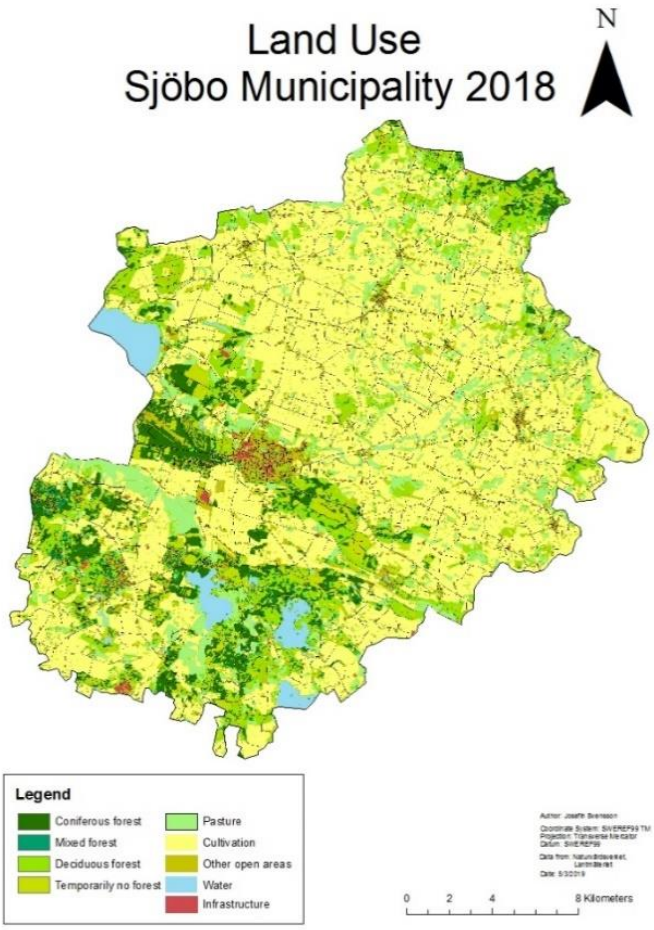

Figure 3 Land use in Sjöbo municipality 2018 (Naturvårdsverket 2018; SLU 2018).

4.3.3 Pastures & Meadows in Sweden

Pastures are defined as "Agricultural land not suitable for ploughing and are used for grazing, with grass, herbs, or sly used for food. Includes alvar-grazing, some of the chalet pastures that are not covered with forest. Forests are not included as pastures", and meadows as "Agricultural land that are not use as cropland and are used during the late summer as forage. The forages are to be covered by grass, herbs, or claimed heather. Meadows are included in pastures" (SCB 2019).

Pastures are linked to important ecological aspects, such as a high biodiversity, carbon sequestration, food production from otherwise unusable land, and recreational use (Maller, 2006; Keesstra, 2018). Pastures and meadows hold a large part of the Swedish flora and fauna. Half of all red-listed species in Sweden use pastures, and around 1/3 are dependent on pastures for survival (Sandström 2015).

The total amount of pastures for Sweden in 2018 is 455 100 ha which is 2 000 ha more than it was 2017 (Olsson 2018). Even though the area of pastures and meadows has had a positive growth during the last years, the overall development is negative. In 1881 when Jordbruksverket started their statistics concerning pastures and meadows they accounted for over 1.6 million hectares. In those days the most common practise was to let animals graze in partly forested land further away from the farms, using meadows and forages for food during the winter. In 2013 the amount of forages reached only 8 000 ha. During in the 60's to the 80's the pastures became obsolete. Croplands started to become productive enough to feed the animals, and the price for pastures sank as a response (Karlsson 2013). This increase in crops could have been due to the final stages of the agricultural industrialisation in Sweden, when the final working horses disappeared during 50's, although this pace was different for different parts in Sweden, some were fast in changing, while others only did it when absolutely necessary. Tractors started to become common, as well as other machines such as combine harvester. What would have taken days to harvest before the industrialisation could now only take hours making the entire process more effective (Borg 2004). It was not until later that the cultural, biological, and recreational values of open areas such as pastures was understood, creating an uplift for pastures (Karlsson 2013).

4.3.4 Pastures and Meadows in Sjöbo

The pastures are relatively evenly distributed all over the municipality. Most of them are however, concentrated to the southern and north-eastern parts of the municipality (figure 4). The land use map (figure 3) shows that most of the pastures are surrounded by crops, with some pastures being connected to the forests.

