



***Vicia sepium* – Breed or Weed?**

Introducing a native legume for Swedish leys

Malin Johansson

Independent project • 15 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences
Agriculture Programme Soil and Plant Science
Uppsala 2024



Vicia sepium – Breed or weed?

– Introducing a native legume for Swedish leys

Häckvicker – Odlas eller ogräs? – upptäcka en inhemsk baljväxt för svenska vallar

Malin Johansson

Supervisor:	David Parsons, Swedish University of Agricultural Sciences, SLU, Dept. of Crop Production Ecology.
Assistant supervisor:	Brooke Micke, Swedish University of Agricultural Sciences, SLU, Dept. of Crop Production Ecology
Examiner:	Nilla Nilsson-Linde, Swedish University of Agricultural Sciences, SLU, Dept. of Crop Production Ecology; Agricultural cropping systems
Credits:	15 credits
Level:	First cycle, G2E
Course title:	Independent project in Biology
Course code:	EX0894
Programme/education:	Agriculture Programme – Soil and Plant Sciences
Course coordinating dept.	Department of Aquatic Science and Assessment
Place of publication:	Uppsala
Year of publication:	2024
Cover picture:	Character Flora holding <i>Vicia</i> ssp., Illustration by Kristina Digman
Copyright:	All featured images are used with permission from the copyright owner
Keywords:	Agrobiodiversity, crop history, native perennial legume, sustainable grassland production

Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences

Department of Crop Production Ecology

Abstract

Introducing native legumes in grassland production systems in northern Sweden can maybe be a sustainable way to produce forage. This thesis examined whether the native perennial legume *Vicia sepium* L. would be suitable to introduce in forage production as a way of diversifying species composition used in leys. Two objectives were examined. The first objective focused on Swedish ethnobotanical history of *V. sepium*, encircling information on previous use and experience of this species as a crop. The second objective was to observe the range of natural environments in which *V. sepium* grows, focusing on the province of Jämtland, Sweden. Site characteristics and management of 15 randomly selected wild growth locations of *V. sepium* were noted, along with observations of the plant community. Soil samples were taken for analysis of soil texture, chemistry, and biology.

The results examining historical sources showed that already from the 18th century and onward, *V. sepium* was considered a good crop with many desirable qualities, such as palatability and durability when established. Up until the mid-20th century it was investigated in field trials on a modest scale and seed collected by farmers were traded to a limited degree. Nevertheless, *V. sepium* was considered a well-known and strong candidate for fodder production when Sweden scouted the Swedish flora for quality crops. Due to small scale production and wild traits, *V. sepium* was outcompeted by more easily accessible species. These other species entered from abroad and had reached further in breeding programmes.

Observations of the natural environments of *V. sepium* present this legume enjoying a quite wide range of habitats. It grows in lighter soils with a large diversity of species, as well as in habitats ranging from grassland to more shaded forest areas. It also handles disturbances well, seemingly with a fast regrowth if the growth site is cut.

Hence, introducing *V. sepium* in today's forage production could be viable. It could support sustainable farming methods as the species suppress weed and show durability. Thus lessening the need of frequent tillage. It could also enhance sustainable farming methods by supporting ecosystem services such as pollination. Wider embracing of native perennial legumes such as *V. sepium* will require commitment from the seed production industry for seed production and distribution.

Keywords: Agrobiodiversity, crop history, native perennial legume, sustainable grassland production

Table of contents

1.	Introduction	6
1.1	Background	6
1.1.1	Introducing <i>Vicia sepium</i>	7
1.2	Purpose, question, and delimitations	8
1.2.1	Objective 1: Rediscover <i>V. sepium</i>	8
1.2.2	Objective 2: Describing a natural environment.....	9
1.2.3	Delimitations	9
2.	Rediscovering <i>Vicia sepium</i> through Swedish agrarian history	11
2.1	Historic mapping of native legumes for grassland production	11
2.2	Field trials.....	13
2.3	Early trade with seed from native plants.....	14
2.4	Challenges for native legumes to enter early breeding programmes	16
3.	Field observation of <i>Vicia sepium</i> in Jämtland, Sweden	18
3.1	Materials and methods.....	18
3.1.1	Overview of materials and methods	18
3.1.2	Study sites	18
3.1.3	Sampling strategy	19
3.1.4	Data collection	20
4.	Results	23
4.1	Sampling locations	23
4.2	Plant community.....	27
4.3	Soil properties	30
5.	Discussion	32
5.1	Sampling locations	32
5.2	Plant community.....	32
5.3	Soil properties	34
6.	Further questions.....	36
7.	Conclusions.....	38

8.	Final words and acknowledgements	40
9.	References	41

1. Introduction

1.1 Background

In pursuing sustainable grassland productivity in the temperate boreal area of northern Sweden, the longevity of leys with a sustained forage quality is an aspect to look further into. In sustainable agrosystems, legumes constitute an important component, yet there are few species commercially available. The native perennial legume *Vicia sepium* L. (pictured in figure 1, 2 and 3), may be due to its qualities, a candidate to enter and support this agronomic context.

The values in introducing perennial wild species of native legumes in green fodder production may be several. First, qualities to look for now and in future crop material may be more diverse than what we have up until today been striving for. Traits found in wild relatives to our cultivars may provide what we now and onwards need to strengthen our agroecological systems (Van Tassel et al. 2020). Through the domestication of wild plants and plant breeding, certain qualities might have been overlooked in favour of others. Maybe we are missing and ignoring traits in the wild that can enhance farming systems under today's, and most certainly the future's, unstable farming conditions (Singh et al. 2020).

Secondly, wild legumes are good colonisers of different habitats. Their symbiosis with nitrogen fixing bacteria transform atmospheric nitrogen to a form usable by plants. Thus legumes support companion crops in the field with nitrogen (Kadžiulienė & Kadžiulis 2007). Since production of fertiliser carries a heavy emissions toll (Krietsch-Boerner 2019) the use of legumes in cropping system may lessen the dependence on costly chemical input.

Thirdly and maybe foremost, strengthening forage production through introducing native perennial legumes will contribute to larger diversity in our agricultural systems. A larger diversity of species would enhance ecosystem services. These could be carbon sequestering (Spohn et al. 2023), pollination by diverse insects (Nibio 2023), as well as strengthened agroecosystem resilience to adapt to changes and to withstand pests, diseases, and weeds (Jing et al. 2017, Frankow-Lindberg 2012). Hector (2022), supported by Furey & Tilman (2021) says how a larger plant diversity leads to better nutrient uptake, more productive plant communities, and more fertile soils. In addition, it is important not to sacrifice yield. Serajchi et al. (2017) shows in a Canadian context, how a more diverse mixture of perennial species increases the biomass compared to grassland mixtures with fewer species. This is supported by Jing et al. (2017) who presents how a mixture of 12 species produces a higher yield than mixes with fewer species. Even though this might not be true for all situations and agricultural systems it is an interesting point made concerning diversity.

Furthermore, finding new species to strengthen the cultivation of leys is of importance, as leys dominate the agrarian land areas in northern Sweden. Leys are interesting as they could enhance biodiversity if composed of more species than what is prevalent today, with two to five species commonly used. In addition, leys last for only three to five years before being reestablished or succeeded by annual crops in the crop rotation. Reasons for this may be difficulties within current farming methods to sustain species composition and thereby the desired fodder quality. Single species may have a tough time lasting throughout the years due to root diseases (particularly relevant for red clover, *Trifolium pratense* L.), intense farming with several harvests every growing season, the influence of weather, soil compaction, and spread of weeds. If a more diverse mixture of species would be used in a Swedish context, these might compensate for the loss of red clover, ensure persistence, and build resilience when facing less optimal conditions.

Farming methods adapted to a climate in change and to a future with less dependence on chemical input need to be promoted (INRAE 2023). Thus, *V. sepium* may be a small yet interesting component and very well a plant with qualities that could contribute to a more resilient and diverse grassland production in Sweden.

1.1.1 Introducing *Vicia sepium*

Vicia sepium has a history in Swedish agriculture. In the contemporary Swedish flora *Nya nordiska floran* it is shortly mentioned as “formerly grown” (Mossberg 2003). However, it never entered any breeding programmes or screening for applicability in modern agroecosystems (Lyhagen, personal communication, 2023). This is why it is interesting to single this species out to be looked at again, since past use and ethnobotanical information can point at interesting agronomical traits and potential nutritional values.

V. sepium is described by Hämet-Ahti (1970) as a perennial legume native to Europe and Central Asia. It can with its two subspecies *ssp. sepium* and *ssp. montana*, be considered a wild crop relative of *Vicia faba* L. and *Vicia sativa* L. It is a glabrous, rhizomatous plant with a long flowering season lasting throughout May until August, and sometimes even into November. It is cross pollinated and grows partly climbing with its tendrils in other vegetation (foremost *ssp. montana*) shown in Figures 3 and 4. It can also grow on its own, more erect (foremost *ssp. sepium*). *V. sepium* is a common species in Sweden, with a distribution throughout various landscapes, such as along agrarian land, in ruderal areas with disturbed soils, and in undisturbed natural areas (Mossberg 2003).

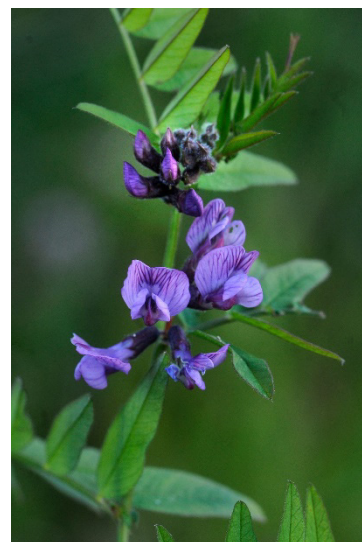


Figure 1. *Vicia sepium*.
Photographer Leif Larsson

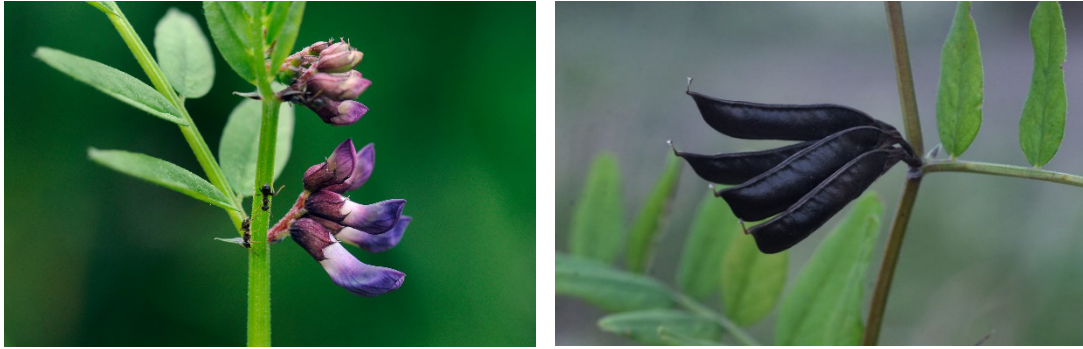


Figure 2. *Vicia sepium* in flowers and second picture showing seed pods. Note the ants, said to visit *Vicia sepium* to enjoy its extrafloral nectaries. Photographs by Leif Larsson

1.2 Purpose, question, and delimitations

Because *Vicia sepium* is a species with ethnobotanical history, this thesis will address two objectives. The first objective will be to map past use and ethnobotanical information in a Swedish context. The second objective will be to observe how it grows in its natural landscapes and to see how these contexts vary. In the following paragraphs these two objectives are presented in more detail.

1.2.1 Objective 1: Rediscover *V. sepium*

Due to information in contemporary floras saying 'earlier cultivated' I will through ethnobotanical descriptions and other literature rediscover agricultural knowledge of *V. sepium*. Micke and Parsons (2023) mention how species with ethnobotanical history may have beneficial traits worth taking into consideration when new plants are to be explored for agricultural purposes. Thus, I intend to start this thesis with a literature review of historical sources. The purpose is to build a backbone for the thesis through mapping past use, experiences, and knowledge on how *V. sepium*, and to some extent other native species, formerly has been described and evaluated in an agricultural context in early emerging grassland production in Sweden.

Questions I intend to answer with this first objective are as follows:

- Is there information about the use and range of environment of *V. sepium* in older floras?
- When and how was *V. sepium* cultivated in Sweden and what are the reasons why it is no longer cultivated?
- What was known or said about its qualities when it was grown for forage?

Sources for this review are not modern scientific publications that have been peer reviewed. Rather, they are first hand ethnobotanical and historical literature written by botanists and professors of the time. Writer and ethnobotanist Kerstin Ljungqvist guided me on how to find

primary historical sources (Ljungqvist, personal communication, 2023). Roland Lyhagen, is a botanist who, during the years of 1971 to 2009, worked at *Sveriges utsädesförening*, *Svalöf AB* and *Svalöf Weibull AB* eventually to become *SW Seed*. He has shared documents, and seed catalogues from his private library, as well as valuable knowledge on early seed breeding programmes and propagation in Sweden.

