Biodiversity in intensive and extensive grasslands in Finland: the impacts of spatial and temporal changes of agricultural land use

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Table 1. Total utilized agricultural area (UAA) and total area of grasslands (leys, grass over 5 years, fallow) in Finland by Centres for Economic Development, Transport and the Environment (ELY Centres; see Fig. 3) in 2013 (data from Anon. 2014). The UAA varies somewhat annually, and in 2017, it covered about 2.27 million hectares, of which approximately one third (about 700000 ha) were grasslands under five years old (Natural Resources Institute Finland 2018). In addition to leys and fallows, also reed canary grass (*Phalaris arundinaceus*) was cultivated on 6600 ha. Its cultivation has become less and less popular during recent years (10400 ha in 2012, 3900 ha in 2018).

ELY Centre	UAA (km^2)	Total leys (km^2)	Total grasslands >5 years (km^2)	Fallow (km^2)	Proportion of UAA (%)		
					Ley	Grass >5 years	Fallow
1 Uusimaa	1806	255	2.9	27.2	14.1	1.6	15.1
2 Southwest Finland	2932	289	4.9	27.2	9.9	1.7	9.3
3 Satakunta	1402	211	1.4	13.4	15.0	1.0	9.6
4 Häme	1866	332	1.6	21.7	17.8	0.9	11.6
5 Pirkanmaa	1633	43	1.3	21.8	26.3	0.8	13.3
6 Southeast Finland	1368	291	1.5	23.8	21.3	1.1	17.4
7 South Savo	717	328	1.0	9.4	45.7	1.4	13.1
8 North Savo	1464	775	1.4	13.5	52.9	1.0	9.2
9 North Karelia	847	423	0.8	10.9	49.9	0.9	12.9
10 Central Finland	935	391	0.7	14.4	41.8	0.7	15.4
11 South Ostrobothnia	246	629	0.8	25.6	25.6	0.3	10.4
12 Ostrobothnia	1945	586	1.4	15.7	30.1	0.7	8.1
13 North Ostrobothnia	2268	909	4.1	22.5	40.1	1.8	9.9
14 Kainuu	312	213	0.5	3.2	68.3	1.6	10.3
15 Lapland	441	371	1.2	2.6	84.1	2.7	5.9
16 Åland	19	6.6	5.3	0.9	34.7	27.9	4.7
Whole country	22586	6495	30.7	254.0	28.8	1.4	11.2

Table 2. Percentage of different types of leys by ELY Centre in Finland in 2013 (data from Anon 2014). Ley areas shown in Table 1.

ELY Centre	Hay	Green fodder	Silage	Pasture	Seed production
1 Uusimaa	19.6	1.2	60.8	14.9	3.5
2 Southwest Finland	22.5	1.4	58.5	10.7	6.9
3 Satakunta	18.5	0.9	64.9	14.7	0.9
4 Häme	17.2	0.9	62.7	14.8	4.5
5 Pirkanmaa	23.3	1.4	59.3	14.2	2.1
6 Southeast Finland	20.6	1.0	60.8	16.2	1.4
7 South Savo	19.8	2.7	64.6	12.5	0.3
8 North Savo	9.3	0.4	75.4	13.3	1.7
9 North Karelia	15.1	0.9	69.5	13.2	1.2
10 Central Finland	18.9	1.0	66.5	12.8	0.5
11 South Ostrobothnia	8.1	1.6	79.5	9.5	1.1
12 Ostrobothnia	10.4	1.0	81.9	6.0	0.7
13 North Ostrobothnia	10.8	1.9	77.4	9.0	0.9
14 Kainuu	11.7	0.9	77.9	8.9	0.0
15 Lapland	12.1	3.0	81.4	3.8	0.0
16 Åland	10.6	0.0	80.3	9.1	0.0
Whole country	14.3	1.3	71.7	11.1	1.5

