Swedish University of Agricultural Sciences
The Faculty of Natural Resources and Agricultural Sciences
Department of Ecology

Long-term development of vegetation in established permanent field margins

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Abstract

Biodiversity loss, pesticide drift and nutrient leakage are some of the negative effects caused by intensified agriculture. One measure to reduce these negative effects is to establish permanent field margins. Between 1988 and 1990 experiments with broadened permanent field margins were established at three sites near Flen and Uppsala in south of Sweden. One of the aims was to study how different treatments affected the margin vegetation and if the abundance of weeds could be suppressed. The treatments consisted of establishing new or broadening pre-existent field margins, sowing different seed-mixtures (e.g. “meadow plants”) and manage them by yearly mowing with removal of cut material. The vegetation was investigated at three occasions after establishment during a 20-year period. At the second and third occasion, adjacent untreated field margins were examined for comparisons.

The results showed that sowing different species, particularly “meadow plants”, can substantially change the field margin flora in a long-term perspective and lower the abundance of weeds, compared to untreated margins. Out of the sown 32 “meadow plants” species, 22 remained after more than 20 years. Several of the sown species that normally occur in well-managed meadows and pastures were able to survive in the experiments.

Keywords: Field margin, Long-term study, Vegetation development, Biodiversity, Meadow plants, Weeds, Agriculture

Populärvetenskaplig sammanfattning

Dagens intensifierade och maskinanpassade jordbruk med stora åkrar, monokultur, användande av kemiska bekämpningsmedel och konstgödsel, och ett skifte från höproduktion till ensilage, har påverkat såväl biodiversitet som hela landskapsbilden. Ett av landskapselementen som ofta har rationaliserats bort är åkerkanten, dels eftersom det är en ekonomisk och praktisk fördel för lantbrukaren att ha sammanhängande åkrar, men även på grund av att åkerkanten har ansetts vara en ogräs- och skadedjursspridare. Det senare har motbevisats av flera undersökningar där permanenta åkerkanter har anlagts (Fritch *et al.*, 2011; Marshall, 2009; Musters *et al.*, 2009; Moonen & Marshall, 2001; Smith *et al.*, 1999; Kleijn *et al.*, 1998). Åkerkanter har visats sig vara viktiga habitat för många växter och djur, däribland insekter, fåglar och däggdjur, och kan också bidra till många ekosystemtjänster, såsom pollinering och biologisk bekämpning av skadedjur, men även förhindrande av erosion och spridning av jordbrukskemilkalier. På senare tid har dessa positiva egenskaper lyfts fram och man har infört olika ersättningssystem med ekonomisk kompensation för lantbrukarna.

I Europa har flera fältförsök startats upp för att studera effekter av olika sorters åkerkanter. Under 1988-1990 inleddes fältförsök med breddade, permanenta åkerkanter på tre lokaler utanför Flen och Uppsala. Ett av syftena var att studera hur olika behandlingar påverkade åkerkantsvegetationen och huruvida åtgärderna hade någon effekt på abundansen av ogräs. Behandlingarna bestod av etablering av helt nya eller breddning av existerande åkerkanter, samt sådd av olika fröblandningar (bl.a. "ängsväxter"). Åkerkanterna har sedan dess skötts genom årlig slåtter och bortförsel av slaget växtmaterial. Vegetationen inventerades vid tre tillfällen under en 20-årsperiod och närliggande obehandlade åkerkanter inventerades vid de två senaste tillfällena för att göra jämförelser.

Resultaten i denna studie visar att man genom sådd av olika arter, i synnerhet ”ängsväxter”, väsentligt kan förändra åkerkantsfloran långsiktigt och även minska abundansen av ogräs jämfört med obehandlade åkerkanter. Över 20 år efter försökens start återfanns 22 av de sådda 32 ”ängsväxterna” i åkerkanterna, varav flera av dessa arter vanligtvis påträffas i välskötta ängs- och betesmarker.

Nyckelord: Åkerkant, Långtidsstudie, Vegetationsutveckling, Biodiversitet, Ängsväxter, Ogräs, Jordbruk

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1 Introduction

Agriculture has been, through thousands of years, the main driver to shape and form the landscape and the biodiversity we see today. In the borders between agriculture and adjacent habitats, used areas with low management, so called semi-natural habitats, can be found. One of these habitats is the field margin, defined as uncropped strips adjacent to the agricultural fields, separating them from the next landscape element. Historically, the field margins and field boundaries (i.e. hedges, ditches etc.) played a major role defining land ownership and to fence field areas from cattle (Marshall & Moonen, 2002), and many species adapted to this type of environment. Remnants of some types of field margins and boundaries has a unique biodiversity and a status as a cultural heritage today (Marshall & Moonen, 2002), e.g. hedges in Britain and stone walls on the Swedish island Öland.

The modern agriculture has developed towards a more intensified and machine-adjusted farming, with increased field sizes, monoculture, use of inorganic fertilisers and pesticides, silage instead of hay production and larger livestock for the last 100 years (reviewed in Fritch *et al.*, 2011). This intensification of agriculture has lead to a significant loss of meadows and other semi-natural habitats, as well as a radical decrease in biodiversity connected to agricultural grasslands (Eriksson *et al.*, 2002; Blackstock *et al.*, 1999). Remaining field margins, field boundaries and road verges became a refuge for many of the affected floral and faunal species (Marshall & Moonen, 2002; Smart *et al.*, 2002) and in some places, e.g. northern France, the majority of todays semi-natural habitats consists of field margins and boundaries (Marshall & Moonen, 2002).

Today, field margins and boundaries have been found to support a great range of animals including invertebrates (Backman & Tiainen, 2002; Svensson *et al.*, 2000; Thomas & Marshall, 1999; Lagerlöf & Wallin, 1993; Dennis & Fry, 1992; Lagerlöf *et al.*, 1992), mammals (Shore *et al.*, 2005; Verboom & Huitema, 1997) and birds (Vickery *et al.*, 2009; Benton *et al.*, 2003). They may act as over-wintering habitats for arthropods (Backman & Tiainen, 2002; Dennis & Fry, 1992) and support movement acting as a corridor for flora (Marshall & Arnold, 1995) and fauna (Albrecht *et al.*, 2010).

Field margins and species connected to them, also deliver a range of ecosystem services such as prevention of soil erosion and pesticide and fertiliser drift to adjacent ditches (Marshall & Moonen, 2002), providing of pollinators (Backman & Tiainen, 2002; Svensson *et al.*, 2000; Lagerlöf & Wallin, 1993) and biological pest-control (Olson & Wackers, 2007; Marshall & Moonen, 2002; Dennis & Fry, 1992). Further, they can provide recreational services since a beautiful species-rich field margin enhance the experience of the agricultural landscape and could thereby also stimulate local economy (Marshall & Moonen, 2002).

From the farmers point of view there is an economic and practical value of having continuous field areas, and therefore keeping field margins is not always prioritized. Farmers may also fear that field margins are sources of weeds, although permanent margins have been found to reduce weed abundance (Fritch *et al.*, 2011; Marshall, 2009; Musters *et al.*, 2009; Moonen & Marshall, 2001; Smith *et al.*, 1999; Kleijn *et al.*, 1998). Since field margins are important in the agricultural landscape, different efforts to maintain and increase their biodiversity have been suggested, among them reducing pesticide and fertiliser drift to the margins or sowing wildflower seed-mixes (Fritch *et al.*, 2011; Critchley *et al.*, 2006; Asteraki *et al.*, 2004). Economic compensation for preserving and enhancing biodiversity in field margins have been incorporated in agri-environmental schemes (AES) in many European countries. The Swedish Board of Agriculture offers compensation payment for establishing spray-free zones (i.e. not applying fertiliser, herbicides and pesticides) in the field edges (Government Offices of Sweden, 2008). They also compensate creation and maintenance of sown margin strips, but only as buffer zones near watercourses (so called riparian strips) in certain areas (Government Offices of Sweden, 2008). Several experiments with creating field margins for specific purposes and evaluate their success have been implemented in Europe (see e.g. Fritch *et al.*, 2011; Noordijk *et al.*, 2010; Smith *et al.*, 2010; Marshall, 2009; Lagerlöf *et al.*, 1992).

In southern Sweden a number of field trials with broadened permanent field margins were established in 1988-90, sowing different combinations of plants and planting bushes at three locations. The field trials have been continuously maintained since then by yearly mowing and taking away the cut material. The aim at the beginning was to create permanent vegetation suitable as a habitat for a rich invertebrate fauna and also to reduce the weed abundance in the margins. Several studies of the vegetation development in these experiments and the effects on different invertebrates have been published out through the years (Bokenstrand *et al.*, 2004; Lagerlöf *et al.*, 2002; Svensson *et al.*, 2000; Lagerlöf & Wallin, 1993; Lagerlöf *et al.*, 1992).

The aim for this study is to investigate the margin flora 21-23 years after the establishment and compare with untreated natural field margins (i.e. reference margins), and to some extent also compare with vegetation data collected in 1991/1993 and 1997. Some soil data was collected in 2011 and analysed as well. The focus in this study will be in trying to answer these questions regarding plant biodiversity, weed abundance and soil composition:

- Are there any differences regarding the number of species, species density (number of species per area unit), weed cover, nitrogen indicator values (according to Hill *et al.*, 1999) and species composition between the treated margins and the reference margins?
- Have the treated margins changed during this time period regarding species number and nitrogen indicator values?
- Which of the sown “meadow plant” species have survived in the experiments?
- Are there any differences in soil composition between the treated margins and the field?

2 Material and Methods

2.1 Site description

The experiments were established at three different sites in south of Sweden. Two of them, Kasby 1 (K1) and Kasby 2 (K2), is situated near Kasby farm, 20 km south-east of Uppsala, Sweden (59°51'N, 17°41'E) (Appendix A). The third site, Ekenäs (E), is situated at Ekenäs research station, 15 km south of Flen, ca 150 km south of Uppsala (58°48'N, 16°44'E) (Appendix A).

2.1.1 Kasby

The landscape around the two Kasby sites consists of large-scale agricultural fields (average field size is about 25 ha), farmed conventionally with a crop rotation including annual crops; e.g. spring barley, winter wheat and oil seed rape, and perennial crops; e.g. clover and grass leys. Nutrients are applied as farmyard manure and inorganic fertilisers and weeds are managed by herbicides. The sites (Kasby 1 and 2) were placed 160 m apart and along a ditch surrounded by arable fields. The soil in the experiments consists of loam with 3-6% organic matter in the south and muddy clay with 6-12% organic matter (former lake floor) in the north (Bokenstrand *et al*., 2004).

2.1.2 Ekenäs

At Ekenäs the site is situated in a more heterogeneous landscape with forests, semi-natural grasslands and smaller fields (about 7 ha). The fields near the site are farmed organically with crop rotation (annual crops; e.g. oats and winter wheat and perennial crops; e.g. clover and grass leys) and with farmyard manure and green manure (i.e. legume leys) as fertilisers. The fields are not treated with chemical pesticides or herbicides. The experimental site was placed along a dirt road with adjacent fields on both sides. The soil in the experiments consist of silty clay with 3-6% organic matter (Bokenstrand *et al.,* 2004).

2.2 Treatments

The experimental field margins were established in 1988-1990 at Kasby 1 (Fig. 1), 1988-1989 at Kasby 2 (Fig. 2) and 1990 at Ekenäs (Fig. 3). The treatments of the three sites consisted of broadening or establishing new field margins, ploughing, harrowing and sowing and/or planting different species. After establishment the margins have been yearly mowed in late summer with removing of plant material (except for the plots with planted bushes). The margins have not been sprayed with herbicides, pesticides or fertiliser after establishment (with an exception for the treatment "Red clover & ley grass, herbicide treated").

The three sites were treated differently regarding the margin area and the species sown. At Kasby 1 a 160 m long pre-existing field margin was broadened to 2 m, at Kasby 2 a 640 m long pre-existing margin was broadened to 4 m and at Ekenäs a new 160 m long and 3 m wide field margin was established. Each margin was then divided into 16 plots, where each plot measured 2 m x 10 m at Kasby 1, 4 m x 40 m at Kasby 2 and 3m x 10 m at Ekenäs.

Each site consisted of four different sowing treatments replicated in four plots each (i.e. 16 plots per site), distributed randomly in the margin at Kasby 1 and Ekenäs and distributed using block design at Kasby 2 (where the 640 m long margin included a soil type gradient, therefore it was divided in 4 blocks, each block with randomly placed treatments).

In total, nine different sowing treatments were established, where seven of them uniquely at one site and two of them established at more than one site; "Meadow plants" (MP) at all three sites and "Bushes and Meadow plants" (BM)[1] at both Kasby 2 and Ekenäs. For a description of the different sowing treatments (henceforth referred as "treatments"), see below.

1. ***"Meadow plants"*** (MP): Sowing a mixture of 32 species of forbs and grasses (Table 2), all originating from Swedish ecotypes, at the rate of 40 kg/ha (sown in plots at Ekenäs 1990, at Kasby 1 in May 1988, additional sowing in November 1989 and in May 1990, and at Kasby 2 in November 1988).

[1] Note that bushes are not separated from the other life-forms (i.e. grasses and forbs) in this study. The flora in treatments with bushes is treated as in other treatments.

2. ***“Bushes & meadow plants”*** (BM): Planting slow (*Prunus spinosa)*, rose bushes (*Rosa canina)* and rowan *(Sorbus aucuparia)* in the outer part of the plots, facing the ditch/road. Sowing the same species mixture as in “Meadow plants” in the inner half of the plots (established at Ekenäs in 1990 and Kasby 2 in November 1989).

3. ***“Rose bushes”*** (RB): Planting 30 rose bushes (*Rosa canina*) per plot (established in Kasby 1 in June 1988).

4. ***“Clover & ley grasses”*** (CG): Sowing a seed mixture of clover and ley grasses (2.1 kg/ha *Trifolium pratense*, 8.4 kg/ha *T. repens*, 16.8 kg/ha *Festuca pratensis*, 8.4 kg/ha *Phleum pratense* and 6.3 kg/ha *Poa pratensis*) (sown at Ekenäs 1990).

5. ***“Red clover & ley grasses”*** (RCG): Sowing a seed mixture of red clover and ley grasses (100 kg/ha *Trifolium pratense*, 10 kg/ha *Dactylis glomerata* and 10 kg/ha *Festuca pratensis*) (sown in barley, *Hordium vulgare*, at Kasby 1 in May 1988).

6. ***“Red clover & ley grass”*** (RC): Sowing a seed mixture of red clover and meadow fescue (20 kg/ha *Trifolium pratense* and 12 kg/ha *Festuca pratensis*) (sown in barley at Kasby 2 in May 1988).

7. ***“Red clover & ley grass, herbicide treated”*** (RCH): Sowing a seed mixture of red clover and meadow fescue (20 kg/ha *Trifolium pratense* and 12 kg/ha *Festuca pratensis*) (sown in barley at Kasby 2 in May 1988 and treated with herbicides the first two years).

8. ***”Borage & Phacelia”*** (BP): Sowing a seed mixture of common borage and lacy phacelia (25 kg/ha *Borago officinalis* and 25 kg/ha *Phacelia tanacetifolia* per plot) (sown at Kasby 1 in May 1988, with superficial soil cultivation and additional sowing in May 1989 and 1990).

9. ***“Free regeneration”*** (FR): No treatment except for ploughing and harrowing at establishment and afterwards yearly mowing (at Ekenäs 1990).