Literature from this ethnobotanical review was obtained from a variety of sources. Books and articles were found using the *Swedish Utility and Cultivated Plants Database*, *Scud*, a database under the organisation of *SLU Swedish Species Information Centre*. Old floras were found at the *Zetterströmska* library in Östersund, Jämtland. This library holds a great amount of historical literature and floras from the 18th century and onwards, as well as literature concerning agricultural development. Digitised version of older books were accessed through the online database *Project Runeberg*, a digital library connected to *The University of Linköping*, which digitises antiquated books and other types of historic literature from Nordic countries. *The National library of Sweden* digitised old books and other printed material upon request.

1.2.2 Objective 2: Describing a natural environment

The second objective of this thesis is to describe the range of natural environments in which *Vicia sepium* grows, focusing on the province of Jämtland, Sweden.

Studying the natural environment of a certain species gives perspective and insight to its ecological requirements. Observations may point out strategies the plant has for responding to disturbances and changes in the environment. Additionally, observations in the field may give hints on how well the species would cope given different conditions considering soil qualities and nutrient applications. This would be of interest in a potential future agricultural context, as the way a species reacts to different conditions might give an indication on how yield and persistence are affected.

To conclude, the research questions for this second objective are as follows:

- What is the range of natural environment for *V. sepium*?
- Can historical sources hint if *V. sepium* is a potential 'new' species to diversify the flora of Swedish leys?
- Would we use this legume differently today or are there possibilities of picking up old knowledge and practices if re-introducing *V. sepium*?

1.2.3 Delimitations

In specifying what this thesis will address, it is also of interest to highlight what it will not. Rules and regulations concerning the commercial use of native plants, as well as the introduction of new wild species in agricultural systems will not be handled. Neither will I touch upon what market practitioner or organisation would be able to implement the introduction of a native plant for commercial use, even though this could be considered a key to further development and highly relevant in the use of native plants in agroecosystems.

Furthermore, the field observation is not a thorough ecological inventory where variables such as total biomass, leaf areas and physiological responses are measured in detail. Rather the observations can be considered estimative and comparative.



*Figure 3. Vicia sepium.
Photograph by Leif Larsson*

2. Rediscovering *Vicia sepium* through Swedish agrarian history

Vicia sepium has been considered as a strong candidate for feeding Swedish livestock before. When opening the contemporary Swedish flora *Den nya nordiska floran* it says, 'formerly cultivated' (Mossberg 2003). To understand why the commonly used red clover (*Trifolium pratense* L.) gained ground as a legume for grassland production while the native *V. sepium* did not, it is interesting to investigate the history of the changing grassland production methods in Sweden in the 17th and 18th centuries.

2.1 Historic mapping of native legumes for grassland production

Studying historic floras and botanical literature is following thorough descriptions of the studied species. The focus of these botanical, as well as economical works is clearly not only morphology and phenology, but also possible uses and gains for agriculture, medicine, and other fields in society. During the 18th century, natural sciences were driven by a strong utilitarian perspective (Osvald 1962) and stood in strong favour of the state. Research was done to enhance economic prosperity of the country, a dire need after tearing wars of the 17th century. The parliament of the time sought to reduce dependence on and costs of the import of goods. Thus, travels conducted by scientists were on many occasions financed by the state to gather information on traditions, natural resources, practices, and experiences.

Furthermore, due to a massive change in methods on how fodder for winter was produced in Sweden, different wild species of grass and legumes were starting to be evaluated for their qualities in the 17th and 18th centuries. Hugo Osvald (1962) accounts for the historic development of how meadows slowly transitioned away from their extensive nature. They were becoming part of a developing system of crop rotation and what would become actively ploughed, fertilised, and managed fields of green fodder. The system of crop rotation gained ground in Sweden when the two-part big land reforms, '*Storskifte*' and '*Laga skifte*' were decided upon and implemented in 1749 and 1827. These resulted in a more effective ownership structure of agricultural land. New land management methods such as crop rotation, could because of this become more effectively adopted by farmers. In addition, news entering the agricultural sphere was more easily spread and practiced throughout the farmer society with the establishment of the nationwide Royal Patriotic Society '*Kungliga patriotiska sällskapet*'. Local initiatives of emerging *Hushållningssällskapet* also spread new ideas and practices concerning farming.

When progress was sought within fodder production attention was paid on species of grass and herbs in meadows that would be valuable to actively sow to get a greater and more nutritional yield (Kåhre 1996). *V. sepium* is listed already in 1749 in what is believed the very first extensive work in Sweden to evaluate palatability of wild herbs and grasses (Kåhre 1996). 856 different wild species was assessed as fodder and the ones conducting this experiment were students supervised by no one other than Carl von Linné. *V. sepium* is in this thorough test listed together with *V. cracca* L. and *V. sativa* L. but only *V. sepium* is noted to be highly preferred by all the categories of animals in the test; cattle, goats, sheep, horses, and pigs (von Linné 1749).

From here on, *V. sepium* along with other vetches and vetchlings are noted for their use as fodder in Swedish botanical and agrarian literature. Works were composed by scientists and professors connected to emerging universities, state coordinated institutions, and local agrarian schools. Information in the literature ranges from the characteristics and natural preferences of *V. sepium* to ethnobotanical knowledge and instructions on how to collect and achieve successful cultivation.

In his *Flora oeconomica* from 1806, botanist Jahan Retzius (Riksarkivet 2023a) describes how farmers have tried to cultivate *Vicia dumetorum* L., *V. sepium*, and *V. sylvatica* L. to use as fodder, as these species are seen to be highly preferred by farm animals (Retzius 1806).¹ However, to succeed with cultivation he stresses how these species need support by other plants in the field. Suitable for this purpose, he mentions *Galega officinalis* L. and *Astragalus galegiformis* L. Another prominent natural scientist and botanist, Olof Swartz, stresses the same. In *Svensk botanik* (Quensel et al. 1807-1808), Swartz describes how livestock eagerly prefer *V. sepium*. Yet, he is more hesitant towards a wider use of it due to its rather weak stem and because of that, its need to be intercropped with other species. A person writing more fondly of *V. sepium* is Carl Fredric Nyman. He lived 1820 to 1893 and is described as one of the greatest botanists of his time (Riksarkivet 2023b). His focus of interest was ethnobotany and also plant geography. Beyond its use as forage he describes *V. sepium* being a 'sociable part of plant communities', spreading easily and staying green long in autumn (Nyman 1868). A trait also stressed by Professor Pehr Wahlberg. He claims *V. sepium* is satisfying to cultivate, as it shows up early in spring giving a long growing season with lasting greenery (Wahlberg 1835).² In addition, both Nyman and Wahlberg stress that even though *V. sepium* will not give any greater harvest until at least a second year, it will compensate by lasting 'a generation' spreading year by year and effectively suppress weeds.

Johan Petter Arrhenius lived 1811 to 1889. He was director of *Ultuna Agricultural Institute*, and teacher in rural management and agronomy (Riksarkivet 2023c). He was also an economist with a predilection for agricultural economics. He mentions *V. sepium* in his teachings. On practices of farming at local schools of practical agriculture, he shows fondness for the use of native species. *V. sepium*, along with *Lathyrus pratensis* L., *Vicia cracca* and *Lotus corniculatus* L are positively denoted. On *V. sepium*, he states that it is not particular about soil

¹ "Alla dessa vickerarter ätes gärna af husdjuren...flera hafva tillstyrkt att odla dem; men de har icke besinnat att för deras växt och trefnad fodrar stöd"

² "Tranvickern uppträder vanligen sällskapligt, så att den på somliga ställen i lundarne bildar en temligen väsentlig beståndsdel i växttäcket. [...] I hvilket hänseende den har sitt största värde i sin tidiga utveckling och sin ända in på hösten varaktiga grönska."

quality and that it suits perfectly as fodder together with *Dactylis glomerata* L. and *Phleum pratense* L. (Arrhenius 1879). It has more succulent and leafy stalks compared to *V. cracca* and appears earlier in spring (Arrhenius, J.P. & Lindqvist, C.A. 1908). It is also described as having a lush regrowth after harvest, making it a good crop for forage even in late fall. Furthermore, in his book on agricultural practices, Arrhenius recommended *V. sepium* to be sown in fall together with other species, as it together with its companion species creates a thick and close vegetation³ (Arrhenius 1879).

2.2 Field trials

Moreover, considering the qualities of *Vicia sepium* stated by these different Swedish botanists and natural scientists, it seems reasonable that it was one of many candidates eventually put to trial in field experiments when these came into action. Field experiments referred to in the literature were conducted abroad, but also done in Sweden by seed companies, private practitioners, and maybe foremost by 'Kongliga Landtbruks-Academien' KLA, later to become *Kungliga skogs- och lantbruksakademien*, KSLA. The trials of KLA took place at *Experimentalfältet* in Stockholm, where activities lasted from 1816 until 1950. These field trials are considered the first rationally and scientifically run. They were an indirect prelude to what later became the field trials run by the *Swedish University of Agricultural Sciences* (Lange 2000). At its location in Stockholm, both imported cultivars were tested along with wild native species, such as *V. sepium*.

Professor and member of KLA Pehr Wahlberg presented results from field trials in England, where *V. sepium* on fertilised sandy clay per hectare gave 19 835 kg green fodder, equalling 4 959 kg hay, and a second harvest of 7 629 kg green fodder. When harvested at podding it gave 22 886 kg green fodder, equalling 6 295 kg hay⁴ (Wahlberg 1835). Publisher and botanist Nils Wilhelm Lundequist (Lundequist 1850) refers to *Experimentalfältet*'s results for the years of 1841 and 1843, where the yield of *V. sepium* is compared with other tested wild species as well as with cultivars of *Trifolium pratense*. Agronomy professor Juhlin-Dannfelt concluded in 1916 that *V. sepium* distinguishes itself as a crop of very high protein content, palatability, and longevity in field experiments grown in single swards, proving itself as 'very promising'⁵ (Juhlin-Dannfelt 1916).

Complementary to field trials run at *Experimentalfältet* and by seed companies, private initiatives were conducted as well. Ethnobotanist and teacher Johannes Henriksson (1853-

³ "[...] ej nogräknad på jordmån. Den har saftigare och bladrikare stjälkar, skjuter tidigare om våren [compared to *V. cracca*] samt har en ypperligare återväxt än fågelvickern"

"Häckvickern trifles synnerligen på alla lösare jordarter, så vida läget ej är för torrt eller besväras av vatten. Denna växt har stort värde deraf, att han med andra foderväxter bildar en tät vall, återväxer fort efter slåttern samt gifver då ett ypperligt bete ända in på senhösten. Utsås helst om hösten, i blandning med andra foderväxter, om kring 5 kappar på tunnlandet. Enbart till fröskörd 10 kappar på dito."

⁴ "[...] på gödd sandblandad lera verkställda försök, gaf den, slagen i blomningen, på Acren 17 696 *ålb* grönfoder, som torkadt utgjorde 4,424 *ålb* hö, samt i efterskörd 6,806 *ålb* grönfoder. Slagen vid fruktmognaden lemnade den 20 418 *ålb*, hvaraf erhöles 5616 *ålb* hö"

⁵ "[...] mycket hög proteinhalt, smaklighet och varaktighet, hafva vid försöksodling i oblandadt bestånd på åker visat sig mycket lofvande."

1935) ran a school focusing on farming practices. Throughout his career he promoted the use of native species in plant breeding (Ljungqvist, personal communication, 2023). Besides teaching in botany, he developed thorough field trials with native plants to be used mainly in medicine, but also as fodder and in silviculture (Ljungqvist 2022). Through his trials he concluded that native species, in many aspects, showed better qualities and adaptation to local conditions than imported ones. In one of his books, he points out how native leguminous species are outstanding in terms of nutritional values as fodder (Henriksson 1923). He claims that our country encompasses about 50 different species of legumes suitable for this purpose. Moreover, he gives prominence to four of these being of exceptional quality due to the following three reasons:

1. These species are perennial.
2. They produce a rich biomass.
3. They are common and found in a wide variety of different biotopes.

His four candidates were *Lathyrus pratensis*, *Vicia sepium*, *V. cracca* and *V. sylvatica*. For these four species, he thoroughly describes his experiences of practical methods to collect, sort, and store seeds, along with how to tend for germination, good establishment techniques in the field and optimal timing for harvest. Table 1 presents nutritional results from Henriksson's harvest of these species.

Table 1. Translated excerpt from Johannes Henrikssons book “Vartill Våra Växter Duga”. Nutritional analysis from his own harvest of the four perennial native legumes of *Lathyrus pratensis*, *V. sepium*, *V. cracca* and *V. sylvatica*. Date of harvest is 1st of July 1912. Analysis is done at “Kem. Kontrollanstalt, Borås” by analyst Sigurd Köhler 8th of August 1912. Results are given in % but it is not specified of what. Presumably it is weight % of total dry mass.

