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Distribution trends of rare vascular plant species in Estonia

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Abstract. On the basis of quantitative analysis of the vascular plant distribution maps for Estonia, we specified the list of rare species which occur in less than 5% of grid quadrangles, and studied the possible correlations between their rarity and habitat preference, distribution, and sensitivity to human impact. Rare species occur statistically more often among species that are at the limit of their geographical range. The proportion of rare species was significantly higher among arctomontane and disjunct circumpolar taxa. Among apophytes, there were less rare taxa than would be expected according to the common native flora, but among hemerophobes, there were significantly more rare species than would be expected. The number of rare species was in strong positive correlation with the species richness of the region. Besides the western part of Estonia, where the greatest number of rare species occur, some small areas rich in rare species also lie in East and North Estonia.

Key words: distribution pattern, floristic elements, margin species, rare plants, sensitivity to human impact

Introduction

A practical application of quantitative accounts of species distributions concerns the organisation of their protection. The additional information can be used to provide more explicit protection in law. In Estonia, the first nature protection area was established in 1910, the first law on nature protection was adopted in 1935, and in 1936, 26 plant species were given protected status. Since then, the habitats have changed and knowledge of rare plants has increased. At present, 185 vascular plant species are legally protected in three categories. The current Estonian Red Data Book comprises 309 species of vascular plants. Altogether 336 species of vascular plants are included in these lists. The lists in the Red Data Book as well as the lists of legally protected species have been reviewed in several previous publications (Kask and Kuusk 1981; Ü. Kukk 1987, 1999; Lilleleht 1998; T. Kukk 1999, etc.).

The terms rarity and commonness represent two ends of a continuum of distribution (Kelly and Woodward 1996). Many definitions of rarity exist. Most of them

consider the limited geographical range of a species, or its limited abundance within an area, or both together (Gaston 1997). Grid mapping databases enable the application of quantitative criteria for rarity. In ecological and conservation studies, measures of areas of occupancy are required, and mapping with regular grid systems has been found most preferable (Gaston 1994). Hodgson (1986), who worked with 5 × 5 km grid maps, used the term 'restricted species' for species occurring in less than 20% of the grid squares; species occurring in more than 5% were 'uncommon', and in 5% or less, 'rare'. In Central England, 17% of the 723 native species were rare. There have been other suggestions for the percentage occupancy of grid squares which would reflect restrictedness. For instance, Stace (1991) proposed the 2.9% limit for the British Isles (100 grid squares out of 3500) for 'rare' and the 0.43% limit (15 grid squares) for 'very rare'. Gaston (1997) has proposed the 'quartile' definition of rarity, which considers the 25% of species with the lowest abundance or smallest range size in an assemblage to be 'rare'.

In this study, we give the list of species that occur in less than 5% of quadrangles (using the grid $6' \times 10'$). In order to find out how these species can be better protected, this list of rare species will be analysed regarding the following aspects:

(1) Is the proportion of floristic elements different between the rare and common native species?
(2) How many of the rare species are on the limit of their distribution area and at which cardinal points do they reach their distribution border in Estonia?
(3) Which are the habitat preferences for rare species?
(4) How does the sensitivity of species to human impact differ in rare species compared to the common ones?
(5) To which rare species does Estonia have to pay special attention, since they are also rare or missing in neighbouring countries?
(6) Does the distribution pattern of the rare species show regional trends?

Materials and methods

Estonia lies in the circumboreal zone between 57°30′ and 59°30′ N, and 22° and 28° E, covering an area of 47 450 km^2. The diversity of bedrock types, considerable climate differences between coastal and inland, and northern and southern parts of the country, the soil diversity, low population density, and high percentage of natural and semi-natural communities make the Estonian flora rich in species. It contains 1538 native species (native species include also archeophytes *sensu* Lahti et al. 1988) and subspecies (T. Kukk 1999). The general character of the Estonian flora is established by species of the boreal temperate zone, usually with wide areas of distribution. For an overview of the general features of the Estonian environment and plant communities see Laasimer (1965) and Paal (1998).

The database of the Atlas of Estonian vascular plants was started at the beginning of the 1970s. Many people have been involved in collecting this data, both in the field and from herbaria; reliable data from literature and from different projects have also been included. All 494 quadrangles have been inspected at least twice. In each quadrangle different habitats were visited. The data were collected mainly by professional botanists. The help of amateurs has been used in some groups (e.g. orchids), in cases where qualified people were available. At the end of the 1990s the database was computerised. The analysis was carried out starting with the rare species, as we consider these data to be most complete.