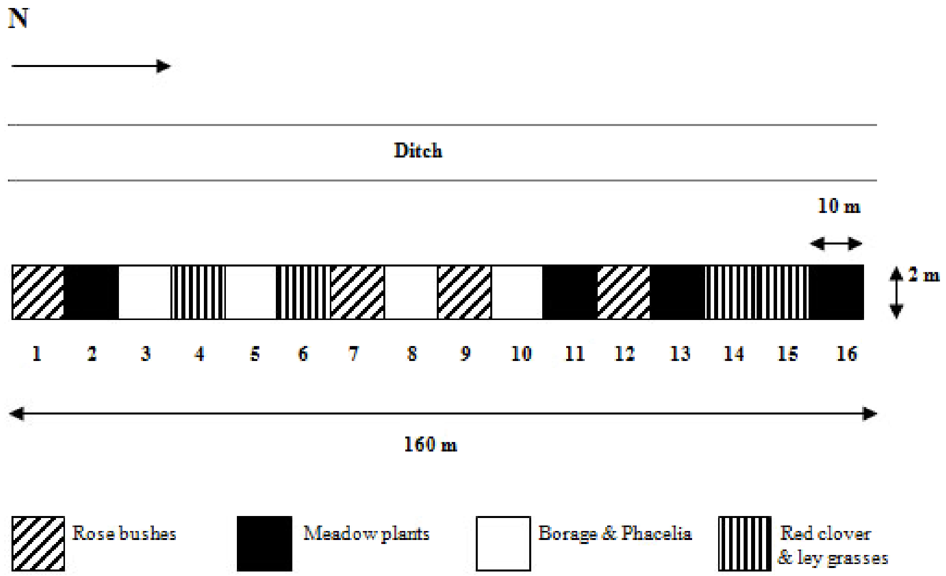

Figure 1. Kasby 1 experiment.

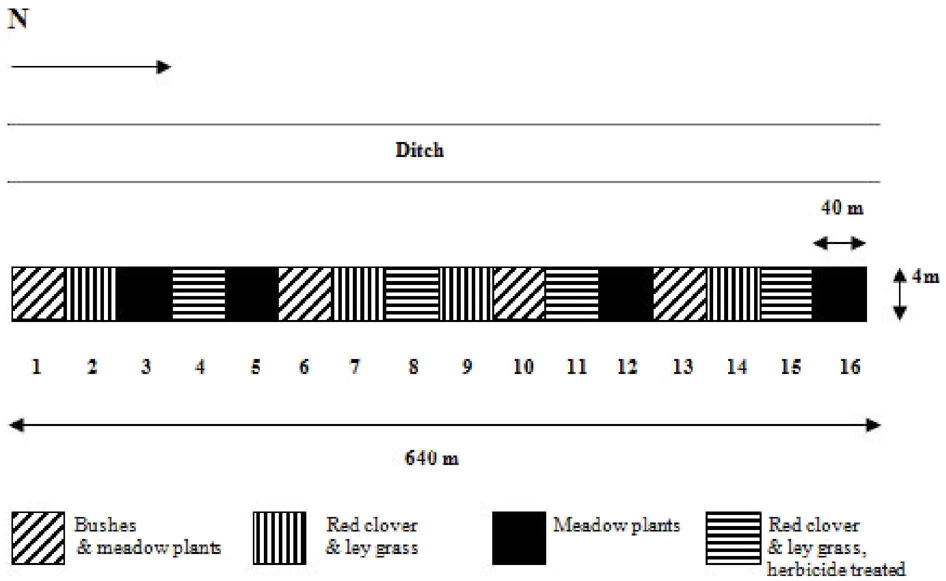

Figure 2. Kasby 2 experiment.

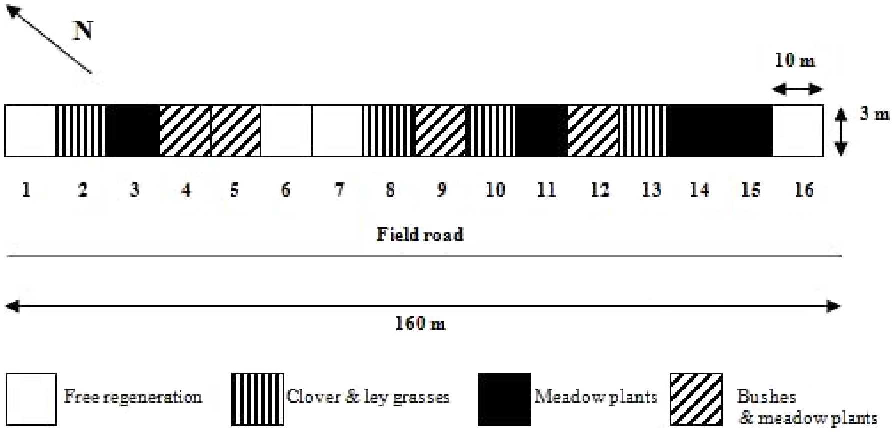

Figure 3. Ekenäs experiment.

2.3 Data collecting

2.3.1 Species data

The species composition and species richness of vascular plants at each treatment has been investigated at three occasions, at Kasby 1 and Ekenäs in 1991, 1997 and 2011 and at Kasby 2 in 1993, 1997 and 2011. The cover per plant species (in %) was recorded in 2011, in five randomly placed 0.5 m x 0.5 m squares per plot placed 0.5 m inside of the plot edges (to avoid edge-effects). The cover per plant was recorded in 1991/1993 and 1997 as well, but part of this data is missing and therefore not statistical analysed in 2011. The nomenclature followed Krok and Almquist (1994).

2.3.2 Reference margins

Adjacent non-experimental natural field margins were investigated 1997 and 2011 as “Reference margins” (REF), although these margins may not be placed at the exact same place in 2011 as in 1997, due to lack of maps and coordinates. At Kasby 1 the “Reference margin” measured 0.5-1.0 m x 160 m (divided in 4 plots), at Kasby 2 it measured 0.5-1.0 m x 640 m (divided in 4 plots), and at Ekenäs 0.5-1.0 m x 120 m (divided in 4 plots). The species composition and cover of vascular plants were recorded as in the treatment plots, although all squares were placed in the field edges in the reference plots, since they all were narrower than the treatment plots.

2.3.3 Nitrogen indicator values

Each plant species occurring 1991/1993, 1997 and 2011 were assigned an Ellenberg nitrogen indicator value according to Hill *et al*. (1999). The nitrogen indicator values, among other indicator values for vascular plants in central Europe, were originally defined by Ellenberg in a series of publications (e.g. Ellenberg, 1991). With bases in the realised ecological niche, i.e. that plants have a certain range of tolerance of temperature, light, moisture etc., the plant species composition could be used to indicate abiotic factors. The nitrogen indicator values (N-values) were developed as general indicators of soil fertility, ranging from extremely infertile sites (value 1, assigned to species like e.g. *Drosera rotundifolia*) to extremely rich places (value 9, e.g. *Artemisia absinthum*) (Hill *et al.*, 1999). This study included species not found in the Ellenberg publications, therefore an extension of the Ellenberg N-values, applied for British and Irish flora, was used (i.e. Hill *et al.*, 1999).

2.3.4 Soil samples

In May 13th 2011 soil samples were taken in the field margin plots with “meadow plants” at Kasby 1 and in equally large areas of the agricultural field adjacent to these plots. For each plot, ten soil samples were taken with an auger (2.1 cm diameter) down to 20 cm depth. These samples were combined to one sample per plot. Chemical analysis of the samples was done for total percent carbon (Tot % C) and nitrogen (Tot % N), pH, amounts (mg/100 g dry weight) of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), as well as amounts (kg/ha) of ammonium (NH_4^+) and nitrate (NO_3^-).

2.4 Statistical analysis

The number of species for each treatment (average per plot) in 2011 was analysed in a One-way ANOVA, followed by a Tukey’s test (95%). When comparing the total number of species (merged for each treatment) between the years 1991/1993, 1997 and 2011, a Binary Logistic Regression was used, followed by a Tukey’s test (95%). The species density in each treatment (number of species per 0.5 m x 0.5 m square) was analysed using a General Linear Model, followed by a Tukey’s test (95%).

The average cover (in %, transformed with an Arcsine transformation prior to analysis) of four selected weeds, *Anthriscus sylvestris*, *Cirsium vulgare*, *Elytrigia repens* and *Taraxacum* sect. *Vulgaria*, in each treatment and reference margins was analysed using a One-way ANOVA, followed by a Tukey’s test (95%). The four selected weeds are all perennial unwanted species spread either rhizomatous and/or by seeds.

The nitrogen indicator values (according to Hill *et al.*, 1999) of the species in the treatments in 1991/1993, 1997 and 2011 were analysed in a regression. Some of the treatments (i.e. "Meadow plants", "Clover & grass", "Red clover & ley grasses", "Red clover & ley grass (merged)", "Free regeneration", "Borage & Phacelia") and the "Reference margins" at Ekenäs, Kasby 1 and 2 were analysed in categories in a One-way ANOVA, followed by a Tukey's test (95%). Weighted average nitrogen indicator values (where species percent cover was included) were calculated for the treatments and reference margins for the 2011 data. The data from the soil samples was analysed in paired t-tests.

The species composition at Kasby 1and Ekenäs[2] in 2011 was analysed using the iterative ordination method NMDS (Non-metric Multidimensional Scaling), which is based on ranked distances between sample units in the data matrix. An NMDS graph gives a multidimensional (often set to two or three dimensional) picture of how similar observations are. In contrast to other ordination methods (e.g. PCA), NMDS does not assume normally distributed data. Since species rarely occur in normal distribution, NMDS was chosen to analyse this data set. NMDS's were performed in the software R© 2.14.0 (R Development Core Team, 2011), in which the number of dimensions is not pre-selected. Therefore the highest dimensionality that reduces the stress by 5 or more was selected. Stress is a goodness of fit-measure in NMDS and it ranges between 0-100, where low stress indicates a high goodness of fit. In ecological community data, stress values between 10-20 are considered to be acceptable (McCune *et al.*, 2002). The NMDS analyses were performed on original species cover data, as well as on reduced data where rare species (i.e. occurred only in one of the plots) were removed, to see if there were any distinct differences between the resulting graphs. Since they gave similar results, it was not considered necessary to reduce the data-set. The data was transformed by a square root transformation followed by a Wisconsin double standardization. The maximum number of random starts (to search a stable solution avoiding local minima) was set to 50. Distance measure was Bray-Curtis dissimilarity (Sørenson index) and the number of dimensions was selected to two. The stress values for two dimensions were 11.5 at Ekenäs and 6.7 at Kasby 1. Significant differences between the treatments at each site were tested in Permutational Multivariate ANOVA (with the Bray-Curtis method and the number of permutations set to 1000). Indicator Species Analysis (ISA)

[2] Kasby 2 was not analysed due to lack of reliable plant cover data.

was performed (with the same data set as for the NMDS) to see if some species were more frequent and abundant in any of the analysed treatments.

The computer software R© 2.14.0 (R Development Core Team, 2011) was used for the NMDS and ISA and Minitab® 15.1.0.0 (Minitab Inc., 2009) was used for all the other statistical analyses.

In Table 2 and 5, Figure 9 and 11, and Appendix C the full species names have been replaced by abbreviated names (a key to these can be found in Appendix B).

2.5 Criticism regarding experiment arrangement & methods

Since the experiments were established at different sites and consisted of different plot areas, it is difficult to distinguish if any differences in the collected ecological data between the sites are due to the plot area or the site conditions. Therefore the treatments at each site will primarily be compared amongst each other and not between the sites.

No margins that could act as "reference" field margins were established at the beginning of the experiments, therefore untreated natural field margins, adjacent to the experiments, were considered as reference margins when collecting data in 1997 and 2011. Although that data may not be comparable over the years since there is a possibility that they have not been collected from the exact same sites (due to lack of maps or coordinates). Because of natural reasons the investigated "reference" margins were narrower compared to the treated margins, which may affect the species composition. To compensate for the smaller margin width, the reference plots were longer than the treatment plots, thus the sample area are approximately the same and one could argue that the sample efforts also are the same.

Since these experiments have been ongoing for several years, they have been investigated by different persons, who may have different knowledge and experience, which may affect the collected data.

There is missing data for recorded species in each plot in 1991 and 1997, only a merged version per treatment exists, therefore in the analysis comparing them with 2011, data for 2011 has been merged as well. Data for treatment "Red clover & ley grass" and "Red clover & ley grass, herbicide treated" was merged in 1991/1993 and 1997, therefore in the analysis comparing these years with 2011, data for the two treatments has been merged for 2011 as well (named "Red clover & ley grass (merged)", RCM). Plant cover data is partly missing for 1991 and 1997.

In 1997 at Ekenäs and in 2011 at Kasby 2, all treatments except for “Bushes and meadow plants” were mown early in the summer before the vegetation was investigated. The recording of species composition and cover may have been affected by this, even though data for these sites was recorded later in the summer when the plants had recovered. The plant cover data at Kasby 2 in 2011 was recorded (Appendix C) but is not included in any of the statistical analysis, since it may not be accurate.

In the “Bushes & meadow plants” treatments, the planted bushes and trees were over 2 m high and impenetrable in 2011, therefore the species density as well as the species cover could not be recorded in those treatments.

Soil data was collected only in the four “Meadow plants” plots at Kasby 1 and additional data for all treatments at all sites, as well for all reference margins would be preferable.

3 Results

3.1 Number of species

There was a significant difference regarding the average number of species per plot between all the treatments (including the reference plots) in 2011 (F:9.04, df:14, p: <0.001) (Fig. 4). Most species were found in the “Clover and ley grasses” (CG) treatment (28 species per plot), followed by the three “Meadow plants” (MP) treatments (27.8-24.3 species per plot) (Fig. 4). The “Free regeneration” (FR) treatment contained nearly the same amount of species (23.5 species per plot) as the “Meadow plants” (MP (E)) treatment (27.8 species per plot) at Ekenäs (no significant difference, $p>0.05$). The “Reference” plots (REF) and the “Rose bushes” plots (RB) contained the fewest species per plot (8.5-14.8), all significantly differed from the MP and CG plots ($p<0.05$) (Fig. 4).

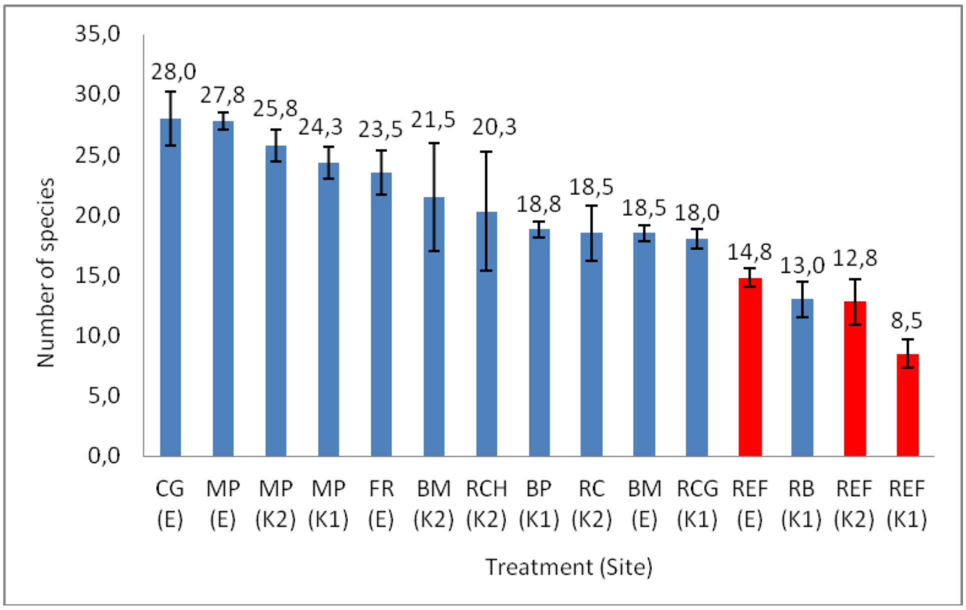

Figure 4. Number of species (average per plot) with standard error bars in the treatments “Clover and grass” (CG), “Meadow plants” (MP), “Free regeneration (FR), “Bushes & meadow plants” (BM), “Red clover & ley grass, herbicide treated” (RCH), “Borage & Phacelia” (BP), “Red clover & ley grass” (RC), “Red clover and ley grasses” (RCG) and “Rose bushes” (RB) as well as in the “Reference margins” (REF), at the sites Ekenäs (E), Kasby 1 (K1) and Kasby 2 (K2) in 2011.