Name of species	Protein %	Fat %	Carbohydrates %		Moisture %	Ash %
			Non-fibre	Crude fibre		
<i>Lathyrus pratensis</i>	19.7	3.1	39.9	25.6	5.4	6.3
<i>Vicia sepium</i>	20.7	2.2	35.6	28.0	6.9	6.6
<i>Vicia cracca</i>	20.3	2.8	34.1	25.8	10.3	6.7
<i>Vicia sylvatica</i>	17.8	2.2	43.0	21.6	6.8	8.6

2.3 Early trade with seed from native plants

Along the slow, yet large-scale transition of farming methods at this time, access to seed to enhance grassland production was a key issue in this process (Lyhagen, personal communication, 2023). In many of the botanical sources cited above, farmers and even children, are encouraged to themselves collect seed from native plants. Johan Arrhenius specifically wanted to spark inspiration among farmers to collect seed themselves. Farmers could with these start seed production plots for further cultivation to be exchanged within local farmer associations. In the introduction to his book on how to succeed in growing crops for seed harvest (Arrhenius 1877) he cites Linné:

We cross the river after bad water when we prescribe foreign seed despising our own, we must therefore collect these ourselves for cultivation.⁶

He hopefully states in 1879 that the qualities of *V. sepium* are so prominent that they in the future could become an export. Pehr Wahlberg wrote already earlier (1835) that since seed of *V. sepium* is not accessible in the trade, farmers would do good to collect and propagate these themselves, reasoning that native seeds are better suited for Swedish conditions than imported ones. Teacher Per J. Rösiö writes thoroughly on how to grow native legumes (Jönson-Rösiö 1904). *V. sepium* is described among other species. He, together with other practitioners, gives instructions on when and how to collect and treat the seed. To some extent local seed development associations popped up, sharing seed of different species between members (Kåhre 1996). Local units of *Hushållningssällskapen* were important in spreading knowledge and encouraging new methods, as well as developing equipment throughout this field (Kåhre 1996). To some extent, local divisions of *Hushållningssällskapen* also offered seed for free to spark farmers' interest in new crops for grassland production. In the county of Jämtland, Arrhenius' book on collecting native seed for propagation was distributed for free among farmers by the local *Hushållningssällskap*.

However, changing farming systems, along with introducing new species takes a lot of effort and attaining the amount of seed needed is difficult. In the late 19th century, seeds from native legumes appears in seed catalogues. Between the years of 1889 and 1908, *Allmänna svenska utsädesföreningen* listed *V. sepium* in their assortment. In 1895 it was one of their most expensive legumes, being sold for 14 SEK per kg, compared to Swedish, German, and Canadian species of clover with prices not exceeding 2.40 SEK per kg (ASU 1895).

Institutions and private companies trading seeds also called for seed collected by private persons (Nilsson 1893). *Allmänna svenska utsädesföreningen* announced in their 1893 periodical that they would pay for seed of good quality accordingly:

Vicia cracca 4 SEK per kg

Lathyrus pratensis 5 SEK per kg

V. sepium and *V. sylvatica* not specified but 'considerably more'

Larger vetchlings 12 to 15 SEK per kg

The seed company Weibull listed *V. sepium* up until 1911 (Lyhagen, personal communication, 2023).

Alongside modest and expensive market supplies of native seed, encouragement to collect and propagate one's own seed continued. Reasons for this were that native, locally collected seed was proven to grow better *in situ* than imported ones. Henriksson strongly promoted that farmers should collect local seed for themselves. Nevertheless, he also informed about prices for native seed in the market. Reasons were both to promote native seed to those able to buy for these prices, but also to show what could be earned by selling to seed trading companies. One example was the seed trading company in Gothenburg: *Göteborgs trädgårdsförening*. Furthermore, if farmers were to invest in, and dare to try, native vetches and vetchlings, despite

⁶ "vi gå öfver ån efter ställastående och ruttet vatten då vi förskrifva utländska höfrön och förakta vårt" ("vi [måste] derföre sjelfva insamla dem till vidare odling.")

the considerably high prices compared to red clover, he encouraged the use of them as it would be a one-time cost to be paid, as they by far outlived the clover, giving a rich harvest many years to come (Henriksson 1923). Another reason that promoted own propagation was that not all seed importers were honest, neither with origin nor rate of germination or even the species specified (Kåhre 1996). It seems that availability of native vetches was scarce yet popular. The trials at *Experimentalfältet* could not do as thorough trials as desired since they sold the seed of the vetches rather than using them in further trials.

Furthermore, seed distribution quickly became more rational and coordinated. Native seed collection and breeding were despite the highly praised benefits, costly and things developed quickly. By 1910, native species such as *Vicia* and *Lathyrus*, found in previous years' seed catalogues, (Göteborgs trädgårdsförening, Svalöf, Weibull) had now become a special assortment not listed, but available upon request (Lyhagen 1991). Probably, these species were superseded by other that had progressed further in field trials and breeding programmes where the so called "wild traits" had become less prominent.

The commercial use of these species in Sweden never reached a large extent. The rewarding field experiments being conducted stood in sharp contrast with the lack of accessible seed. In addition, even though these native species, *V. sepium* included, kept on being mentioned as substantial in school-books, propagations were not picked up by seed firms. According to Lyhagen (Lyhagen, personal communication, 2023), access to seed was the key issue for further use of vetches as cultivars, even for the work at *Experimentalfältet*. Stepping into the fast-developing plant breeding programmes of the 20th century, modern forage farming progressed too quickly for all the promising native candidates; *V. sepium* being one of them.

2.4 Challenges for native legumes to enter early breeding programmes

Consequently, *V. sepium* didn't enter plant breeding processes through these eager years of using native species. Why *V. sepium* and other wild species didn't make it may be due to their wild traits (Lyhagen, personal communication, 2023). First, wild native species of grasses and legumes ripen in a disproportionate manner. The same plant, as well as other individuals and ramets in the population, may be in full bloom at the same time as pods are ripening. Secondly, the seed coat of the seed from native plants, especially vetches and vetchlings, are tough and hard, resulting in low germination rates, something that was addressed by seed production firms (Nilsson 1893). Delayed germination is an important strategy to save the seed, so it does not germinate when conditions are unfavourable. Even though the seed bank in the ground will build up with a large amount of seed that in time might germinate, a higher germination rate has been something to strive for in seed production and agriculture.

De-synchronised ripening makes the harvest of seed a tedious work. However, this is one trait of *V. sepium* that would be a good quality to add into our agroecological systems today, as a long flowering season would support pollinators. Arrhenius (1877) even writes how this could be overcome concerning the de-synchronised ripening of red clover. He proposes the field to be cut once letting plants regrow and first by then harvest for seed.

Furthermore, overcoming a tough seed coat was the case for red clover when it first entered breeding programmes. The seed coat was hard and methods to enhance germination were done alongside breeding programmes (Lyhagen, personal communication, 2023). When *V. sepium* was traded by Svalöf in 1889 to 1909, it was done alongside promotions of methods of mechanical scarification of the seed coat. A special tumbler was sold by *Allmänna svenska utsädesföreningen* for the purpose of removing the hard seed coat of wild and cultivated species of legumes. Using this tumbler, the germination rates were said to be enhanced to the same levels as other cultivars (Lyhagen 1991). A simpler approach was given by Anders Larsson Kilian a writer and small-scale farmer in Jämtland: scratch the seed coat by shaking seed in a box clad with sandpaper (Larsson-Kilian 1912). Furthermore, overcoming the need of preparing the seed coat, Olof Swartz suggested that propagation of vetches and vetchling were better done with pieces from the roots than from collecting the seed (Quensel 1807–1808). Today, a hard seed coat does not have to be a problem as the seed can be scarified to increase germination.



Figure 4. Illustration of *Vicia sepium* from "Bilder ur Nordens Flora" (Lindman 1917). 1. Top of the plant in bloom, 2 stem with stipules (3/1), 3. flower (2/1), 4. seed pod (1/1), 5. seed (1/1 and 4/1)

3. Field observation of *Vicia sepium* in Jämtland, Sweden

In the following sections, the second objective, field observations of wild populations of *V. sepium* in Jämtland, is presented.

3.1 Materials and methods

3.1.1 Overview of materials and methods

The body of this part of the thesis is composed of field observations of 15 randomly selected locations in the province of Jämtland, Sweden where *V. sepium* reportedly is a natural part of the plant community. The field observations included taking soil samples to examine the chemistry, as well as the physical and biological composition of the soil. In addition, abiotic and biotic features of the locations were observed.

Locations where *V. sepium* grows were found using *Artportalen*⁷, a Swedish internet-based report system for observations and information on Swedish flora and fauna. This portal is developed and administered by the *Swedish Species Information Centre* at the *Swedish University of Agricultural Sciences* and it is financed by *The Swedish Environmental Protection Agency*¹.

3.1.2 Study sites

The field observations were conducted in the province of Jämtland in the center of Sweden. The time of sampling and observations was two weeks in July and early August 2023, throughout the flowering period of *V. sepium*. Jämtland is a region of overall high elevation with mountainous areas from 300 m above sea level and higher. The defined search area was set to a radius of 55 km from Oviken, Jämtland, presented in Figure 5. Within this chosen limitation, the area covers the high-altitude mountainous area in the west, as well as lower residing locations around the grand lake *Storsjön* with its fertile soils and actively farmed land. Jämtland has a cold temperate climate influenced by the Atlantic Ocean and the Norwegian Sea in the west, giving winters with high precipitation in the west and less in the middle and eastern regions. Historically, this specific region of Jämtland has given a rich return from

⁷ *Artportalen* is to be used by citizens and researchers. Anyone can create an account and report observations and observers decide themselves what to report. All observations are published and reviewed for quality by responsible persons in acknowledged and to the specific species, associated organisations.

grazing cows in terms of butter and cheese. This was given from the use of off-farm grazing in the mountain areas, a system internationally called *transhumance*. This system was for this area productive, giving such a vast amount that it played a great role in times of famine throughout the 16th and 17th century, as well as rendering a substantial export income for the whole nation of Sweden (Osvald 1962). Dairy and beef production still constitute the dominating farming practice, due to the limitations of climate and length of season. Thus, grassland production dominates in the region with barley as the main grain cereal in the crop rotation (SJV 2023a).

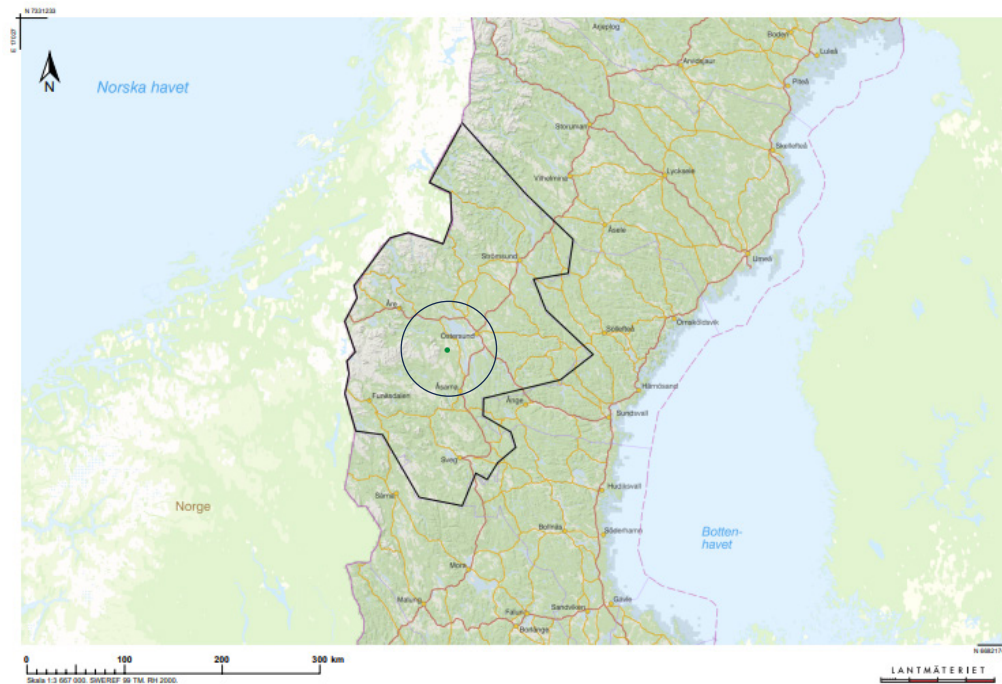


Figure 5. Map over Jämtland County with the area of observation encircled, Oviken in center

3.1.3 Sampling strategy

In selecting sites to visit, I used stratified random sampling. By using this method, relatively diverse subgroups within areas where *V. sepium* grows would be included in the selection of study sites. From the given information in *Artportalen*, I could single out my own categories relevant to the research question. These categories were not dependent on the biotope in specific, but rather on land use and management at site. The defined strata were:

- *Cultivated/disturbed/used in some way or cut/grazed.*
This category encompasses all agricultural land; grazing areas, leys or by other means cultivated land, but also golf courses, ski slopes, gardens and to some extent roadsides.
- *Natural environment/undisturbed*
This category includes forest areas even though these might not truly be called undisturbed or even natural, since forests can be recently cut or planted. Forests are also immensely diverse – dominated by coniferous or deciduous trees, be

homogenous or diverse in age, open or dense in character or grazed by animals. Still the management of forests is not as intense as agricultural landscapes and forests follow another cycle of activities. Grasslands are also in this stratum, even though they might be man-made earlier, yet now abandoned or not managed.