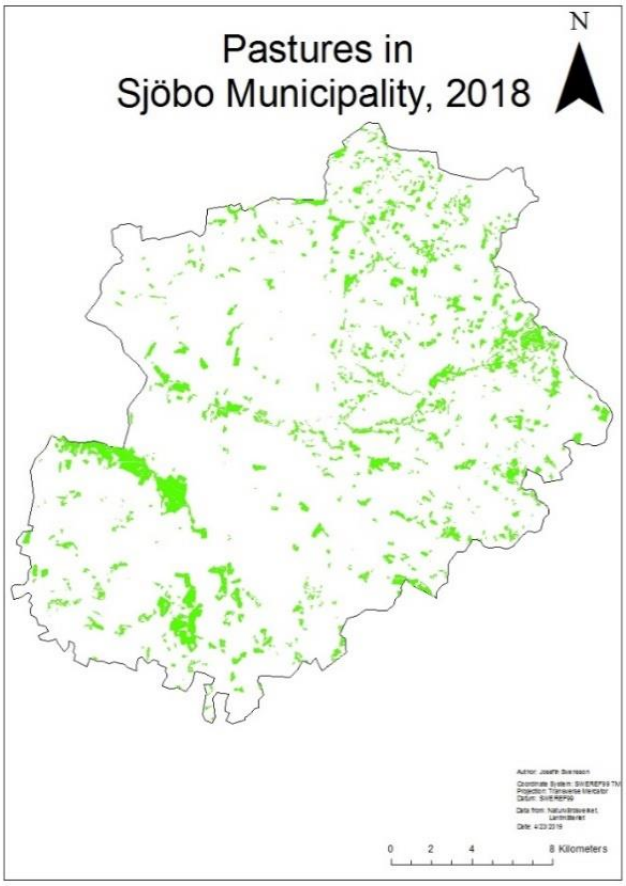

Figure 4 Area of pastures in Sjöbo municipality in 2018

4.4 Agricultural land use changes

The land use and landscape is ever-changing. The landscape we see today is a result from different time periods with their own economic and political landscape, as well as new techniques and management concerning the agriculture in Sweden (Ihse 1995). The focus in this section is on changes in the open land, but also related changes in the forest will be explained. The drivers behind the evolving landscape, as well as what the risks related to these changes could be will be examined.

4.4.1 Loss of Open land

The reasons for changes in the open landscape, as well as the loss of pastures are many. The main reason is the development of efficiency in the agriculture. A higher efficiency has

resulted in larger areas, where smaller fields are aggregated into larger fields, as well as pastures being ploughed up in order to plant crops (Ihse 1995).

The main threats to these areas and their biotopes are according to artdatabanken afforestation and overgrowth (Sandström 2015). The reason why so many species are threatened by extinction in Sweden is due to reduced open lands, and specifically the major loss of natural grazing areas. This could lead to plenty of the red-listed species in Sweden (of which 1/3 are dependent on pasture land, and plenty others prefers mosaic landscapes) becoming extinct. Sweden has 21 600 confirmed species, of which over 4 000 are red-listed and 2 000 are threatened (Sandström 2015).

As explained in the introduction the amount of open land, specifically pastures and meadows has been declining since, at least, the end of the 1800's (Karlsson 2013). During the 1930's grazing habits for cattle in Sweden changed. Before this change cattle used to graze in forests and on outlands, further away from the farms. This change caused some of the previously grazed areas to become abandoned or afforested, the reduced number of animals leading to a further loss of pastures and meadows (Westin 2006). The amount of animals in the Swedish agriculture has decreased significantly. The only animal type which historically has increased is sheep, although during recent years they have also started to decline (Jordbruksverket 2018).

The receding presence of animals in the landscape does not only affect pastures and meadows as a land use type, but also the self-reliance of food in Sweden. With loss in both pastures and crop lands the Swedish self-reliance on food has seen a major turn for the worse. In 1988 the self-reliance was calculated to have been 75 percent, today that number is only 50 percent (LRF 2019; Sveriges radio 2017). Some claim that this number is wrong and potentially even lower, especially in case for emergency (Bergström 2015). Most agree on the importance of increasing food production in Sweden in order to secure food supply, especially during emergencies (Sveriges radio 2017), as well as a way to lower the carbon footprint. This can be achieved by clearing up more pastures and let more animals into the landscape again as they can graze on areas which are not suitable for crops, which would strengthen the Swedish food production, as well as help the national nature goals "A rich and varied plant- and animal life", and "a rich agricultural landscape" (Wallman, 2013).

Another possible effect is that the cultural and historical values will be threatened. As the population in Sweden has been dependent on grazing animals for a long time, these types of areas have been shaped by both humans and nature. These areas therefore hold a historical value also, not only for the biodiversity. This can be explained as biological - cultural heritage, which is exactly as it sounds, a cultural heritage shown through nature and biology, not to be mixed up with biodiversity. Humans, as all living things on this planet are dependent on nature, and thus, *Homo sapiens* has always used nature in one way or another. This relationship has been going on for a long time and can be seen in the landscape, sometimes vaguely, other times the presence of humans and human activities are strong (Riksantikvarieämbetet 2014). There seems to be a notion that any and all human influence on nature is bad and wrong, this is simply not true. There are plenty of biotopes which has greatly benefited from human interaction. Pastures and meadows, for example, have benefited from grazing throughout the years, especially if the grazing has been going on for a long time without interruptions, thus establishing a rich biotope (Nilsson 2009). A large part of Sweden's history is also located on the countryside, as ancient monuments, such as rune stones, ruins, signs of settlements, old graves, stone hedges, amongst many other historical features. These areas used to be taken care of by grazing animals foraging the meadows and hindering overgrowth. Today, with a different, larger and more intense agriculture this has greatly reduced the maintenance of these sites, leaving them to be destroyed, either by overgrowth or afforestation (Riksantikvarieämbetet 2017).