The total number of species tended to decrease over time (Table 1), with the largest drop between 1991/1993 and 1997. Most of the species lost were annual weeds (Appendix C). Between 1997 and 2011 there was a species increase in 6 out of 11 treatments (Table 1), partly due to species spreading between the treatments. Five of the sown species (*Alopecurus pratensis*, *Centaurea jacea*, *Galium verum*, *Hypericum perforatum* and *Vicia cracca*) were recorded in all the treatments at all three sites in 2011 (Appendix C).

*Table 1. Total number of species in the treatments and reference margins in 1991/1993, 1997 and 2011 (species data merged for each treatment) and differences(in %, significant differences marked with *) between the years. Reference margins were not considered comparable between the years.*

Site and treatment	No of species 1991/93	No of species 1997	No of species 2011	Diff. 1991/93-1997	Diff. 1997-2011	Diff. 1991/93-2011
Ekenäs						
Meadow plants	50	31	45	-38.0%*	+45.2%*	-10.0%
Bushes & meadow plants	54	32	28	-40.7%*	-12.5%	-48.1%*
Clover & ley grasses	16	25	46	+56.3%*	+84.0%*	+187.5%*
Free regeneration	42	37	38	-11.9%	+2.7%	-9.5%
Reference margins	no data	34	21	-	-	-
Kasby 1						
Meadow plants	44	32	35	-27.3%*	+9.4%	-20.5%
Rose bushes	38	14	22	-63.2%*	+57.1%*	-42.1%*
Red clover & ley grasses	27	21	25	-22.2%	+19.0%	-7.4%
Borage & Phacelia	35	23	22	-34.3%*	-4.3%	-37.1%*
Reference margins	no data	32	14	-	-	-
Kasby 2						
Meadow plants	50	45	35	-10.0%	-22.2%*	-30.0%*
Bushes & meadow plants	61	43	39	-29.5%*	-9.3%	-36.1%*
Red clover & ley grass (merged)	46	40	38	-13.0%	-5.0%	-17.4%
Reference margins	no data	35	25	-	-	-

Out of 32 sown meadow plant species, 20 were found in one or more plots in 1991/1993, 22 in 1997 and 22 in 2011 (Table 2). Six of them have been recorded in all five “Meadow plants”/”Bushes & Meadow plants” treatments at all occasions, among them *Centaurea jacea*, *Galium verum*, *Knautia arvensis* and *Leucanthemum vulgare*. Three species have never been found after sowing (*Cirsium helenoides*, *Luzula multiflora* and *Myosotis scorpioides*) and four species have not been recorded after 1991 (*Crepis praemorsa*, *Cynosurus cristatus*, *Rhinanthus serotinus and Succisa pratensis*). Between 1997 and 2011 three species were lost in all treatments, *Anthyllis vulneraria*, *Hypericum maculatum* and *Plantago media*. In 2011 four sown species that had not been recorded in earlier investigations were found in one or more treatments, *Briza media*, *Filipendula ulmaria*, *F. vulgaris* and *Valeriana officinalis*. The total percent cover of sown meadow plant species in the “Meadow plants” treatments has increased between 1997 and 2011, from 37-53% of total cover in 1997 to 52-63% in 2011 (Table 2).

Table 2. Plant species sown 1988 (Ekenäs 1990) in the experimental plots and species remaining in 1991/1993, 1997 and 2011 (percent cover or X if <0.2%, (X) if cover was not measured but the species was present). A key to the abbreviated species names can be found in Appendix B.

Sown meadow-plant seed mixture (wt.% in 40 kg/ha)	Kasby 1			Kasby 2						Ekenäs					
	Meadow plants			Meadow plants			Bushes & meadow plants			Meadow plants			Bushes & meadow plants		
	-91	-97	-11	-93	-97	-11	-93	-97	-11	-91	-97	-11	-91	-97	-11
Alop pra(4.4)	(X)	7.3	9.2	(X)	12.3	5.1	(X)	5.8	(X)	(X)	8.0	22.6		4.0	(X)
Anth vul(1.3)	(X)	0.7		(X)	X		(X)			(X)	1.0		(X)		
Briz med(1.8)			X									0.2			
Camp rot(0.4)			0.3		0.2	0.2			(X)						
Cent jac(2.2)	(X)	5.4	6.6	(X)	3.0	10.8	(X)	0.6	(X)	(X)	12.1	7.2	(X)	12.1	(X)
Cirs hel(0.9)															
Crep pra(0.4)										(X)			(X)		
Cyno cri(17.8)	(X)			(X)			(X)			(X)			(X)		
Fest pra(8.8)	(X)	1.0	1.7	(X)	2.1	X	(X)	0.2	(X)	(X)	X	1.6	(X)	0.2	(X)
Fest rub(38.9)	(X)	23.2	6.3		7.0	5.3		1.4	(X)		14.2	0.5	(X)	20.0	
Fili ulm(1.3)			X			X			(X)						
Fili vul(2.2)												X			
Gali bor(0.4)					X	X		X							
Gali ver(0.4)	(X)	0.7	6.0	(X)	0.3	10.2	(X)	0.2	(X)	(X)	0.6	5.3	(X)	1.1	(X)
Gera syl(1.3)	(X)		2.1		X	X		X	(X)	(X)	X	X		X	(X)
Geum riv(0.9)		0.2	1.2		0.2	X		X	(X)		X	X		1.0	
Hype mac(0.4)		0.6			0.3			0.2		(X)	0.2		(X)		
Hype per(0.4)	(X)	X	11.7	(X)	0.2	11.2	(X)	0.7	(X)		X	5.1		0.3	(X)
Knau arv(1.3)	(X)	3.0	4.1	(X)	2.2	4.7	(X)	0.2	(X)	(X)	0.2	0.7	(X)	1.1	(X)
Leuc vul(0.9)	(X)	3.8	0.6	(X)	4.4	1.1	(X)	3.0	(X)	(X)	4.4	0.6	(X)	0.4	(X)
Luzu mul(0.9)															
Lych flo(0.9)				(X)	0.2		(X)			(X)		0.2	(X)	0.2	
Myos sco(0.4)															
Plan med(0.9)		0.2			0.2			X			0.2				
Prim ver(1.3)		1.5	10.4	(X)	1.1	6.6		2.0	(X)			2.0			(X)
Prun vul(0.4)	(X)				0.5	X	(X)			(X)	2.1	X	(X)		
Ranu acr(1.3)	(X)	2.4	0.8	(X)	2.0	4.3	(X)	0.2	(X)	(X)	2.7	3.2	(X)	1.2	(X)
Rhin ser(1.3)	(X)			(X)			(X)			(X)			(X)		
Serr tin(0.9)						X			(X)			X		X	
Succ pra(2.8)										(X)			(X)		
Vale off(0.3)			X									0.6			(X)
Vici cra(2.2)	(X)	2.6	2.2		0.6	3.5	(X)	X	(X)	(X)	0.2	2.0	(X)	1.5	(X)
Tot. % cover	-	52.6	63.2	-	36.8	63.0	-	14.5	-	-	45.9	51.8	-	43.1	-
No of species	15	15	17	13	20	18	14	16	16	17	16	19	16	14	12

3.2 Species density

There was a difference in species density (average number of species per 0.5 m x 0.5 m square) between the treatments in 2011 (F: 34.03, df: 12, $p<0.001$) (Fig. 5). The highest species density was recorded in the treatment "Meadow plants" in Kasby 1 (10.1 species/square) and the lowest in the "Reference margins" in Kasby 1 (2.2 species/square). There was no significant difference between the "Reference margin" (REF(E)) and the treatments ("Meadow plants" (MP(E)), "Clover & grass" (CG) and "Free regeneration" (FR)) at the Ekenäs site, but at Kasby 1 and 2 the species density in the "Reference margins" (REF(K1) and REF(K2)) were significantly lower compared to the density in all the treatments at the two sites ("Meadow plants" (MP(K1)), "Borage & Phacelia" (BP), "Red clover & ley grasses" (RCG), "Rose bushes" (RB), "Red clover & ley grass" (RC) and "Red clover & ley grass, herbicide treated" (RCH)) (Tukey's test, $p<0.05$).

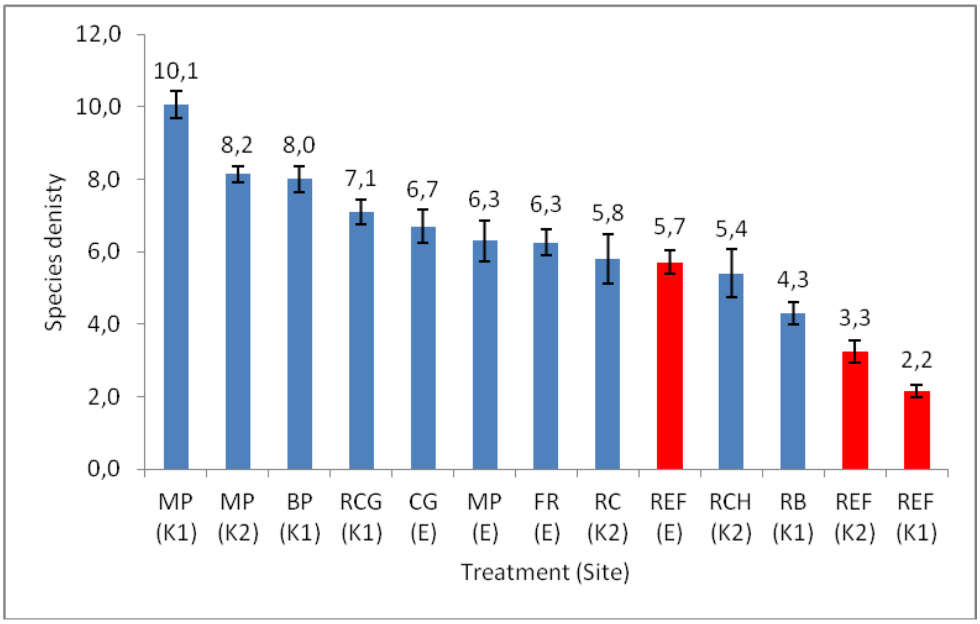

Figure 5. Species density (average number of species per 0.5 m x 0.5 m square) with standard error bars in the treatments "Meadow plants" (MP), "Borage & Phacelia" (BP), "Red clover and ley grasses" (RCG), "Clover and grass" (CG), "Free regeneration (FR), "Red clover & ley grass" (RC), "Bushes & meadow plants" (BM), "Red clover & ley grass, herbicide treated" (RCH) and "Rose bushes" (RB) as well as in the "Reference margins" (REF), at the sites Ekenäs (E), Kasby 1 (K1) and Kasby 2 (K2) in 2011.

3.3 Weed cover

There was a significant difference in percent cover of the four investigated weeds (*Anthriscus sylvestris*, *Cirsium vulgare*, *Elytrigia repens* and *Taraxacum* sect. *Vulgaria*) between the treatments (F:9.32, df:8, p<0.001). It was highest in the two "Reference margins" (REF(E): 32.0% and REF(K1): 43.7%) and lowest in the two "Meadow plants" treatments (MP(E): 4.6% and MP(K1): 6.5%) (Fig. 6). The percent weed cover in the two "Reference margins" were significantly higher than the cover in the treatments at each site (p<0.05), with an exception for the "Rose bushes" (RB: 25.3%) treatment.

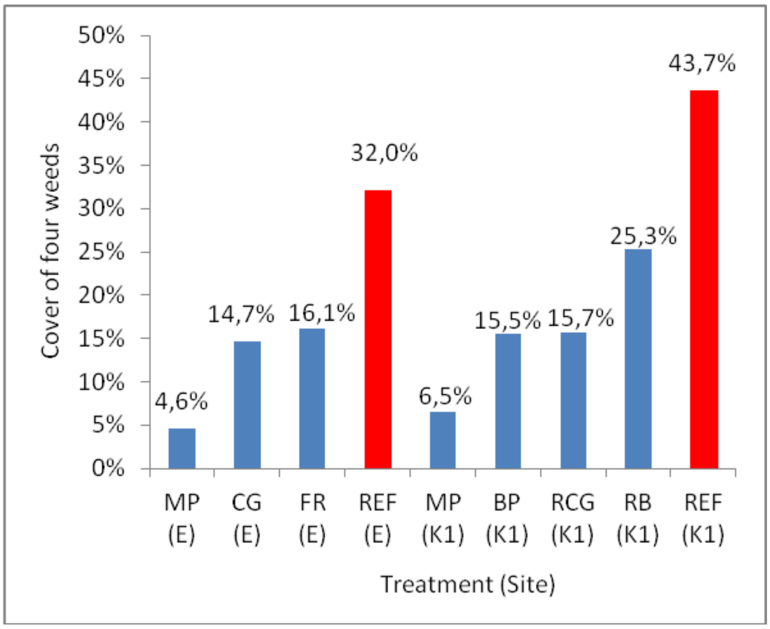

Figure 6. The percent cover of four selected weeds (*Anthriscus sylvestris*, *Cirsium vulgare*, *Elytrigia repens* and *Taraxacum* sect. *Vulgaria*) in the treatments "Meadow plants" (MP), "Clover and grass" (CG) and "Free regeneration (FR) at the Ekenäs (E) site and the treatments "Meadow plants" (MP), "Borage & Phacelia" (BP), "Red clover and ley grasses" (RCG) and "Rose bushes" (RB) at the Kasby 1 (K1) site, as well as in the "Reference margins" (REF) at each site, in 2011.

3.4 Nitrogen indicator value

The average nitrogen indicator value (Hill *et al.*, 1999) in the treatments tended to decrease over time (1991: 5.80±1.35, 1997: 5.27±1.41 and 2011: 5.08±1.42) (y= -0.0319x + 69.204, R^2: 0.77, p< 0.001), with the largest drop between 1991 and 1997. Some of the treatments were analysed categorical in groups[3] (i.e. “Meadow plants”, “Clover and ley grass” and “Free regeneration”) and compared with merged data for the “Reference margins” plots, showing a decrease in nitrogen indicator value between 1991/1993 and 1997, as well as between 1991/1993 and 2011 in all the treatment categories (Fig. 7) ($p<0.05$).