- *Ruderal land/rocky, gravel*

Areas in this stratum include "man-made" places, such as locations with excavation masses and moved soils such as areas close to city dumps, building sites and railroads. Naturally rocky sites are included here.

- *Wetland*

Wetland areas, shorelines are included in this stratum.

3.1.4 Data collection

After reaching the location, the first step was to determine presence and constancy of *V. sepium*. Specifically, to detect if the population was still around and correctly reported in *Artportalen*. The next step was to decide if the population was big enough to include in data collection, meaning reoccurring and part of the plant community. Depending on the actual biotope of the site and how detailed the report in *Artportalen* was, this concluded to reoccurring along 100 meters if the location was a strip along a path or field. If the location was a larger area "big enough" concluded to specimens of *V. sepium* reoccurring within 30 × 30 meters. If the population at the reported location was composed of less than 50 plants, an alternative location was selected.

The field protocol used to take notes on the characteristics of the site were formed by the following questions:

- What companion species does *V. sepium* grow with?
- Are there any specifics in terms of land use management that seemingly affect the morphology of the species or size/spread of the population?

In the field protocol, name of site, date, and coordinates, as well as elevation and aspect were noted, followed by:

- | | |
|----------------------------------|---|
| • Site characteristics | • Plant community at site |
| • Current land use / disturbance | • Morphology / developmental stage / height of vegetation |
| • Land use history / disturbance | • Other interactions and observations |
| • Size and spread of population | • Weather and time of day |
| • Level of shade | |

On noting land use history, things in the landscape possibly unveiling any kind of biotic succession or change in use or management was noted. This could be tree stumps from earlier logging or relic plants from another form of management. In addition, *Lantmäteriets*

application 'Min karta' was used to identify past management, as it presents useful satellite pictures as far back as the 1960s where changes in management, land use, and tree cover are clearly visible.

Describing the level of shade at a location is describing the relief of sunlight, thus pointing at possible adaptations in morphology or other responses in the plant for such growth. Morphology may change as for how the plant adapts to or avoids shade, or the lack of it, to maintain productivity.

The plant height of the community was assessed. The length of 5 specimens of *V. sepium* was measured and the mean value of these 5 was noted.

At each site, 15 samples of the topsoil layer were collected with a soil probe (Figures 6 and 7). Maximum depth was 25 cm, and all samples were taken close to where a specimen of *V. sepium* grew. The samples were mixed in a bag and then kept in an earth cellar at a temperature of 8 degrees Celsius until being sent to *Eurofins Agro* for analysis of chemical, physical, and biological properties. For soil analysis Eurofins follows a procedure described by Reijneveld et al. (2022). With the use of 0,01 M CaCl₂ extraction directly available nutrients are assessed and with *Near InfraRed Spectroscopy* - 'NIRS' assessments of physical, chemical, and biological characteristics are made. Analysis data are transformed into kg/ha by Eurofins Agro. Eurofins Agro takes density and depth of sampling into account. The analysis result is divided by kg and then multiplied by density, hectare, and depth of sampling (Daniel Pettersson, personal communication, 2024).

Trips to different locations were done at different dates, thus it differed how for how many days samples were kept in the cellar. Sample from location No. 1 was kept for 2 days, Sample from no, 2-7, 11 days, no 8: 6 days, no 9: 9 days, no 10, 12 and 13: 18 days, no 11 and 14: 19 days and no 15: 21 days.

As for noting the companion species of *V. sepium*, the area was limited with a sling with a diameter of 1 m, shown in Figure 6. Within the sling, I took notice of the immediate floristic composition accompanying *V. sepium*. Only the occurrence of species was taken note of, not abundance. Even though many of the species noted were familiar, identification was confirmed with help of two floras: *Svensk flora – Fanerogamer och ormbunksväxter* (Krok & Almqvist, 2003) and *Nya nordiska floran*. (Mossberg & Stenberg, 2003).



*Figure 6. Sling used at field locations to note immediate companion species of *V. sepium* and soil probe to collect soil samples.*



Figure 7. Soil probe with soil sample.

4. Results

4.1 Sampling locations

The defined search area gave 287 locations in *Artportalen* where *V. sepium* grew. Some of the observations dated back as far as 1915. Because land use most certainly has changed over time, a limit was set to observations from 1991 up until present day, generating a remaining 257 locations. Sorting the locations into different strata, as listed in Table 2, gave the proportions for a random sample. From these the final 15 locations were selected. Figure 8 presents these 15 locations on a map. Figure 9 shows the view of these locations, followed by a more thorough description of the sites in Table 3.

Table 2. The number of locations rendered in *Artportalen*. These are sorted on the selected categories, followed by their proportion of the total count rendering the final number of locations in each stratum to visit.

Category	Quantity	Proportion of strata	Sample	Nr. of locations
Cultivated, disturbed, cut, grazed	105	0.41	6.1	6
Natural environment, undisturbed	96	0.37	5.6	6
Ruderal, rocky, gravel	40	0.16	2.3	2
Wetland	16	0.06	0.9	1

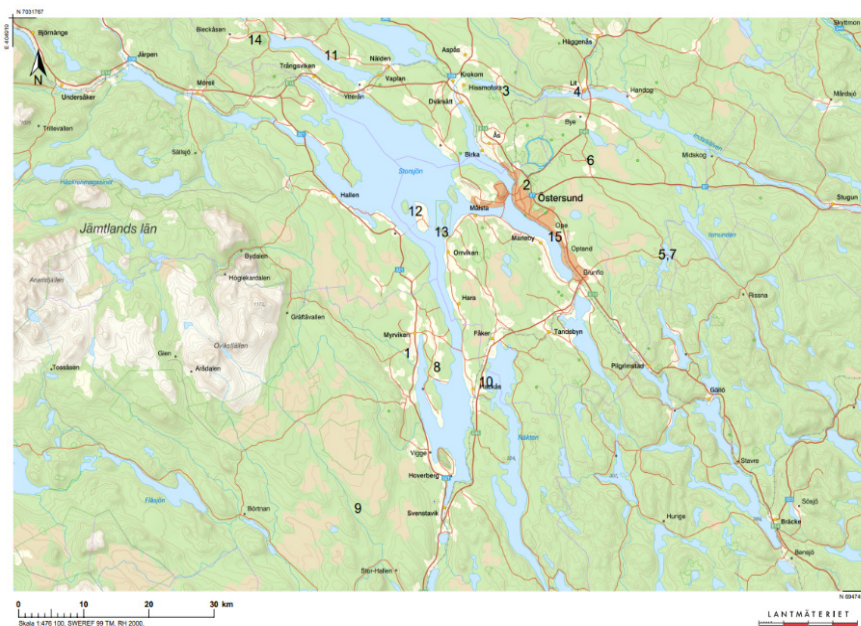


Figure 8. Map with sampling locations.



Figure 9. Photos showing the view of the field locations, No. 2 Rannåsen excluded.

Table 3. Presentation of site characteristics of the field locations with number and name of location. Coordinates are according to the World Geodetic System 1984 (WGS84). Elevation measured in metres above sea level, m a.s.l. Aspect is the orientation of the slope, measured clockwise in degrees from 0 to 360 degrees, where 0 is north, 90 is east, 180 is south and 270 is west. Last column, disturbance, states if the site is managed.

Location	Coordinates wgs84	Elev. m a.s.l.	Slope %	Aspect degrees	Habitat	Disturbance
1 Häggån	62°58'25.2"N 14°17'57.6"E	328	11	198° SSW	Opening in a coniferous forest at riverbank. Garden waste tossed in slope. Decaying logs.	None
2 Rannåsen	63°11'58.7"N 14°40'52.3"E	329	none		Shadowy gravel path leading down to a wetland area and small lake. Surrounding mixed forest draped in <i>V. sylvatica</i> and orchids. Natural conservation area.	Trimmed once a year
3 Kattstrupeforsen	63°19'22.8"N 14°35'21.0"E	262	4	42° NE	Grassland/alongside and in ley	Actively farmed land
4 Söre	63°18'54.1"N 14°50'23.3"E	253	none		Very wet area adjacent to farmed land and the great river Indalsälven. On occasions possibly flooded.	None
5 Hästön woodland	63°5'58.4"N 15°6'20.4"E	370	13	124° SE	Woodland meadow with old pines	Trimmed once a year
6 Kyrkås	63°13'31.7"N 14°51'33.2"E	390	6	48° NE	Grassland, extensively tended meadow	Actively farmed land
7 Hästön ruderal	63°5'58.2"N 15°6'27.7"E	360	none		Ruderal site around an old manure pit along gravel road. 15 m from Lake Singsjön	None
8 Funäs	62°57'25.4"N 14°23'31.5"E	322	none		Grassland / Abandoned pasture with birch and salix, rocks and decaying wood	None
9 Anners-Persbuan	62°46'10.1"N 14°10'29.7"E	494	8	252° SW	Grassland / Old pasture surrounded by forest. Very old mountain summer farm / 'fäbod'	Extensive grazing
10 Våle	62°56'11.7"N 14°32'50.3"E	335	None		Grassland, overgrown vegetable garden next to a lawn	Cut at maximum once a year
11 Rödegård	63°21'23.3"N 14°4'56.6"E	321	30	202°SSW	Grassland / meadow in glade surrounded by coniferous forest beneath steep mountain	Trimmed once a year
12 Lervik	63°9'33.1"N 14°20'29.0"E	300	4	304° NW	Coniferous 'rough' open forest with young pine and old salix, many sick trees	None
13 Sunne	63°7'41.0"N 14°25'50.1"E	296	none		Grassland / alongside as well as in ley and lawn around ancient ruin	Actively farmed land
14 Raskhus	63°23'0.5"N 13°50'43.0"E	388	none		Lush young forest with pine, spruce, birch, and rowan, max 30 yrs old with canopy reaching 12 meters, herbs, anthills and old junipers. Large clusters of <i>Vicia sylvatica</i> . Decaying birches, no tree stumps	None
15 Ope	63°7'42.8"N 14°45'44.4"E	324	10	228° SW	Grassland, strip next to a path in between fields of black currants and oats/peas	Trimmed once a year

Location No. 6 *Kyrkås* and No. 14 *Raskhus* are two examples of the different strata selected. Location No. 14, shown in Figure 10, is an example of an undisturbed site in the middle of a forest. No. 6 shown in Figure 11, is an example of the opposite: an open sunny, actively managed agricultural site with *Vicia sepium* growing along and in a ley being cut. These two locations show the extremes of how different the biotopes could be.



Figure 10. Pictures from location No. 14 *Raskhus*, where *V. sepium* grows undisturbed in the middle of a young coniferous forest.



Figure 11. Pictures from location No. 6 *Kyrkås*, showing *V. sepium* growing in and along a harvested ley.

4.2 Plant community

Table 4, 5 and 6 present different aspects of the plant communities at the sampling locations. Characteristics of the populations are presented in Table 4. In Table 5 the level of shade is estimated and Table 6 presents the floristic composition at each location.

Table 4. Field locations with details on population characteristics with estimations on population density and dispersion pattern. The table is sorted after population size. Large corresponds to a population estimated to more than 500 plants in the area, medium large is 300–500 plants, medium-small is 100–300 plants and small is between 50 and 100 plants.

Location	Height M	Population size	Population density	Dispersion pattern
3 Kattstrupeforsen	0.7	Large	Sparse	Random
4 Söre	1	Large	Dense	Cluster
8 Funäs	0.7	Large	Dense	Cluster
10 Våle	0.4	Large	Dense	Random
12 Lervik	0.4	Large	Sparse	Evenly
15 Ope	0.5	Large	Sparse	Random
7 Hästön rud	1	Medium-large	Dense	Cluster
11 Rödegård	0.7	Medium-large	Dense	Random
2 Rannåsen	0.2	Medium-small	Sparse	Random
6 Kyrkås	0.2	Medium-small	Sparse	Random
5 Hästön woodland	0.2	Small	Sparse	Evenly
9 Anners-Persbuan	0.3	Small	Sparse	Evenly
13 Sunne	0.7	Small	Dense	Random
1 Häggån	0.8	Small	Dense	Cluster
14 Raskhus	0.4	Small	Sparse	Evenly

12 out of the 15 locations were categorised as lightly to fully shaded. The remaining three locations were in full sun exposure. No population was found in a location of deep shade reached by no direct sunlight.

Table 5. Estimated level of shade at locations. 'No shade' corresponds to an open country with no shrub or tree canopy. 'Light shade' refers to edges of woodland with shade from single trees or other source. 'Partial shade' equals a glade in forest or other type of area with more than one tree. 'Full shade' corresponds to full tree coverage with filtered or dappled sunlight. As for 'Deep shade' direct sunlight seldom reaches the ground.