We have applied the Central European grid system ($6' \times 10'$). The size of the grid quadrangles in Estonia is about 100 km^2 (11.1×9.45 km). The database includes the lists of flora for all 494 quadrangles. For the main analysis of rare species the data recorded after the year 1970 was used. The apomictic genera *Alchemilla*, *Crataegus*, *Euphrasia*, *Hieracium*, *Pilosella*, and *Taraxacum* were excluded since the data on their distribution is not readily comparable with that of all the other taxa. We define as 'rare species' species that occur in less than 25 (5%) quadrangles. The taxonomy, classification of floristic elements, sensitivity to human impact, and distribution borders follow the earlier study (T. Kukk 1999). For comparing species' distributions in neighbouring countries the Red Data Book of the Baltic region (Ingelög et al. 1993), and several floras and atlases (Jalas and Suominen 1972–1996; Minjaev et al. 1981; Hultén and Fries 1986; Mossberg et al. 1992; Laasimer et al. 1993; Kuusk et al. 1996; Hämet-Ahti et al. 1998; Jalas et al. 1999) were used. In the further analysis the taxonomic rank difference between species and subspecies will not be considered.

Habitat types mostly follow Flora of the Baltic countries (Laasimer et al. 1993) with some notes from Paal (1997). The classification of floristic elements in Estonia follows that of T. Kukk (1999), based on Hultén (1950, 1971) and Hultén and Fries (1986), but the groups defined are slightly different in content and structure.

For statistical analysis in comparing rare and common species the χ^2 test was applied.

Results

The number of species (some subspecies included) occurring in less than 25 quadrangles (5%) is 257 (17%), if we consider only the records made later than 1970 in the database of the Atlas of Estonian vascular plants (Appendix 1). Among these rare species, 69 (20%) are neither under nature protection nor in the Red Data Book.

Floristic elements

In Estonian flora the largest number, 28.7%, of species (T. Kukk 1999) belong to the Euro-Siberian element and this element is also very abundant among rare species

(24.5%). The comparison of the proportions of different floristic elements among the common native flora (83 endemic taxa were excluded as they mainly were apomicts excluded from the rare species list) and among rare species revealed significant differences regarding arctomontane, circumpolar, and disjunct circumpolar species (Figure 1). There are more arctomontane and disjunct circumpolar species among rare ones than we would expect from their share in the common flora, and less circumpolar ones.

Border of the distribution area

In the Estonian flora, 455 species (30%) reach the limit of their distribution area (T. Kukk 1999). In the list of rare species the number of such species is 178 (69%), and among common ones 227 (18%). These ratios differ significantly ($P = 0.05$) and we can conclude that there is a greater proportion of rare species among margin species than in the total native flora. There are no significant differences in the cardinal points. In the total native flora, the largest number of these species reach the limit of their distribution in the north and northeast, and there is a similar ratio among the rare (Table 1). However, 64% of species on their SW limit are rare.

Habitats

Rare species occur in all 21 habitats listed for the analysis (Figure 2; Appendix 1). The smallest number of species occur in the sea, in bogs, and in drained peatland forests, where the species richness is generally low. The habitats richest in rare species are dry and fresh forests and grasslands, bushes and forest margins, ruderal open habitats. Thirty-six species, many water plants among them, occur only in one habitat type

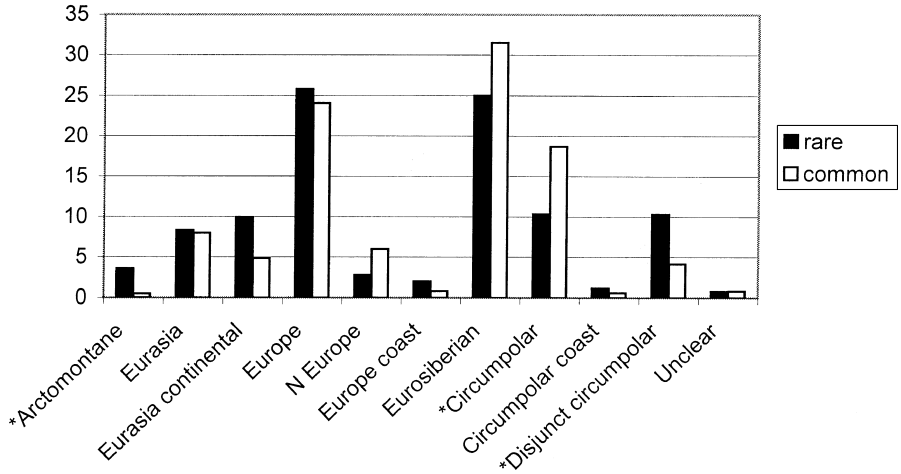

Figure 1. Percentage of different floristic elements in rare and common flora. Statistically significant differences are noted with an asterisk.

Table 1. Number and percent of margin species among rare and common species.

