

Plant communities of field boundaries in Finnish farmland

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To determine the importance of field boundary habitats for farmland biodiversity, we surveyed a total of 193 boundaries from four climatically and agriculturally dissimilar regions in Finland. We measured the current plant species richness and composition of the boundaries, and, based on the differences in vegetation characteristics, we describe six boundary types.

The observed plant species were mainly indicators of fresh to wet soils and moderate to rich mineral nitrogen content. The most frequent species were tall, perennial monocots and dicots indicating the high productivity of the vegetation. Moreover, herbicide-tolerant species were common. No species rare for Finland were found. In animal husbandry regions, the most frequent species were sown grassland species and typical grassland weeds. In cereal production regions, fast-spreading root weeds tolerant of herbicides were the most frequent. Mean species richness was highest in the cluster *Calamagrostis-Phalaris* (24 species (s) / boundary (b)), which we considered as representative of moist sites with some disturbance by agricultural practices. Most species-poor were the clusters *Elymus-Anthriscus* (14 s/b) and *Elymus-Cirsium* (16 s/b), both found predominantly in cereal production regions in southern Finland.

Our results suggest that the biodiversity value of boundaries is lowest in the most intensive cereal production areas and highest in areas of mixed farming.

Key words: plant communities, correspondence analysis, boundaries, diversity, species richness

Introduction

Intensified agricultural land use has drastically reduced semi-natural habitats. Traditional

pastures and a variety of natural meadow types have almost disappeared (Alanen 1997). Moreover, the amount of field boundaries has been considerably reduced (Ruuska and Helenius 1996, Hietala-Koivu 1999). In particular, sub-

surface draining of fields to increase the cultivated area has decreased boundary areas, a common phenomenon in many European countries since the 1950s. In Finland, the area of fields with subsurface drainage increased from 5.1% (of a total field area of 2 292 000 ha) in 1945 (Hilli 1949) to 53% (2 501 000 ha) in 1998 (Information Centre of the Ministry of Agriculture and Forestry 1999). Subsurface drainage is more common in cereal production regions in southern parts of Finland, where up to 91% of the parcel ditches have been removed during the last four decades (Hietala-Koivu 1999). Besides the decrease in the total boundary area, the remaining boundaries have been exposed to herbicide drift from crop spraying and fertiliser misplacement or runoff from cultivated fields, both of which simplify plant community structure and decrease species richness (Marrs et al. 1991, Kleijn and Snoeiijing 1997, Hansson and Fogelfors 1998). Higher plant species diversity increases the temporal stability of plant communities (Tilman et al. 1996). More diverse plant communities may also utilise soil mineral nitrogen more efficiently than a species-poor ecosystem (Tilman et al. 1996). Diverse plant communities are important also for heterotrophs exploiting these habitats. Siemann (1998) demonstrated that plant species diversity and productivity increased diversity also at higher trophic levels.

The decreased area and harmful impacts of agricultural practices on remaining boundary habitats have been a common phenomena in Western Europe during the last century. Despite this, the importance of these habitats for wildlife of the agricultural environment has been shown in many studies. Boundaries enhance arthropod diversity, including the natural enemies of crop pests (Dennis and Fry 1992, Canters and Tamis 1999, Pfiffner and Luka 2000). They increase overall carabid densities (Fournier and Loreau 1999) in cultivated areas and provide overwintering habitats for e.g. spiders (Bayram and Luff 1993). Flowering plants are a food resource for pollinators (Lagerlöf et al. 1992,

Bäckman and Tiainen 2002). Field boundaries also provide important links among favourable habitat patches for butterfly species (Dover et al. 1992, Sparks and Parish 1995), and the various boundary types support a diverse butterfly fauna (Saarinen et al. 1998). Boundaries provide important feeding and nesting habitats for gamebirds (e.g. Aebischer et al. 1994, Tiainen and Pakkala 2000). As a consequence of intensified land use, the decline in numbers of grey partridge, as well as several other farmland bird species, has been reported in Finland (Väisänen 1999).

In this research, we tried to estimate the biodiversity value of Finnish field boundaries by surveying plant assemblages. Our specific objectives were: 1) to describe plant species diversity and composition in Finnish field boundaries, 2) to identify boundary plant communities based on species composition, and 3) to describe the factors determining these types on the basis of the ecological requirements of the plant species. In addition, our objective was to estimate the value of boundary plant communities as secondary habitats for meadow plant species. The importance of current boundary plant communities for animals is also discussed.

We know only one earlier study on Finnish field boundary vegetation, which focused on the species' value as silage for cattle, rather than on the biodiversity aspect (Hilli 1949).

This study was made just before management measures of the 1st Finnish agri-environmental scheme required by EU regulations were applied. One target of the agri-environmental scheme is to maintain biodiversity and landscape in agricultural environment. In the basic scheme, management agreement includes the widening of boundaries along waterways to one (main ditches) or three (stream, river, lake) meters wide. Boundaries should not be fertilized or treated with pesticides. Mowing is mentioned as a useful management for wildlife, but it is not obligatory treatment (Ministry of Agriculture and Forestry 2000).

Material and methods

Botanical studies of field boundaries were included in a broad nationwide MYTVAS -project on Monitoring the Impacts of the Agri-Environmental Support Scheme in 1995–1999. This project was carried out in four watershed regions, which are representative of agricultural regions in Finland. Lepsämäenjoki, about 30 km N of Helsinki, and Yläneenjoki, about 50 km NE of Turku, are predominantly cereal production regions. Lestijoki, about 60 km SE of Kokkola, is a region of animal husbandry and mixed farming, and Taipaleenjoki, about 20 km W of Joensuu, is a typical animal husbandry region of small farms and fine-grained landscape structure. The co-ordinates of the regions are Lepsämäenjoki 60°20' N, 60°27' N, 24°37' E, 24°49' E, Yläneenjoki 60°47' N to 60°56' N and 22°25' E to 22°40' E, Lestijoki 63°39' N, 63°50' N, 24°09' E, 24°25' E and Taipaleenjoki 62°36' N, 62°38' N, 29°10' E, 29°20' E.

The most common soil types in Lepsämäenjoki are sandy clay (in 55% of the boundaries), fine sand (26%), and clay (16%); in Yläneenjoki fine sand (61%) and sandy clay (31%); in Lestijoki fine sand (91%), and in Taipaleenjoki fine sand (59%), mull (19%) and silt (13%) (Tarmi and Helenius, unpublished data). The average thermal growing season in Yläneenjoki and Lepsämäenjoki is 170 days, in Taipaleenjoki 155 days, and in Lestijoki 150 days (Alalammi 1987). Average annual precipitation is 582, 619, 612 and 544 mm, respectively.

Our fieldwork period was from the beginning of July to mid-August 1995. To facilitate site selection in the field, we made a preliminary choice of boundaries from aerial photographs (scale 1:20000). Subsequently we refined the choice using the following criteria. (1) Location next to a waterway such as a main ditch, river or lake. (2) No or only a few trees and shrubs present (because these might affect the species composition in the herbaceous layer). (3) No forest edge next to a site because of the possible shading effects and the dispersal of forest field

layer species. Only sites matching these criteria were included.