No shade	Light shade	Partial shade	Full shade	Deep shade
10 Våle	3 Kattstrupeforsen	1 Häggån	2 Rannåsen	-
13 Sunne	4 Söre	5 Hästön woodland	12 Lervik	
15 Ope	6 Kyrkås	8 Funäs	14 Raskhus	
	7 Hästön ruderal	9 Anners-Persbuan		
		11 Rödegård		

Table 6. Floristic composition at locations observed within sling. The species are presented with their Swedish common name, their scientific name in Latin, followed by Authority. Names are according to the Swedish flora "Nya Nordiska Floran" (Mossberg, 2003). The columns are grouped after the four strata: Natural land / Undisturbed, Agrarian land / Disturbed, Ruderal and Wetland. The values are sorted after the most frequently found species summed in the right column as total count, C, of locations where said species was found. At the bottom of the table the total count of species at each location is summed.

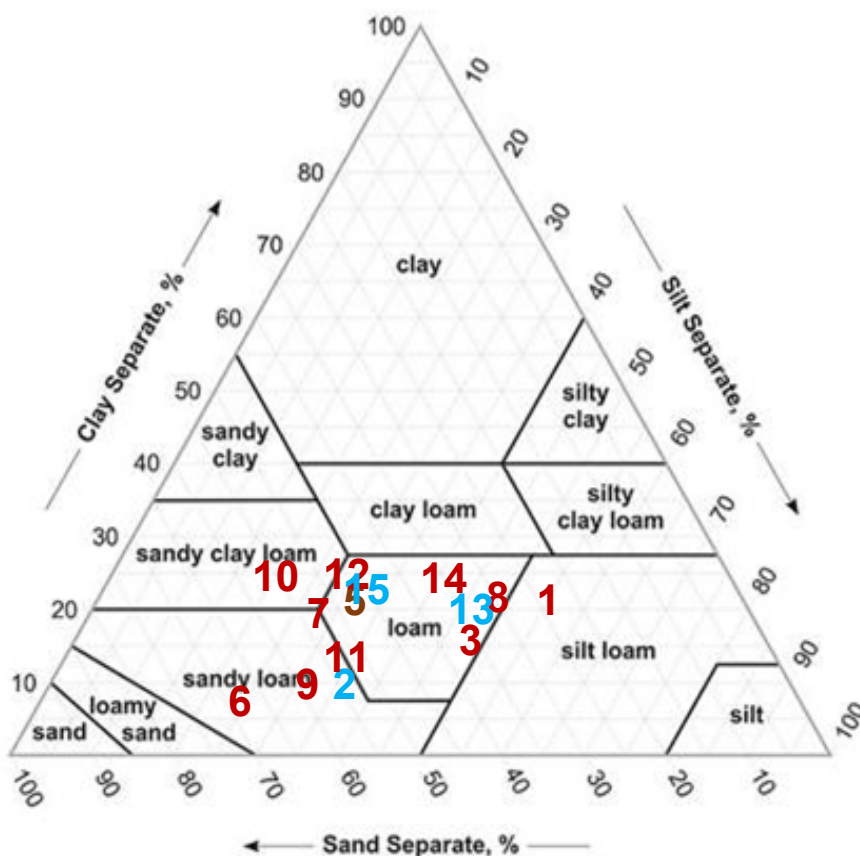
Swedish name	Scientific name				Nat. Undisturbed	Agr. /Disturbed					Rud. W.			C.							
	Family	Species	Authority	1		5	8	11	12	14	3	6	9		10	13	15	2	7	4	
Skogsnäva	Geraniaceae	Geranium	Sylvaticum	L.		5	8	11		14		3		9	10		15	2	7		10
Smultron	Rosaceae	Fragaria	Vesca	L.	1	5	8	11	12	14				9			15		7		9
Gulvial	Fabaceae	Lathyrus	Pratensis	L.		5	8		12	14		3	6		10		15	2			9
Skogsklöver	Fabaceae	Trifolium	Medium	L.		5		11	12			3	6	9	10			2	7		9
Röllika	Asteraceae	Achillea	Millefolium	L.			8					3	6		10	13	15	2	7		8
Timotej	Poaceae	Phleum	Pratense	L.		5	8						6		10	13	15	2	7		8
Vitklöver	Fabaceae	Trifolium	Repens	L.			8		12			3	6		10		15	2	7		8
Kräkvicker	Fabaceae	Vicia	Cracca	L.		5	8					3		9		13	15	2	7		8
Ångskavle	Poaceae	Alopecurus	Pratensis	L.			8	11				3	6		10			2	7		7
Maskros	Asteraceae	Taraxacum	ssp.	FH Wigg.	1							3	6			13	15	2	7		7
Blåklöcka	Campanulaceae	Campanula	Rotundifolia	L.				11					6		10	13	15	2			6
Hundäxing	Poaceae	Dactylis	Glomerata	L.				11					6			13	15	2	7		6
Vårbrodd	Poaceae	Anthoxanthum	Odoratum	L.		5			12				6	9			15				5
Hundkåx	Apiaceae	Anthriscus	Sylvestris	(L.) Hoffm.								3			10	13		2	7		5
Blåsippa	Ranunculaceae	Hepatica	Nobilis	Mill.	1	5		11	12					9							5
Prästkrage	Asteraceae	Leucanthemum	Vulgare	Lam.									6	9	10		15	2			5
Stenbär	Rosaceae	Rubus	Saxatilis	L.				11	12	14			6					2			5
Hallon	Rosaceae	Rubus	Idaeus	L.	1		8			14		3							7		5
Rödsklöver	Fabaceae	Trifolium	Pratense	L.			8								10	13	15	2			5
Lingon	Ericaceae	Vaccinium	vitis- idaea	L.	1	5			12	14			9								5
Ängsdaggkåpa	Rosaceae	Alchemilla	Subcrenata	Buser			8						6			13	15				4
Mjölkört	Onagraceae	Epilobium	Angustifolium	L.			8					3	6					7			4
Fårsvingel	Poaceae	Festuca	Ovina	L.			8		12	14						13					4
Luddhavre	Poaceae	Helictotrichon	Pubescens	(Huds.) Pilg.					12				6			13	15				4
Fibbla	Asteraceae	Hieracium	sect. Vulgata	-	1					14			6	9							4
Ängsfryle	Poaceae	Luzula	Multiflora	(Ehrh.) Lej.		5			12				6			13					4
Vårfryle	Poaceae	Luzula	Pilosa	(L.) Willd.		5			12	14				9							4
Skogskovall	Scrophulariaceae	Melampyrum	Sylvaticum	L.		5			12	14				9							4
Ängsgröe	Poaceae	Poa	Pratensis	L.			8						6			13		7			4
Smörblomma	Ranunculaceae	Ranunculus	Acris	L.			8					3	6					7			4
Ängsskallra	Scrophulariaceae	Rhinanthus	Minor	L.									6		10			2	7		4
Teveronika	Scrophulariaceae	Veronica	Chamaedrys	L.			8			14				9			15				4
Rödsvingel	Poaceae	Festuca	Rubra	L.		5							6					7			3
Älggräs	Rosaceae	Filipendula	ulmaria	(L.) Maxim.														2	7	4	3
Stormåra	Rubiaceae	Galium	album	Mill.												13	15				4
Husmossa	Hylocomiaceae	Hylocomium	splendens	(Hedw.)Schimp.	1				12	14											3
Ekorrbär	Convallariaceae	Maianthemum	bifolium	(L) FW Schmidt		5				14				9							3
Rödkämpar	Plantaginaceae	Plantago	media	L.		5	8								10						3
Rödblåra	Caryophyllaceae	Silene	dioica	(L) Clairv.									6					7	4		3
Hästhov	Asteraceae	Tussilago	farfara	L.								3						7	4		3
Blåbär	Ericaceae	Vaccinium	myrtillus	L.	1				12	14											3
Nysört	Asteraceae	Achillea	ptarmica	L.								3						7			2
Rödven	Poaceae	Agrostis	capillaris	L.									6					7			2
Betesdaggekåpa	Rosaceae	Alchemilla	monticola	Opiz								3					15				2
Ormrot	Polygonaceae	Bistorta	vivipara	(L.) Delarbre									6	9							2
Lomme	Brassicaceae	Capsella	bursa-pastoris	(L.) Medik.								3						7			2
Åkertistel	Asteraceae	Cirsium	arvense	(L.) Scop.			8					3									2
Borsttistel	Asteraceae	Cirsium	helenioides	(L.) Hill								3						7			2
Bergdunört	Onagraceae	Epilobium	montanum	L.			8													4	2
Åkerfräken	Equisetaceae	Equisetum	arvense	L.								3						7			2
Jordrök	Fumariaceae	Fumaria	officinalis	L.									3								2
Pipdån	Lamiaceae	Galeopsis	tetrahit	L.			8													4	2
Vitmåra	Rubiaceae	Galium	boreale	L.											10		15				2
Sibirisk björnlöka	Apiaceae	Heracleum	sphondylium sibiricum	(L.) Simonk.														7		4	2
Skogsfibbla	Asteraceae	Hieracium	sect. Hieracium	-		5				14											2
Johannesört	Clusiaceae	Hypericum	Maculatum	Crantz					11									7			2
Linnéa	Caprifoliaceae	Linnaea	Borealis	L.						12	14										2
Ängskovall	Scrophulariaceae	Melampyrum	Pratense	L.		5				14											2
Fjällgröe	Poaceae	Poa	Alpina	L.		5							6								2
Rosettjungfrulin	Polygalaceae	Polygala	Amarella	Crantz		5							6								2

Continuation of table 6: 'Floristic composition at locations observed within sling', from previous page.