4.4.2 Policy regarding land use changes

Changing land use today, or even restoration is not that straight forward. Due to the environmental goal "A Rich Farmland" a lot of elements in the landscape are to be spared, especially those linked to cultural biology (Jordbruksverket 2019).

When the land usage changes, or if the production is laid off the intended area must be taken out of production (Jordbruksverket 2019; Naturvårdsverket 2018). This might happen if a forest is to be planted on pastures or croplands, or farmland is being used for building infrastructures (Naturvårdsverket 2018).

In order to take land out of production the county government must be notified of intentions. The notice must include: owner/owners of the land – as well as contact information, which municipality the area is situated in, the intended areal, what the new usage will be, for possible tree plantation – the tree species that will be planted, information regarding eventual conservation, relics, or other cultural values that are present on the area, which year the land will be taken out of production, and a map over the area where any and all relevant information is noted (Jordbruksverket 2019). The earliest the land can be taken out of production is eight months after the notice. It can be taken out earlier, but the reasons needs to be stated in the notice (Jordbruksverket 2019; Naturvårdsverket 2018).
There are exceptions to this, such as planting Christmas trees on crop fields – as Christmas trees are seen as a type of crop. However, if the plantation are on a pasture or meadow then the notice must be sent in (Naturvårdsverket 2018).

5. Land use in Sjöbo 1957 - 1975

1957 - 1975

In 1957 the most common land use type was open land, mainly arable (figure 7). Most of the forests can be seen in the northern and southern part, and near the waters in the municipality. There seems to be a small band of mostly open areas going from NW towards SE. The total amount of forests in the municipality in 1957 was calculated to have been 10 513 ha, which is 21% of the total land area in the municipality.

In the afforestation map covering 57 – 75 (figure 8), most of the afforestation can be seen in the southern parts of the municipality, as well as towards west. From 1957 to 1975 the forest has increased by 946 ha, this was an increase of 52.6 ha/yr. The total increase covers 3% of the open land area, and 2% of the total land area (table 1).

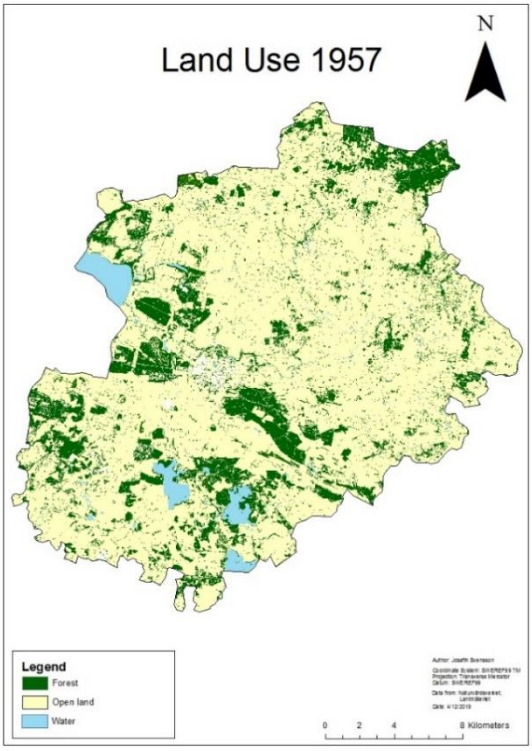

Figure 7 Land use in Sjöbo municipality 1957

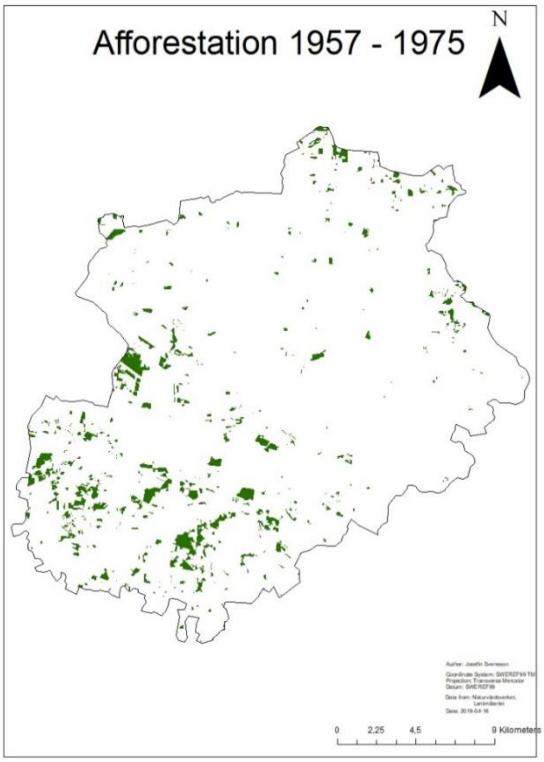

Figure 8 Afforestation in Sjöbo municipality 1957 – 1975

The most common forest type back in 1957 was deciduous forest by a large marginal. The difference between deciduous and coniferous areas was around 5 000 ha at this time. The mixed forests were barely present, less than 100 ha mixed forest existed in 1957 (figure 19).