We studied 193 boundaries in all (50 in Yläneenjoki, 52 in Lepsämäenjoki, 58 in Lestijoki and 33 in Taipaleenjoki). The boundary was determined as a zone from a field edge to the beginning of a slope. All plant species were measured in one to five 0.25 m² quadrates (0.5 m x 0.5 m) in each boundary (Fig. 1). The distance of a quadrate to the field was measured as the distance from the field edge to the nearest, parallel side of the quadrate. We aimed at a quadrate distance of 50 cm from the field edge, but in practice these varied from zero to over two metres depending on the variation in boundary widths. When the boundary width was less than 50 cm, less than five quadrates were studied. When the boundary width was less than one metre, quadrate distance from the field was less than aimed 50 cm. In cases of over one metre the distance from the field was more than 50 cm. The width of a boundary was measured in all five quadrate sites to calculate the mean width based on five values. The minimum distance of the first sample quadrate from one end of a boundary was 10 metres and the distance between quadrates 20 metres.

We used Oksanen's nine class scale (1981), 1 – ≤0.8%, 2 – ≤1.6%, 3 – ≤3.1%, 4 – ≤6.3%, 5 – ≤12.5%, 6 – ≤25%, 7 – ≤50%, 8 – ≤75%, 9 – ≤100%, in estimating plant species' coverage. Because our field work schedule was tight, field workers identified sterile or difficult grasses only to genus level. In species nomenclature, we follow Hämet-Ahti et al. (1986). To describe the ecological characters of the species, we applied Ellenberg et al. (1991) indicator values.

In the original data, we determined the cover values of the species in each 0.25 m² sample quadrate using a nine-class scale. For the statistical analyses, we combined the quadrate data to calculate the mean cover of each species in a boundary. Boundaries with only two quadrates were made passive in the correspondence analysis (CA), but were included in classification. Species which were present only in one boundary were dropped from the CA (listed in App. 1)

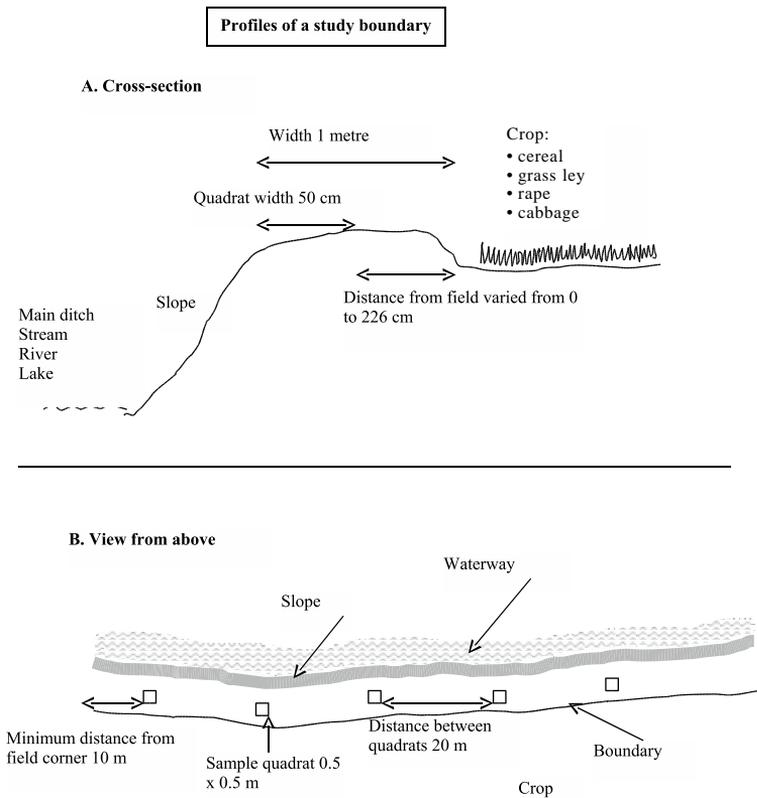


Fig. 1. Profiles of a study boundary. The optimal location for sample quadrates was 50 cm from field edge. See Tables 2 and 5 for the variation of boundary widths and distances of quadrates from fields.

and those present only in two or three boundaries were unweighted, because in some applications individual samples with species of low frequency may distort the analysis (Hill 1979).

The quadrat data transformation was as follows: Cover class 9 was merged with class 8.

The classes for each species were replaced with the corresponding class centres by calculating the geometric means of lower and upper limits of cover percentages. The first cover class, >0–0.8%, was replaced by the arithmetic mean of the lower and the upper limits, as 0 does not

Table 1. Number of boundaries/areas, their division into clusters, and the mean width (cm) of boundaries/clusters.

Cluster	LEPSÄ	YLÄNE	TAIPA	LESTI	Total	Mean width	SE	Min	Max
1	1	0	4	40	45	139	23.9	6	780
2	1	1	8	8	18	82	13.1	12	276
3	0	0	11	1	12	109	18.4	18	204
4	1	0	1	3	5	78	11.8	40	100
5	22	37	4	1	64	86	13.9	4	860
6	13	4	1	5	23	130	30.1	13	660
7	14	8	1	0	26	63	5.1	28	108
Total	52	50	33	58	193				

SE = standard error of the mean

allow computing a geometric mean. A mean cover percentage per species was then obtained as an arithmetic mean of the quadrates. Finally, these cover percentages were replaced with the corresponding value from the original scale (classes from 1 to 8). These new values approximate the cover percentages of species (Oksanen 1981).

We used ordination technique to reveal the major variation in the species abundance data of boundaries. CA was performed with the program Canoco™ (ter Braak 1987). By CA it may be possible to detect whether unknown environmental variables determine the species occurrences in the data set (Jongman et al. 1995). The ordination diagram presented the similarity or dissimilarity of the species compositions of the test boundaries. Based on the scores of the first four axes of ordination, the boundaries were grouped into clusters by Ward's method (see Jongman et al. 1995). Cluster analysis was performed using the SAS™ Statistical package's CLUSTER and TREE procedures.

The mean species richness was measured for each cluster using only boundaries with an equal sample size of five quadrate samples to allow for the asymptotic dependence of the species number on the sample size. Because clustering is a subjective method, i.e. one may decide the number of groups to be left after fusion, we found it inappropriate to make any statistical test for species richness between clusters. However, we found it important to check whether the distance from the field could, at least partially, be one of the factors affecting the species richness in these data. To test the effect of distance from the field edge on plant species richness, we divided boundaries into three classes: 1) the mean distance of the quadrates from field edge 0–19 cm ($n = 60$), 2) distance 20–39 cm ($n = 36$), and 3) distance ≥ 40 cm ($n = 50$). To test the differences between classes we used ANOVA, which was performed with SYSTAT™ (SPSS™ Inc. 1997). The normality of variables in ANOVA was checked from the normal probability plots of residuals. The homogeneity of variables was tested with Cochran's test.

Results

The results of the CA ordination indicated dissimilarities in boundary vegetation between the regions. The studied regions formed three groups of plots in the first two axes in CA ordination (Fig. 2). Southern regions were plotted as one cloud of plots, whereas Lestijoki and Taipaleenjoki formed their own groups, from which Taipaleenjoki sites were plotted in a more scattered way. Points in the first two groups were arranged in relation to the first axis, while the Taipaleenjoki sites were scattered in relation to the second axis (Fig. 2).