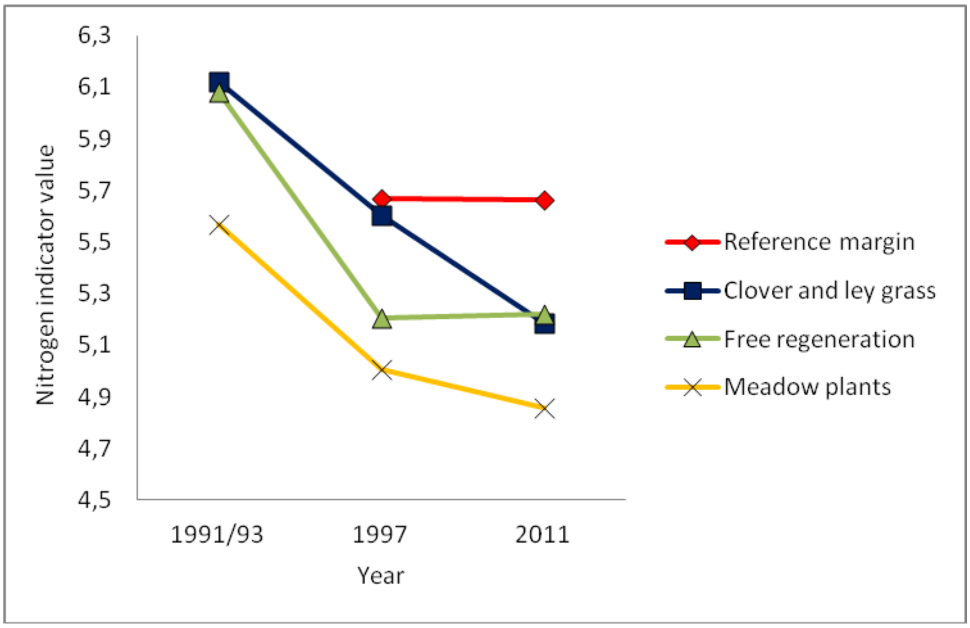

Figure 7. Average nitrogen indicator value (according to Hill *et al.*, 1999) for the treatment categories “Clover and ley grass”, “Free regeneration” and “Meadow plants” in 1991/1993, 1997 and 2011, and for the “Reference margins” (“Reference”) in 1997 and 2011.

Weighted average nitrogen indicator values (where percent cover of the species is included) were calculated for each treatment and reference margin in 2011 (Table 3). The lowest values were found in the three “Meadow plants” treatments (4.8-5.4) and the highest values in the three “Reference margins” (6.0-6.6) as well as in the “Rose bushes” treatment (6.3) (Table 3).

[3] *“Meadow plants”*: data merged for the “Meadow plants” treatments at Ekenäs, Kasby 1 and 2, *“Clover and ley grass”*: data merged for “Clover & ley grasses”, “Red clover & ley grasses” and “Red clover & ley grass (merged)”, *“Free regeneration”*: data merged for “Free regeneration” and “Borage & Phacelia”, and *“Reference margin”*: data merged for the “Reference margins” at Ekenäs, Kasby 1 and 2. “Borage & Phacelia” was considered to be comparable with “Free regeneration” since the sown species in that treatment never have been recorded after sowing.

*Table 3. Nitrogen indicator values (weighted averages) for the treatments and reference margins at Kasby 1(K1), Kasby 2 (K2), and Ekenäs (E) in 2011. Note that some treatments (marked with *) were mown before species cover was recorded, which may have affected the recorded species cover data.*

Treatment (Site)	N-value (weighted average)
"Meadow plants" (K2)	4.80*
"Meadow plants" (K1)	4.98
"Meadow plants" (E)	5.38
"Borage & Phacelia" (K1)	5.48
"Free regeneration" (E)	5.64
"Red clover & ley grasses" (K1)	5.68
"Red clover & ley grass, herbicide treated" (K2)	5.71*
"Clover & ley grasses" (E)	5.81
"Red clover & ley grass" (K2)	5.84*
"Reference margin" (E)	6.00
"Reference margin" (K2)	6.33
"Rose bushes" (K1)	6.33
"Reference margin" (K1)	6.66
"Bushes & meadow plants" (K2)	no data
"Bushes & meadow plants" (E)	no data

3.5 Soil analysis

There were significant differences (df:3, $p<0.05$) regarding some of the analysed soil components between the “Meadow plants” treatment and the adjacent field at Kasby 1, with higher total percent nitrogen (Tot % N) and carbon (Tot % C), lower pH, lower amount of phosphorus (P (mg/100g)) and nitrate (NO_3^- (kg/ha)) in the “Meadow plants” treatment (Table 4). There were no significant differences between them regarding the amount (mg/100g) of potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) and the amount (kg/ha) of ammonium (NH_4^+).

Table 4. Soil data collected from the "Meadow plants" treatment and in adjacent field in Kasby 1 in May 2011.There were significant differences(p<0.05)between them regarding Tot-N (in %), Tot-C (in %), pH, P (mg/100g) and NO_3^- (kg/ha).

Sample site	Soil variables (average data)									
	Tot-N %	Tot-C %	pH	P (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Na (mg/100g)	NH_4^+ (kg/ha)	NO_3^- (kg/ha)
"Meadow plants"	0.23	2.70	6.00	14.28	37.91	277.03	21.48	0.98	17.69	5.09
Field	0.18	1.85	6.77	19.77	39.54	460.27	22.87	1.23	37.13	120.00

3.6 Species composition

Data for recorded species for each treatment and site in 1991/1993, 1997 and 2011, with species cover data for the treatments in 2011 (except for the "Bushes & meadow plants" treatments), can be found in Appendix C. The NMDS graphs (Fig. 8 and 10) illustrate in two-dimensional figures how similar the treatments are regarding species composition. Treatments plotted close to each other are more similar than treatments plotted far apart. Confidence intervals (95%) are illustrated as ellipses around each treatment. Axis 1 explains the most variation followed by axis 2. Two additional graphs (Fig. 9 and 11) show how the species are arranged in the NMDS graphs.

3.6.1 Kasby 1

Species composition differed over-all between the treatments at Kasby (F:16.5, df:4, p<0.05), where "Meadow plants" and "Reference margins" significantly differed from each-other and the rest of the treatments (Fig. 8). The NMDS graph where the species are plotted (Fig. 9) shows that the right half is dominated by weeds, whereas the left part is dominated by sown "meadow plants".

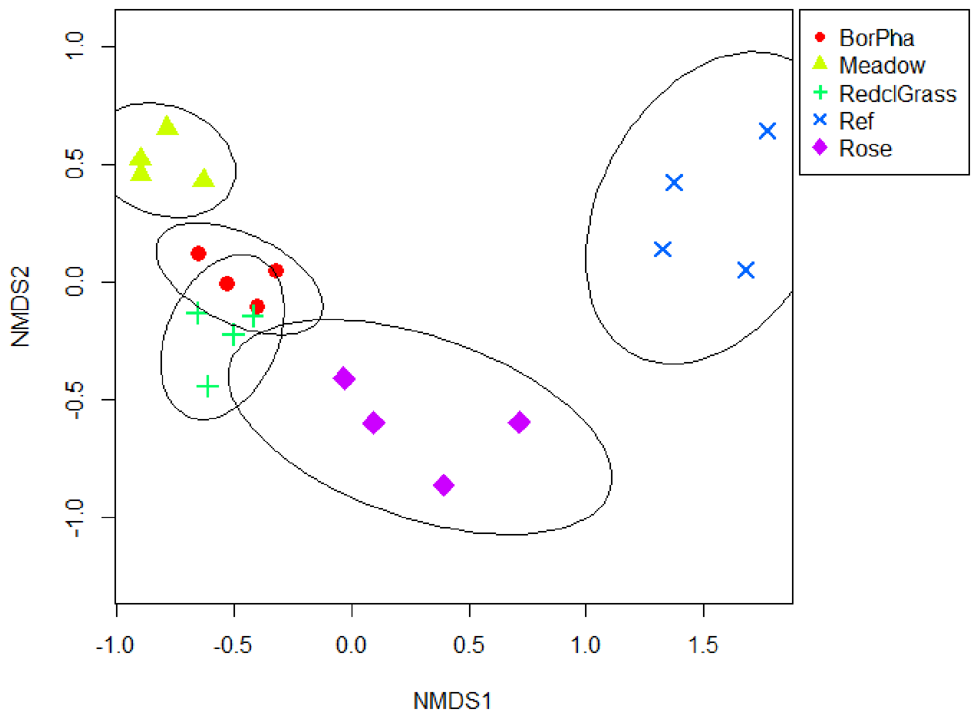

Figure 8. NMDS graph for Kasby 1 showing similarities between the treatments “Borage & Phacelia” (BorPha), “Meadow plants” (Meadow), “Red clover & ley grasses” (RedclGrass), “Reference margins” (Ref) and “Rose bushes” (Rose). Each symbol represent a plot and there are four plots per treatment. The ellipses shows standard deviation with 95% confidence interval (where the ellipses do not over-lap there is a significant difference). Axis 1 explains the most variation and after that, axis 2. The distance measure was Bray-Curtis and the stress was 6.7.

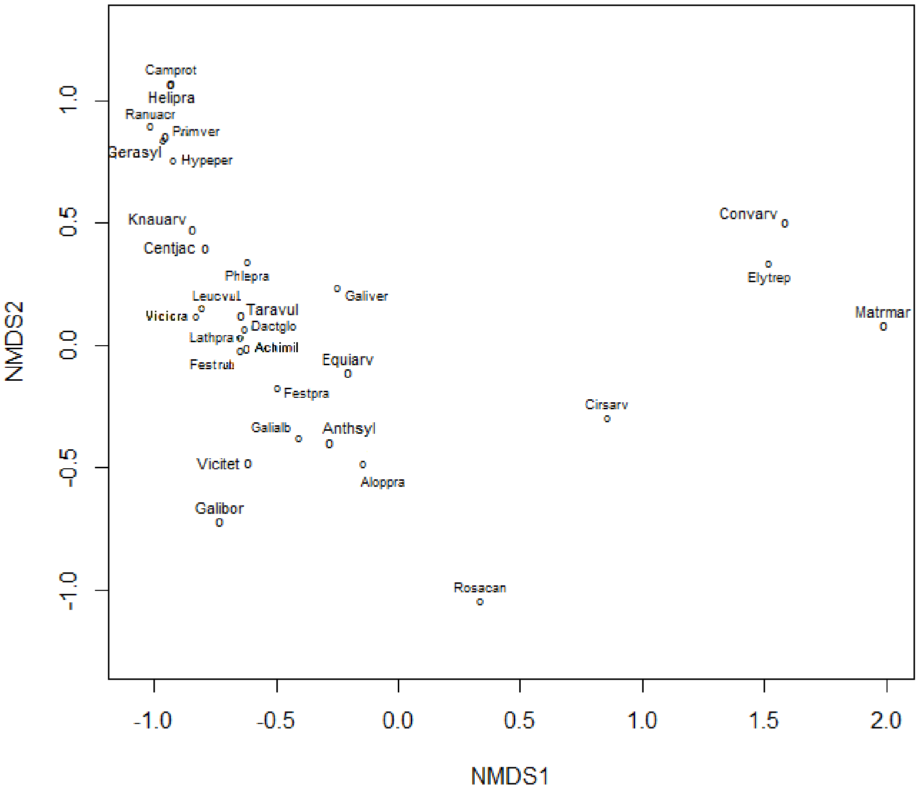

Figure 9. Additional NMDS graph showing how the species are arranged in the NMDS graph for Kasby 1 (Fig. 8). The distance measure was Bray-Curtis and the stress was 6.7. A key to the plotted species names can be found in Appendix B.

3.6.2 Ekenäs

Species composition differed over-all between the treatments at Ekenäs (F:6.06, df:3, $p<0.05$), where "Free regeneration" and "Reference margins" significantly differed from each-other and the rest of the treatments (Fig. 10). The NMDS graph where the species are plotted (Fig. 11) shows similar results as the Kasby 1 graph (Fig. 9), where the species in the right half are mostly weeds and the left part is dominated by sown "meadow plants".

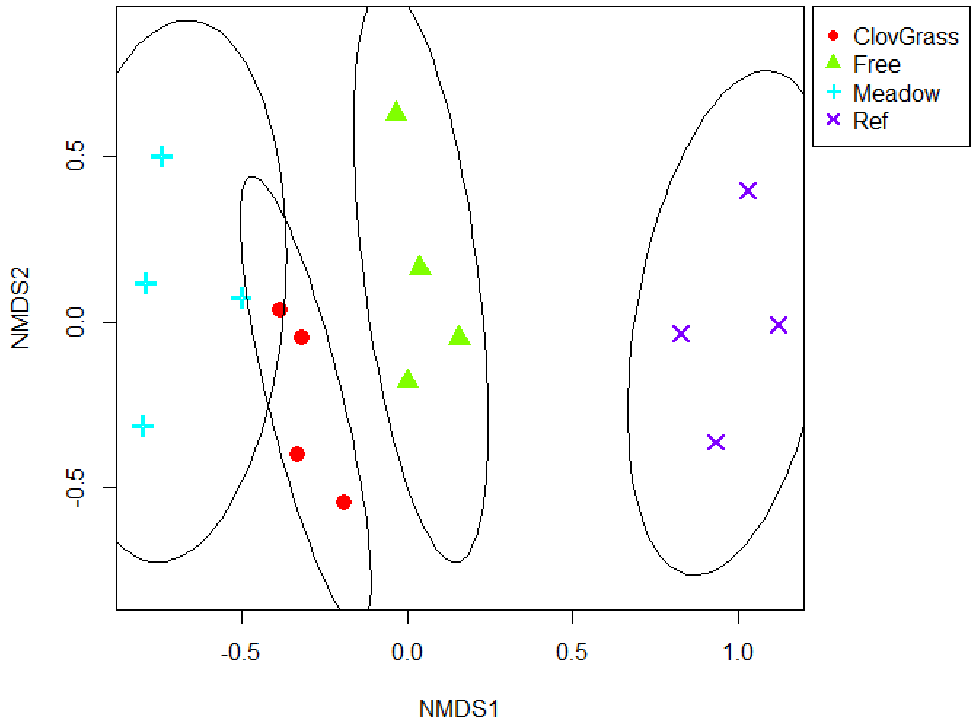

Figure 10. NMDS graph for Ekenäs showing similarities regarding species composition for the treatments “Clover & grasses” (ClovGrass), “Free regeneration” (Free), “Meadow plants” (Meadow) and “Reference margins” (Ref). The ellipses shows standard deviation with 95% confidence interval (where the ellipses do not over-lap there is a significant difference). Axis 1 explains the most variation and after that, axis 2. The distance measure was Bray-Curtis and the stress was 11.5.