Table 1 Statistics over the relationship between forests and open land in Sjöbo

	1957	1975	2018
Total area (ha)	50895	50895	50895
Forest area (ha)	10513	11459	13353
Percent	21	23	26
Afforested area (ha)	946	1894	-
Afforestation/year (ha)	53	44	-
Percent of open land	3	5	-
Percent of total land	2	4	-

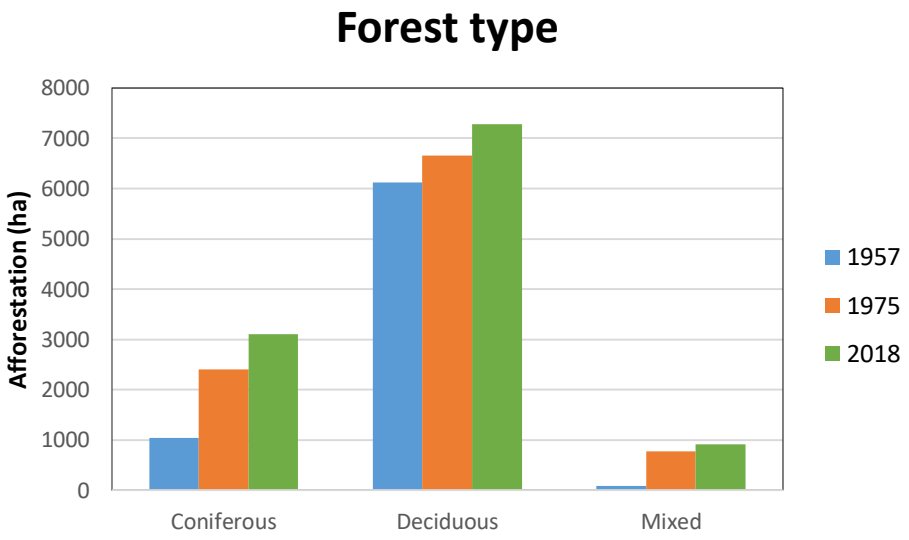

Figure 9 Forest types in Sjöbo throught the years

The confusion matrix over the afforestation map 1957 - 1975 shows that both the producer's accuracy and the user's accuracy are reasonable good, with the exception of the producer's accuracy for forest which only reach 65. The overall accuracy reaches 88% with a Kappa of 69 (table 2).

What more can be seen is that the accuracy for the user is more stable with both the accuracy for the open land and the forest being around a marginal of ten. Producer's accuracy are more unstable as the accuracy for open land reach 99 while the forest only reach 65.

Table 2 Confusion matrix for the afforestation 1957- 1975

	Open land	Forest	Total	User's Accuracy
Open land	68	11	79	86
Forest	1	20	21	95
Total	69	31	100	-
Producer's Accuracy	99	65	-	-
Overall Accuracy (%)	88			
Kappa	69			

In this time period the most common planted forest type was deciduous forest, reaching almost 700 ha. Over 500 ha of coniferous forests was also being planted in this duration. Planting mixed forests is not overly common, only around 150 Ha mixed forest was planted (figure 10).

1975 – 2018

The increased forest area can be seen all over the municipality where forest is a common land use type. There has been a slight increase of forests in the entire municipality, but mainly towards the edges of Sjöbo (figure 11).