Based on the scores of the first four axes of ordination, we classified the boundaries by using Ward's clustering method. We found seven clusters to represent a reasonable level of ag-

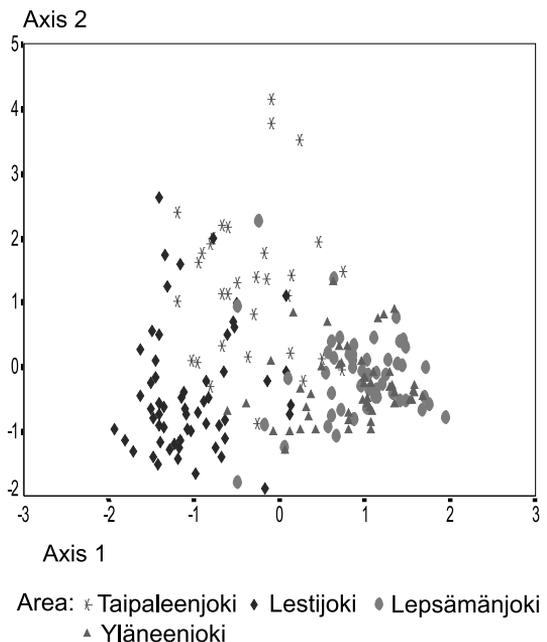


Fig. 2. Ordination diagram of correspondence analysis of the studied field boundaries based on their plant species composition. Different symbols represent the four study areas. For axis 1 eigenvalue = 0.424, percentage variance of species data 10.6, and for axis 2 eigenvalue = 0.224, percentage variance of species data 5.6.

glomeration even though cluster 4 (C4) included only five boundaries at this level (Table 1, Fig. 3). Boundaries in C4 were interpreted as outliers and were not considered as representative boundary group. In the next level of fusion C4 would have been merged with cluster 2 (C2). As in CA results, groups that were formed by clustering also indicated that some local environmental factors may determine the vegetation composition of boundaries. Cluster 1 (C1) included mainly Lestijoki sites and cluster 3 (C3) mainly Taipaleenjoki sites (Fig. 3, Table 1). Cluster 2 (C2) represents mainly sites from Taipaleenjoki and Lestijoki whereas clusters 5 (C5) and 7 (C7) represent mainly sites from Lepsämänjoki and Yläneenjoki. Cluster 6 (C6) is the most independent of any particular region and includes several sites from southern regions and Lestijoki.

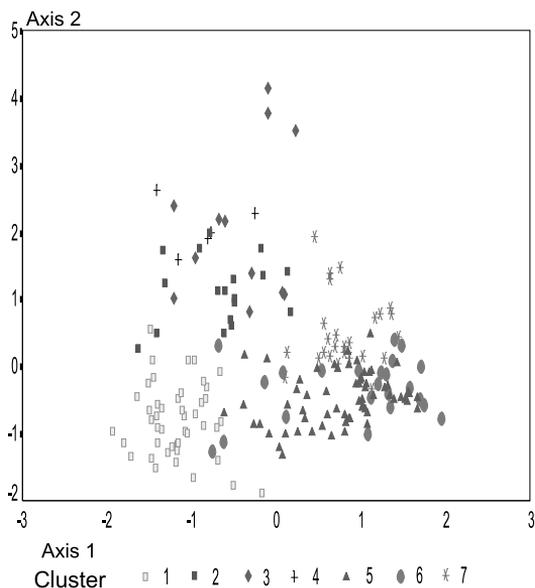


Fig. 3. Ordination diagram of correspondence analysis. Each plot represents one field boundary. Based on their species composition, boundaries are grouped into seven clusters from a cluster analysis (Ward's method). For axis 1 eigenvalue = 0.424, percentage variance of species data 10.6, and for axis 2 eigenvalue = 0.224, percentage variance of species data 5.6. Each symbol represents one cluster.

Each cluster was described as a group of boundaries that had the most similar plant species compositions (Figs. 3 and 4). Because we have mainly genus data on monocot (grassy) species, we use the preliminary results of later studies in these regions to introduce the exact species. Unidentified species belonged most often to the genera *Poa*, *Festuca*, *Agrostis*, *Calamagrostis* and *Carex* (App. 1). According to the later studies on these regions (Tarmi and Helenius, unpublished results from 1997–1999), *Poa* turned out to be mostly *P. pratensis*, *Festuca F. pratensis* or *F. rubra*, and *Agrostis A. capillaris*, *A. gigantea* or *A. stolonifera*. *Calamagrostis* was most often *C. canescens*, *C. arundinacea*, *C. epigejos* or *C. purpurea*. *Carex* was identified as *C. acuta*, *C. canescens*, *C. nigra*, *C. ovalis* or *C. vesicaria* species.

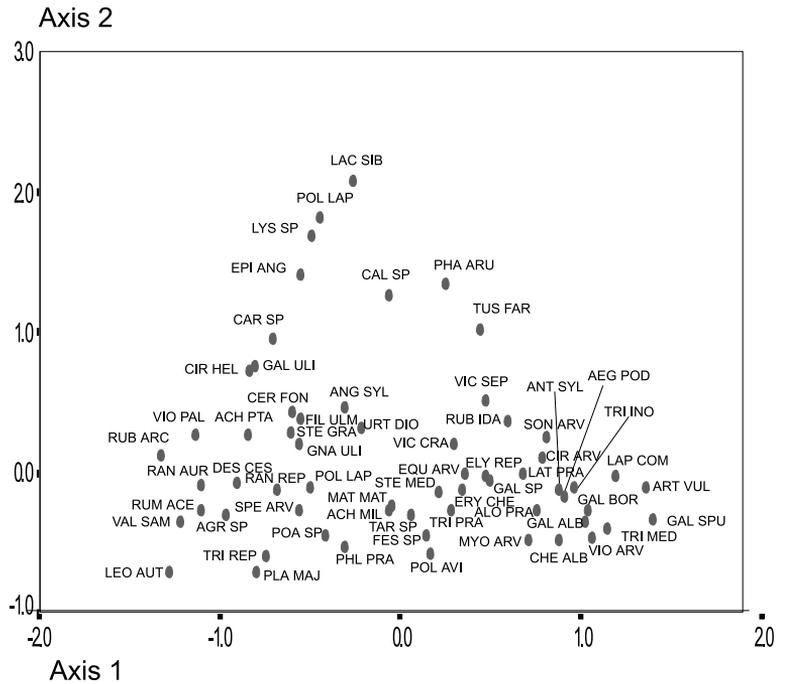
Each cluster was named by the characteristic species (Table 2) and were described as follows:

C1 – Ranunculus-Phleum: Grasses such as *Phleum pratense*, *Poa* sp., *Agrostis* sp., and *Festuca* sp. were common. The perennial herbs *Ranunculus repens*, *Rumex acetosa*, *Trifolium repens*, *Achillea millefolium*, and *Leontodon autumnalis* were abundant. Annual species were rarely found.

C2 – Filipendula-Ranunculus: In this cluster, none of the species attained absolute dominance compared to each other, but many species occurred with moderate frequency. It was characterised by tall herbs favouring moist sites such as *Filipendula ulmaria*, *Angelica sylvestris*, *Cirsium helenioides* and *Calamagrostis* sp.. Moreover, species of nutrient rich sites such as *Urtica dioica*, *Epilobium angustifolium* and *Galeopsis* sp. were common.