Cardinal point	Number of rare species	% Among rare species	Number of common species	% Among common species
N	53	29.8	68	24.5
NE	49	27.5	79	28.5
E	16	9.0	29	10.5
SE	14	7.9	42	15.2
S	13	7.3	14	5.1
SW	7	3.9	4	1.4
W	6	3.4	9	3.2
NW	20	11.2	32	11.6
	178		277	

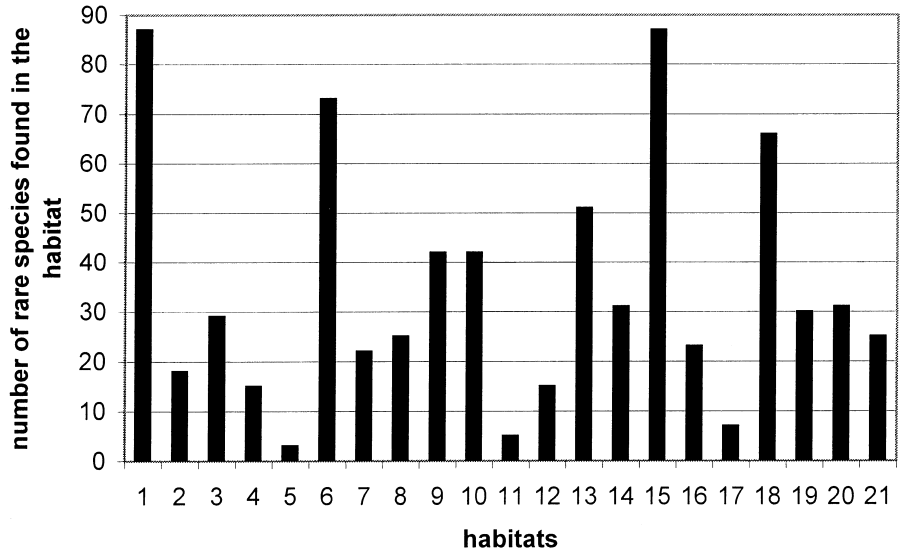

Figure 2. Habitat preferance of rare species. 1 – dry and fresh forests, 2 – floodplain forests, 3 – paludified forests, 4 – peatland forests, 5 – drained peatland forests, 6 – dry and fresh meadows, 7 – floodplain meadows, 8 – coastal meadows, 9 – paludified meadows, 10 – fens, 11 – bogs, 12 – rocks, 13 – shores, 14 – dunes and sandy plains, 15 – bushes and forest margins, 16 – freshwater, 17 – sea, 18 – open ruderal habitats, 19 – cultivated meadows and fields, 20 – parks and gardens, 21 – burnt-over and clear cut forests.

(Figure 3). Most of the species can grow in 2–3 habitats. The number of habitats in which a species can occur and the number of quadrangles that it inhabits is not highly correlated ($r = 0.25$).

Sensitivity to human impact

Describing the different tolerance of the species to human impact, the classification proposed by Linkola (1916) and applied by T. Kukk (1999) was used, where

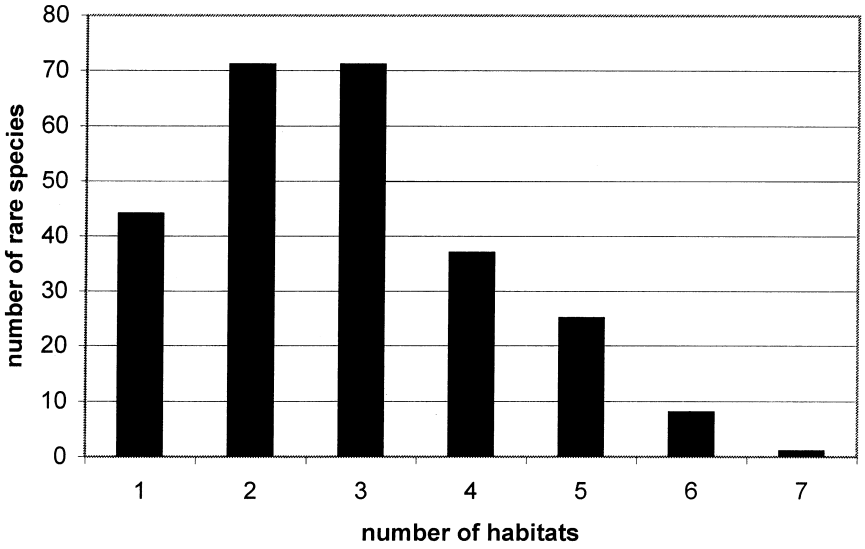

Figure 3. Number of habitats (from 21 distinguished) applied by a rare species.

hemerophobes are species that shun human impact, hemeradiaphores are species that can tolerate weak impact, apophytes make use of human impact, and antropophytes have at one time been introduced by man and cannot survive without human activity (old field weeds).

The analysis showed that significant differences exist in the proportions of apophytes and hemerophobes among rare taxa and in the common flora (Figure 4).