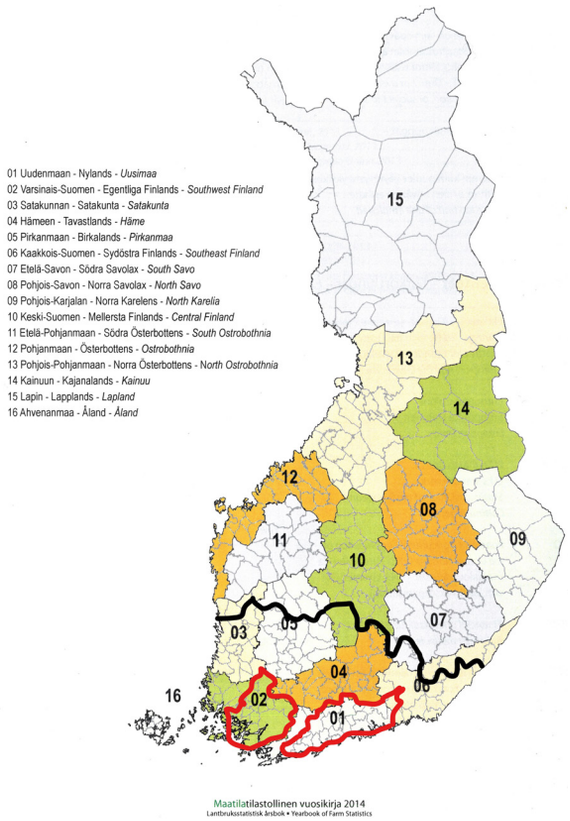

Fig. 1. Centres for Economic Development, Transport and the Environment (ELY Centres) used as regions for UAA and leys in Tables 1 and 2 of this Appendix. In the article proper, we use the concepts southern and western Finland and eastern and northern Finland to approximately refer to regions where the grass area is less or more than 40% of UAA, respectively. Red and black lines represent the borders of agricultural A and B support areas, respectively. Adopted from Anon 2014.

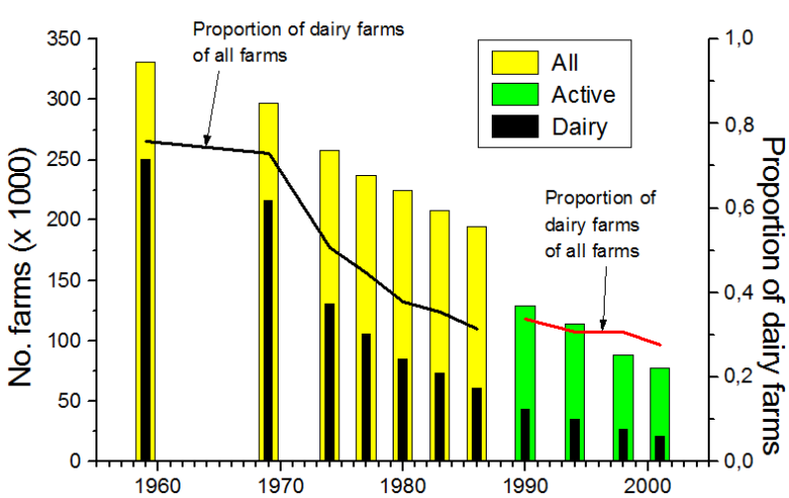

Fig. 2. Structural development of Finnish agriculture 1959–2001 (Tiainen 2004). Changes in the compilation methods of statistics make it difficult to continue the time series, but the decline of the number of both all farms and dairy farms as well as of the proportion of dairy farms have continued (based on annual farm statistics of Official Statistics of Finland, Anon 2014 and earlier).

Table 3. Farm statistics in Finland (data from Anon 2014)

Year	No. farms	Number of cattle farms	% cattle farms of all farms	% dairy farms of cattle farms	% beef farms of cattle farms	% mixed dairy and beef farms of cattle farms
2013	53241	12438	23.4	68.3	24.6	7.1
2014	51738	11887	23.0	68.0	25.6	6.4
2015	49923	11423	22.9	67.7	26.6	5.7
2016	48664	10779	22.1	67.5	27.2	5.3
2017	47664	10189	21.4	65.8	28.8	5.4
2018	46717	9642	20.6	64.9	29.7	5.4

Table 4. Average numbers of vascular plant taxa (species or, in some cases, genus) found in the fields of different soil types by geographical zones (number of fields studied in brackets) (from Raatikainen and Raatikainen 1975)

Zone	Coarse mineral soils	Clay soils	Organic soils	All soils
South and Archipelago Finland	34 (404)	32 (230)	34 (176)	34 (810)
Middle Finland	32 (302)	32 (87)	28 (211)	31 (600)
North Finland	30 (89)	29 (14)	27 (107)	28 (210)
Whole country	33 (795)	32 (331)	30 (494)	32 (1620)

Table 5. Total number of species and number of species found in more than one field out of 30 in the study areas of Raatikainen and Raatikainen (1975)[1] neighbouring study areas of Table 6. The top part of the list consists of cultivated clovers and graminids, other ten most abundant graminids of these study areas which were not listed in studies of Table 6. The lower part lists 50 most abundant dicot species of the pooled list. The original data were collected from 30 fields in each study area. For species, the figures show from how many fields each of the species was found. The lasts column presents the abundance of the North Savo and North Karelia species in whole Finland as percentages of all fields (n = 1620) showing the proportion fields containing the species (taxon) (figures in parentheses show abundance rank orders).