C3 – Calamagrostis-Phalaris: Tall grasses *Calamagrostis* sp. and *Phalaris arundinacea* were characteristic of the cluster. Perennial species indicating moist or wet sites – *Carex* sp., *Achillea ptarmica*, *Angelica sylvestris*, *Lysimachia* sp., *Polygonum amphibium*, *Peucedanum palustre*, *Lactuca sibirica* – were

Fig. 4. Ordination diagram of correspondence analysis. Plotted are the most frequently occurring species, with each plot representing one species. For axis 1 eigenvalue = 0.424, percentage variance of species data 10.6, and for axis 2 eigenvalue = 0.224, percentage variance of species data 5.6.



Species abbreviations: ACH MIL *Achillea millefolium*, ACH PTA *A. ptarmica*, AEG POD *Aegopodium podagraria*, AGR SP *Agrostis* sp., LYS SP *Lysimachia* sp., ALC SP *Alchemilla* sp., ALO PRA *Alopecurus pratensis*, ANG SYL *Angelica sylvestris*, ANT SYL *Anthriscus sylvestris*, ART VUL *Artemisia vulgaris*, CAL SP *Calamagrostis* sp., CAR SP *Carex* sp., CER FON *Cerastium fontanum*, CHE ALB *Chenopodium album*, CIR ARV *Cirsium arvense*, CIR HEL *C. helenioides*, DES

CES *Deschampsia cespitosa*, ELY REP *Elymus repens*, EPI ANG *Epilobium angustifolium*, ERY CHE *Erysimum cheiranthoides*, EQU ARV *Equisetum arvense*, FES SP *Festuca* sp., FIL ULM *Filipendula ulmaria*, GAL SP *Galeopsis* sp., GAL ALB *Galium album*, GAL BOR *G. boreale*, GAL SPU *G. spurium*, GAL ULI *G. uliginosum*, GNA ULI *Gnaphalium uliginosum*, LAC SIB *Lactuca sibirica*, LAP COM *Lapsana communis*, LAT PRA *Lathyrus pratensis*, LEO AUT *Leontodon autumnalis*, MAT MAT *Matricaria matricarioides*, MYO ARV *Myosotis arvensis*, PHA ARU *Phalaris arundinacea*, PHL PRA *Phleum pratense*, PLA MAJ *Plantago major*, POA SP *Poa* sp., POL AMP *Polygonum amphibium*, POL AVI *P. aviculare*, POL LAP *P. lapathifolium*, RAN ACR *Ranunculus acris*, RAN REP *R. repens*, RUB ARC *Rubus arcticus*, RUB IDA *R. idaeus*, RUM ACE *Rumex acetosa*, SON ARV *Sonchus arvensis*, SPE ARV *Spergula arvensis*, STE GRA *Stellaria graminea*, STE MED *S. media*, TAR SP *Taraxacum* sp., TRI MED *T. medium*, TRI PRA *T. pratense*, TRI REP *T. repens*, TRI INO *Tripleurospermum inodorum*, TUS FAR *Tussilago farfara*, URT DIO *Urtica dioica*, VAL SAM *Valeriana sambucifolia*, VIC CRA *Vicia cracca*, VIC SEP *V. sepium*, VIO ARV *Viola arvensis*, VIO PAL *V. palustris*.

frequent, as well as some annuals such as *Polygonum hydropiper*, *Stellaria media* and *Galium uliginosum*.

C4 – *Epilobium-Urtica*: Most frequent species were *Elymus repens*, *Epilobium angustifolium* and *Urtica dioica*.

C5 – *Elymus-Anthriscus*: *Elymus repens* was a highly dominant species. Other frequent species were mostly grasses, such as *Phleum pratense*, *Poa* sp., *Alopecurus pratensis* and ruderal herbs like *Cirsium arvense*, *Anthriscus sylvestris*. A characteristic species for

only this cluster, even if not very frequent, was *Aegopodium podagraria*.

C6 – *Elymus-Tripleurospermum*: *Elymus repens* and *Alopecurus pratensis* were the most frequent grasses. Annual herbs such as *Galeopsis* sp., *Stellaria media*, *Tripleurospermum inodorum*, and *Polygonum aviculare* were characteristic of this cluster.

C7 – *Elymus-Cirsium*: The most frequent species were *Elymus repens*, *Calamagrostis* sp., *Cirsium arvense*, *Equisetum arvense*, *Lathyrus pratensis*, *Tussilago farfara*, *Vicia cracca* and *Achillea millefolium*.

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Table 2. Most frequent and abundant species and genera of Clusters 1–7. **Bold and underlined**: species frequency > = 50% of the sites. **Bold**: species frequency < 50% > = 40% of the sites. *Italics and underlined*: noticeably more frequent compared to other clusters. For the number of sites in each cluster, see Table 1. Mean (log) of cover class is given in brackets.

Vegetation type	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Species	<i>Ranunculus - Phleum</i>	<i>Filipendula- Ranunculus</i>	<i>Calamagrostis- Phalaris</i>	<i>Epilobium- Urtica</i>	<i>Elymus- Anthriscus</i>	<i>Elymus- Tripleuro Spernum</i>	<i>Elymus- Cirsium</i>
Total							
Monocotyledons							
<i>Elymus repens</i>	78 (4.2)	72 (3.6)	67 (2.4)	80 (3.6)	92 (5.6)	83 (4.0)	92 (5.9)
<i>Phleum pratense</i>	60 (2.2)	61 (0.8)	67 (1.3)	20 (0.2)	52 (2.2)	39 (1.5)	50 (1.2)
<i>Poa</i> sp.	60 (2.0)	67 (1.2)	67 (1.3)	20 (0.6)	53 (1.6)	35 (1.4)	54 (1.5)
<i>Alopecurus pratensis</i>	44 (1.7)	22 (0.5)	17 (0.3)	60 (1.6)	64 (3.0)	61 (2.0)	50 (2.2)
<i>Calamagrostis</i> sp.	28 (1.2)	61 (2.8)	100 (4.4)	60 (5.4)	2 (0.03)	9 (0.1)	69 (2.9)
<i>Deschampsia cespitosa</i>	36 (1.5)	76 (3.5)	58 (2.3)	20 (0.2)	17 (0.7)	9 (0.3)	8 (0.3)
<i>Agrostis</i> sp.	36 (1.3)	82 (3.9)	58 (1.3)	20 (0.8)	8 (0.1)	17 (0.2)	19 (0.4)
<i>Festuca</i> sp.	33 (1.2)	40 (1.2)	8 (0.2)	20 (0.2)	42 (1.6)	13 (0.2)	42 (1.9)
<i>Phalaris arundinacea</i>	13 (0.5)	2 (0.1)	75 (3.9)		3 (0.1)	17 (0.3)	27 (1.4)
<i>Carex</i> sp.	11 (0.4)	13 (0.6)	75 (1.8)		2 (0.1)		4 (0.2)
Perennial dicotyledons							
<i>Ranunculus repens</i>	58 (1.8)	83 (2.8)	75 (2.1)	40 (1.4)	44 (0.9)	39 (1.2)	23 (0.4)
<i>Vicia cracca</i>	41 (1.1)	56 (1.2)	50 (1.3)	20 (0.6)	42 (1.1)	43 (1.4)	58 (1.6)
<i>Cirsium arvense</i>	46 (1.6)	33 (0.9)	33 (1.0)	40 (1.6)	59 (1.9)	57 (2.3)	85 (3.1)
<i>Achillea millefolium</i>	48 (1.2)	72 (1.4)	25 (0.7)		48 (1.7)	17 (0.2)	58 (1.4)
<i>Achillea ptarmica</i>	25 (0.3)	51 (0.6)	67 (0.9)		6 (0.1)	4 (0.04)	8 (0.1)
<i>Filipendula ulmaria</i>	34 (1.0)	53 (1.3)	42 (0.7)	40 (2.0)	14 (0.4)	22 (0.7)	23 (0.5)
<i>Trifolium repens</i>	33 (0.6)	62 (1.6)	58 (0.7)		17 (0.2)	30 (0.3)	23 (0.1)
<i>Urtica dioica</i>	28 (0.8)	67 (1.7)	8 (0.1)	80 (4.2)	22 (0.5)	35 (1.2)	15 (0.3)
<i>Angelica sylvestris</i>	26 (0.6)	67 (1.8)	58 (1.2)		19 (0.6)	9 (0.1)	15 (0.2)
<i>Cirsium helenioides</i>	18 (0.6)	36 (0.8)		60 (3.4)	5 (0.2)		
<i>Rumex acetosa</i>	28 (0.7)	76 (2.1)	17 (0.3)	20 (0.2)	5 (0.1)	13 (0.1)	8 (0.1)