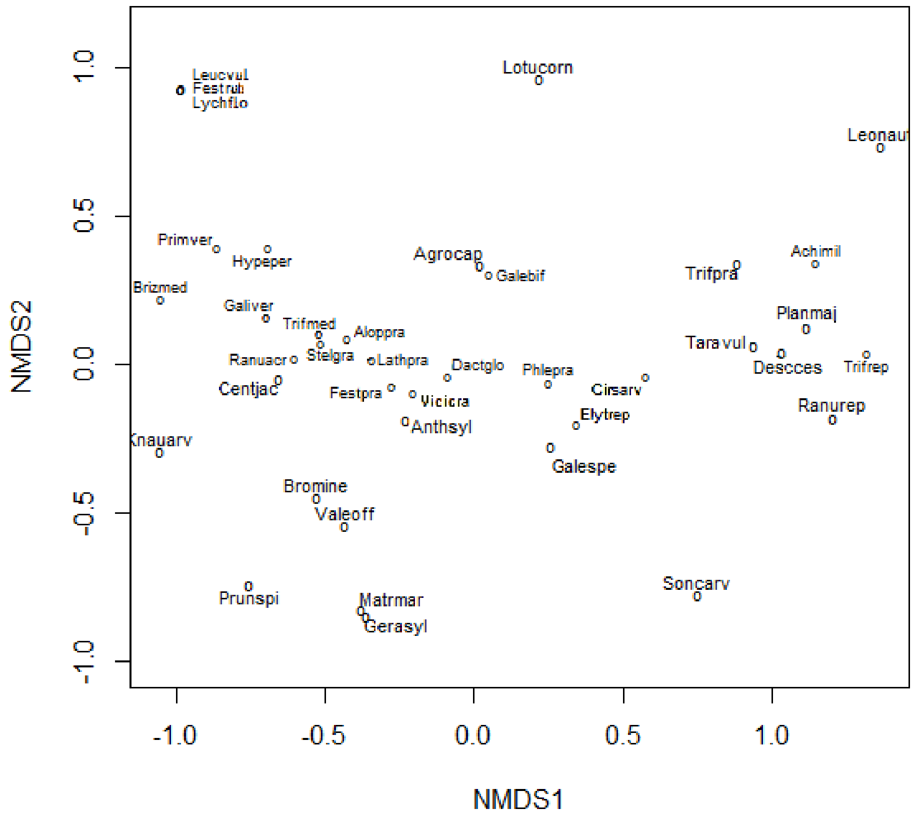

Figure 11. Additional NMDS graph showing how the species are arranged in the NMDS graph for Ekenäs (Fig. 10). The distance measure was Bray-Curtis and the stress was 11.5. A key to the plotted species names can be found in Appendix B

3.6.3 Indicator species

The Indicator Species Analysis (ISA) uses a combination of species abundance and frequency to calculate if there are any species that are more abundant, frequent and exclusive to one of the treatments. Each found species gets an Indicator Value, where a high value (maximum 1.00) represents an abundant and frequent species that mostly occurs in that specific treatment. Table 5 shows that the Indicator Species in the “Reference margins” at Kasby 1 and Ekenäs consist of perennial weeds (e.g. *Elytrigia repens*), whereas in the treatments “Meadow plants” at Kasby 1 and Ekenäs the Indicator Species only consist of sown “meadow plants” (e.g. *Primula veris*).

Table 5. Significant (p<0.05) Indicator Species for the treatments and reference margins at Kasby 1 and Ekenäs. The indicator value is a combination of species abundance and frequency, where a high number (max:1.00) indicates the species is abundant, frequent and mostly occurs in that specific treatment..

Species	Site	Treatment	Indicator value	p-value
Taraxacum sect. *Vulgaria*	Kasby 1	Borage & Phacelia	0.51	0.031
Geranium sylvaticum	Kasby 1	Meadow plants	1.00	0.001
Primula veris	Kasby 1	Meadow plants	1.00	0.003
Hypericum perforatum	Kasby 1	Meadow plants	0.95	0.002
Knautia arvensis	Kasby 1	Meadow plants	0.77	0.002
Centaurea jacea	Kasby 1	Meadow plants	0.76	0.001
Ranunculus acris	Kasby 1	Meadow plants	0.75	0.018
Equisetum arvense	Kasby 1	Red clover & ley grasses	0.40	0.040
Elytrigia repens	Kasby 1	Reference margins	0.86	0.001
Convolvulus arvensis	Kasby 1	Reference margins	0.79	0.003
Rosa canina	Kasby 1	Rose bushes	0.98	0.003
Alopecuris pratensis	Kasby 1	Rose bushes	0.36	0.001
Bromus inermis	Ekenäs	Clover & grasses	0.57	0.033
Festuca pratensis	Ekenäs	Clover & grasses	0.55	0.009
Agrostis capillaries	Ekenäs	Free regeneration	0.67	0.014
Galium verum	Ekenäs	Meadow plants	0.79	0.004
Primula veris	Ekenäs	Meadow plants	0.75	0.027
Trifolium repens	Ekenäs	Reference margins	1.00	0.003
Taraxacum sect. *Vulgaria*	Ekenäs	Reference margins	0.91	0.002
Ranunculus repens	Ekenäs	Reference margins	0.75	0.027
Plantago major	Ekenäs	Reference margins	0.67	0.024

4 Discussion

The results in this study show that after more than 20 years, the vegetation in the established field margins clearly differed from natural field margins, both considering the number of species, the species density, the weed cover, nitrogen indicator values and species composition. Since the experiments were established in ordinary agricultural soil, it also shows that sown meadow plants can survive in a long-term perspective and even spread to adjacent permanent margins, even if sown in rich fertile soil.

4.1 Number of species

Compared to reference margins, the different treatments seem to have an over-all higher number of species in 2011 (with some exceptions, e.g. “Rose bushes”). The highest amounts were found in the “Clover & ley grasses” and “Meadow plants” treatments (28.0-24.3 species per plot), where most of the found species were sown “meadow plants” (Appendix C).

Even though the total number of species in the treatments seems to decrease in the first years after establishment (ranging from -10.0% to -63.2% between 1991/1993 and 1997), a loss due to annual weeds and some sown species, it increased again the following years (between 1997 and 2011) in six out of eleven treatments. The increase could be caused by species migration by hay-movement or wind dispersal between the treatment plots, for instance five of the sown “meadow plant” species were found in all treatments in 2011. This could be one explanation to the comparably high amounts of species found in the “Clover & ley grasses” and “Free regeneration” treatments at Ekenäs (28.0 and 23.5 species per plot). Fritch *et al.* (2011) also detected a species increase in plots adjacent to sown plots due to species spreading, while Smith *et al.* (2010) found that sown species failed to colonize adjacent unsown plots after a closed sward was formed. Interestingly, there was also an increase in total number of species in two of the three "Meadow plants" treatments between 1997 and 2011. This could partly be explained by reappearence of sown species that were not recorded in 1997, but also by spreading of species sown in other treatments (e.g. *Trifolium pratense* and *Dactylis glomerata*) (Appendix C).

In spite of the fact that species seem to have spread between the treatments in these experiments, there is still a difference in species richness among them after over 20 years, emphasizing the importance of selecting a proper seed-mix for a long-term establishment. For example, sowing grass has been found to negatively affect species richness, converting the margins to ordinary field margin conditions after only three years (Kleijn *et al.*, 1998).

Remarkably, the species *Briza media*, *Filipendula ulmaria*, *F. vulgaris* and *Valeriana officinalis* were recorded in some treatments for the first time after sowing, 21-23 years after establishment. Whether this is due to different conditions from year-to-year or caused by human factors, there is a possibility that these species need some years to establish.

4.2 Species density

There was an over-all difference in species density (i.e. the average number of species per 0.5 m x 0.5 m square) between the treatments in 2011, with significantly higher species density in the treatment plots at Kasby 1 and 2 compared to the reference plots at those sites. The highest species density was found in the "Meadow plants" treatments at Kasby 1 and 2 (10.1 and 8.2 species per square), whereas the lowest was found in the two "Reference margins" at the same sites (2.2 and 3.3 species per square). The "Reference margins" at Kasby were quite species-poor, with a few weeds dominating the flora, for example *Cirsium arvense*, *Elytrigia repens* and *Convolvulus arvensis* (Appendix C). At the Ekenäs site there was no significant difference in species density between the treatments and the reference plots, although the species composition differed amongst them (Fig.10). The ordinary field margin flora at Ekenäs was rather species-rich with many different weed species compared to the reference margins at Kasby (Appendix C), probably due to the species-rich surrounding landscape and/or to the fact that adjacent fields are farmed organically at Ekenäs. Compared to conventional farming, organic farming has been found to promote increased biodiversity (Benton *et al.*, 2003), for example with a more diverse field margin and boundary flora (Petersen *et al.*, 2006) with species of conservational value (Bassa *et al.*, 2011).

4.3 Weed cover

More than 20 years after establishment, almost all the treatments had significantly lower percent cover of the four investigated weeds (*Anthriscus sylvestris*, *Cirsium vulgare*, *Elytrigia repens* and *Taraxacum* sect. *Vulgaria*) compared to "Reference margins", both at Kasby 1 and Ekenäs. It has been shown in other experiments that establishing sown field margins may reduce weed cover of certain species in the margin (Fritch *et al.*, 2011; Marshall, 2009; Musters *et al.*, 2009; Moonen & Marshall, 2001; Smith *et al.*, 1999; Kleijn *et al.*, 1998), but it has no influence on the weeds in the centre of the field (Marshall, 2009).

In the "Meadow plants" treatments, the cover of the four weeds was as low as 4.6-6.5%, to compare with 32.0-43.7% in the reference plots. Although sown field margins may reduce the weed abundance, it may be difficult to eliminate weeds completely (Marshall & Moonen, 2002).

4.4 Nitrogen indicator value

Over time, the average nitrogen indicator value (N-value) (Hill *et al.*, 1999) in the treatments over-all tended to decrease, indicating a plant species composition shift as well as a decrease in soil nitrate concentrations. The largest drop was between 1991 and 1997, probably due to the loss of annual weed species with higher nitrogen indicator values. Musters *et al.* (2009) observed similar results, with a decrease in nitrogen indicator values 4 years after establishment of sown field margins.

When comparing the treatments in categories ("Meadow plants", "Clover and ley grass" and "Free regeneration") the average N-values all tend to decrease over time. The "Meadow plants" treatments seem to have the continuous lowest nitrogen indicator value among them. Even though the "Reference margins" may not have been placed at the exact same site, the average N-values do not seem to differ between the years.

A weighted average N-value, where species percent cover was included, could provide a more correct N-value since species that are more abundant get a greater impact. Due to lack of percent cover data, weighted average N-values could not be calculated for previous years, but weighted averages for 2011 indicate differences between the treatments and the reference margins. The largest difference (1.68) was between the “Meadow plants” treatment at Kasby 1 and the “Reference margin” at the same site. In the “Meadow plants” treatment, the weighted average N-value (4.98) indicates a site of intermediate fertility (Hill *et al.*, 1999), whereas the value in the “Reference margin” (6.66) indicates a richly fertile place (Hill *et al.*, 1999). Even though the difference is not very distinct, it is interesting that margins adjacent to arable fields could indicate a comparably low nitrogen indicator value. Unfortunately, no soil samples were taken from the “Reference margins” to compare the two with actual values of plant available nitrogen (i.e. NH_4^+ and NO_3^-).

4.5 Soil analysis

Logically there were higher amounts of minerals (P, K, Ca, Mg, Na) and solved nitrogen (NH_4^+ and NO_3^-) in the field than in the margin strip, due to fertilising the fields in spring. The plant species composition of field margins have been found to correlate strongly with nitrogen, phosphorus and crop rotation, where species richness decreases with increased nitrogen and phosphor inputs on the crops (Kleijn & Verbeek, 2000).

The total percent carbon and nitrogen were significantly higher in the treatment compared to the field, despite the fact that cut plant material were removed each year. If nitrogen and carbon can be captured in permanent field margins in this manner, they could provide an additional solution to prevent climate changes. To draw any general conclusions regarding this, more data is needed from the other sites, treatments and “reference margins”.

4.6 Species composition

Species composition differed over-all between the treatments at respectively Kasby 1 and Ekenäs. On the right sides of the NMDS graphs (Fig. 8 and 10) the “Reference margins” were placed, significantly separated from the treatments, and furthest on the left sides were the “Meadow plants” treatments. Both species graphs (Fig. 9 and 11) indicate a trend on axis 1, where sown “meadow plants” are placed near zero and dominance of weed species the farther to the right. The indicator species in the “Meadow plants” treatments consisted of sown “meadow plants”, such as *Primula veris*, *Hypericum perforatum* and *Galium verum*, whereas weed species (e.g. *Elytrigia repens*, *Taraxacum* sect. *Vulgaria* and *Trifolium repens*) were indicator species in the “Reference margins” (Table 5). This shows that fundamental differences between permanent field margins sown with "meadow plants" and natural field margins can be achieved in a long-term perspective.

Various seed-mixes were used with different success regarding the species maintenance. The species sown in the "Borage & Phacelia" treatment disappeared early in the establishment, and was not found in 1997 or 2011 (Appendix C). This is as expected since these two species rarely survive the Swedish winters as plants, but only as seeds. In the different clover and ley grass treatments ("Clover & ley grasses", "Red clover and ley grass", "Red clover and ley grasses, herbicide treated" and "Red clover & ley grasses") the sown species did not remain dominant after sowing, whereas the majority (i.e. >50% of total plant cover) of the species in the "Meadow plants" treatments still consisted of sown meadow plants in 2011 (Appendix C). Over 20 years after establishment, 22 of the 32 sown meadow plant species could still be found in the "Meadow plants" treatments, and five of these species (*Alopecurus pratesis*, *Centaurea jacea*, *Galium verum*, *Hypericum perforatum* and *Vicia cracca*) had spread to all the other treatments, indicating a suitable seed-mixture.

Remarkably, the treatment "Free regeneration" at the Ekenäs site did not consist of significantly fewer species, nor had a lower species density than the "Meadow plants" treatment at the same site in 2011. This contradicts the results in other studies comparing natural regenerated field margins with margins with sown grass and/or wild-flower mixes, suggesting that sown margins establish a more species-rich flora over time (i.e. after 7 and 13 years, respectively) (Fritch *et al.*, 2011; Smith *et al.*, 2010). Explanations to the results in this study could be that species rather easily could spread between the treatment plots and/or that the plots at Ekenäs are situated in a varied landscape with a naturally species-rich flora and the fields are farmed organically, providing a source of plant re-establishment. But when the species composition of the different treatments is compared in a NMDS, it indicates that there is a difference between them (Fig. 10). Thus it is important to include more factors than just species-richness to describe the flora.

4.7 Management of field margins

There are several factors that influence both the short-term and the long-term effects of establishment of new field margins, including soil type, level of nutrients and abundance of weeds. Since field margins may differ distinctly from each other, a standardized management approach should not be desirable, at least not from a biodiversity conservation point of view. For example, sown field margins may be a threat to rare arable weed species (Marshall, 2009; Moonen & Marshall, 2001), which can get out-competed by perennial species. This should be considered in areas where rare arable weeds with conservational value are abundant.

Another aspect to consider when designing field margins for a specific purpose, e.g. for game birds or wildlife conservation, is that they may be unsuitable for providing other ecological services, such as supporting biological pest control (Olson & Wackers, 2007). This may be adjusted by simple modifications, such as altering the plant composition and management. With an appealing flora, the field margin may be helpful sustaining different arthropods, including beneficial ones (Backman & Tiainen, 2002; Marshall & Moonen, 2002; Svensson *et al.*, 2000; Thomas & Marshall, 1999; Lagerlöf & Wallin, 1993; Dennis & Fry, 1992), although there is little known about the long-term effects (Noordijk *et al.*, 2010). Further, an invertebrate-rich field margin is of great importance to other taxa, such as farmland birds (Douglas *et al.*, 2009; Vickery *et al.*, 2009).

In addition to conserving biodiversity, a field margin with permanent vegetation may also provide buffering effects, preventing pollution by agrochemicals to neighbouring habitats (reviewed in Marshall & Moonen, 2002).

4.7.1 Sowing seed-mixes

The results in this study shows that the plant composition may be completely altered and maintained long-term by sowing different plant species and manage them by yearly mowing with removal of cut material. In these experiments, overall the seed-mixture "Meadow plants" seemed most successful after 20 years, both regarding the number of species, the species density, the abundance of weeds, the nitrogen indicator value and maintenance of the species composition. Even though the treatment "Free regeneration" had a high number of species and rather low weed cover, it is difficult to exclude the fact that species spreading between the treatments and/or a species-rich environment has affected this outcome. In experiments with other conditions, e.g. in intensively managed grasslands, the success of restoration by natural regeneration may be limited due to less diverse seed banks (Fritch *et al.*, 2011). In those cases the use of seed-mixes may help reintroduce botanical diversity (Fritch *et al.*, 2011). It is important to incorporate a variety of seed-mixes to avoid homogeneity in created field margins in a wider landscape perspective. To promote local genetic variety, seeds with a local origin are preferred (reviewed in Walker *et al.*, 2004).