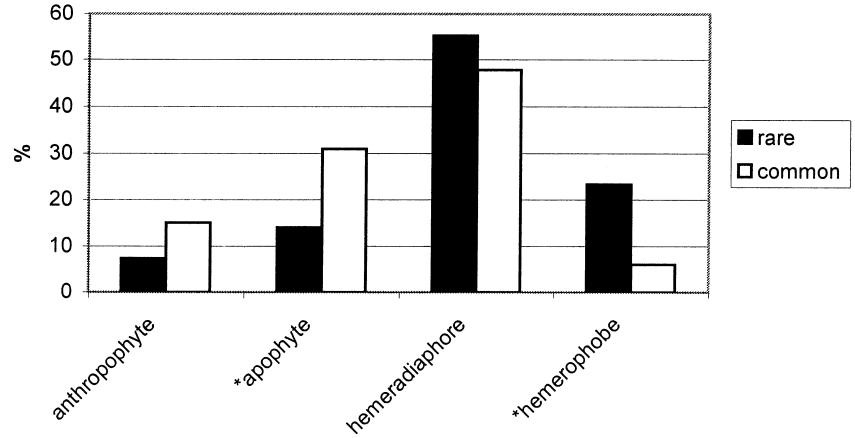

Figure 4. Sensitivity of rare and common species to human impact. Statistically significant differences in total flora and rare taxa are noted with an asterisk.

Distribution patterns of rare species

Among Estonian rare species there are 86 that are rare or missing in the neighbouring territories (Åland, Finland, Sweden, Latvia and Leningrad district of Russia). These species are marked in the list (Appendix 1) in bold, and Estonia has to pay special attention to their protection. There are 35 species, whose occurrence in quadrangles has drastically decreased during the last decades – there have been four or more times more finds before the 1970s. These species are shown by an asterisk in Appendix 1. Figure 5 depicts the map of all the recordings of these species throughout the 20th century, and Figure 6 only the recordings since 1971. The decline has been great in most regions.

In Figure 7 the distribution of all 257 rare species is depicted. The main centres of distribution of rare species lie in the western part of the island of Saaremaa and in the island of Hiiumaa. On the mainland besides the western coast some concentration of rare species can be seen in SE Estonia. Remarkable in that region is the vicinity of Tartu city. Some other quadrangles rich in rarities are Kurtna Nature Reserve (NE Estonia) and Endla Nature Reserve (north from Tartu). In all the quadrangles where there are at least 13 rare species the total list of native species exceeds 400. The correlation of species richness and number of rarities in quadrangles is shown in Figure 8. Geographically, species richness decreases significantly from west to east (Figure 9) and so does the number of rare species in quadrangles (Figure 7).

Discussion

It has been suggested that rare species differ from taxonomically related common species in several biological traits (Rabinowitz 1978, 1981; Gaston and Kunin 1997). For instance, rare species tend to display more extreme values for floral traits than the common plants (Kunin and Shmida 1997). However, several works report that the characteristics are broadly overlapping (Lahti et al. 1991; Kunin and Gaston 1993; Thompson et al. 1999). Seed and germination traits are most often considered (Edwards and Westoby 1996; Eriksson and Jakobsson 1998; Thompson et al. 1999). No single trait influences both abundance and geographical distribution range (Eriksson and Jakobsson 1998). Seed removal patterns in a widespread and an endemic tree species pair did not explain the differences in range size (Pirie et al. 2000). In addition to these morphological and life history traits, there may exist differences between rare and common species in their biogeographical and habitat preference traits that are objects of current study.

Border of the distribution area

Historical and ecological reasons make the diversity of species to decline towards the poles (Dahl 1998). Hodgson (1986) has reported a high proportion of rare species

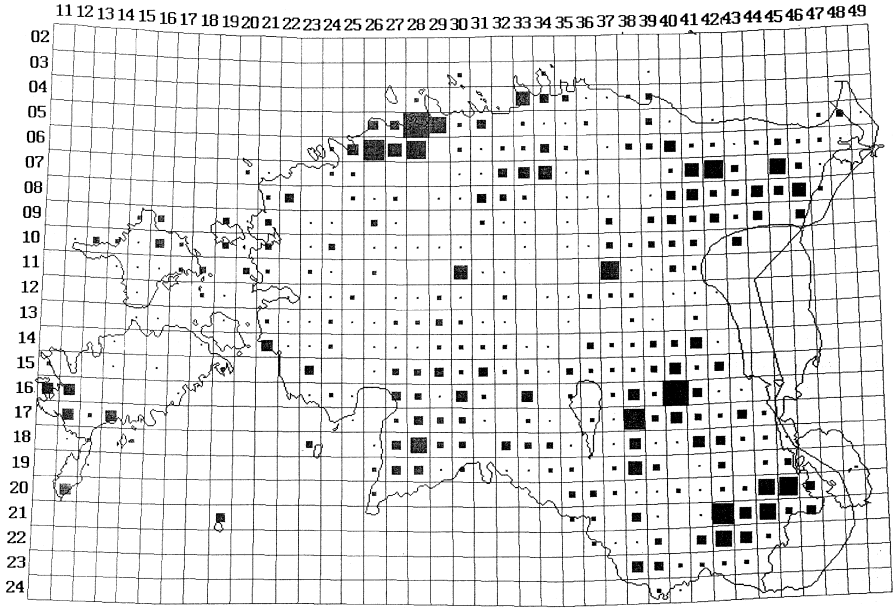

Figure 5. The distribution pattern of 35 decreasing species throughout the 20th century. Fully filled square denotes the occurrence of 10 species.