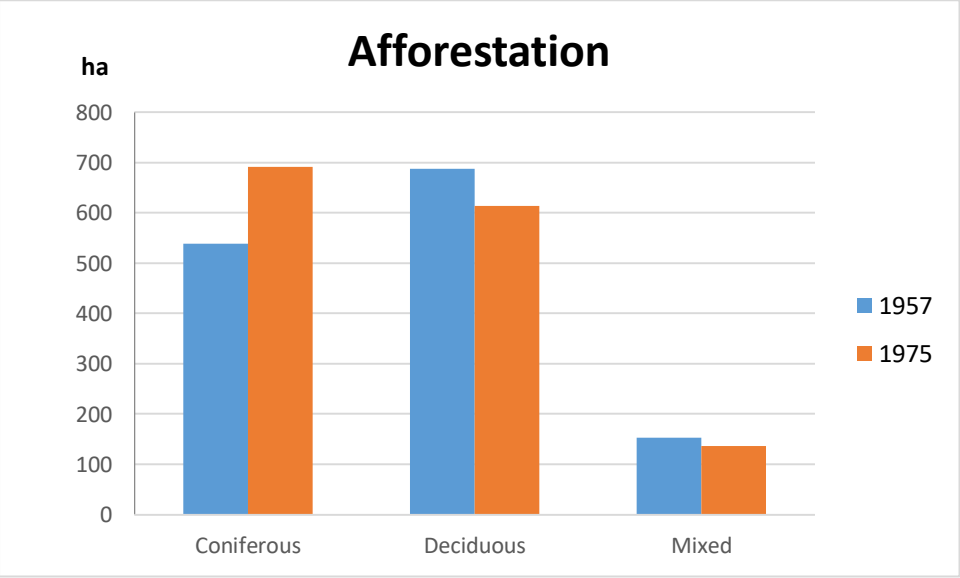

Figure 10 Statistics of which forest types used for afforestation in 1957 and 1975

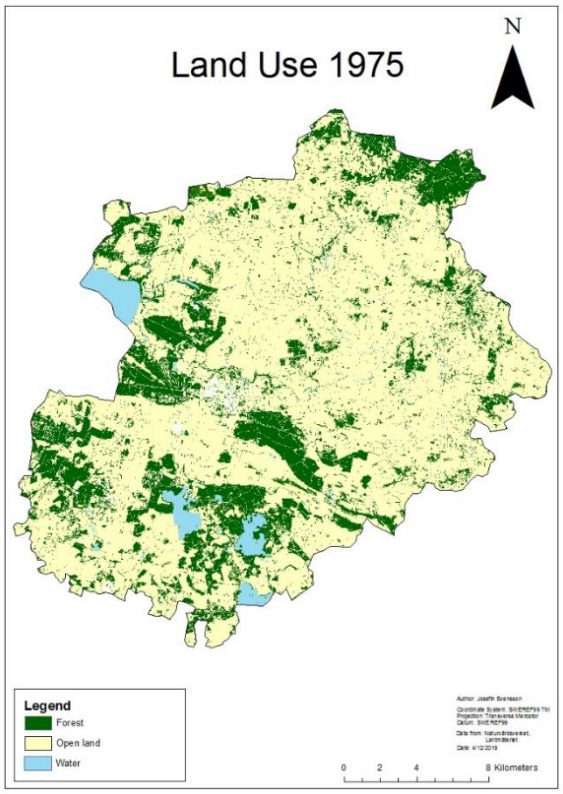

Figure 11 Land use Sjöbo municipality 1975

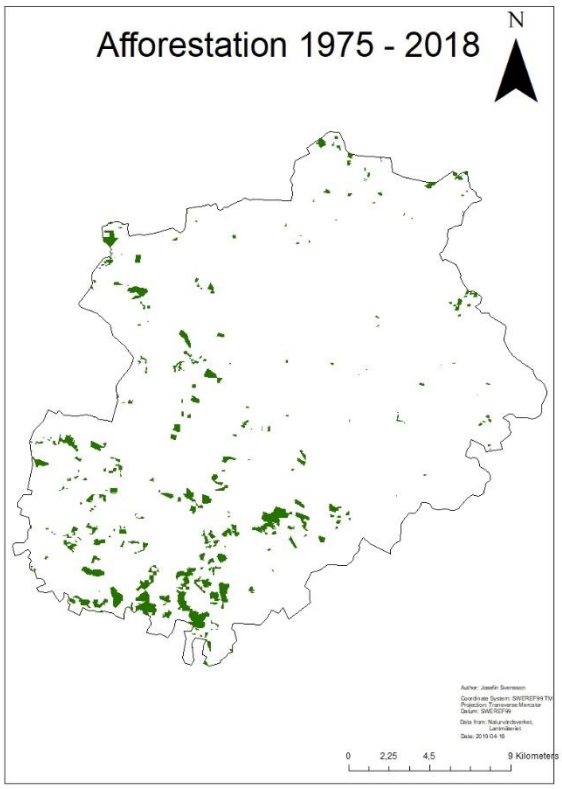

Figure 12 Afforestation Sjöbo municipality 1975 - 2018

In the afforestation map for the years 1975 – 2018 most of the afforestation seems to be happening in the southern and middle parts of the municipality, with some small new forests growing in the north (figure 12). The afforested area has now increased to 1894 ha (table 2), 17% of the total forest in the municipality, and an increase by 4% of the total area.

In the 70's the coniferous trees had a large upswing. In a 20 year window more than 1 000 ha were planted with coniferous trees, while almost only 500 ha deciduous trees were planted in the same time period. The mixed forests have got a small increase as well, being well over 500 ha at this point, but is still not common in the municipality (figure 19).