Since there is a correlation between plant diversity and invertebrate diversity in field margins (Woodcock *et al.*, 2007; Asteraki *et al.*, 2004; Thomas & Marshall, 1999; Lagerlöf & Wallin, 1993) using seed-mixes with wild-flowers and grasses may also benefit invertebrate diversity (Backman & Tiainen, 2002; Thomas & Marshall, 1999; Lagerlöf & Wallin, 1993) and therefore provide a more diverse food resource for birds (Vickery *et al.*, 2009).

4.7.2 Margin width

In this study it may be difficult to draw any conclusions regarding the effect of margin width, since the differences between the experiments were not only in margin width and length, but also regarding treatments and site conditions. In other studies it has been shown that margin and boundary width could have an impact on species composition, exemplified in Mediterranean and Scandinavian environments (Bassa *et al.*, 2011; Tarmi *et al.*, 2009). Fritch *et al*. (2011) concluded that a wide margin can enhance the initial success of establishment of a sown field margin, with an increased herb cover and decreased weed cover. Although the margin width did not seem to influence plant species richness after 7 years (Fritch *et al.*, 2011). In another study with a long-term data simulation and a field experiment, the effect on plant diversity in margins correlated positively with margin width, at least when the margin was wider than the fertiliser misplacement (Schippers & Joenje, 2002).

A wide margin may also increase densities of animals, for example bumblebees and cuckoo bumblebees (Backman & Tiainen, 2002) and small mammals (Shore *et al.*, 2005). Further, the width and length of permanent field margins have been found to be more important than the vegetation height, to influence the surface water movement, affecting soil erosion and pesticide and fertiliser drift to adjacent ditches (reviewed in Marshall & Moonen, 2002).

4.7.3 Margin age

There is little known about the long-term effects on plant establishment in permanent field margins, though this study suggests that field margins can develop a relatively species-rich vegetation given the proper management, seed sources and time. Unfortunately most agri-environmental schemes (AES) are created for a rather short time-period (Kleijn *et al.*, 2006), since most agreements within the EU subsidy network are 5 year-agreements. Even though opportunities to prolong the commitments occur, fluctuations in compensation payments and grain prices are important factors influencing farmers' descisions. In the Netherlands it is common to create sown field margins to provide habitats for animals, although the average installation period is only 6 years (Noordijk *et al.*, 2010).

The results in this study show a species decrease in the first years, due to loss of annual weeds, although the number of species seems to increase in some of the treatments between the 7th-9th and 21st-23rd year after establishment (i.e. between the years 1997 and 2011). In the “Meadow plants” treatment the vegetation consisted of up to 63% of sown plants after 21-23 years, comparable to 53% of sown grass and wild-flower species after 13 years in a British field margin experiment (Smith *et al.*, 2010). Although Smith *et al.* (2010) observed that the advantageous effect of sowing declined after 13 years, with an increase of rhizomatous, perennial weeds. Other studies of sown field margins suggest a weed cover decrease over time (Fritch *et al.*, 2011; Musters *et al.*, 2009; Smith *et al.*, 1999). Since this study lacks data for weed cover in earlier years, any similar conclusion is difficult to draw, but the weed cover was found to decrease between 1991 and 1997 in two of the three study sites (Ekenäs and Kasby 1) in a previous study (Bokenstrand *et al.*, 2004). In 2011, over 20 years after establishment, the cover of four perennial weeds[4] in the treatments was comparably low, especially in the “Meadow plants” treatments (4.6%-6.5%) (Fig. 6).

Permanent margins have been shown to be important for species that do not disperse easily (e.g. most plant species), to protect adjacent watercourses from agro-chemical pollution and to make it easier to control weeds, while temporary margins may provide a habitat for rare arable species and are easier for the farmer to include in normal crop management (Marshall & Moonen, 2002).

Further, field margins taken out of production are preferable over cropped margins for invertebrate species richness (Olson & Wackers, 2007; Backman & Tiainen, 2002; de Snoo, 1999) and invertebrates seem to benefit from increased field margin age (Noordijk *et al.*, 2010; Musters *et al.*, 2009; Olson & Wackers, 2007).

4.7.4 Mowing and removal of cuttings

These experiments did not include different types of management; all were mown yearly with removal of cuttings, except for the plots with bushes (“Bushes & meadow plants” and “Rose bushes”). Other studies indicate that the rate of species loss can be lowered by mowing (Fritch *et al.*, 2011; Smith *et al.*, 2010; Schippers & Joenje, 2002), both in sown and naturally regenerated margins (Smith *et al.*,

[4] *Anthriscus sylvestris, Cirsium vulgare, Elytrigia repens* and *Taraxacum* sect. *Vulgaria.*

2010). The timing of mowing may have an impact on other taxa, such as beetles (Woodcock *et al.*, 2007), granivorous birds (Vickery *et al.*, 2009) and small mammals (Shore *et al.*, 2005). To provide a suitable over-wintering habitat for invertebrates, it has been recommended not to cut the margins too late in the autumn (Noordijk *et al.*, 2010).

To sustain botanical diversity the importance of removal of cuttings after mowing has been emphasized by various researchers (e.g. Musters *et al.*, 2009; Schippers & Joenje, 2002; Kleijn & Verbeek, 2000). Nutrient demanding species, e.g. *Urtica dioica*, and more competitive species have been found to increase at the expense of more slow-growing sown species when hay is left lying in mowed margins (Noordijk *et al.*, 2011; Smith *et al.*, 2010), particularly in the establishment phase (Smith *et al.*, 2010). Removal of cuttings may also provide a more suitable habitat for beneficial invertebrate predators (Noordijk *et al.*, 2010) and prevent nutrient leakage (Schaffers *et al.*, 1998). Furthermore, the cuttings can be used as fodder and therefore have some economic value for farmers.

4.7.5 Field margins and farmers

Since field margins generally are maintained by farmers, it is important to take their objective into account. Farmers may fear that field margins provide sources of weeds (Cordeau *et al.*, 2011) and crop pests, that could cause them to spray the margins with herbicides and pesticides (which is not allowed near watercourses in Sweden), counteracting the aim of established field margins. It has been found that it is important to leave an unsprayed zone of several meters next to the field margin to benefit margin plants, insect density and species richness (Marshall & Moonen, 2002; de Snoo, 1999; de Snoo & van der Poll, 1999; Kleijn & Snoeijing, 1997), as well as to avoid pesticide drift (de Snoo & van der Poll, 1999). Further, a fertilisation buffer zone next to the margin is also important to reduce weed abundance, hence the positive correlation between weeds in the zone next to arable fields and level of nutrients applied at the crops (Kleijn & Verbeek, 2000). With the proper field margin management, such as implementing buffer zones for herbicides and pesticides (reviewed in Kleijn & Snoeijing, 1997), and annual mowing with removing of cuttings (Noordijk *et al.*, 2011), weed problems can be reduced.

Cordeau *et al.* (2011) interviewed French farmers who had to set aside 3% of their field areas connected to rivers, to create sown field margins in order to decrease erosion and pesticide levels. They found that almost 70% of the interviewed farmers mentioned weed problems in their new margins, although this was found to be related more to weed presence than species richness and abundance of weeds

(Cordeau *et al.*, 2011). Farmers may still find field margins as sources of weeds, since it may be difficult to eliminate them entirely.

The field margins can be a sources of certain crop pests, such as gastropods (Frank, 1998) and nematodes (Musters *et al.*, 2009), although they have not been found to harbor high amounts of crop pest insects (Lagerlöf & Wallin, 1993). Unwanted gastropod species may be prevented by choosing certain crops or applying molluscicides (Frank, 1998), and the nematodes in Musters *et al.*'s study (2009) scarcely spread into adjacent fields, but they may cause a problem if the margin is reassumed in the crop production (Musters *et al.*, 2009). It is also important to avoid establishment of species that could act as intermediate hosts for plant diseases (e.g. *Berberis vulgaris* for *Puccinia graminis*) or over-wintering plants for pest insects (e.g. *Prunus padus* for the aphid *Rhopalosiphum padi*).

On the other hand, field margins may promote reproductive success of natural enemies (i.e. biological pest control) by providing an all-year-round availability of food, shelter and other resources (Olson & Wackers, 2007; Marshall & Moonen, 2002; Dennis & Fry, 1992). Margins sown with wild-flower is preferable over grassy ones for non pest-insects as well as some pest antagonists, such as aphid predators (Lagerlöf & Wallin, 1993).

Botanically diverse field margins may also contribute to other ecosystem services, such as crop pollination, by providing suitable habitats for bees, bumblebees and other pollinating insects (Backman & Tiainen, 2002; Svensson *et al.*, 2000; Lagerlöf & Wallin, 1993) and supplying alternative food sources during the time when crops are not mature (Svensson *et al.*, 2000).

Even though permanent field margins can be beneficial for farmers in some ways, setting arable land aside comes with a cost of reduced crop production, as well as costs of sowing and mowing. Farmers may fear that it could negatively affect their income, especially if there is a lack of compensation payment (Cordeau *et al.*, 2011). Establishing permanent field margins may be supported economically by the European Union, if it is done according to the set-up schemes. Although many agri-environment schemes (AES) suggest an establishment of 6 m wide margins, which may be irrational for farms with small field areas, e.g. the margin would consist of 12% of the field area in a typical Irish field (Fritch *et al.*, 2011). In Sweden, compensation payment for sown margin strips as buffer zones near watercourses (in specific regions) is currently SEK 4000 (€ 444.4) per hectar and year (Government Offices of Sweden, 2008). There is no other economic compensation for establishing sown field margins, but payment can be received for not applying fertiliser, herbicides and pesticides 6 m from the field edges (Government Offices of Sweden, 2008).

The fears of farmers considering establishment of field margins must be evaluated and taken into account to be able to succeed with permanent margins on a broader landscape scale.

4.8 Conclusions

This study shows that permanent, sown field margins managed by yearly mowing and taking away cut plant material, can be established and sustained in a long-term perspective. The number of plant species decreased in the first years, due to loss of annual weeds and some sown species, but it still maintained high compared to reference margins over 20 years after establishment. One of the conclusions to be drawn is that the long-term success is partly due to the choice of appropriate seed mixtures. Margins sown with “meadow plants” seem to maintain their sown species composition better than the other treatments, e.g. sowing clover and ley grass. Out of the 32 sown species, 22 were still present in the “Meadow plants” treatments after more than 20 years. In the experiments the “Meadow plants” treatments had the highest species density and among the highest number of species, as well as the lowest average weed cover and nitrogen indicator value.

Over-all, the treatments differed from the natural reference margins at the sites, regarding the number of species, the species density, the weed cover, the nitrogen indicator values and species composition. Even though sown “meadow plant” species seem to have spread between the treatments, differences still occurred among them after 20 years.

Since permanent field margins could provide many important functions, such as acting as a refuge for species with declining natural habitats (Albrecht *et al.*, 2010; Smart *et al.*, 2002; Lagerlöf & Wallin, 1993; Dennis & Fry, 1992), prevent fertiliser, herbicide and pesticide drift to adjacent ditches (Marshall & Moonen, 2002), lower the weed abundance (Fritch *et al.*, 2011; Marshall, 2009; Musters et al., 2009; Moonen & Marshall, 2001; Smith *et al.*, 1999; Kleijn *et al.*, 1998), support biological pest control (Olson & Wackers, 2007; Marshall & Moonen, 2002; Dennis & Fry, 1992) and provide a habitat for pollinators (Backman & Tiainen, 2002; Svensson *et al.*, 2000; Lagerlöf & Wallin, 1993), a margin design including many different functions would be a cost-efficient choice in a landscape perspective. But it is also very important to have a variety of margins to provide a wide range of habitats for different species; therefore a simple standard solution should not be preferable.

It may be difficult to answer the posed question regarding differences in soil composition between the treatments and the field, since only one treatment at one site was analysed. But this study indicates that carbon and nitrogen could be incorporated in permanent field margins. Taking more soil samples for the other treatments at all sites, including the reference margins, could show if this is a general trend.

For further studies of these margins, a follow-up recording of plant species in spring and autumn could include other eventual species not present in summer. An additional recording of the species cover in the treatments at Kasby 2 would also make it possible to statistically analyse this site regarding weed cover and species composition. To study the presence and abundance of other taxa, such as arthropods and birds, could also show if these kinds of margins are beneficial for other species groups.

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Maps

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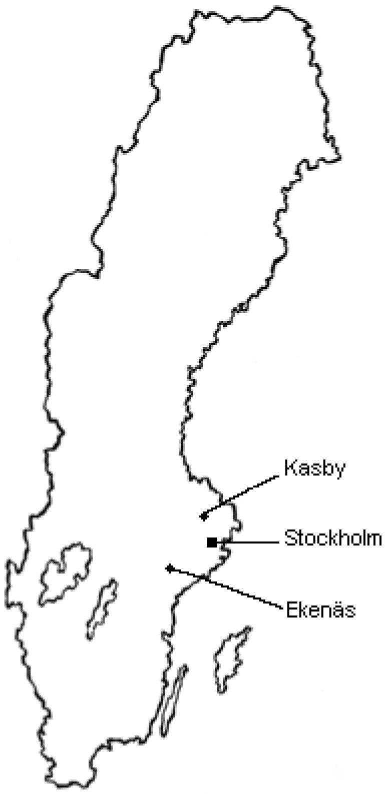
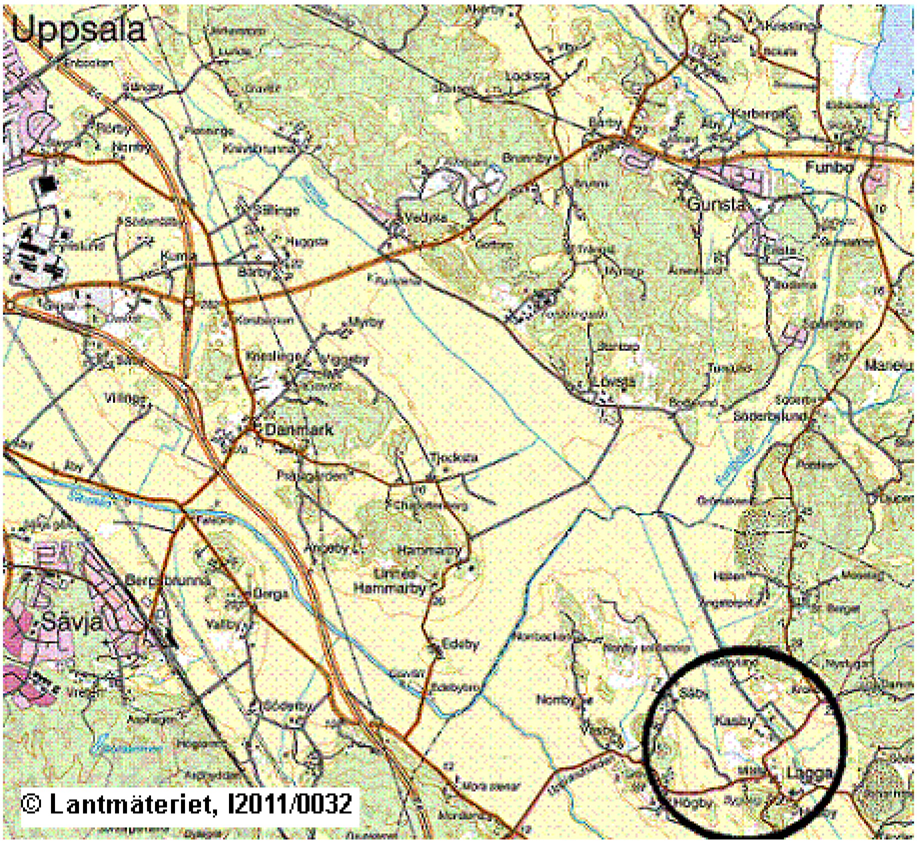
Appendices

Appendix A. Maps of the study area



Map 1. Geographical placement of the two study sites (Kasby and Ekenäs).