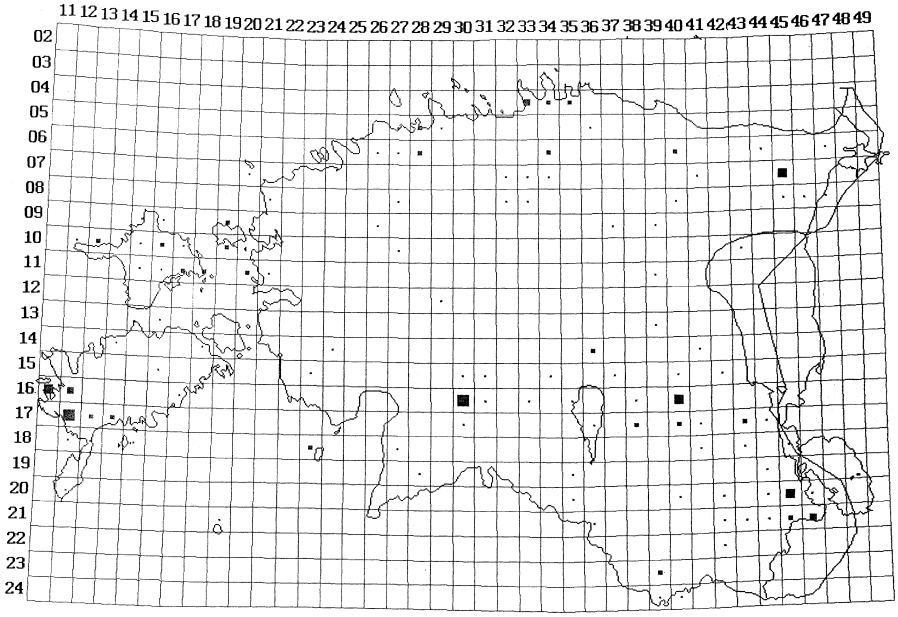

Figure 6. The distribution pattern of 35 decreasing species since the 1970s. Fully filled square denotes the occurrence of 10 species.

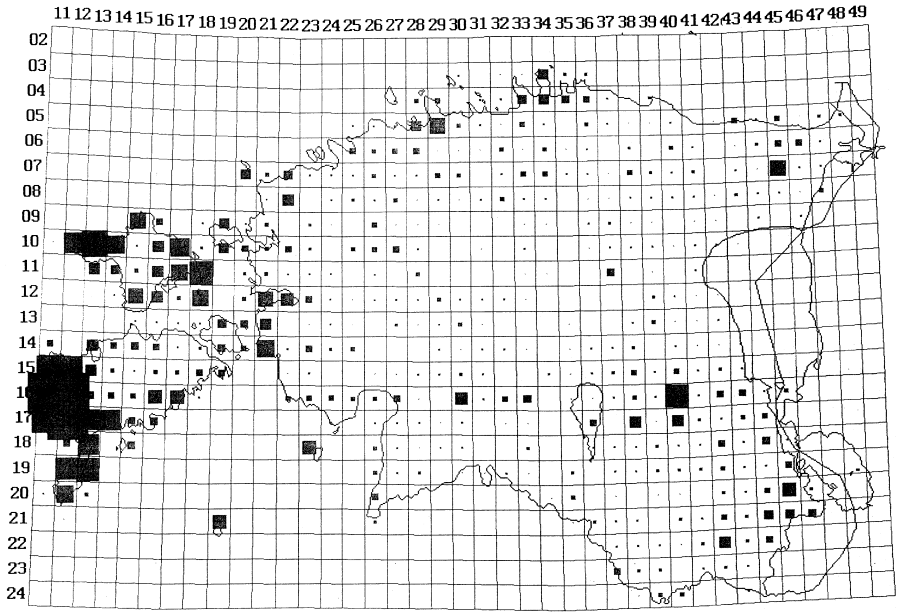

Figure 7. Distribution pattern of 257 rare species in Estonia (data since the 1970s). Fully filled square denotes the occurrence of 25 species.