For the 1975 - 2018 period the tree type used for afforestation has changed a bit. What has mostly been planted is coniferous types of trees, around 700 ha. An increase by 200 ha from 1957 – 1975. Areas planted with deciduous trees has declined 100 ha between 1975 and 2018 in comparison with the previous time period where the area was around 700 ha. The mixed afforestation forest area is stable and continue to reach around 150 ha (Figure 10).

For the latest year, 2018 the forest has reached 13553 ha, which is equal to 26 % of the total area in the municipality (table 2).

The confusion matrix for the time period 1975 – 2018 shows that both the producer's accuracy and the user's accuracy are extremely good (table 3). The lowest accuracy is, again, the producer's accuracy for forests with 81%. The overall accuracy is 94% with a Kappa of 85.

Table 3 Confusion matrix for the afforestation 1975 - 2018

	Open land	Forest	Total	Users's Accuracy
Open land	69	6	75	92
Forest	0	25	25	100
Total	69	31	100	-
Producer's Accuracy	100	81	-	-
Overall Accuracy (%)	94			
Kappa	85			

6. Discussion

From what can be seen in the timeline over Sjöbo municipality, both from the land use series and the afforestation maps it is evident that there has been an afforestation of open land in the area. The overall afforestation between 1975 and 2018 was slightly larger than between 1957 – 1975. The most probable explanation for this is due to the larger time gap in the second time period. However, the yearly afforestation shows (table 1) that the period 1957 – 1975 had a higher afforestation rate (53 ha/year) than 1975-2018 (44 ha/year). This match the statistics gathered by SLU, where most of the planting in Sweden happened around 1969 to 1970 (riksskogstaxeringen 2016).

In 1957 – 1975 the most common tree type to be planted was various deciduous trees, the reason for this is unclear, as most data found have supported coniferous forest plantations. It would therefore suggest that at least some of this afforestation is due to abandoned pastures growing uncontrolled into forests. This changed between 1975 and 2018 where the most planted type was coniferous, showing the growing popularity of spruce (pine as well) as a reliable tree with many advantages over planting and managing deciduous trees. Deciduous trees are still being planted (or by natural afforestation), although not at the same rate as it was between 1957 and 1975. It also shows that coniferous forests are becoming more popular in the south as well. Overall from 1957 until 2018 it is evident that there has been afforestation going on in the municipality, with more coniferous trees being planted in more recent years. The drivers of these seems to be correlated with what Göran Ericsson has said, less animals might lead to previously grazed areas, or other open areas to become afforested (Ericsson 2016).

In the entire Sweden there is no large afforestation going on in the most recent years. What has been reported by the news articles as a doubling of the forest area, is actually a growing intensity of the forest management, by being planted denser plantation as well as lengthening the rotation periods for the forests, which has resulted in more and larger trees per hectare than before (Riksskogstaxeringen 2018). This is also an effect of changing grazing habits, where cows used to graze in the forests and on outlands, leading to sparser forests and open areas (Karlsson 2013). In combination with the agricultural industrialisation with tractors and machines, this led to formerly grazed areas being abandoned. The farmers then started to afforest previously open areas, plant trees tighter in already forested areas, as to get a higher

economic return. At some point the agriculture and the forestry departed from each other creating two "branches" of what used to be one. This greatly shifted the way the forests and the open landscape interacted with each other and might have led farm owners to plant previously open areas with forest (Borg 2004).

The effects of increased and denser forests also depend on which forest type is planted and where. Forest damage due to storms is higher today than before. This is due to the forests becoming more dense and older. Large coniferous forests are also more prone to storm damage than mixed forests since coniferous tree types are less robust and stable in comparison to deciduous tree types. After the storm Gudrun 75 million m^3 forest was damaged (SMHI 2009). Planting coniferous forests in Scania can threaten the extent of deciduous trees in the area, and decrease the biodiversity values. However, if mixed forests are planted more sparsely this could instead help to increase the natural values and biodiversity in the area (Sandström 2015)

The afforestation usually happened on different types of open landscapes such as croplands or pastures. Afforesting today is more difficult than before. If a private owner want to plant a forest on an area such as a pasture, a notice would have to be sent in to the local authorities. This notice should state when and where the change to be taken place, and what type of change is going to take place – including specific species for forest planting. Information regarding nature values or cultural values needs to be sent in as well. If local authorities deem the area of land to have large natural values then they can deny production removal on that specific land, leading to the farmers being required to leave that plot of land as it is, or possibly having it become protected areas (Naturvårdsverket 2018; Jordbruksverket 2019).

The main threat for pastures (or other open land) is therefore not afforestation, as there is plenty of regulations governing changes of land use, as well as no clear indicator of afforestation going on in Sweden today. The main threat would therefore be abandonment and overgrowth of previously grazed areas, especially tree covered pastures, due to the reduced presence of cattle in Sweden as well as changed grazing methods. A meadow or pasture that has been abandoned will overgrow, and can overgrow to the point that the shrub can grow up to small trees, leading to loss of biodiversity and other cultural values.