<i>Epilobium angustifolium</i>	12 (0.5)	9 (0.2)	61 (2.6)	17 (0.7)	80 (4.6)	2 (0.1)	9 (0.1)	69 (1.4)
<i>Equisetum arvense</i>	38 (0.9)	33 (0.7)	33 (0.8)	17 (0.2)		41 (1.0)	30 (0.8)	42 (0.7)
<i>Anthriscus sylvestris</i>	35 (1.0)	4 (0.1)	33 (0.8)	17 (0.2)		63 (2.1)	26 (1.0)	62 (2.2)
<i>Lathyrus pratensis</i>	33 (0.9)	9 (0.1)	28 (0.6)	33 (0.4)	20 (0.2)	44 (1.3)	22 (0.4)	58 (2.1)
<i>Tussilago farfara</i>	17 (0.6)	2 (0.02)	17 (0.7)	42 (1.8)	20 (0.4)	9 (0.2)	4 (0.2)	50 (1.5)
<i>Taraxacum</i> sp.	37 (0.9)	36 (0.7)	39 (0.6)	33 (0.3)	20 (0.8)	47 (1.2)	4 (0.04)	
<i>Leontodon autumnalis</i>	17 (0.4)	58 (1.6)	17 (0.2)	8 (0.1)		2 (0.1)	4 (0.04)	
<i>Lysimachia</i> sp.	8 (0.2)	4 (0.1)	28 (0.9)	50 (1.7)			4 (0.04)	
<i>Polygonum amphibium</i>	7 (0.2)	4 (0.1)	17 (0.6)	50 (1.4)		2 (0.02)	9 (0.22)	
<i>Peucedanum palustre</i>	4 (0.1)			50 (0.8)		2 (0.02)		
<i>Ranunculus acris</i>	16 (0.3)	33 (0.9)	44 (0.7)	17 (0.3)	40 (0.8)	3 (0.1)	9 (0.13)	
<i>Sonchus arvensis</i>	22 (0.5)	2 (0.02)	17 (0.6)	25 (0.4)	40 (0.4)	17 (0.3)	43 (1.4)	
<i>Aegopodium podagraria</i>	16 (0.7)	4 (0.1)	6 (0.3)			31 (1.5)	17 (0.5)	
<i>Artemisia vulgaris</i>	7 (0.3)		6 (0.1)			3 (0.1)	39 (2.0)	
<i>Lactuca sibirica</i>	5 (0.1)	2 (0.1)	17 (0.3)	42 (1.1)			4 (0.1)	
Annual dicotyledons								
<i>Galeopsis</i> sp.	45 (0.8)	22 (0.3)	56 (1.00)	25 (0.3)	20 (0.2)	47 (1.0)	87 (2.0)	50 (0.6)
<i>Stellaria media</i>	45 (0.7)	36 (0.5)	28 (0.6)	67 (0.7)	20 (0.2)	42 (0.5)	83 (2.3)	42 (0.6)
<i>Tripleurospermum inodorum</i>	31 (0.8)	9 (0.1)	17 (0.2)	42 (0.4)	20 (0.2)	22 (0.6)	83 (2.8)	50 (1.4)
<i>Galium uliginosum</i>	13 (0.2)	18 (0.3)	39 (0.4)	58 (0.7)		2 (0.02)	4 (0.04)	
<i>Polygonum aviculare</i>	17 (0.2)	18 (0.3)	11 (0.1)	8 (0.1)		6 (0.1)	15 (0.2)	
<i>Lapsana communis</i>	15 (0.2)		11 (0.2)			13 (0.2)	43 (0.8)	31 (0.5)
<i>Chenopodium album</i>	12 (0.2)	7 (0.1)	11 (0.1)			9 (0.1)	43 (0.7)	12 (0.2)
<i>Erysimum cheiranthoides</i>	9 (0.1)	4 (0.04)	11 (0.1)			3 (0.03)	35 (0.4)	15 (0.2)
<i>Fallopia convolvulus</i>	7 (0.1)					3 (0.03)	35 (1.0)	12 (0.1)
<i>Galium boreale</i>	15 (0.4)	4 (0.1)	6 (0.1)			19 (0.7)	35 (1.0)	19 (0.5)
<i>Galium spurium</i>	7 (0.1)	2 (0.02)				3 (0.03)	30 (0.6)	12 (0.3)
<i>Polygonum hydropiper</i>	6 (0.1)	2 (0.02)	11 (0.2)	42 (0.4)	20 (0.2)	2 (0.02)	9 (0.2)	
<i>Gnaphalium uliginosum</i>	13 (0.2)	16 (0.2)	22 (0.4)	33 (0.3)		3 (0.03)	26 (0.7)	12 (0.1)
<i>Myosotis arvensis</i>	12 (0.2)	7 (0.1)		8 (0.1)	20 (0.2)	9 (0.1)	35 (0.5)	15 (0.2)
<i>Spergula arvensis</i>	11 (0.2)	16 (0.2)	11 (0.2)	17 (0.2)		3 (0.03)	30 (0.7)	4 (0.04)
<i>Viola arvensis</i>	9 (0.1)	2 (0.02)	6 (0.1)			8 (0.1)	30 (0.4)	15 (0.2)

Table 3. Plant species richness per 1.25 m² (five 0.25 m² quadrates) and distance (cm) of quadrates from the field edge in each cluster.