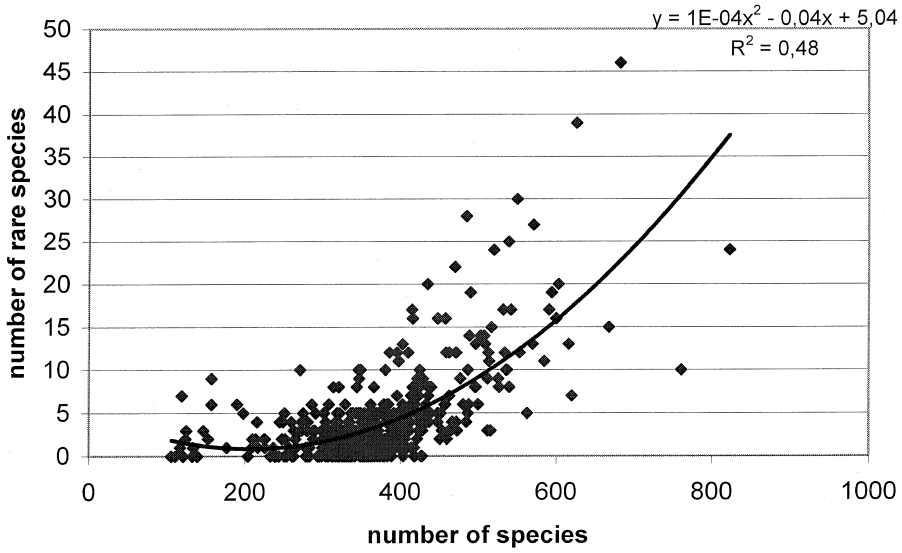

Figure 8. The correlation of total species richness and number of rare species in the quadrangles.

among those near the northern limit of their distribution area in Britain. In Finland, the number of species decreases severely from south to north and so does the number of rare species (Lahti et al. 1988). In Germany, species' richness increases from

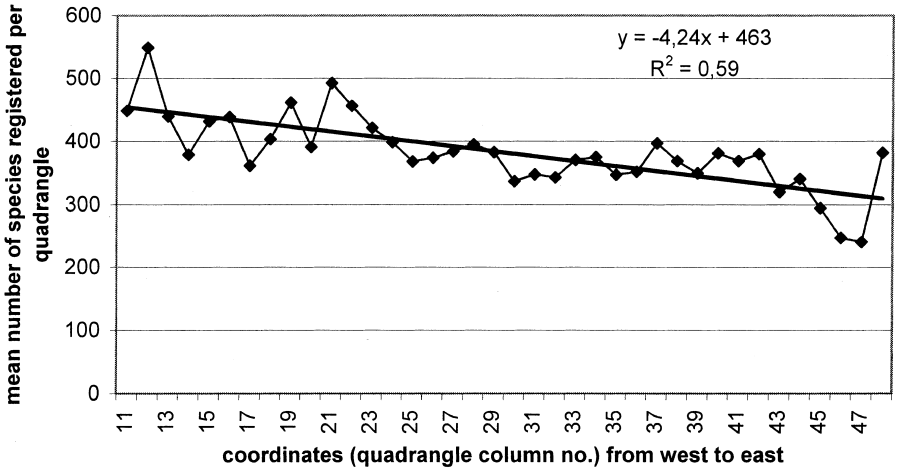

Figure 9. The west-east trend in the total number of species registered in quadrangles.

northwest to southeast (Haeupler and Vogel 1999). In Sweden the number of threatened taxa and the total number of taxa decrease from south to north (Gustafsson 1994).

Estonia is a small round-shaped country, however, many species reach there the northern limit of their geographical range, and, among them, many are rare (Table 1). The country reaches sea in north and west, and the same regions are characterised by calcium-rich soils and a milder climate. These asymmetries in the territory may explain why the decrease of species richness from south to north is nonsignificant contrary to the significant decrease from west to east.

Floristic elements

Floristic elements have been considered useful tools in phytogeographical analysis (Preston and Hill 1997) and therefore the distribution of our rare species among these categories was of great interest. It has been noted earlier that Euro-Siberian taxa are prevailing in the Estonian flora (Laasimer 1965; Kask and Laasimer 1987). The other abundant group is European species (Figure 1). In the rare species list, as in the total list of Estonian flora, Euro-Siberian and European taxa prevail. However, more than a quarter of species among disjunct circumpolar, coastal circumpolar, coastal European, continental Eurasian, and arctomontane taxa are rare. Among arctomontane species many are very rare: *Cerastium alpinum* ssp. *lanatum*, *Oxytropis campestris*, *Pinguicula alpina*, *Poa alpina*, *Saxifraga adscendens*. The gradually warming climate could be one of the reasons, and the gradual loss of habitats of these species may be another.

Among continental Eurasian species some (*Cruciata glabra*, *C. laevipes* and *Veronica dillenii*) have been always rare, but some (*Arenaria procera*, *Dracoceph-*

alum ruyschiana, *Festuca trachyphylla*, *O. pilosa*, *Silene chlorantha*) are decreasing as a result of the overgrowing of their open, sandy habitats.