Trampört	<i>Polygonaceae</i>	<i>Polygonum</i>	<i>Aviculare</i>	L.				7	4	2
Blodrot	<i>Rosaceae</i>	<i>Potentilla</i>	<i>Erecta</i>	(L.) Raeusch.	5	12				2
Brunört	<i>Lamiaceae</i>	<i>Prunella</i>	<i>Vulgaris</i>	L.	5		6			2
Revmörblomma	<i>Ranunculaceae</i>	<i>Ranunculus</i>	<i>Repens</i>	L.			3 6			2
Ängssyra	<i>Polygonaceae</i>	<i>Rumex</i>	<i>Acetosa</i>	L.			6		4	2
Rönn	<i>Rosaceae</i>	<i>Sorbus</i>	<i>aucuparia</i>	L.	5		9			2
Grässtjärnblomma	<i>Caryophyllaceae</i>	<i>Stellaria</i>	<i>graminea</i>	L.				15	4	2
Nässlor	<i>Cannabaceae</i>	<i>Urtica dioica</i>	<i>ssp dioica</i>	-					7	4
Skogsvicker	<i>Fabaceae</i>	<i>Vicia</i>	<i>silvaticum</i>	-	5		9			2
Stymorsviol	<i>Violaceae</i>	<i>Viola</i>	<i>Tricolor</i>	L.			6		7	2
Trolldruva	<i>Ranunculaceae</i>	<i>Actaea</i>	<i>Spicata</i>	L.		11				1
Valldaggkäpa	<i>Rosaceae</i>	<i>Alchemilla</i>	<i>subglobosa</i>	G.C. Westerl.			3			1
Njurdaggkäpa	<i>Rosaceae</i>	<i>Alchemilla</i>	<i>murbeckiana</i>	Buser			10			1
Akleja	<i>Ranunculaceae</i>	<i>Aquilegia</i>	<i>vulgaris</i>	L.			13			1
Sandtrav	<i>Brassicaceae</i>	<i>Arabidopsis</i>	<i>arenosa</i>	(L.) Lawalrée					7	1
Krustätel	<i>Poaceae</i>	<i>Avenella</i>	<i>flexuosa</i>	(L.) Drejer			14			1
Sommargyllen	<i>Brassicaceae</i>	<i>Barbarea</i>	<i>vulgaris arcuate</i>	Čelak					7	1
Björk	<i>Polygonaceae</i>	<i>Betula</i>	<i>pubescens</i>	Ehrh.	1					1
Berggrör	<i>Poaceae</i>	<i>Calamagrostis</i>	<i>epigejos</i>	(WDJ Koch) VN Vassil.			14			1
Krustistel	<i>Asteraceae</i>	<i>Carduus</i>	<i>crispus</i>	L.					4	1
Vanlig hundstarr	<i>Cyperaceae</i>	<i>Carex</i>	<i>nigra</i>	(L.) Reichard					7	1
Kummin	<i>Apiaceae</i>	<i>Carum</i>	<i>carvi</i>	L.					7	1
Kråkklöver	<i>Rosaceae</i>	<i>Comarum</i>	<i>palustre</i>	L.	1					1
Jungfru Marie nycklar	<i>Orchidaceae</i>	<i>Dactylorhiza</i>	<i>maculata</i>	(L.) Soó		12				1
Tibast	<i>Thymelaeaceae</i>	<i>Daphne</i>	<i>mezereum</i>	L.		11				1
Tuvtätel	<i>Poaceae</i>	<i>Deschampsia</i>	<i>cespitosa</i>	(L.) P. Beauv.					7	1
Kråkbär	<i>Ericaceae</i>	<i>Empetrum</i>	<i>hermaphroditum</i>	Hagerup			14			1
Skogsfräken	<i>Equisetaceae</i>	<i>Equisetum</i>	<i>sylvaticum</i>	L.					2	1
Åkerkårel	<i>Erysimum</i>	<i>Erysimum</i>	<i>cheiranthoides</i>	L.			3			1
Revormstörel	<i>Euphorbiaceae</i>	<i>Euphorbia</i>	<i>helioscopia</i>	L.				15		1
Ögontröst	<i>Scrophulariaceae</i>	<i>Euphrasia</i>	<i>stricta</i>	Kunth					2	1
Toppdån	<i>Lamiaceae</i>	<i>Galeopsis</i>	<i>bifida</i>	L.			3			1
Hampdån	<i>Lamiaceae</i>	<i>Galeopsis</i>	<i>speciosa</i>	Mill					4	1
Humbleblomster	<i>Rosaceae</i>	<i>Geum</i>	<i>rivale</i>	L.		12				1
Ekbräken	<i>Woodsiaceae</i>	<i>Gymnocarpium</i>	<i>dryopteris</i>	(L.) Newman			14			1
Flockfibbla	<i>Asteraceae</i>	<i>Hieracium</i>	<i>Umbellatum</i>	L.				13		1
Vårärt	<i>Fabaceae</i>	<i>Lathyrus</i>	<i>Vernus</i>	(L.) Bernh.	5					1
Blomsterlupin	<i>Fabaceae</i>	<i>Lupinus</i>	<i>Polyphyllus</i>	Lindl.	1					1
Bergsslok	<i>Poaceae</i>	<i>Melica</i>	<i>Nutans</i>	L.			14			1
Ögonpyrola	<i>Diapensiaceae</i>	<i>Moneses</i>	<i>Uniflora</i>	(L.) A. Gray	5					1
Åkerförgätmigej	<i>Boraginaceae</i>	<i>Myosotis</i>	<i>Arvensis</i>	(L.) Hill					4	1
Skogsförgätmigej	<i>Boraginaceae</i>	<i>Myosotis</i>	<i>Sylvatica</i>	Ehrh. Ex Hoffm.			6			1
Åkerförgätmigej	<i>Boraginaceae</i>	<i>Myosotis</i>	<i>Arvensis</i>	(L.) Hill			9			1
Stagg	<i>Poaceae</i>	<i>Nardus</i>	<i>Stricta</i>	L.			9			1
Tvåblad	<i>Orchidaceae</i>	<i>Neottia</i>	<i>Ovata</i>	(L.) Bluff & Fingerh.		12				1
Backskärvrö	<i>Brassicaceae</i>	<i>Noccaea</i>	<i>Caerulescens</i>	(J&C Presl.)FK Mey.			6			1
Harsyra	<i>Oxalidaceae</i>	<i>Oxalis</i>	<i>Acetosella</i>	L.		12				1
Ormbär	<i>Triliaceae</i>	<i>Paris</i>	<i>quadrifolia</i>	L.		11				1
Pilört	<i>Polygonaceae</i>	<i>Persicaria</i>	<i>lapathifolia ssp pallida</i>	Ekman & Knutsson					4	1
Fjälltimotej	<i>Poaceae</i>	<i>Phleum</i>	<i>alpinum</i>	L.	5					1
Revfibbla	<i>Asteraceae</i>	<i>Pilosella</i>	<i>lactucella</i>	(Wallr.) P.D. Sell & C. West			9			1
Bockrot	<i>Rosaceae</i>	<i>Pimpinella</i>	<i>saxifraga</i>	L.				15		1
Groblad	<i>Plantaginaceae</i>	<i>Plantago</i>	<i>major</i>	L.			6			1
Väggmossa	<i>Hylcomiaceae</i>	<i>Pleurozium</i>	<i>schreberi</i>	(Willd.ex Brid) Mitt.	11					1
Kärrgröe	<i>Poaceae</i>	<i>Poa</i>	<i>Trivialis</i>	L.					2	1
Vitgröe	<i>Poaceae</i>	<i>Poa</i>	<i>Annua</i>	L.					7	1
Klotpyrola	<i>Diapensiaceae</i>	<i>Pyrola</i>	<i>Minor</i>	L.	5					1
Bergssyra	<i>Polygonaceae</i>	<i>Rumex</i>	<i>Acetosella</i>	L.			6			1
Ängssvingel	<i>Poaceae</i>	<i>Schedonorus</i>	<i>Pratensis</i>	(Huds.)P.Beauv.			6			1
Ängsruta	<i>Ranunculaceae</i>	<i>Thalictrum</i>	<i>Flavum</i>	L.			9			1

[illegible]

The textures of the soil samples are presented in Figure 12, showing the different locations, all presenting light soils with a mixture of clay and sand resulting in different types of loam.



30

Table 7. Results from Eurofins soil analysis. Topsoil characteristics at the different field locations are presented, including soil chemistry, pH, and soil biology variables. Variables are sorted by pH. Eurofins measures pH(CaCl₂) which has values approximately 0.6 units lower than pH (H₂O), more commonly used in Sweden. Transformation of analysis data into ha amounts are done by Eurofins Agro and is described in the section 'Material and Methods'.

	Location	pH CaCl ₂	Total N kg/ha	Ratio C/N	Available S kg/ha	Available P kg/ha	Available cations kg/ha				CEC mmol+ /kg	Ratio Base-cation saturation %	Org-C %	Carbonate Lime %	Microbial biomass mg C/kg	Microbial activity mg N/kg	Fungi/ bacteria mg C/kg
							K	Ca	Mg	Na							
9	Anners-Persbuan	4.4	8480	12	22	2.7	230	25	340	<27	71	83	3.16	2.3	911	112	0.8
5	Hästön woodland	4.8	9850	14	18	<0.9	140	265	400	<24	179	78	4.60	1.7	532	85	0.6
10	Våle	4.9	7880	12	21	<1.0	235	1800	310	<27	165	80	2.96	1.9	499	1	1.2
12	Lervik	4.9	8020	17	26	<0.9	190	905	330	<23	196	75	4.90	2.3	551	60	0.6
14	Raskhus	4.9	5800	24	15	<0.9	95	620	225	22	159	88	5.10	1.2	587	22	0.9
8	Funäs	5.2	11360	16	25	1.3	640	190	625	29	250	95	6.80	2.4	783	81	0.7
3	Kattstrupeforsen	5.6	8700	11	22	<1.0	100	250	185	<25	128	100	3.12	1.5	519	52	0.7
11	Rödegård	5.7	10920	12	26	<0.9	140	145	340	<24	164	98	4.37	1.2	383	53	0.6
1	Häggån	5.7	7200	13	18	<1.0	90	305	185	<26	127	99	2.93	2	926	55	0.7
15	Ope	6.2	11370	11	12	<1.0	215	540	195	<25	198	99	3.99	2.8	1528	90	0.7
4	Söre	6.2	17090	12	44	<0.7	70	475	125	17	462	95	9.70	4.7	908	24	0.8
13	Sunne	7.1	13280	12	17	15.7	225	800	185	<21	316	100	6.00	3.6	1035	30	1
7	Hästön rud	7.2	8000	12	21	<1.0	195	310	205	<26	169	100	2.95	2.6	140	17	1.4
2	Rannåsen	7.2	6580	11	21	<0.1	120	330	255	<28	144	100	2.14	2.7	417	24	0.8
6	Kyrkås	7.4	6580	12	23	<1.1	130	720	70	<28	93	100	2.19	1.7	492	71	0.8
	MEAN	6	9407	13	22	7	188	512	265	23	188	93	4	2	681	52	1
	STDEV	1.01	2995.72	3.42	7.25	7.94	137.05	437.15	134.26	6.03	96.30	9.22	2.01	0.93	339.30	31.83	0.23
	MIN	4.8	5800	11	12	1.3	70	145	70	17	93	75	2.14	1.2	140	1	0.6
	MAX	7.4	17090	24	44	15.7	640	1800	625	29	462	100	9.7	4.7	1528	112	1.4

5. Discussion

5.1 Sampling locations

All the sites reported in Artportalen from which the random samples were taken were predominantly reported as some kind of managed grassland. However, quite many locations were reported as forest and to a lesser extent wetland areas. Thus, the range according to these reported observations is quite wide.

Regarding elevation and aspect of the sites, neither of these two variables seemed to have any effect on either size or spread of the populations. However, the range of elevation measured at these 15 locations were not very big. The lowest altitude was 262 m above sea level and the highest was 494 m. Seven of the 15 locations were not situated in any slope, two were steep, and six of the locations were along gentle slopes, with aspect facing northeast as well as southeast and southwest. *V. sepium* seems to grow well across these different conditions.

5.2 Plant community

V. sepium grows with a large amount of diversity. The floristic composition at each location shows how *V. sepium* does not seem to prefer any type of plant as a companion species. Rather, this species may be called a generalist growing with a wide range of species. In habitats encompassing a higher diversity such as No. 6 Kyrkås, a seemingly meadow-like habitat, *V. sepium* is not taking over nor suffering under pressure from these other species. It grows erect and single, not taller than other species. The ruderal site No. 7. Hästöen next to a manure pit also shows a larger diversity of species. At this site *V. sepium* grew tall and lush, clinging on to *Dactylis glomerata* (L.) and other taller grasses, without weighing them down and without any invasive manners. Information from the historical references indicated that *V. sepium* does not spread nor climb as heavy as *V. cracca* does on its companion species. Still, it is said in these sources it needs to be intercropped to produce a thick vegetation. However, Juhlin-Dannfelt (1916) referred to field trials where *V. sepium* did well grown in single swards.

In addition, the effect of disturbance and management seems to play a role in how *V. sepium* is growing and with what company. The floristic composition shows more species richness in managed grassland areas. In an experiment evaluating different methods of management in semi-natural grassland vegetation, Wahlman & Milberg (2002) showed that *V. sepium* thrives and regrow more eagerly when mowed or grazed every year, rather than if the grassland is

mowed less frequently, burnt, or left untreated. This corresponds well with field observations of *V. sepium* in this study. However, in Wahlman's and Milberg's experiment, *V. sepium* is especially associated with grazing, a disturbance only shown at one of the locations in this field observation; No. 9 Anners-Persbuan. At this site the population of *V. sepium* was small with a sparse density, dispersed evenly. If grazing would have been more intense this might have shown a difference in this population's characteristics. At the disturbed sites in this field observations, where grassland has been cut, *V. sepium* regrew easily. This is supported by descriptions in historical literature (Juhlin Dannfelt 1901, Arrhenius 1879) where *V. sepium* is said to regrow effectively after harvest when it has established at a site. To some extent it has also spread into adjacent leys and lawns at some of the sites visited. In historical literature *V. sepium* is also noted to do well in systems comprising a first harvest for green fodder followed by grazing (Arrhenius 1879).

In addition, *V. sepium* seems to respond differently in different locations, showing a variance in how the population disperses over the site. At some locations the population is spread out with many plants and ramets, yet still the single plants may be small and distributed evenly over the site. In addition, other locations present a lush population growing densely together intertwined with other vegetation, with single plants reaching high. The plants of these populations grew cluster-like and concentrated to a smaller area. The characteristics of the populations, the different dispersion patterns, and the size of the populations may render some information on how *V. sepium* responds to constraints and opportunities in different habitats. Throughout the field observations there is a clear difference between populations showing a sparse density, evenly dispersed over the area, compared to dense populations with a cluster-like dispersion pattern. The dispersion pattern of the populations at No. 5 Hästön woodland, No. 9 Anners-Persbuan No. 12 Lervik, and No. 14 Raskhus are all evenly distributed over the area. All of these locations are in or nearby coniferous forests. Three out of these four populations are categorised as small. This suggests that *V. sepium* can grow in areas dominated or affected by forests yet colonises better in areas with more favourable conditions. These four locations might be under constraint due to low pH. Root nodulation and N₂ fixation in legumes works better in pH 6 and above (REF?). Another explanation may be that land use at these locations has changed from the 1960s. Number 9. Anners-Persbuan, was more grazed and the remaining 3 forests were of a more open character. Thus, these populations might be declining due to a lack of management, such as grazing or that the higher tree canopy gives too much shade. It would be interesting to revisit these locations in a couple of years to monitor any changes and to see if the population size remains constant. Furthermore, dispersion patterns, being clusters or randomly spread, suggest that the populations are fit for the site. An even distribution can indicate competition for a resource such as light (Stoll and Bergius 2005). All locations with a more active management (2. Rannåsen, 3. Kattstrupeforsen, 6. Kyrkås, 10. Våle, 13. Sunne and 15. Ope) had a sparse density of the population with a random dispersion. This may suggest no competition is needed over nutrients, as conditions are good and not restrictive.