Cluster	N	Species richness				Distance from field			
		Mean	SE	Min	Max	Mean	SE	Min	Max
1	37	19	5.4	6	28	28	2.9	0	50
2	12	20	8.2	10	35	40	17.4	0	226
3	9	24	8.3	12	36	38	5.7	0	50
4	3	13	3.6	8	15	43	1.8	40	46
5	48	14	5.1	2	24	21	3.2	0	80
6	19	19	5.6	11	35	29	6.1	0	89
7	19	16	5.6	7	23	19	3.9	0	50

N = number of boundaries, SE = standard error of the mean

The mean species richness was highest in the *Calamagrostis-Phalaris* type (Table 3) whereas *Elymus-Anthriscus* and *Elymus-Cirsium* types were the most species-poor among all types. When the effect of distance from the field on species richness was tested, no statistically significant differences between the three classes (ANOVA, $df = 2$, $f = 1.23$, $P = 0.29$) was found. The mean species richness next to field edges with crops was 16.12 ± 0.87 (mean \pm SE), at 20–39 cm distance from the field edge 17.14 ± 1.12 , and at 40 cm or more from the edge 18.14 ± 0.95 .

The mean widths of the boundaries were highest in C1 and in C6 (Table 1). The narrowest boundaries, slightly over half metre in width, were in C7. The total number of plant species identified in the boundaries was 140. This number does not include plants identified only to genus level, except the *Taraxacum* genus.

After the data modifications that preceded statistical analyses, 100 identified species were included in CA and cluster analysis. The ecological requirements of these species were described based on Ellenberg et al. (1991) classification. However, some species' ecological requirements are not fully understood, so that the occurrence of 87 species in relation to soil moisture and 80 species in relation to soil nitrogen were included for further description.

In this study, none of the examined species

indicated dry soil conditions, but 12% of the species indicated soil conditions between dry and fresh. More than half of the species (52%) indicated moderately fresh conditions, 25% indicated moist or nearly wet soils, and 11% indicated wet soils. For mineral nitrogen, 17% of the species indicated poor soils and the largest group, 45% of the species, indicated intermediate soils. Nitrogen-rich soils were indicated by 17% of species and 16% (13 species) were nitrogen indicators.

Discussion

Plant species observed during the survey were mainly species indicating fresh to wet soil moisture conditions and moderate to rich mineral nitrogen content in the soil. The most frequent species were tall, perennial monocots and dicots indicating high productivity in the boundaries. Moreover, many of the observed species are known to tolerate herbicides, which has probably enhanced their abundance in boundaries exposed to herbicide drift from crop sprayings, or from direct sprayings that were permitted until 1994. As with the results of Kleijn et al. (1998) study of boundaries elsewhere in Europe, we observed no rare plant species. Species listed by

Hilli (1949) as the most abundant were similar to those in our study except *Leucanthemum vulgare*. It used to be a common grassland weed species, but has declined due to gradual changes in cultivation methods (Raatikainen 1991). In this study it was found only once.

Lestijoki and Taipaleenjoki are dairy production regions (Granlund et al. 2000) and more than half of the cultivated area in the crop rotation is grassland (Grönroos et al. 1998) for grazing and silage. These are not ploughed annually but at intervals of three to five years. Compared to cereal production herbicides are rarely used. According to our field observations, especially on the pastures, grassland fields often reach in to the boundary area or, on gently sloping riverbanks, even to the shoreline. This means that the border between the original boundary and cultivated grassland is unclear, or in extreme situations there is no original boundary but only ley grassland. Boundaries highly similar in species to ley grassland were mainly grouped into the C1, *Ranunculus-Phleum* type, even if their relative abundance of species was different. The most commonly cultivated species such as *Phleum pratense* and *Festuca pratensis* as well as many species that are considered typical grassland weeds in leys, were frequent. Especially *Leontodon autumnalis* is common in boundaries and in old leys, where the coverage of sown grasses has decreased (Raatikainen 1991). For C2, the *Calamagrostis Phalaris* type, several species favouring nitrogen and moist soils were characteristic. Of the boundaries studied, C2 represents probably the most fertile sites. In C2 the dominant species indicate moist or wet soil conditions. Moisture conditions may explain the high species richness in this group. These boundaries were probably left in a natural state and were not affected by cultivation practices, as the species composition would indicate. This is because seasonally wet habitats are impossible or not profitable to cultivate. Thereby these boundaries seem to belong to the least disturbed habitat type among the groups. *Lactuca sibirica*, typically a species of river and stream shores in E and N Finland, is more frequent in this than in

the other clusters. C2 and C3 have the highest species diversity of all the groups. This may be partly explained by crop rotation, which is common in the Lestijoki and Taipaleenjoki regions. Crop rotation has been shown to be an important factor for boundary species composition (Kleijn and Verbeek 2000). In Taipaleenjoki, the landscape is also more fine-grained, and agriculture is less intensive than in the other regions, which may have contributed to the higher species richness in C2, the *Calamagrostis-Phalaris* group.

Clusters C5, *Elymus-Anthriscus*, C6, *Elymus-Tripleurospermum*, and C7 *Elymus-Cirsium*, represent southern regions. There more than half the field area is under spring cereal production yearly, which means ploughing, tilling and the use of herbicides are annual practices. In these fairly similar clusters, species tolerant of herbicides and/or capable of spreading fast by rhizomes or seeds to bare soil gaps were the most common. *Elymus repens* and *Cirsium arvense* were frequent everywhere, most of all in C7. These most frequent species indicate fresh soil moisture conditions. Of all six representative clusters C5 was the poorest in species. Only a few species, mainly ruderals, constituted the main part of the vegetation in C5. However, the mean number of species was clearly higher even in this species poor group compared with a study on Dutch boundaries (Kleijn 1997). Even though the sampling areas in the Dutch study were larger than ours (4 m²), the highest mean number of species among groups was 11.8. *Aegopodium podagraria* was the characteristic species of C5. It is native to southern Finland and easily invades new sites using rhizomes. C7 is close to C5, but the higher numbers of frequently encountered species indicate a slightly more heterogeneous vegetation structure. However, the frequency and abundance of *Elymus repens* was very high in both groups. C6 differs from others by the frequent occurrences of annual species, which is indicative of recent disturbance destroying permanent vegetation cover. This was probably caused by recent mechanical disturbance during cultivation. Also, heavy rains in summer 1995, just be-

fore our fieldwork started, may have caused soil disturbance. In several boundaries we observed gaps caused by erosion without permanent vegetation cover. Exceptional weather conditions may have enhanced the amount of annuals in 1995 compared to more typical summers. This suggests that temporal aspects such as the stage of vegetation succession, should also be considered in boundary classification.

According to this study, the sample quadrat distance from the field was not a significant factor for species richness. However, boundary width has been shown to be significant for overall species diversity in boundary habitats (Ma et al. 2002). Cultivation practices affect boundary vegetation with different intensity depending on the distance from the field. As a result, variable vegetation zones have developed in the boundary, which increases species diversity in the whole boundary community (Ma et al. 2002).

On the basis of our study, the effects of farming practices on species composition seem obvious. However, also indirect factors should be considered. The current division between crop and dairy production along Finland's north-south gradient is partly a consequence of the country's climatic conditions, which allows profitable crop production only in southern parts of Finland. Another explanatory factor is the agricultural policy of the 70s, which also supported this regional specialisation of farms into crop or dairy production. In the past few years an increase in organic production has favoured mixed farming also in the south because of the need for animal manure for organic crop production. Mixed farming could enhance the diversity of boundary types at farm level, which was reported as being important in e.g. providing food for granivorous birds (Wilson et al. 1999).