	Nilsiä	Kuopio mlk–Karttula	Joroinen–Jäppilä	Tuusniemi	Tohmajärvi	N Savo and Karelia pooled	Whole Finland
Total no. species	139	118	121	125	152	184	307
No. species in >1 field	103	99	97	94	114	151	207
Trifolium pratense	29	29	29	30	29	146 (2)	87 (3)
Trifolium repens	27	20	26	30	26	129 (4)	77 (6)
Trifolium hybridum	22	18	17	9	12	78 (28)	41 (25)
Trifolium spp.	11	7	3	7	10	38 (50)	11 (72)
Phleum pratense	30	30	30	30	30	150 (1)	100 (1)
Poa pratensis s. lat.	27	20	25	28	30	130 (6)	77 (5)
Festuca pratensis	12	9	14	14	6	55 (37)	29 (39)
Dactylis glomerata	2	18	3	0	10	33 (58)	14 (64)
Lolium multiflorum	1	1	0	1	0	3 (148)	2 (146)
Lolium perenne	1	2	0	0	0	3 (148)	3 (132)
Poa trivialis	23	23	30	29	30	135 (5)	73 (8)
Agrostis tenuis	24	25	21	24	28	122 (9)	74 (7)
Deschampsia caespitosa	20	23	25	26	24	118 (11)	68 (10)
Anthoxanthum odoratum	22	25	16	20	25	108 (15)	27 (41)
Agropyron (Elymus) repens	17	30	15	27	12	101 (18)	52 (19)
Festuca rubra	15	25	15	16	25	96 (22)	47 (22)
Alopecurus pratensis	3	1	9	9	6	28 (61)	18 (59)
Poa palustris	13	1	2	7	3	26 (64)	15 (61)
Alopecurus geniculatus	3	1	3	9	3	19 (78)	18 (57)
Secale cereale	5	6	3	5	0	19 (78)	10 (79)

Achillea millefolium	30	24	28	30	30	142 (3)	87 (4)
Ranunculus repens	26	30	29	29	26	140 (4)	89 (2)
Taraxacum spp.	26	24	27	23	27	127 (8)	66 (12)
Rumex acetosella s. lat.	24	23	21	23	29	120 (10)	72 (9)
Campanula patula	27	18	22	26	21	114 (12)	46 (23)
Vicia cracca	19	15	23	27	29	113 (13)	57 (15)
Ranunculus acris s. lat.	20	23	26	17	23	109 (14)	54 (17)
Myosotis arvensis	24	22	19	20	19	104 (17)	49 (20)
Achillea ptarmica	26	19	19	19	21	104 (17)	63 (13)
Cerastium caespitosum	16	16	22	23	23	100 (19)	61 (14)
Prunella vulgaris	22	19	21	22	14	98 (20)	29 (40)
Leontodon autumnalis	21	21	14	19	22	97(21)	53 (18)
Rumex acetosa s. lat.	22	16	21	19	18	96 (22)	67 (11)
Chrysanthemum leucanthemum s. lat.	17	14	17	21	23	92 (24)	40 (28)
Veronica serpyllifolia	14	18	20	22	17	91 (25)	57 (16)
Plantago major	19	15	22	18	17	91 (25)	38 (30)
Tripleurospermum inodorum s. lat.	18	15	22	9	22	86 (27)	48 (21)
Alchemilla vulgaris coll.	13	11	19	16	15	74 (29)	21 (48)
Vicia sepium	2	19	13	16	21	71 (30)	14 (62)
Galeopsis speciosa	21	11	10	16	9	67 (31)	33 (36)
Viola arvensis	9	14	17	13	10	63 (33)	33 (33)
Rumex longifolius s. lat.	19	14	13	4	13	63 (33)	40 (29)
Lathyrus pratensis	9	10	20	7	13	59 (35)	32 (35)
Equisetum arvense	7	16	18	8	7	56 (36)	41 (26)
Equisetum silvaticum	10	7	15	11	9	52 (38)	31 (37)
Galium uliginosum	15	9	4	14	9	51 (39)	34 (32)
Veronica chamaedrys	12	9	16	12	2	51 (39)	21 (51)
Spergula arvensis	15	8	4	9	15	51 (39)	26 (42)
Stellaria media	11	11	5	12	10	49 (42)	35 (31)
Chenopodium album s. lat.	14	12	5	1	15	47 (43)	25 (43)
Stellaria graminea	10	9	7	11	9	46 (44)	41 (27)
Cirsium arvense	5	10	15	4	12	46 (44)	30 (38)
Galeopsis bifida	8	7	10	1	18	44 (46)	31 (36)
Lapsana communis	0	12	20	5	5	42 (47)	24 (46)
Sonchus arvensis	6	9	9	8	9	41 (48)	24 (44)
Chamaenerion angustifolium	18	4	5	2	11	40 (49)	24 (45)
Viola palustris	11	5	6	10	5	37 (51)	21 (49)
Cirsium palustre	13	2	11	6	4	36 (52)	20 (52)
Anthriscus silvestris	6	8	10	4	8	36 (52)	21 (50)
Potentilla norvegica	15	3	12	0	6	36 (52)	14 (65)
Knautia arvensis	5	1	8	0	22	36 (52)	5 (106)
Potentilla erecta	4	12	3	7	9	35 (56)	10 (81)
Viola tricolor	1	2	9	0	22	34 (57)	4 (117)
Filipendula ulmaria	11	6	9	4	3	33 (58)	19 (55)
Erysimum cheiranthoides	8	1	5	3	14	31 (60)	19 (53)
Capsella bursa-pastoris	3	6	4	3	11	27 (62)	13 (67)
Geum rivale	9	8	7	1	2	27 (62)	11 (74)