Among disjunct circumpolar plants, where significantly more rare species exist than expected, there are several whose distribution is decreasing, mainly pteridophytes (*Botrychium* sp.), water and mire plants (*Juncus stygius*, *J. squarrosus*, *J. bulbosus*, *Swertia perennis*, *Rhynchospora fusca*, *Drosera intermedia*, *Lobelia dortmanna*, *Isoetes lacustris*). Coastal plants, both European and circumpolar, embrace mainly species that have always been rare in Estonia, such as *Cochlearia danica*, *Eryngium maritimum*, *Ruppia cirrhosa*.

Among circumpolar species, few rare ones occur (Figure 1). Circumpolar plants have a wide geographical range and may exist in quite a wide range of habitats. Therefore, a few found their way onto the list of rare species. Among them, anthropophytes *Agrostemma githago* and *Neslia paniculata*, and several water plants such as *Alisma gramineum*, *Najas marina* ssp. *intermedia*, *Utricularia minor*.

Habitats

Many rare species occur in more than one habitat, and species that inhabit only one quadrangle may grow in more than one habitat type. *Carex demissa*, *Equisetum* × *litorale*, *Lathyrus linifolius*, *S. otites*, *C. laevipes*, *Teesdalia nudicaulis*, *Rorippa sylvestris* occur only in one quadrangle, but should be able to inhabit maybe even five habitat types. Among species that occur in 10 or more quadrangles, water plants may inhabit only one habitat type. The restricted habitat specificity was the most frequent rarity form at the regional scale in Norwegian decidous woods (Sætersdal 1994). Although habitat deficit plays a role in species' rarity it cannot be the main factor in Estonia. Decreases in species distribution are probably caused by fragmentation of habitats and by peculiarities in plants' reproductive systems.

Sensitivity to human impact

The coastal territories of Estonia were inhabited 8000–7000 years ago, but agricultural activities that really changed the landscape started about 4000 years ago (Lang 1995). During this time the floristic composition has changed due to climate changes, but during the last centuries human activity has led the process. Different species tolerate human activity to a different extent. It could be expected that among hemerophobes there are more rare species, since human large-scale impact could have decreased the abundance of these species. The analysis confirmed this statement. Among apophytes the difference between their abundance in the common flora and in rare species was also significant, but in this case there was a smaller proportion of apophytes among rare ones. This can be explained by the fact that among the apomictic groups that were excluded from the rare species list, the majority were apophytes.

For a quick estimation of plant diversity, the number of rare and endangered plants has been found to be more suitable than the total number of species (Haeupler and Vogel 1999). Still, these figures might be well correlated and the number of all species being a better predictor of rarity than area (Järvinen 1982). In Germany, endangered species are concentrated in the biogeographically most diverse parts of the country (Schönfelder 1999). In Britain, the loci of 139 rare plant species were more aggregated at the 10 km scale than expected by chance, and relative dispersal ability and pollination type had an influence on the degree of loci aggregation (Quinn et al. 1994). Besides biological features, soil characteristics also play an important role in this. Our analysis also indicates a correlation between the number of rare species and general phytodiversity (Figure 6).

The greater number of rare species restricted to calcareous rather than acidic soils is consistent with the greater number of calcicoles than calcifuges within the (British) flora (Hodgson 1986). More threatened taxa in Swedish forests grow on soils with higher pH than nonthreatened taxa (Gustafsson 1994). The plant species pools for limestone and chalk areas are generally bigger than for the areas of acid bedrock in Europe (Kukk and Kull 1997). In Estonia, the concentration spots of rarities lie in the regions with high species richness and with an almost neutral soil pH. In most concentration spots the high phytodiversity is supported by protected areas.

Those 35 species whose recorded distribution has drastically decreased during the last quarter of a century probably contain some species that are not easily identifiable and whose sightings are therefore more scarce. However, there may be objective explanations:

(a) ancient field weeds have been killed by herbicides and new agricultural techniques (*A. githago*, *Bromus arvensis*, *B. secalinus*);
(b) mires have been drained in some regions and they are now overgrown with trees. This has influenced sporadically distributed species such as *Lycopodiella inundata* and *S. hirculus*;
(c) meadows and alvars (habitat with thin soil layer on limestone), the typical sites for *Anthyllis* species, *Trifolium campestre* etc. are overgrowing with bushes due to a decrease in their agricultural use.

The Estonian flora is diverse and so is the list of rare species containing representatives of all plant groups. The concentration spots are mainly correlated with lime-rich soils in West Estonia and small local lime-rich areas in East Estonia or with SE continental sandy areas.

Schnittler and Günther (1999) have published a list of 417 taxa which are threatened throughout Central Europe and show predominantly Central European distribution. Among the Estonian rare species, 37 occur in the Central European list, a few with a mark of high responsibility, e.g. *Potamogeton trichoides*, *Orobanche*

elatior, *Epipogium aphyllum*, *Dactylorhiza incarnata* subsp. *ochroleuca*, *Crepis mollis* and *Botrychium matricariifolium*.