In our results, many of the boundaries were species-poor and dominated by grasses. At a boundary level they have low diversity value but at a landscape level they may increase the inter-boundary diversity among boundaries with dissimilar species compositions (Le Coeur et al. 1997). Tussocks forming grasses are important overwintering sites for spiders and ground bee-

flies, some of them being also beneficial to pest predators (Bayram and Luff 1993, Dennis et al. 1994). Among grasses of this growth form *Agrostis* and *Poa* species and *Deschampsia cespitosa* were common in the studied boundaries. We did not measure the flowering intensity of plants, which prevents us from estimating the exact importance of species as sources of nectar. However, it is known that many frequently found species such as *Cirsium arvense* and *Epilobium angustifolium* are important nectar flowers for butterflies (Kuussaari et al. 2001) and for bumblebees (Bäckman and Tiainen 2002). Moreover, such species as *Urtica dioica*, *Festuca* sp. and *Poa* sp. are important host plants for butterfly larvae (Silfverberg 1996).

Many common weed species were observed frequently in the boundaries and farmers often regard boundaries as a source of weeds and thus basically harmful. However, weeds have been reported as spreading only short distances into a field (Marshall 1989, Marshall and Arnold 1995, Wilson and Aebischer 1995). When weeds, especially fast spreading clonal weeds such as *Elymus repens* and *Cirsium arvense*, dominate the boundary community, management is needed to diminish their abundance. Cutting and removing should thus be applied in order to reduce not only weeds but also nutrient and litter accumulation in boundaries. If nutrients are not diminished by biomass removal, boundaries buffer nutrient leaching to surface waters for only a short time. Moreover, increased mineral nitrogen results in higher productivity and litter accumulation, which may decrease the species diversity by preventing seedlings from becoming established (Foster and Gross 1998). Kleijn (1996) also stressed the importance of cutting and removing to avoid nutrient accumulation, because boundary species are able to capture nutrients from a field. If weeds are a serious problem in a boundary, re-establishment by sowing could be an option. Biodiversity values remains low if only grassy species are sown. However, species such as *Dactylis glomerata* have been demonstrated to be effective in suppressing invasions of *Elymus repens* (Marshall 1990).

Ideally local seed mixtures of wild plants could be used to enhance species richness, but this may be difficult in practice. Sown species may be too sensitive to herbicides, so that one accidental herbicide drift may destroy the vegetation. Such species may also not have the ability to survive in nutrient rich, disturbed habitats such as boundaries most often are.

Agricultural practices are important for determining plant communities in boundaries. These habitats are exposed to herbicides, fertilisers, ploughing, and sometimes even used as grassland. The intensity of different disturbance factors and the species' response to them largely determines the species composition. Variation in species compositions was found mainly between regions, therefore regionally focused studies are needed to gain a better understanding about local factors. This study provides a basis for further planning of more analytical studies of field boundary plant communities, and animals dependent on the vegetation.

Kleijn et al. (2001) made evident the insuffi-

ciency of current agri-environment schemes to protect biodiversity in the Netherlands, where agriculture is extremely intensive comparing to Finland. Nevertheless, we found species poor boundaries especially in southern areas, which may need additional management as mowing with biomass removal or cattle grazing to improve species diversity. However, these practises are difficult to carry out in boundaries usually not more than three meters wide.

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SELOSTUS

Pellon pientareiden kasviyhteisöt Suomessa

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Pientareiden kasviyhteisöjen lajiston selvittämiseksi tutkimme kaikkiaan 193 piennarta, jotka sijaitsivat tuotantosuunniltaan ja ilmastoltaan erilaisilla alueilla Suomessa. Pientareet ryhmiteltiin kasvillisuutensa perusteella kuuteen kasvillisuustyyppiin.

Pientareiden kasvilajit olivat enimmäkseen tuoreilta tai sitä kosteammilta kasvupaikoilta. Lisäksi kasvit olivat typen suosijoita, jotka viihtyvät parhaiten kohtalaisesti tai sitä runsaammin mineraalityppeä sisältävillä kasvupaikoilla. Yleisimmät lajit olivat korkeakasvuisia, monivuotisia yksi- ja kaksisirkkaisia, jotka tuottavat biomassaa runsaasti. Myös rikkakasvien torjunta-aineita sietävät lajit olivat yleisiä. Suomessa harvinaisia kasvilajeja ei pientareilta havaittu. Tuotantomuotojen alueelliset erot näkyivät kasviyhteisöissä. Karjatalousvaltaisilla alueilla yleisimmät lajit olivat kylvettäviä nurmilajeja ja nurmien rikkakasveja. Viljanviljelyalueilla herbisidejä sietävät ja nopeasti leviävät juuririkkakasvit olivat yleis-

impiä. Lajimäärä oli suurin *Calamagrostis-Phalaris* tyyppissä (24 lajia /piennar), jonka tulkitimme olevan kostea ja luonnontilainen kasvupaikka. Pienimmät lajimäärät olivat *Elymus-Anthriscus* (14 lajia/piennar) ja *Elymus-Cirsium* tyypeillä, joita löytyi eniten viljanviljelyyn keskittyneiltä eteläisiltä alueilta.

Tulosten perusteella viljelytoimilla on suuri merkitys pientareiden kasviyhteisöjen lajikoostumukseen. Nurmen kuulumisen viljelykiertoon, muokkauksen tehokkuus ja rikkakasvien torjunta-aineiden käyttö ovat ilmeisesti tärkeitä kasvillisuuteen vaikuttavia tekijöitä. Aiemman maatalouspolitiikan seurauksena viljanviljely on keskittynyt eteläisille ja karjatalous taas pohjoisemmille maatalousalueille, mikä on epäsuorasti vaikuttanut alueelliseen piennarkasvillisuuteen. Jatkotutkimuksissa on tarpeen selvittää, miten pientareet eroavat alueiden sisällä toisistaan ja mikä paikalliset tekijät eroja aiheuttavat.

AGRICULTURAL AND FOOD SCIENCE IN FINLAND

Appendix 1. List of species found in boundaries.