Map 2. The study site Kasby marked in a circle (Terrängkartan, Lantmäteriet).

Map 3. The study site Ekenäs marked in a circle (Terrängkartan, Lantmäteriet).

Appendix B. Species list

Names of occurring species in Latin, in an abbreviated version, in English and in Swedish.

Latin	Abbrev.	English	Swedish
Achillea millefolium	Achi mil	Yarrow	Röllika
Achillea ptarmica	Achi pta	Sneezewort	Nysört
Aegopodium podagraria	Aego pod	Ground-Elder	Kirskål
Agrimonia eupatoria	Agri eup	Common agrimony	Småborre
Agrostis capillaris	Agro cap	Common bent	Rödven
Agrostis stolonifera	Agro stol	Creeping bent	Krypven
Alchemilla sp.	Alch sp		
Allium oleraceum	Alli ole	Field garlic	Backlök
Alopecurus pratensis	Alop pra	Meadow foxtail	Ängskavle
Anthriscus sylvestris	Anth syl	Cow parsley	Hundkäx
Anthyllis vulneraria	Anth vul	Kidney vetch	Getväppling
Artemisia absinthium	Arte abs	Absinthe wormwood	Malört
Artemisia vulgaris	Arte vul	Mugwort	Gråbo
Barbarea vulgaris	Barb vul	Bittercress	Sommargyllen
Betula pendula	Betu pen	Silver birch	Vårtbjörk
Borago officinalis	Bora off	Borage	Gurkört
Brassica napus	Bras nap	Rapeseed	Raps
Briza media	Briz med	Quaking-grass	Darrgräs
Bromopsis inermis	Brom ine	Hungarian Brome	Foderlosta
Bunias orientalis	Buni ori	Warty-cabbage	Ryssgubbe
Campanula rotundifolia	Camp rot	Harebell	Liten blåklocka
Capsella bursa-pastoris	Caps bur	Shepherd's-purse	Lomme
Caryophyllaceae sp.	Cary sp		
Centaurea cyanus	Cent cya	Cornflower	Blåklint
Centaurea jacea	Cent jac	Brown Knapweed	Rödklint
Cerastium fontanum	Cera font	Common Mouse-ear	Hönsarv
Chamomilla recutita	Cham rec	Scented Mayweed	Kamomill
Chamomilla suaveolens	Cham sua	Pineappleweed	Gatkamomill
Chenopodium album	Cheno alb	Fat-hen	Svinmålla
Chenopodium sp.	Chen sp		
Cirsium arvense	Cirs arv	Creeping Thistle	Åkertistel
Cirsium helenioides	Cirs hel	Melancholy Thistle	Brudborste
Cirsium vulgare	Cirs vul	Spear Thistle	Vägtistel

Consolida regalis	Cons reg	Forking Larkspur	Riddarsporre
Convolvulus arvensis	Conv arv	Field Bindweed	Åkervinda
Crataegus monogyna	Crat mon	Hawthorn	Trubbhagtorn
Crepis praemorsa	Crep pra	Leafless Hawk's-beard	Klasefibbla
Cynosurus cristatus	Cyno cri	Crested Dog's-tail	Kamäxing
Dactylis glomerata	Dact glo	Cock's-foot	Hundäxing
Daucus carota	Dauc car	Wild Carrot	Vildmorot
Deschampsia cespitosa	Desc ces	Tufted Hair-grass	Tuvtåtel
Elytrigia repens	Elyt rep	Common Couch	Kvickrot
Epilobium ciliatum	Epil cil	Fringed Willowherb	Vit mjölkört
Equisetum arvense	Equi arv	Field Horsetail	Åkerfräken
Erysimum cheiranthoides	Erys che	Treacle-mustard	Åkerkårel
Euphorbia helioscopia	Euph hel	Sun Spurge	Revormstörel
Fallopia convolvulus	Fall con	Black-bindweed	Åkerbinda
Festuca pratensis	Fest pra	Meadow Fescue	Ängssvingel
Festuca rubra	Fest rub	Red Fescue	Rödsvingel
Filipendula ulmaria	Fili ulm	Meadowsweet	Älggräs
Filipendula vulgaris	Fili vul	Dropwort	Brudbröd
Fumaria officinalis	Fuma off	Common Fumitory	Jordrök
Fumaria vaillantii	Fuma vai	Few-flowered Fumitory	Blek jordrök
Galeopsis bifida	Gale bif	Bifid Hemp-Nettle	Toppdån
Galeopsis sp.	Gale sp		
Galeopsis speciosa	Gale spe	Large-flowered Hemp-Nettle	Hampdån
Galeopsis tetrahit	Gale tet	Common Hemp-Nettle	Pipdån
Galium album	Gali alb	Hedge Bedstraw	Stormåra
Galium aparine	Gali apa	Cleavers	Snärjmåra
Galium boreale	Gali bor	Northern Bedstraw	Vitmåra
Galium verum	Gali ver	Lady's Bedstraw	Gulmåra
Geranium sylvaticum	Gera syl	Wood Crane's-bill	Midsommarblomster
Geum rivale	Geum riv	Water Avens	Humleblomster
Helictotrichon pratense	Heli pra	Meadow Oat-grass	Ängshavre
Hieracium umbellatum	Hier umb	Narrowleaf Hawkweed	Flockfibbla
Hypericum maculatum	Hype mac	Imperforate St John's-wort	Fyrkantig johannesört
Hypericum perforatum	Hype per	Perforate St John's-wort	Äkta johannesört
Juniperus communis	Juni com	Common Juniper	En
Knautia arvensis	Knau arv	Field Scabious	Åkervädd
Lamium album	Lami alb	White Dead-nettle	Vitplister
Lamium amplexicaule	Lami amp	Henbit Dead-nettle	Mjukplister
Lamium purpureum	Lami pur	Red Dead-nettle	Rödplister

Lapsana communis	Laps com	Nipplewort	Harkål
Lathyrus pratensis	Lath pra	Meadow Vetchling	Gulvial
Leontodon autumnalis	Leon aut	Autumn Hawkbit	Höstfibbla
Leucanthemum vulgare	Leuc vul	Oxeye Daisy	Prästkrage
Linum usitatissimum	Linu usi	Flax	Lin
Lotus corniculatus	Lotu corn	Common Bird's-foot-trefoil	Käringtand
Luzula multiflora	Luzu mul	Heath Wood-rush	Ängsfryle
Lychnis flos-cuculi	Lych flo	Ragged-Robin	Gökblomster
Matricaria maritima	Matr mar	Scentless Mayweed	Baldersbrå
Medicago lupulina	Medi lup	Black Medick	Humlelusern
Medicago sativa	Medi sat	Lucerne	Blålusern
Melilotus officinalis	Medi off	Ribbed Melilot	Sötväppling
Myosotis arvensis	Myos arv	Field Forget-me-not	Åkerförgätmigej
Myosotis scorpioides	Myos sco	Water Forget-me-not	Äkta förgätmigej
Myosurus minimus	Myos min	Mousetail	Råttsvans
Papaver dubium	Papa dub	Long-headed Poppy	Rågvallmo
Papaver rhoeas	Papa rho	Common Poppy	Kornvallmo
Persicaria lapathifolia	Pers lap	Pale Persicaria	Vanlig pilört
Phacelia tanacetifolia	Phac tan	Phacelia	Honungsört
Phleum pratense	Phle pra	Timothy	Timotej
Phleum pratense ssp. Bertolonii	Phle pra Ber		Vildtimotej
Pimpinella saxifraga	Pimp sax	Burnet-saxifrage	Bockrot
Plantago major	Plan maj	Greater Plantain	Groblad
Plantago media	Plan med	Hoary Plantain	Rödkämpar
Poa annua	Poa ann	Annual Meadow-grass	Vitgröe
Poa pratensis	Poa pra	Smooth Meadow-gras	Ängsgröe
Poa trivialis	Poa tri	Rough Meadow-grass	Kärrgröe
Polygonum aviculare	Poly avi	Knotgrass	Trampört
Populus tremula	Popu tre	Aspen	Asp
Potentilla sp.	Pote sp		
Primula veris	Prim ver	Cowslip	Gullviva
Prunella vulgaris	Prun vul	Selfheal	Brunört
Prunus spinosa	Prun spi	Slow	Slån
Quercus robur	Quer rob	Pedunculate Oak	Ek
Ranunculus acris	Ranu acr	Meadow Buttercup	Smörblomma
Ranunculus auricomus	Ranu aur	Goldilocks Buttercup	Majsmörblomma
Ranunculus bulbosus	Ranu bul	Bulbous Buttercup	Knölsmörblomma
Ranunculus repens	Ranu rep	Creeping Buttercup	Revsmörblomma

Ranunculus sp.	Ranu sp		
Rhinanthus serotinus	Rhin ser	Greater Yellow-rattle	Höstskallra
Rosa canina	Rosa can	Dog-Rose	Stenros
Rubus idaeus	Rubu ida	Raspberry	Hallon
Rumex crispus	Rume cri	Curled Dock	Krusskräppa
Rumex longifolius	Rume lon	Northern Dock	Gårdskräppa
Salix caprea	Sali cap	Goat Willow	Sälg
Senecio vulgaris	Sene vul	Groundsel	Korsört
Serratula tinctoria	Serr tin	Saw-wort	Ängsskära
Seseli libanotis	Sese lib	Moon Carrot	Säfferot
Sonchus arvensis	Sonc arv	Perennial Sow-thistle	Åkermolke
Sonchus asper	Sonc asp	Prickly Sow-thistle	Svinmolke
Sonchus oleraceus	Sonc ole	Smooth Sow-thistle	Kålmolke
Sorbus aucuparia	Sorb auc	Rowan	Rönn
Spergula arvensis	Sper arv	Corn Spurrey	Åkerspärgel
Stachys palustris	Stac pal	Marsh Woundwort	Knölsyska
Stellaria graminea	Stel gra	Lesser Stitchwort	Grässtjärnblomma
Stellaria media	Stel med	Common Chickweed	Våtarv
Succisa pratensis	Succ pra	Devil's-bit Scabious	Ängsvädd
Taraxacum sect. Ruderalia	Tara vul	Common Dandelion	Ogräsmaskros
Thlaspi arvense	Thla arv	Field Penny-cress	Penningört
Tragopogon pratensis	Trag pra	Goat's-beard	Ängshaverrot
Trifolium hybridum	Trif hyb	Alsike Clover	Alsikeklöver
Trifolium medium	Trif med	Zigzag Clover	Skogsklöver
Trifolium pratense	Trif pra	Red Clover	Rödklöver
Trifolium repens	Trif rep	White Clover	Vitklöver
Triticum aestivum	Trit aes	Bread Wheat	Vete
Tussilago farfara	Tuss far	Colt's-foot	Hästhov
Urtica dioica	Urti dio	Common Nettle	Brännässla
Valeriana officinalis	Vale off	Garden Valerian	Läkevänderot
Veronica agrestis	Vero agr	Green Field-speedwell	Åkerveronika
Veronica arvensis	Vero arv	Wall Speedwell	Fältveronika
Veronica chamaedrys	Vero cham	Germander Speedwell	Teveronika
Veronica persica	Vero per	Common Field-speedwell	Trädgårdveronika
Veronica serpyllifolia	Vero ser	Thyme-leaved Speedwell	Majveronika
Vicia cracca	Vici cra	Tufted Vetch	Kråkvicker
Vicia hirsuta	Vici hir	Hairy Tare	Duvvicker
Vicia tetrasperma	Vici tet	Smooth Tare	Sparvvicker
Viola arvensis	Viol arv	Field Pansy	Åkerviol

Appendix C. Species occurrence in 1991/1993, 1997 and 2011

Species occurring in the different treatments and reference margins at Kasby 1, Kasby 2 and Ekenäs in 1991/1993, 1997 and 2011 (percent cover or X if <0.2%, (X) if cover was not measured but the species was present). A key to the abbreviated species names can be found in Appendix B.

Species	**Site, Treatment, Year**													
	Kasby 1													
	MP (K1)			RCG			RB			BP			REF (K1)	
	1991	1997	2011	1991	1997	2011	1991	1997	2011	1991	1997	2011	1997	2011
Achi mil		(X)	0.5		(X)	1.4	(X)	(X)	X	(X)	(X)	1.5	(X)	X
Alch sp			X											
Alli ole		(X)												
Alop pra	(X)	7.3	9.2	(X)	(X)	16.4	(X)	(X)	20.0	(X)	(X)	12.5	(X)	X
Anth syl	(X)	(X)	4.5	(X)	(X)	10.7	(X)	(X)	7.2	(X)	(X)	9.6	(X)	X
Anth vul	(X)	0.7		(X)							(X)			
Arte vul									X					X
Bora off										(X)				
Bras nap													(X)	
Briz med			X											
Buni ori		(X)								(X)	(X)		(X)	
Camp rot			0.3										(X)	
Caps bur										(X)				
Cent jac	(X)	5.4	6.6			1.0			X			1.0		
Cera font	(X)													
Cham rec					(X)									
Cham sua											(X)			
Chen alb							(X)							
Chen sp													(X)	
Cirs arv	(X)	(X)	0.4	(X)	(X)	2.7	(X)	(X)	13.2	(X)	(X)	1.8	(X)	6.2
Cirs vul														
Cons reg	(X)													
Conv arv	(X)		0.2	(X)		0.6	(X)		0.9	(X)	(X)	1.9	(X)	9.6
Crat mon						X								
Cyno cri	(X)													

Dact glo	(X)	(X)	0.5	(X)	(X)	0.7	(X)	(X)		(X)	(X)	2.1	(X)	
Desc ces			X											X
Elyt rep	(X)	(X)	0.5	(X)	(X)	1.0	(X)	(X)	4.8	(X)	(X)	1.9	(X)	37.4
Epil cil							(X)							
Equi arv	(X)	(X)	2.0	(X)	(X)	5.2	(X)	(X)	1.3	(X)	(X)	4.3	(X)	0.4
Erys che										(X)				
Fest pra	(X)	1.0	1.7	(X)	(X)	4.9	(X)		2.4	(X)	(X)	3.8		
Fest rub	(X)	23.2	6.3		(X)	4.2	(X)	(X)	0.6		(X)	3.9		
Fili ulm			X											
Fuma off	(X)			(X)			(X)			(X)			(X)	
Fuma vai	(X)									(X)				
Gale spe				(X)										
Gali alb	(X)		1.6	(X)	(X)	5.9			1.6			5.8	(X)	
Gali apa	(X)			(X)	(X)		(X)			(X)			(X)	
Gali bor						0.4								
Gali ver	(X)	0.7	6.0			3.4			0.5		(X)	7.1	(X)	0.3
Gera syl	(X)		2.1									X		
Geum riv		0.2	1.2											
Heli pra			0.2											
Hype mac		0.6												
Hype per	(X)	X	11.7			X			X			0.5		
Knau arv	(X)	3.0	4.0			0.3			X		(X)	0.8		
Lami alb	(X)	(X)					(X)							
Lami pur	(X)			(X)			(X)			(X)			(X)	
Laps com	(X)			(X)			(X)			(X)			(X)	
Lath pra		(X)	7.8			10.7			0.9		(X)	8.8	(X)	X
Leuc vul	(X)	3.8	0.6		(X)	0.9	(X)				(X)	0.3		
Linu usi													(X)	
Matr mar	(X)	(X)		(X)	(X)		(X)			(X)			(X)	0.3
Medi lup		(X)									(X)			
Myos arv	(X)			(X)			(X)			(X)			(X)	
Myos min							(X)			(X)				
Papa dub							(X)						(X)	
Phac tan										(X)				
Phle pra			0.7			X			X			2.3	(X)	