If left undisturbed, the dispersion pattern of the population is foremost cluster-like. These undisturbed populations will not get any help spreading their seed as no machinery or other elements move over the area. Thus, seed drop at site and grow there. On the other hand, the

dispersion manner may also indicate that resources such as nutrients are unevenly distributed or that the root environments differ across the site. Plant heights were also the tallest noted at these sites, ranging from 0.7 to 1 m.

Moreover, *V. sepium* is found in areas with ranging levels of shade. This may indicate how this species has many ways of coping with light-availability variations. As it grows both in shade and direct sunlight, it may do well in open grassland production, even though most of the populations were found in locations lightly or partially shaded. Gommers et al. (2013) points at how shade coping strategies, as opposed to shade avoiding strategies are important in an agronomical context. Agronomically suitable plants should use carbohydrates for leaf production and root development instead of taking measures to avoid shadow. Thus, *V. sepium* may be a plant of good agronomical use since it may direct energy and resources to physical defense and leaf production even though it grows shaded either by companion species or a higher tree canopy. This might be one way of explaining historical information saying it establishes well among other plants staying green and lush, producing a high density even in the lower strata of the vegetation. On the other hand, a field trial in Missouri USA, examining forage yield in an agroforestry setting, shows how grass and legume forages may produce more in lightly shaded environments compared to forage production in open pastures (Pang et al., 2023). This might be applicable for *V. sepium*.

5.3 Soil properties

V. sepium has in these field observations shown to grow in fairly light textured soils. This correlates well to what is said concerning soil preferences of *V. sepium* written in historical descriptions (Wahlberg 1835). Soils should be light and not too dry. *V. cracca* is described as more able to grow in heavier, clayey soils. The results are not surprising, as the soil textures of Jämtland are typically sandy loams.

Five locations, No. 5 *Anners Persbuan*, No. 9 *Hästön woodland*, No. 10 *Våle*, No. 12 *Lervik* and No. 14 *Raskhus* showed strongly acidic soils with pH levels measured from 4.4 to 4.9. All these locations, except one, No. 10 *Våle*, are situated in or nearby coniferous dominated forest, thus low pH is not surprising. Still the available magnesium, calcium, and potassium are not lower here than for locations with higher pH. This may be explained by soil biology, as the microbial biomass is large with a satisfactory ratio between fungi and bacteria.

Concerning legumes and potassium, recommendations on adding fertiliser are generally to give a higher application rate than for grasses, thus this may not be an issue when it comes to *V. sepium*. Even though the populations 4. *Söre* and 1. *Häggån* were small it was two of the lushest locations for *V. sepium*, still these locations showed the lowest amount of accessible potassium. Nevertheless, No. 8 *Funäs*, one of the largest populations showed the highest amount of potassium recorded among these samples, possibly showing how higher levels of potassium are favourable.

Additionally, *V. sepium* seems to thrive in a wide range of phosphorous availability. Number 1, *Häggån*, showed a widespread and lush population, as did No. 4, *Söre* and No. 10, *Våle*. All these locations had low amounts of available phosphorous. Moreover, considering the different

levels of available phosphorous, it is interesting to discuss whether *V. sepium* would do good in agricultural systems with low applications of phosphate, as in long-term leys with little phosphorous added. Generally, legumes need more phosphorous than grasses to support root nodulation and N₂ fixation. However, according to Swedish recommendations on fertiliser, crops like flax, peas and *Vicia faba* (L.), as well as leys, don't present any larger yields in one year field trials when higher phosphorous applications have been given (SJV 2023b). This might not be applicable for long-term leys.

Moreover, soil fertility depends on many interacting components. A soil analysis presents the biological, chemical, and physical status of the soil. Evaluating interactions and dependence of these different aspects may help improve land use practices to sustain a fertile soil.

V. sepium thrived both in woodland locations and nearby or *in* actively farmed land. However, why *V. sepium* would grow in the very acidic soils of a forest may be due to interactions connected to humus and microbes in undisturbed soils. The fungi/bacteria ratio for all soil samples showed results of 0.6 and above. These values are considered good or sufficient for a healthy soil and when values exceed 0.6, microbes enhancing pest and disease control are supported (Daniel Pettersson, personal communication, 2023). Higher ratios of this quota also indicate undisturbed ecosystems, organic or low-input agricultural systems. Disturbances, such as tillage and removal of crop residues, lower this ratio. Placing *V. sepium* from a natural context into an agronomic context, changes a lot of parameters for how factors of growth can be analysed. Factors supporting plant growth in a natural context can be brought into the agronomical one. Huey (2020) stresses how biological interactions are important for sustainable agriculture, as they maintain plant growth and development through biological processes rather than with agrochemicals. In addition, a soil rich in biological activity is a soil capable of withstanding diseases and pests. Biological activity also helps make nutrients available, retain moisture, and store CO₂ (Abbott & Murphy 2003). Chemical fertilisers affect the soil biology negatively and positive services of a healthy soil with soil bacteria controlling root diseases may be lost (Jambagi et al, 2023).

6. Further questions

In historical sources, information is clear concerning the difficulty in obtaining seed. This is still a key issue when introducing wild species in agronomical contexts. However, we may be at that point when the late 20th century rules and regulations concerning seed homogeneity meets new issues regarding sustainability in our farming systems. In a small-scale project lasting over two years, norwegian farmers produced seed from native wild pollinator friendly species (Nibio 2023). 1 tonne of seed was produced by 5 different farmers sold to the market as a ‘pure Norwegian alternative’ of native pollinator friendly species. It would be of high interest to see if it would be possible to do a parallel of this project in a Swedish context, and eventually enrich leys with native seed from wild species with good forage quality. Pratensis AB is a company in Sweden that collects seed and propagate wild native species to sell (Pratensis 2023). Their objective is to recreate the rich biodiversity of meadows.

Mapping the range of natural environment in which *V. sepium* grows and seeing how it can handle different aspects of a growth site, leads to how well it would do in an agronomic context. In agroecosystems, removal of harvest and addition of manure/fertiliser will generate another physical more changing environment. For example, leys with legumes have a stronger acidifying effect on the soil than leys without (Karlsson 2013). This is due to legumes consuming more cations such as potassium, calcium, and magnesium and that these then will be removed through harvest. However, if manure instead of fertiliser is added, the acidification processes will be reduced. Would this also comply for *V. sepium* and how will the agricultural system be designed to suit a more diverse mixture of species? The way we use manure and fertiliser affects rhizobia nodulation, and this would be a trait to examine. Other questions include studying how active rhizobia bacteria are at different locations with different management and evaluating the level of nitrogen fixation compared to the availability of nitrogen in the soil.

Furthermore, in Swedish guidelines concerning fertilising and liming (Jordbruksverket 2023b), a mixed ley of both grasses and a moderate amount of clover give a good nutritional balance between energy and protein. An unfertilised ley can be dominated by clover. How *V. sepium* would complement this balance of protein and energy depending on how frequent the ley would be harvested is another question to research.

Furthermore, since *V. sepium* in the literature, as well as in this study, is observed to prefer lightly shaded areas, it would be of interest to examine morphological adaptations when grown under no shade; for example, how is biomass allocated and is leaf area affected? Will flowering be accelerated? If we conclude that *V. sepium* as a semi-woodland species is shade tolerant, as well as shade indifferent, it might show high functional plasticity.

Moreover, I reached a few locations where I decided to go elsewhere as *V. sepium* did not occur to a sufficient extent or did not even occur at all. To fully understand the range of natural environments in which *V. sepium* grows, it would be interesting to detect what type of management or circumstance at these locations led a population to decrease or eventually disappear. This would require more detailed information on a specific set of locations to be followed over a period.

7. Conclusions

In this work I have provided information on the range of environments in which the native perennial legume *V. sepium* grows in the county of Jämtland, Sweden. In addition, I have also tracked ethnobotanical historical use and experiences of utilising this species as a forage plant. The combination of these two objectives demonstrates that there are obvious reasons to keep an interest in *V. sepium*.

This native legume dropped out of focus in mid-20th century, mainly because of tedious seed propagation. Seed collection and propagation were hard, due to struggles to overcome wild traits such as a hard seed coat and asynchronous germination. Still the species was rich in other agronomic qualities. This is where we may pick up the work today.

Moreover, the results from the field observations, point at how *V. sepium* grows in various contexts and a wide range of natural environments. As this species is a generalist, it might be able to adapt to change faster than specialists can.

The field observation of natural environments of *V. sepium* has shown that:

- *V. sepium* can grow in fields, even though the population is reported to grow adjacent to these cultivated areas. It does in other words spread effectively when conditions are appropriate. At the locations where it grew in a cultivated already harvested field, it was easy to see how it already grew higher than companion grasses.
- *V. sepium* seems to do well across a wide pH range.
- *V. sepium* seems to grow in a wide range of both phosphorous and potassium availability.
- *V. sepium* handles wet conditions, as shown by the population in Söre being lush and dense with slender stalks and a bushy way of growing.
- Historical floras and literature state *V. sepium* needs supporting species to be intercropped with. However, in the field *V. sepium* seems to be able to grow both sturdy and erect on its own and at other locations climbing and growing intertwined with other species without weighing these down.
- *V. sepium* has shown to be a shade tolerant species that can easily grow and adapt under different levels of shade.
- *V. sepium* grows easily when shaded by companion species. It adjusts and responds to environmental variations, possibly showing an economical allocation flexibility as a response to environmental variations.

- Neither aspect nor slope can through this limited field observation be said to have any effect on how the population grows or the morphology of the plants.

Information given from historical sources does not spell out specific soil characteristics nor characteristics on how a population is dispersed over an area. However, what is given apart from its nutritional values as well as palatability, is the information that *V. sepium*:

- Is commonly recognised to grow well under different circumstances and in different environments.
- Lasts long – 'a generation' where it once has established.
- Effectively suppresses weeds.
- Regrow effectively when cut and stays green during a long season.
- Takes time to establish but gives a rich harvest in the second and following production years.
- Needs companion species to build a thick vegetation. Arrhenius proposes *Dactylis glomerata* and *Phleum pratense* as suitable companions (Arrhenius 1879). These two were also frequently seen at sampling locations as was *Alopecurus pratensis*, as presented in Table 6. To mention another species, *Lathyrus pratensis* looks like *V. sepium*'s best friend showing up at almost all different locations as well as in literature.

Some of the environments researched in this field study are applicable to agricultural contexts. The disturbed areas are all cut / mowed at least once a year and show that *V. sepium* responds positively with this treatment. However, concerning lack of tillage at all soil sampling locations, soil analysis data may not relate well to an agricultural context. Instead, a healthy undisturbed soil structure and rich soil biology is shown supporting a rich and diverse flora.

Finally, reconnecting to my word play title of this thesis; whether *V. sepium* is to be considered a breed or a weed – my conclusion is: of course, it should be a breed! It may well be a good species to use in diversifying long lasting leys.

8. Final words and acknowledgements

Throughout this work I linger on the question of how we may promote different levels of biodiversity in our agricultural systems. I believe knowledge in this sphere creates a highly needed sense of connectivity with our actions and make us take care. Scientific results may promote ecosystem services for our needs, but maybe also for the sake of biodiversity itself: can we strengthen, in contrast to exploiting, ecosystems when practicing agriculture and could using a more diverse range of species play a role?

In his book *Från höfrö till vallfrö* Lennart Kåhre touches upon how these left out most prominent native candidates would be worth looking at again as we may open new doors today, hopefully having more knowledge and a broader perspective on the use and diverse qualities of plants (Kåhre 1996, p. 107). This was 30 years ago! His thoughts upon this go well into the work needed, building resilience and adaptation in the gene pool of our cultivars as well as in our land use methods.

Finally, considering how many in Sweden that in former times engaged in farming having farming as their livelihood, it must have been an interesting period! Time was not influenced by market economy and a global seed market. Working local and *in situ* with what then was given might have spurred more diverse experiences. It is striking how small local practical farming schools run by private persons were engaged and committed in developing farming methods. People of this time being more dependent on surrounding nature might have carried thorough knowledge of local wild flora and fauna. Old local names told of growth nature and use compared to now, when common wild species may stay unknown for many, simply being called flowers.

Thank you, David Parsons, and Brooke Micke, letting me take a part in this very interesting subject '*Diversifying the utility and species composition of Nordic forage systems*'.

Thank you, my flower expert Leif Larsson, for your professional pictures of *Vicia sepium*. And thank you, Kristina Digman, for letting me use your wonderful drawing of Flora for my title page. And Roland Lyhagen thank you for sharing material, thoughts, and knowledge on this subject!