Abbreviation	Species	Abbreviation	Species	
I	ACH MIL	<i>Achillea millefolium</i> L.	O	<i>Leucanthemum vulgare</i> Lam.
I	ACH PTA	<i>A. ptarmica</i> L.	I	<i>Linaria vulgaris</i> Mill.
I	AEG POD	<i>Aegopodium podagraria</i> L.	I	<i>Lolium perenne</i> L.
I		<i>Agrostis capillaris</i> L.	O	<i>Luzula pallescens</i> Swartz
O		<i>A. gigantea</i> Roth	O	<i>L. sudetica</i> (Willd.) DC.
O		<i>A. stolonifera</i>	I	LEO AUT
I	AGR SP	<i>Agrostis</i> sp. L.	I	LYS SP
I	ALC SP	<i>Alchemilla</i> sp. L.	O	<i>Lysimachia</i> sp. L.
I		<i>Alopecurus geniculatus</i> L.	I	MAT MAT
I	ALO PRA	<i>A. pratensis</i> L.	I	<i>Matricaria matricarioides</i> (Less.) Porter
I	ANG SYL	<i>Angelica sylvestris</i> L.	I	<i>Mentha arvensis</i> L.
O		<i>Anthoxanthum odoratum</i> L.	I	MYO ARV
I	ANT SYL	<i>Anthriscus sylvestris</i> (L.) Hoffm.	O	<i>Myosotis arvensis</i> (L.) Hill
O		<i>Arctium tomentosum</i> Miller	O	<i>Nardus stricta</i> L.
I	ART VUL	<i>Artemisia vulgaris</i> L.	I	<i>Odontites vulgaris</i> Moench
O		<i>Atriplex patula</i> L.	I	<i>Peucedanum palustre</i> (L.) Moench
I		<i>Barbarea vulgaris</i> R.Br.	I	PHA ARU
			I	PHL PRA
			I	<i>Phalaris arundinacea</i> L.
				<i>Phleum pratense</i> L.
				<i>Phragmites australis</i> (Cav.) Trin. ex Steud.
			O	<i>Pimpinella saxifraga</i> L.
I		<i>Betula</i> sp. L.	I	PLA MAJ
I		<i>Bidens tripartita</i> L.	I	POA SP
I	CAL SP	<i>Calamagrostis</i> sp. Adans.	I	POL AMP
I		<i>C. rotundifolia</i> L.	I	POL AVI
O		<i>Caltha palustris</i> L.	I	<i>P. aviculare</i> L.
O		<i>Campanula glomerata</i> L.	I	<i>P. hydro Piper</i> L.
O		<i>C. patula</i> L.	I	POL LAP
I		<i>Capsella bursa-pastoris</i> (L.) Medik.	I	<i>Potentilla anserina</i> L.
I	CAR SP	<i>Carex</i> sp. L.	O	<i>P. erecta</i>
I		<i>Cerastium arvense</i> L.	I	<i>P. norvegica</i> L.
I	CER FON	<i>C. fontanum</i> Baumg.	I	RAN ACR
I	CHE ALB	<i>Chenopodium album</i> L.	I	RAN REP
I		<i>C. suecicum</i> Murr	O	<i>Rhinanthus serotinus</i> (Schönh.) Oborny
O		<i>Cicuta virosa</i> L.	I	<i>Rorippa palustris</i> (L.) Besser
I	CIR ARV	<i>Cirsium arvense</i> Mill.	O	<i>Rosa majalis</i> J. Herrmann
I	CIR HEL	<i>C. helenioides</i> (L.) Hill	I	<i>Rosa</i> sp. L.
O		<i>Convallaria majalis</i> L.	I	RUB ARC
I		<i>Cuscuta europaea</i> L.	I	RUB IDA
I		<i>Dactylis glomerata</i> L.	I	RUM ACE
I	DES CES	<i>Deschampsia cespitosa</i> (L.) P.Beauv.	I	<i>Rumex acetosa</i> L.
O		<i>Eleocharis mamillata</i> (H. Lindb.) H. Lind. ex Dörfler	I	<i>R. acetosella</i> L.
			I	<i>R. longifolius</i> DC.
			O	<i>Sagina procumbens</i> L.
I	ELY REP	<i>Elymus caninus</i> (L.) L.	I	<i>Salix</i> sp. L.
I		<i>E. repens</i> (L.) Gould	I	<i>Scirpus sylvaticus</i> L.
I		<i>Epilobium adenocaulon</i> Hausskn.	O	<i>Scleranthus annuus</i> L.
I	EPI ANG	<i>E. angustifolium</i> L.	O	<i>Scrophularia nodosa</i> L.
I		<i>E. palustre</i> L.	O	<i>Solidago virgaurea</i> L.
I	EQU ARV	<i>Equisetum arvense</i> L.	I	SON ARV
I		<i>E. fluviatile</i> L.	I	<i>Sonchus arvensis</i> L.
I		<i>E. palustre</i> L.	I	<i>S. asper</i> (L.) Hill
I		<i>E. sylvaticum</i> L.	I	SPE ARV
O		<i>Eriophorum angustifolium</i> Honckeney	O	<i>Spergula arvensis</i> L.
I	ERY CHE	<i>Erysimum cheiranthoides</i> L.	I	STE GRA
I		<i>Euphorbia helioscopia</i> L.	I	STE MED
				<i>S. media</i> (L.) Vill.

AGRICULTURAL AND FOOD SCIENCE IN FINLAND

Appendix 1. List of species found in boundaries.

Abbreviation	Species	Abbreviation	Species
I	<i>Euphrasia stricta</i> D. Wolff ex J.F.Lehm.	O	<i>Succisa pratensis</i> Moench
I	<i>Fallopia convolvulus</i> (L.) Á. Löve	I	<i>Tanacetum vulgare</i> L.
I FES SP	<i>Festuca</i> sp.L.	I TAR SP	<i>Taraxacum</i> sp. Weber
I FIL ULM	<i>Filipendula ulmaria</i> (L.) Maxim.	I	<i>Thalictrum flavum</i> L.
I	<i>Fumaria officinalis</i> L.	O	<i>Thelypteris phegopteris</i> (L.) Slosson
I GAL SP	<i>Galeopsis</i> sp. L.	O	<i>Thlaspi arvense</i> L.
I GAL ALB	<i>Galium album</i> Mill.	I	<i>Trifolium hybridum</i> L.
I GAL BOR	<i>G. boreale</i> L.	I TRI MED	<i>T. medium</i> L.
I	<i>G. palustre</i> L.	I TRI PRA	<i>T. pratense</i> L.
I GAL SPU	<i>G. spurium</i> L.	I TRI REP	<i>T. repens</i> L.
I GAL ULI	<i>G. uliginosum</i> L.	I TRI INO	<i>Tripleurospermum inodorum</i> Sch. Bip.
O	<i>Geranium sylvaticum</i> L.	I TUS FAR	<i>Tussilago farfara</i> L.
O	<i>Glechoma hederacea</i> L.	I URT DIO	<i>Urtica dioica</i> L.
O	<i>Glyceria fluitans</i> (L.) R. Br.	O	<i>U. urens</i> L.
I GNA ULI	<i>Gnaphalium uliginosum</i> L.	O	<i>Vaccinium myrtillus</i> L.
I	<i>Hierochloë hirta</i> (Schrank) Borbás	I VAL SAM	<i>Valeriana sambucifolia</i> J.C. Mikan
I	<i>Hypericum maculatum</i> Crantz	O	<i>Valeriana</i> sp.
I	<i>Juncus bufonius</i> L.	I	<i>Veronica chamaedrys</i> L.
O	<i>J. effusus</i> L.	I	<i>V. officinalis</i> L.
I	<i>J. filiformis</i> L.	O	<i>V. serpyllifolia</i> L.
I LAC SIB	<i>Lactuca sibirica</i> (L.) Maxim.	O	<i>V. spicata</i> L.
I	<i>Lamium hybridum</i> Vill.	O	<i>Veronica</i> sp. L.
O	<i>Lamium</i> sp. L.	I VIC CRA	<i>Vicia cracca</i> L.
I	<i>L. purpureum</i> L.	I VIC SEP	<i>V. sepium</i> L.
I LAP COM	<i>Lapsana communis</i> L.	I VIO ARV	<i>Viola arvensis</i> Murray
I LAT PRA	<i>Lathyrus pratensis</i> L.	O	<i>V. canina</i>
O	<i>Lemna minor</i> L.	I VIO PAL	<i>V. palustris</i> L.

Species marked with (I) were included in and species marked with (O) were omitted or made passive in correspondence analysis. The 60 most frequent species (with abbreviations) are plotted in Fig. 3.