Plan maj		(X)												
Plan med		0.2												
Poa pra	(X)	(X)		(X)	(X)		(X)	(X)		(X)	(X)		(X)	
Poa tri							(X)							
Poly avi							(X)			(X)				
Prim ver		1.5	10.4		(X)	X								
Prun vul	(X)													X
Ranu acr	(X)	2.4	0.8		(X)			(X)						
Ranu bul					(X)			(X)			(X)		(X)	
Ranu rep	(X)			(X)			(X)			(X)				
Rhin ser	(X)													
Rosa can				(X)		0.4	(X)	(X)	17.3					
Sese lib													(X)	
Sonc arv	(X)			(X)			(X)			(X)			(X)	
Sonc asp													(X)	
Stel med				(X)			(X)							
Tara vul	(X)	(X)	1.0	(X)	(X)	1.3	(X)	(X)	X	(X)	(X)	2.2	(X)	
Thla arv	(X)						(X)			(X)			(X)	
Trag pra										(X)				
Trif pra	(X)		X	(X)			(X)			(X)				
Trif rep		(X)			(X)						(X)			
Trit aes	(X)			(X)			(X)			(X)				
Tuss far	(X)	(X)	X		(X)		(X)	(X)	X			X	(X)	
Vale off			X											
Vero agr	(X)			(X)			(X)			(X)				
Vero arv	(X)			(X)			(X)			(X)				
Vero cha			X											
Vero per	(X)									(X)				
Vero ser							(X)			(X)				
Vici cra	(X)	2.4	2.2			2.2			X		(X)	0.9		X
Vici hir									X					
Vici tet			X			0.4								
Viol arv	(X)						(X)							
No of species	44	32	35	27	21	25	38	14	22	35	23	22	32	14

Species	Site. Treatment. Year												
	Kasby 2												
	MP (K2)			BM (K2)			RCM			RC	RCH	REF (K2)	
	1993	1997	2011	1993	1997	2011	1993	1997	2011	2011	2011	1997	2011
Achi mil	(X)	(X)	0.9	(X)	(X)	(X)	(X)	(X)	(X)	1.5	2.3	(X)	X
Alli ole						(X)							
Alop pra	(X)	12.3	5.1	(X)	5.8	(X)	(X)	(X)	(X)	4.0	5.4	(X)	X
Anth syl	(X)	(X)	3.7	(X)	(X)	(X)	(X)	(X)	(X)	12.6	8.2	(X)	0.8
Anth vul	(X)	X		(X)									
Arte abs								(X)					
Arte vul													0.8
Barb vul				(X)			(X)						
Bras nap	(X)			(X)			(X)	(X)				(X)	
Brom ine									(X)		X		
Buni ori	(X)	(X)	X	(X)	(X)		(X)	(X)	(X)	X	X		X
Camp rot		0.2	0.2			(X)			(X)	X			
Caps bur	(X)	(X)		(X)	(X)		(X)						
Cent cya				(X)									
Cent jac	(X)	3.0	10.8	(X)	0.6	(X)		(X)	(X)	0.6	3.1		
Cera font	(X)			(X)			(X)					(X)	
Cham rec		(X)						(X)					
Chen alb												(X)	
Chen sp	(X)			(X)			(X)	(X)					
Cirs arv	(X)	(X)	X	(X)	(X)	(X)	(X)	(X)	(X)	7.3	5.0	(X)	7.2
Cons reg				(X)									
Conv arv	(X)	(X)		(X)			(X)					(X)	11.5
Crat mon						(X)							
Cyno cri	(X)			(X)									
Dact glo	(X)		0.9	(X)	(X)	(X)		(X)	(X)	3.2	3.9	(X)	
Dauc car												(X)	
Desc ces						(X)			(X)		X		X
Elyt rep	(X)	(X)	0.2	(X)	(X)	(X)	(X)	(X)	(X)	6.6	9.2	(X)	24.9
Epil cil				(X)			(X)						
Equi arv	(X)	(X)	0.5	(X)	(X)	(X)	(X)	(X)	(X)	0.9	2.9	(X)	1.3
Erys che	(X)	(X)		(X)			(X)						

Fest pra	(X)	2.1	X	(X)	0.2	(X)	(X)	(X)	(X)		X	(X)	0.6
Fest rub		7.0	5.3		1.4	(X)		(X)	(X)	0.5	2.8	(X)	0.8
Fili ulm			X			(X)							
Fuma off	(X)			(X)			(X)					(X)	
Fuma vai							(X)						
Gale bif				(X)			(X)						
Gale sp	(X)			(X)			(X)						
Gale spe	(X)	(X)				(X)	(X)	(X)					X
Gale tet	(X)			(X)		(X)							
Gali alb		(X)	3.3		(X)	(X)	(X)	(X)	(X)	5.3	1.5	(X)	0.8
Gali apa	(X)	(X)		(X)	(X)		(X)	(X)				(X)	
Gali bor		X	X		X								
Gali ver	(X)	0.3	10.2	(X)	0.2	(X)			(X)	2.9	4.6	(X)	0.3
Gera syl		X	X		X	(X)			(X)	X	X		
Geum riv		0.2	X		X	(X)							
Hype mac		0.3			0.2								
Hype per	(X)	0.2	11.2	(X)	0.7	(X)			(X)	2.6	X		
Juni com						(X)							
Knau arv	(X)	2.2	4.7	(X)	0.2	(X)		(X)	(X)	X	0.7		
Lami alb	(X)			(X)	(X)		(X)	(X)					0.4
Lami amp												(X)	
Lami pur	(X)			(X)			(X)	(X)				(X)	
Laps com	(X)			(X)			(X)	(X)				(X)	
Lath pra	(X)	(X)	1.2			(X)		(X)	(X)	5.2	2.3	(X)	0.6
Leuc vul	(X)	4.4	1.1	(X)	3.0	(X)		(X)	(X)	0.3	3.7		
Lych flo	(X)	0.2		(X)									
Matr mar	(X)	(X)		(X)	(X)	(X)	(X)	(X)				(X)	0.3
Medi lup		(X)						(X)	(X)		X		
Myos arv	(X)	(X)		(X)	(X)		(X)	(X)				(X)	
Papa rho				(X)									
Pers lap					(X)			(X)	(X)	X	X		
Phle pra		(X)	1.3	(X)	(X)	(X)	(X)	(X)	(X)	7.4	5.5	(X)	
Plan med		0.2			X								
Poa ann		(X)											
Poa pra		(X)		(X)	(X)			(X)				(X)	

Poa tri							(X)						
Poly avi	(X)			(X)			(X)						
Prim ver	(X)	1.1	6.6		2.0	(X)			(X)	0.3	1.3		
Prun vul		0.5		(X)					(X)	1.2	X		0.3
Prun spi			X	(X)	(X)	(X)			(X)		X	(X)	
Quer rob				(X)									
Ranu acr	(X)	2.0	4.3	(X)	0.2			(X)	(X)		0.2		
Ranu aur						(X)							
Ranu bul												(X)	
Ranu rep	(X)			(X)			(X)						
Rhin ser	(X)			(X)									
Rosa can				(X)	(X)	(X)			(X)	X	X		
Rubu ida					(X)			(X)	(X)	X		(X)	
Rume cri							(X)	(X)					
Rume lon							(X)						
Sali cap												(X)	
Sene vul				(X)									
Serr tin			X			(X)							
Sonc arv	(X)			(X)			(X)						X
Sonc asp							(X)						
Sorb auc				(X)	(X)	(X)							
Stel gra			0.2		(X)	(X)	(X)	(X)	(X)	0.2	0.3		
Stel med	(X)			(X)			(X)						
Tara vul	(X)	(X)	2.6	(X)	(X)	(X)	(X)	(X)	(X)	5.9	3.9	(X)	1.2
Thla arv	(X)			(X)			(X)	(X)				(X)	
Trag pra		(X)	0.2		(X)		(X)	(X)	(X)	X	X	(X)	0.3
Trif hyb	(X)	(X)											
Trif med													2.2
Trif pra	(X)	(X)	0.3	(X)	(X)		(X)	(X)	(X)		X		
Trif rep			X		(X)								
Trit aes	(X)			(X)			(X)						
Tuss far	(X)	(X)	X	(X)	(X)	(X)	(X)	(X)	(X)	X	X		X
Urti dio					(X)	(X)	(X)	(X)	(X)	2.4	0.3	(X)	
Vero arv	(X)			(X)									
Vero ser	(X)			(X)									

Vici cra		0.6	3.5	(X)	X	(X)			(X)	0.8	X	(X)	X
Vici tet			X						(X)		X		
Viol arv	(X)			(X)			(X)						
No of species	50	45	35	61	43	39	46	40	38	30	36	35	25

Species	**Site. Treatment. Year**													
	Ekenäs													
	MP (E)			BM (E)			CG			FR			REF (E)	
	1991	1997	2011	1991	1997	2011	1991	1997	2011	1991	1997	2011	1997	2011
Achi mil			X					(X)	X		(X)	0.2	(X)	1.4
Achi pta													(X)	
Aego pod													(X)	
Agri eup												X	(X)	
Agro cap		(X)	0.6		(X)				0.6		(X)	3.5		0.6
Agro stol											(X)		(X)	
Alop pra	(X)	8.0	22.6		4.0	(X)			9.8	(X)	(X)	15.8	(X)	
Anth syl			2.5			(X)			3.4			2.1	(X)	1.3
Anth vul	(X)	1.0		(X)										
Arte vul	(X)		X	(X)					X	(X)			(X)	
Betu pen									X					
Briz med			0.2									X		
Brom ine			0.7			(X)			2.8			0.2		
Caps bur	(X)			(X)						(X)				
Cary sp										(X)				
Cent jac	(X)	12.1	7.1	(X)	12.1	(X)		(X)	8.2		(X)	X		
Cera font	(X)									(X)				
Cham sua	(X)			(X)						(X)				
Chen alb	(X)		X						X	(X)				
Cirs arv		(X)	X	(X)	(X)	(X)	(X)	(X)	2.0	(X)	(X)	7.9	(X)	8.5
Cirs vul												X		
Conv arv													(X)	
Crep pra	(X)			(X)										
Cyno cri	(X)			(X)										

Dact glo			0.3						1.6		(X)	4.9	(X)	
Desc ces		(X)	X			(X)			X		(X)	1.1		3.3
Elyt rep	(X)	(X)	1.6	(X)	(X)	(X)	(X)	(X)	8.3	(X)	(X)	6.0	(X)	11.0
Equi arv			X		(X)	(X)		(X)					(X)	
Euph hel				(X)					X		(X)			
Fall con	(X)			(X)						(X)				
Fest pra	(X)	X	1.6	(X)	0.2	(X)	(X)	(X)	3.5	(X)		1.0	(X)	0.3
Fest rub		14.2	0.5	(X)	20.0			(X)			(X)		(X)	
Fili vul			X											
Fuma off	(X)		X						X			X		
Gale bif			X						X	(X)		0.4		
Gale sp	(X)			(X)			(X)			(X)				
Gale spe			X		(X)				0.3	(X)		1.2		0.3
Gali alb			X			(X)			X			X		
Gali apa	(X)			(X)			(X)		X	(X)				
Gali ver	(X)	0.6	5.3	(X)	1.1	(X)			0.7			0.6	(X)	
Gera syl	(X)	X	X		X	(X)			0.8					
Geum riv		X	X		1.0									
Hier umb									X				(X)	
Hype mac	(X)	0.2		(X)				(X)			(X)			
Hype per		X	5.1		0.3	(X)			0.9	(X)	(X)	0.9		
Knau arv	(X)	0.2	0.7	(X)	1.1	(X)		(X)						
Lami pur	(X)				(X)					(X)				
Laps com	(X)			(X)						(X)			(X)	
Lath pra		(X)	3.0	(X)	(X)	(X)		(X)	4.5	(X)	(X)	5.6	(X)	
Leon aut											(X)			0.4
Leuc vul	(X)	4.4	0.6	(X)	0.4	(X)		(X)	X		(X)	X		
Lotu corn	(X)	(X)	0.4	(X)	(X)		(X)		X	(X)	(X)	0.4		0.4
Lych flo	(X)		0.2	(X)	0.2									
Matr mar	(X)	(X)	X	(X)		(X)	(X)	(X)	1.0	(X)		X	(X)	X
Medi lup				(X)										
Medi sat					(X)									
Medi off	(X)	(X)	X					(X)			(X)	X		
Myos arv	(X)		X	(X)					X	(X)	(X)	X	(X)	
Phle pra	(X)	(X)	1.7	(X)	(X)		(X)	(X)	8.7	(X)	(X)	3.6	(X)	4.4

Phle pra Ber								(X)			(X)			
Pimp sax									X					
Plan maj	(X)			(X)					0.3	(X)	(X)			2.5
Plan med		0.2		(X)						(X)				
Poa ann	(X)			(X)					X	(X)		X		
Poa pra	(X)			(X)	(X)		(X)	(X)		(X)	(X)		(X)	
Poly avi	(X)			(X)			(X)			(X)				
Popu tre													(X)	
Pote sp													(X)	
Prim ver			2.0			(X)			X					
Prun vul	(X)	2.1	0.3	(X)					0.2	(X)	(X)	X		
Prun spi			X	(X)	(X)	(X)			X					
Ranu acr	(X)	2.7	3.2	(X)	1.2	(X)		(X)	4.4		(X)	X		
Ranu aur											(X)			
Ranu bul								(X)			(X)		(X)	
Ranu rep	(X)			(X)						(X)			(X)	1.9
Ranu sp	(X)	(X)		(X)							(X)			
Rhin ser	(X)			(X)										
Rosa can				(X)	(X)	(X)								
Serr tin			X		(X)									
Sonc arv	(X)			(X)		(X)	(X)		0.3	(X)	(X)		(X)	0.7
Sonc asp														X
Sonc ole				(X)										
Sorb auc				(X)	(X)	(X)								
Sper arv										(X)				
Stac pal	(X)			(X)			(X)			(X)				
Stel gra			X						0.2		(X)	X		
Stel med	(X)			(X)			(X)			(X)				
Succ pra	(X)			(X)										
Tara vul	(X)	(X)	0.5	(X)	(X)	(X)		(X)	0.9	(X)	(X)	X	(X)	11.3
Thla arv	(X)													
Trag pra													(X)	
Trif hyb	(X)	(X)		(X)				(X)		(X)	(X)			
Trif med		(X)	14.7	(X)	(X)	(X)		(X)	8.9			12.2	(X)	
Trif pra	(X)	(X)		(X)	(X)		(X)	(X)	X	(X)	(X)	1.3	(X)	3.5

Trif rep	(X)	(X)		(X)			(X)	(X)	X	(X)	(X)	X		14.6
Trit aes														X
Tuss far	(X)									(X)				
Urti dio						(X)						X	(X)	
Vale off			0.6			(X)			2.4			2.1		
Vero agr	(X)		X		(X)				X					
Vero ser				(X)						(X)	(X)			
Vici cra	(X)	0.2	2.0	(X)	1.5	(X)	(X)	(X)	1.8	(X)	(X)	3.4	(X)	0.6
Vici hir								(X)			(X)			
Vici tet				(X)										
Viol arv				(X)						(X)				
No of species	50	31	45	54	32	28	16	25	46	42	37	38	34	21