9. References

- Abbott, L.K. & Murphy, D.V. (2003). *What is soil biological fertility?* In: Abbott L.K. & Murphy D.V. (eds.). *Soil biological fertility – a key to sustainable land use in agriculture*. Kluwer Academic Publishers, the Netherlands, pp. 1–15.
<https://link.springer.com/content/pdf/10.1007/978-1-4020-6619-1.pdf#page=11>
- Frankow-Lindberg, B.E. (2012). Grassland plant species diversity decreases invasion by increasing resource use. *Oecologia* 169(3), 793–802.
<https://link.springer.com/article/10.1007/s00442-011-2230-7>
- Furey, G.N. & Tilman, D (2021). Plant biodiversity and the regeneration of soil fertility. *Proceedings of the National Academy of Sciences of the United States of America*. 118(49).
<https://doi.org/10.1073/pnas.2111321118>
- Gommers, C.M.M., Visser, E.J.W., Onge, K.R.S., Voesenek, L.A.C.J. & Pierik, R. (2013). Shade tolerance: when growing tall is not an option. *Trends in plant science*. 18(2), 65–71.
<https://doi.org/10.1016/j.tplants.2012.09.008>
- Hämet-Ahti, L. (1970). Taxonomy of *V. sepium* L. (*Leguminosae*) in Finland. *Annales Botanici Fennici*. 7(2), 170–176. <http://www.jstor.org/stable/23724687>
- Hector, A. (2022). The importance of biodiverse plant communities for healthy soils. *Proceedings of the National Academy of Sciences of the United States of America*. 119(1), e2119953118.
<https://doi.org/10.1073/pnas.2119953118>
- Huey, C.J., Gopinath, S.C.B., Uda, M.N.A., Zulhaimi, H.I., Jafaar, M.N., Kasim, F.H. & Yaakub, A.R.W. (2020). Mycorrhiza: a natural resource assists plant growth under varied soil conditions. *3 Biotech*. 10(204). <https://doi.org/10.1007/s13205-020-02188-3>
- Jing, J., Søegaard, K., Cong, W. F., & Eriksen, J. (2017). Species diversity effects on productivity, persistence and quality of multispecies swards in a four-year experiment. *PLoS One*, 12(1), e0169208. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0169208>
- Kadžiulienė, Ž., & Kadžiulis, L. (2007). Nitrogen accumulation and efficiency in herbage depending on legume species in grassland sward. *Biologija*, 53(1).
<https://www.lmaleidykla.lt/ojs/index.php/biologija/article/view/718>
- Karlsson, T. (2013). *Soil carbon, pH and yield development in a long-term humus balance trial*. (Independent project 2013:19) Swedish university of agricultural sciences. Agricultural Programme – Soil and Plant Sciences.
https://stud.epsilon.slu.se/6247/7/karlsson_t_131105.pdf
- Kåhre, L. (1996). *Från höfrö till vallfrö: Den svenska fröförsörjningen 1740–1870*. Skogs- och lantbruksakademien.
- Krietsch-Boerner, L. (2019). Industrial ammonia production emits more CO₂ than any other chemical-making reaction. Chemists want to change that. *Chemical & engineering news*. 97(24).
- Krok, T.O.B.N. & Almqvist, S. (2003). *Svensk flora – Fanerogamer och ormbunksväxter*. 28 ed.. Liber.

- Lange, U. (2000). *Experimentalfältet: Kungl. Lantbruksakademiens experiment- och försöksverksamhet på norra Djurgården i Stockholm 1816–1907*. Diss. Sveriges lantbruksuniversitet. <http://epsilon.slu.se/avh/2000/91-576-5760-2.pdf>
- Ljungqvist, K. (2022). *Nyttans växter: uppslagsbok med över tusen växter: historik om svensk medicinalväxtodling*. 5th ed., Dals Rostock: Calluna.
- Lyhagen, R. (1991). Några glimtar från 100 års utsädesförsäljning. *Svensk botanisk tidskrift*, Häfte 6, (85). 385–396. <https://uu.diva-portal.org/smash/get/diva2:1203007/FULLTEXT01> [2023-07-07]
- Micke, B. & Parsons, D. (2023). Using botanical resources to select wild forage legumes for domestication in temperate grassland agricultural systems. *Agronomy for Sustainable Development*. 43(1). <https://doi.org/10.1007/s13593-022-00853-w>
- Mossberg, B. & Stenberg, L. (2003). *Nya nordiska floran*. Wahlström och Widstrand
- Osvald, H. (1962). *Vallodling och växtföljder*. Natur och Kultur.
- Pang, K., Van Sambeek, J.W., Navarrete-Tindall, N.E., Lin, C.-H., Jose, S. & Garrett, H.E. (2019). Responses of legumes and grasses to non-, moderate, and dense shade in Missouri, USA. I. Forage yield and its species-level plasticity. *Agroforestry systems*. 93, 11–24. <https://doi.org/10.1007/s10457-017-0067-8>
- Reijneveld, J.A., van Oostrum, M.J., Broelsma, K.M., Fletcher, D. & Oenema, O. (2022). Empower Innovations in Routine Soil Testing. *Agronomy*. 12(1): 191. <https://doi.org/10.3390/agronomy12010191>
- Serajchi, M., Schellenberg, M.P., Mischkolz, J.M. & Lamb, E.G. (2018). Mixtures of native perennial forage species produce higher yields than monocultures in a long-term study. *Canadian journal of plant science*. 98(3), 633–647. <https://doi.org/10.1139/cjps-2017-0087>
- Singh, A., Dubey R.K., Bundela, A.K. & Abhilash, P.C. (2020) The Trilogy of Wild Crops, Traditional Agronomic Practices, and UN-Sustainable Development Goals. *Agronomy*. 10(5), 648. <https://doi.org/10.3390/agronomy10050648>
- Spohn, M., Bagchi, S., Biederman, L.A., Borer, E.T., Bråthen, K.A., Bugalho, M.N., Caldeira, M.C., Catford, J.A., Collins, S.L., Eisenhauer, N., Hagenah, N., Haider, S., Hautier, Y., Knops, J.M.H., Koerner, S.E., Laanisto, L., Lekberg, Y., Martina, J.P., Martinson, H., McCulley, R.L., Peri, P.L., Macek, P., Power, S.A., Risch, A.C., Roscher, C., Seabloom, E.W., Stevens, C., Veen, G.F.C., Virtanen, R. & Yahdjian, L. (2023). The positive effect of plant diversity on soil carbon depends on climate. *Nature communications*. 14, 6624. <https://doi.org/10.1038/s41467-023-42340-0>
- Stoll, P. & Bergius, E. (2005). Pattern and Process: Competition Causes Regular Spacing of Individuals within Plant Populations. *Journal of Ecology*. 93(2), 395–403. <http://www.jstor.org/stable/3599406>
- Van Tassel, D.L., Tesdell, O., Schlautman, B., Rubin, M.J., DeHaan, L.R., Crews, T.E. & Streit Krug, A. (2020). New Food Crop Domestication in the Age of Gene Editing: Genetic, Agronomic and Cultural Change Remain Co-evolutionarily Entangled. *Frontiers in plant science*. 11, 789–789. <https://doi.org/10.3389/fpls.2020.00789>
- Wahlman, H. & Milberg, P. (2002). Management of semi-natural grassland vegetation: evaluation of a long-term experiment in southern Sweden. *Annales Botanici Fennici*. 39(2), 159–166. <https://www.jstor.org/stable/23726791>

Telephone contacts, videos and webpages

Kerstin Ljungqvist, telephone contact [2023-05-30]

- Roland Lyhagen, telephone contact [2023-07-09]
- Daniel Pettersson, Eurofins Agro, telephone contact [2023-09-21]
- Daniel Pettersson, Eurofins Agro, e-mail communication [2024-03-13]
- INRAE (2023). *Agriculture sans pesticides: les grands défis sur le terrain*. [Video].
<https://www.youtube.com/watch?v=joEyQSHJqYM&t=75s> [2023-09-23]
- Nibio (2023). *Effektivisering av norsk frøproduksjon av pollinatorvennlige natrufrøblandinger til bruk i landbruket*. Norsk institutt for bioøkonomi.
<https://www.landbruksdirektoratet.no/nb/prosjektmidler/prosjekter-og-resultater/nasjonale-klima-og-miljotiltak/effektivisering-av-norsk-froproduksjon-av-pollinatorvennlige-naturfroblandinger-til-bruk-i-landbruket> [2023-09-08]
- Pratensis AB (2023). *Pratensis – Ängsfröer och ängsplantor*, Pratensis
<https://pratensis.se> [2023-09-28]
- Riksarkivet (2023a). *Anders Jahan Retzius*, Svenskt biografiskt lexikon
<https://sok.riksarkivet.se/sbl/Presentation.aspx?id=6599> [2023-09-10]
- Riksarkivet (2023b). *Carl Fredric Nyman*, Svenskt biografiskt lexikon.
<https://sok.riksarkivet.se/sbl/artikel/8490> [2023-09-28]
- Riksarkivet (2023c). *Johan Petter Arrhenius*, Svenskt biografiskt lexikon.
<https://sok.riksarkivet.se/sbl/artikel/18847> [2023-09-08]
- SJV (2023a). *Hektar- och totalskörd efter län och gröda. År 1965–2022*. Jordbruksverkets statistikdatabas.
https://statistik.sjv.se/PXWeb/pxweb/sv/Jordbruksverkets%20statistikdatabas/Jordbruksverket%20statistikdatabas__Skordar/JO0601J01.px/table/tableViewLayout1/ [2023-08-12]
- SJV (2023b). *Rekommendationer och strategier för gödsling*. Statens Jordbruksverk.
<https://jordbruksverket.se/vaxter/odling/vaxtnaring/rekommendationer-och-strategier-for-godsling> [2023-08-11]

Historical sources

- Arrhenius, J.P. & Lindqvist, C.A. (1908). *Landbruks-praktika. Första delen: Jordbrukslärans hufvudgrunder*. 11th ed., Beijers bokförlags-aktiebolag.
<http://runeberg.org/jordbruk/0358.html>
- Arrhenius, J.P. (1877). *Den svenske fröodlaren och frösamlaren: meddelanden till Sveriges landtbrukare och trädgårdsodlare*. J. Arrhenii förl. <http://runeberg.org/landthus/18/>
- Arrhenius, J.P. (1879). *Handbok i svenska jordbruket, andra delen*. 4th ed., Författarens förlag.
- ASU (1895). Allmänna Svenska Utsädesaktiebolaget, Svalöf
- Henriksson, J. (1923). *Vartill våra växter duga*. Björck & Börjesson.
- Juhlin-Dannfelt, H. (1916). *Handbok i Jordbrukslära, senare delen*. Fritze.
- Jönson-Rösiö, P. (1904). *Några anvisningar för odling af våra vilda mångåriga baljväxter: Ur Landtmannens bok*. Stockholm. <https://urn.kb.se/resolve?urn=urn:nbn:se:kb:eod-3023184>
- Larsson-Kilian, A. (1912). *Småbruket – En bok till väckelse och ledning för Sveriges småbrukare*. J. A. Lindblands förlag.
- Lindman, C.A.M. (1917). *Bilder ur Nordens flora*. 3d ed., Wahlström & Widstrand
- Lundequist, N.W. (1850). *Handbok i svenska landbruket, förra delen*. 3d ed., Bokhandlaren N.W. Lundequist.
- Nilsson, N.H. (1893). *Allmänna Svenska utsädesföreningens tidskrift. Tredje Årgången* Skånska Litografiska Aktiebolaget.

- Nyman, C.F. (1868). *Utkast till svenska växternas naturhistoria eller Sveriges fanerogamer skildrade i korthet med deras växtställan och utbredning m.m., deras egenskaper, användning och historia i allmänhet. Senare delen. Foderblomstriga och kronlösa dicotyledoner. Monocotyledoner*. Abr. Bohlin, Örebro.
- Quensel, C., Swartz, O. & Wahlenberg, G. (1807-1808). *Svensk botanik, utgifven af J.W. Palmstruch. Femte bandet. 1-10. 1802-29. 11 och register 1830-43. Med konungens nådigste privilegium*. Deleen.
- Retzius, A.J. (1806). *Försök til en Flora Oeconomica Sveciæ eller Svenska Växters Nytt och Skada i hushållningen.*, Joh. Lundblad, Lund.
- Wahlberg, P.F. (1835). *Anvisning till svenska foderväxternas kännedom*. Nordström.
- von Linné, C. (1749). *Pan Svecicus, quem, consensu ampliss. Facult. Med. in Reg. Acad. Upsaliensi, præside Viro celeberrimo et experientissimo, Dn. Doct. Carolo Linnæo ... publico examini modeste submittit Nicolaus L. Hesselgren, Wermelandus. In audit. Carol. Major. ad diem IX. Decemb. anni MDCCXLIX. Horis, ante meridiem, consvetis.*
<http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-399465>

Publishing and archiving

Approved students' theses at SLU can be published online. As a student you own the copyright to your work and in such cases, you need to approve the publication. In connection with your approval of publication, SLU will process your personal data (name) to make the work searchable on the internet. You can revoke your consent at any time by contacting the library.

Even if you choose not to publish the work or if you revoke your approval, the thesis will be archived digitally according to archive legislation.

You will find links to SLU's publication agreement and SLU's processing of personal data and your rights on this page:

☒ YES, I, Malin Johansson, have read and agree to the agreement for publication and the personal data processing that takes place in connection with this.

☐ NO, I/we do not give my/our permission to publish the full text of this work. However, the work will be uploaded for archiving and the metadata and summary will be visible and searchable.