Rhinanthus spp.	9	2	5	5	5	26 (64)	16 (60)
Equisetum palustre	18	3	2	0	3	26 (64)	109 (85)
Matricaria matricarioides	3	1	6	9	5	24 (67)	6 (100)

[1] Raatikainen and Raatikainen (1975) conducted a countrywide inventory of plant communities of ley fields. They randomly selected 54 study areas in 87 municipalities where 1 620 fields from 830 randomly selected farms (1–3 fields per farm, mean field size 0.81 ha) were selected for the study. The number of fields studied was 30 in each study area. Additional information was recorded on establishment, treatment, quality, and harvest. Only fields for hay were sampled, because silage was already cut during sampling periods. The number of 30 fields for the study was obviously enough to saturate the accumulation of new species, as usually only one more species was found when the sample was increased from 29 to 30 fields.

Table 6. Abundance ranks of 20 most abundant dicot species found in four studies. The results from Liperi (Siikasalmi Research Farm) come from experiments into crop quality with various treatments (Kuusela and Hytti 2001, Kuusela 2004). The Kajan and Nousiainen (2006) results came from a farm weed control study carried out in silage leys in North Savo without and with herbicide treatment on 15 paddocks, respectively. The fourth study made in the Maaninka Research farm in North Savo listed species recorded in silage leys and pastures (Virkajärvi et al. 2012). Listed are 20 most abundant species in first three studies or their presence in the fourth one (x = included among most relevant). Monocots and cultivated clovers were excluded. In the last column, rank order of Raatikainen and Raatikainen (1975) species lists of Table 5 is shown after exclusion of species belonging to *Trifolium*, Graminae, Cyperaceae or Juncaceae which were not recorded in the other studies.

Grassland type and region	Organic pasture	Silage leys	Silage leys	Silage and pasture	Hey leys
Type of research	Siikasalmi Research farm	Farm weed control study (15 paddocks)		Maaninka Research Farm	Pooled
Herbicide treatment	No treatment	No treatment	Treatment	No information	
Study years	1998	2005	2005	2005–2011	
Achillea millefolium		19	5		1
Alchemilla spp.			14		18
Apiaceae		17	13		–
Barbarea vulgaris		7	8	x	59
Capsella bursa-pastoris		8		x	46
Chenopodium album		3	11	x	30
Circium arvense				x	32
Euphrasia stricta coll.		12			106
Galeopsis bifida		18		x	33
Lapsana communis			19		34
Leontodon autumnalis			17		12
Myosotis arvensis				x	8
Plantago major	2	4	4	x	16
Polygonum spp.	5	11	15		54, 55, 69
Ranunculus repens	3	2[1]	2	x	2
Rumex acetosella		10	12		4
Rumex longifolius	4	6	7	x	22
Sonchus arvensis		5	3	x	35
Spergula arvensis		16			28
Stellaria media	6	13	6	x	29
Taraxacum spp.	1	1	1	x	3
Tripleurospermum inodorum		20		x	17
Urtica dioica		15	9	x	84
Veronica serpyllifolia	7[2]	9[2]	10[2]		15
Viccia cracca		14	16		6
Viola arvensis			18		21

[1] *Ranunculus repens* or *R. acris;* [2] *Veronica* spp.