The reliability of the afforestation maps can be seen in the confusion matrices created to verify the identifications (table 2 and 3). The overall accuracies of the matrices are 94% (1975), and 88% (1957) respectively. These are both rather high percentages and indicates that the maps are reliable in terms of where the afforestation has been ongoing in the municipality. The Kappas are also high which strengthens the notion of the classification being truthful rather than lucky. The area that has been problematic is the producer's accuracy for forest. That was the lowest accuracy for both 1975 and 1957, indicating that there are some problems in identifying that specific land use type.

The reason why the years 1957, 1975, and 2018 were chosen is because 2018 is the latest year with data available over Sweden, compiled by Naturvårdsverket making the extraction of data easy. 1957 and 1975 were chosen due to being the years when Sjöbo was being photographed from air with the reference years 1960 and 1975 in Sweden. To make the report more reliable another date around 1990 should have been chosen as well, creating a time difference of 15 – 20 years between the different maps. However, including 1990 would have required the use of landsat data, which is different from the other two data sets. This could have resulted in miss-calculations when dealing with two different data sets.

Another issue is the inability to separate crop land with pastures in the old black and white photographs. This causes the afforestation rate of either cropland or pastures to be unknown, causing one important aspect of the work to not be properly researched. This could potentially be resolved by doing the photo interpretations manually and not digitally.

This project would have greatly benefitted from an excursion to Sjöbo municipality in order to become more accustomed to the area and the nature there. However, due to the time-limit for this project it was decided that an excursion might have set back this project too much in regard of available time.

As this is a well-studied area, this project has not found out any new information. However, for the future more emphasis on cultural biology might be important, especially if we want to preserve those values for the future.

7. Conclusion

In Sjöbo municipality the afforestation that has been going on during the last 60 years is visible. Most of it was planted between 1975 and 2018, which is understandable due to the larger time gap in that period. The preferred forest type for planting in the municipality has shifted, going from deciduous to coniferous forest. The confusion matrices shows high overall accuracy and Kappa, indicating that the maps are correctly classified and relevant.

The area of forest in Sweden is overall stagnant at the moment with small changes. Most of the afforestation took place during the 50's to the 70's, leading to a visible increase of the forest area in Sweden. Today no such afforestation is on-going. The main difference and why it has been claimed that the Swedish forests are increasing, are due to the forests becoming denser as a result of intensified forest management.

8. References

ATL. 2015. Sveriges självförsörjningsgrad är 0. *ATL*.

Barichivich, J., K. R. Briffa, R. B. Myneni, T. J. Osborn, T. M. Melvin, P. Ciais, S. Piao, and C. Tucker. 2013. Large-scale variations in the vegetation growing season and annual cycle of atmospheric CO2 at high northern latitudes from 1950 to 2011. *Global Change Biology,* 19**:** 3167-3183. DOI: 10.1111/gcb.12283

Borg, H., and C. Olsson. 2004. Jordbrukets industrialisering

Clement, F., D. Orange, M. Williams, C. Mulley, and M. Epprecht. 2009. Drivers of afforestation in Northern Vietnam: assessing local variations using geographically weighted regression. *Applied Geography*, *29:*4 561-576. DOI: 10.1016/j.apgeog.2009.01.003

Ericsson, G. 2016. Europas skogar breder ut sig allt mer. https://internt.slu.se/nyheter-originalen/2016/12/europas-skogar-breder-ut-sig-allt-mer/

Felton, A., M. Lindbladh, J. Brunet, and Ö. Fritz. 2019. Replacing coniferous monocultures with mixed-species production stands: An assessment of the potential benefits for forest biodiversity in northern Europe. *Forest Ecology and Management,* 260**:** 939-947. DOI: 10.1016/j.foreco.2010.06.011

Forest Europe. 1990. General Declaration. Ministerial Conference for the Protection of Forests in Europe. Strasbourge/France. *European Union.*

Forest Europe, 2015. State of Europe's Forests. Ministerial Conference on the Protection of Forests in Europe. *FOREST EUROPE*. Liaison Unit Madrid. Report. [in Swedish, English summary]

Forsberg, M. 2012. Skogen som livsmiljö - En rättsvetenskaplig studie om skyddet för biologisk mångfald. PhD Thesis Uppsala University

Hallsby, G., 2013. Skogsskötsleserien - Plantering av barrträd. *Skogsstyrelsen.*

Ihse, M. 1995. Swedish agricultural landscapes — patterns and changes during the last 50 years, studied by aerial photos. *Landscape and Urban Planning*, 31:1-3 21-37. DOI 10.1016/0169-2046(94)01033-5

Jordbruksverket. Regler för hänsyn till natur- och kulturmiljöer. Retrieved 05-08 2019, from http://www.jordbruksverket.se/amnesomraden/miljoklimat/ettriktodlingslandskap/hansyntillnaturochkulturmiljoer.4.37e9ac46144f41921cd21624.html.

Jordbruksverket. 2018. Lantbrukets djur- juni 2018. ed. Jordbruksverket.

Karlsson, A.-M. 2013. Utvecklingen av ängs-och betesmarker 1890-2013. Retrieved 05-04 2019, from

Karlsson, A.-M. 2015. Basfakta: Jordbruket i Skåne län. Retrieved 05-05 2019, from https://jordbruketisiffror.wordpress.com/2015/10/20/basfakta-jordbruket-i-skane-lan/.

Keesstra, S., J. Nunes, A. Novara, D. Finger, D. Avelar, Z. Kalantari, and A. Cerda. 2018. The superior effect of nature based solutions in land management for enhancing ecosystem services. *Science of the Total Environment,* 610**:** 997-1009. DOI: 10.1016/j.scitotenv.2017.08.077

Klarin G. 2016. Europas skogar breder ut sig allt mer. *Sveriges Radio*.

Karlsson, L., J. Wallander. 2018. Ett rikt odlingslandskap - Fördjupad utvärdering 2019 Report. [in Swedish, English summary]

LRF. Självförsörjning. Retrieved 05-11 2019, from https://www.lrf.se/politikochpaverkan/foretagarvillkor-och-konkurrenskraft/nationell-livsmedelsstrategi/sjalvforsorjning/.

Maller, C., M. Townsend, A. Pryor, P. Brown, and L. S. Leger. 2006. Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International,* 21**:** 45 - 54. DOI: 10.1093/heapro/dai032

Naturvårdsverket. Samråd vid ändring av markanvändning på jordbruksmark. Retrieved 05-08 2019, from https://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledningar/Samhallsplanering/Samrad-vid-andring-av-markanvandning-pa-jordbruksmark/#omvandla.

Nilsson, F. O. L. 2009. Biodiversity on Swedish pastures: Estimating biodiversity production costs. *Journal of Environmental Management,* 90**:** 131-143. DOI: 10.1016/j.jenvman.2007.08.015

Olsson, Y. 2018. Priser på jordbruksmark 2017. *Jordbruksverket.* ISSN: 1654-4072 (Online)

Osterman, E. N., and J. Tufvesson, 2016. NATUR I SJÖBO: GRÖNSTRUKTUR- OCH NATURVÅRDSPROGRAM FÖR SJÖBO KOMMUN. Lokala naturvårdssatsningen. *Sjöbo kommun.*

Piao, S., P. Friedlingstein, P. Ciais, L. Zhou, and A. Chen. 2006. Effect of climate and CO2 changes on the greening of the Northern Hemisphere over the past two decades. *Geophysical Research Letters*, 33. DOI: 10.1029/2006GL028205

Göterborgs Posten. 2016. Svensk skog allt tätare. *Göteborgs posten*.

Riksantikvarieämbetet, 2014. Biologiskt kulturarv – växande historia. *Riksantikvarieämbetet* ISBN: 978-91-7209-687-5

Riksantikvarieämbetet. 2017. Fornvård. Retrieved 05-10 2019. From https://www.raa.se/kulturarv/landskap/fornminnesvard/

Riksskogstaxeringen, 2016. Skogsdata 2016. Umeå. Instutitionen för skoglig resurshållning. *SLU*. Report. [in Swedish, English summary]

Riksskogstaxeringen, 2018. Skogsdata 2018. Umeå. Instutitionen för skoglig resurshållning. *SLU*. Report. [in Swedish, English summary]

Sandström, J., U. Bjelke, T. Carlberg, and S. Sundberg, 2015. Tillstånd och trender för arter och deras livsmiljöer– rödlistade arter i Sverige 2015. Artdatabanken. *SLU*. Report. [in Swedish, English summary]

SCB, 2019. Markanvändningen i Sverige. 7:th edition. Statistics Sweden, Regions and Environment Department. *SCB*. Report. [in Swedish, English summary].

Svanström, S. 2015. Urbanisering - från land till stad. Retrieved, from https://www.scb.se/hitta-statistik/artiklar/2015/Urbanisering--fran-land-till-stad/.

Sveriges Radio. 2017. Kan Sverige bli självförsörjande på mat igen? *Sveriges radio*.

SVT. 2016. Svensk skog breder ut sig allt mer. *SVT*.

United Nations. 1992. REPORT OF THE UNITED NATIONS CONFERENCE ON ENVIRONMENT AND DEVELOPMENT. *United Nations.*

Westin, A., and S. A. O. Cousins. 2006. The History (1620-2003) of Land Use, People and Livestock, and the Relationship to Present Plant Species Diversity in a Rural Landscape in Sweden. *Environment and History*, 12**:** 191-212. DOI: 10.3197/096734006776680218

Wallström, Y. Natur och friluftsliv. Retrieved 05-11 2019, from https://www.sjobo.se/uppleva-och-gora/natur-och-friluftsliv.html.