Historical bird community changes having taken place with changes in farmland use

Two examples can be raised to describe the magnitude of bird community changes as a result of the change in agriculture. In Lammi, 24 species were found in farmland in the 1930s. In 1984, seven of them had significantly increased and another seven species significantly decreased and three disappeared. Seven species did not reveal significant changes. Five of the decreased species preferred farmland with dairy cattle, and most of the increased species were favoured by cereal cultivation (Fig. 3). At the same time, 16 new species had established themselves on the study plots, nine of which as a result of regional population growth and seven as a result of expanding the distribution (Tiainen et al. 1985, Tiainen and Pakkala 2001). Three of these new species would belong to the species favouring mixed farming with cattle.

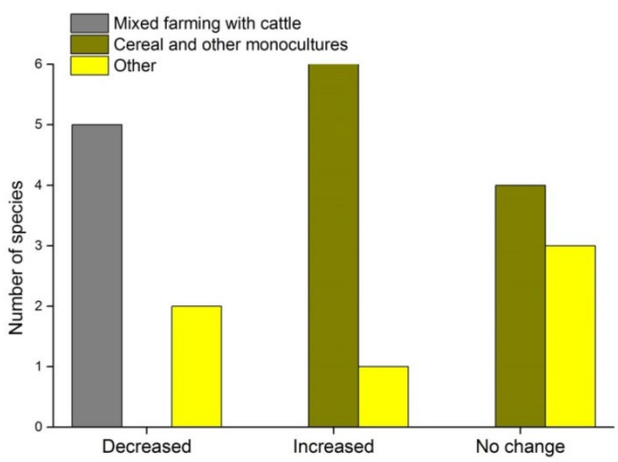

Fig. 3. Habitat preferences of bird species (no. species) classified according to significant population change between the 1930s and 1984 (based on Tiainen et al. 1985). Three species disappeared, two of which belong to those which prefer mixed dairy farmland and one is insignificant for dairy vs. cereal farmland.

The second example is from Marttilankylä, Kauhajoki, western Finland (Marttila 1963, Ylimaunu and Siira 1985). The study area of 460 ha was drained with open ditches and represented a diverse landscape with cereals, pastures and hay fields in 1960–62, the years of the first census. In 1984 dairy farming had been replaced with specialized cereal cultivation and the fields were drained subsurfically. The significant changes of the bird community can be connected to the farming and landscape changes (Table 7).

Table 7. Bird population changes in Marttilankylä, Kauhajoki (western Finland) between 1960–62 and 1984 (based on censuses by Marttila 1963, Vähämäki 1984). These censuses were based on one-visit methodology and they were made in mid-June. This reduces census efficiency and the results are not comparable with those made with visits in both in May and June (used in other studies referred to in this review; two visits: Tiainen et al. 1985, Tiainen and Pakkala 2001, or three visits: Tiainen and Seimola 2014).

Species	1960–62	1984
Ortolan Bunting *Emberiza hortulana*	60	37
Whinchat *Saxicola rubetra*	48	17
Yellow Wagtail *Motacilla flava*	31	1
Skylark *Alauda arvensis*	28	55
Meadow Pipit *Anthus pratensis*	11	0
Yellowhammer *Emberiza citrinella*	11	8
Curlew *Numenius arquata*	11	22
Barn Swallow *Hirundo rustica*	10	2
Whitethroat *Sylvia communis*	10	1
Lapwing *Vanellus vanellus*	8	6
Partdridge *Perdix perdix*	4	0
Crow *Corvus corone*	4	0
Wheatear *Oenanthe oenanthe*	3	1
Sedge Warbler *Acrocephalus shoenobaenus*	2	15
Reed Bunting *Emberiza schoeniclus*	0	12
Scarlet Rosefinch *Carpodacus erythrinus*	0	10
Wagtail *Motacilla alba*	0	4
Magpie *Pica pica*	0	2
Blyth's Reed Warbler *Acrocephalus dumetorum*	0	1
Red-backed Shrike *Lanius collurio*	0	1
Total	241	185

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