Accordingly, the list of protected and Red Data Book species should be revised considering these results as 20% of these species are neither under nature protection nor in the Red Data Book. Special attention should be paid to the study of the 35 species that have dramatically decreased during the last decades.

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Appendix 1. The rare species of Estonia, occurring in less than 5% of quadrangles.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
1	×*Ammocalamagrostis baltica* (Flüggé ex Schrad.) P. Fourn.	2	2	Northern Europe	NE	HR		3	13,14
2	***Aconitum lycoctonum*** L. subsp. ***lasiostomum*** (Rchb. ex Besser) Warncke	1	1	European	NW	HP	1	1	1,9
3*	***Agrostemma githago* L.**	1	39	Circumpolar		AN		1	18,19
4	*Ajuga pyramidalis* L.	2	5	European	E	HP	1	2	1,15
5*	*A. reptans* L.	1	5	Euro-Siberian		HR	2	1	1,15,20
6	***Alisma gramineum*** Lej.	3	5	Circumpolar	N	HR		3	16,17
7	*Allium ursinum* L.	13	21	European	NE	HR	3	4	1,3,5,20
8	*A. vineale* L.	11	12	European	NE	HR	2	3	6,8,13,18
9	***Alyssum montanum* L.** subsp. ***gmelinii*** (Jord.) Hegi & Em.Schmid	2	3	Euro-Siberian	N	HR	2	3	1,13,14
10	*Ammophila arenaria* (L.) Link	17	22	European coastal	NE	AP			13,14
11	***Anacamptis pyramidalis*** (L.) Rich.	8	16	European	NE	HR	2	2	6,8
12*	*Anthyllis* × *colorata* Juz.	4	24	Baltic	endemic	HR			1,6,13,14,18
13*	*A.* × *polyphylloides* Juz.	3	12	Distribution unclear		HR			1,6,18
14*	*A. macrocephala* Wend.	9	28	Eurasian continental		HR			1,6,14,15,18
15	***Aphanes arvensis*** L.	1	1	European	NE	AN		5	18,19
16	*Arctium nemorosum* Lej.	2	2	Euro-Siberian	NE	HR		1	1,15,21
17	***Arenaria procera*** Spreng.	5	10	Eurasian continental	NW	HR	2	2	1,14,21
18	***Artemisia maritima* L.** subsp. ***humifusa*** (Fr. ex Hartm.) K.M. Perss.	4	7	Baltic	endemic	HR	2	3	8,13
19	*Asplenium ruta-muraria* L.	14	24	Euro-Siberian		HR	2	2	12
20	*A. septentrionale* (L.) Hoffm.	1	3	Discontinous circumpolar	SE	HP	1	3	12
21	*A. trichomanes* L. subsp. *quadrivalens* D.E. Mey. emend. Lovis	15	37	Discontinous circumpolar	E	HR	2	3	12

22*	***Astragalus arenarius*** L.	1	8	Euro-Siberian	NW	HR	2	2	1,14,15
23	*Atriplex longipes* Drejer subsp. *longipes*	4	4	Northern Europe	SE	HR			13,18
24	*A. longipes* Drejer subsp. *praecox* (Hülph.) Turesson	7	9	Northern Europe	SE	HR			13,18
25	***Avena strigosa*** Schreb.	2	3	Eurasian continental		AN			18,19
26	*Berula erecta* (Huds.) Coville	20	23	Circumpolar	N	HR	2	4	10,16
27	*Bidens radiata* Thuill.	10	12	Eurasian continental	SW	AP	2	4	10,13
28*	***Botrychium matricariifolium*** (Retz.) A. Braun ex W.D.J. Koch	2	13	Discontinous circumpolar		HP	1	1	1,6,14,15
29*	*B. multifidum* (S.G. Gmel.) Rupr.	6	53	Discontinous circumpolar		HR	2	1	1,6,14,15
30*	***B. virginianum*** (L.) Sw.	4	30	Discontinous circumpolar	SW	HP		5	1,3,15
31*	*Bromus arvensis* L.	5	47	Euro-Siberian		AN			18,19
32	***B. benekenii*** (Lange) Trimen	14	21	Euro-Siberian	N	HR	2	3	1,15,20
33*	***B. secalinus*** L.	17	83	Euro-Siberian		AN		5	18,19
34	***Bupleurum tenuissimum*** L.	2	2	European	NE	HR	2	3	13
35	*Cardamine impatiens* L.	21	24	Euro-Siberian	N	HR			1,2,3,4,13,15
36	*Carduus acanthoides* L.	11	26	Euro-Siberian		AN		5	18,19
37*	*C. nutans* L.	3	24	Euro-Siberian		AN		5	18,19,20
38*	*C. thoermeri* Weinm.	1	10	Euro-Siberian		AN		5	18,19,20
39	***Carex brizoides*** Jusl.	1	1	European	N	AP			1,20
40*	*C. demissa* Hornem.	1	7	European	SE	HR			3,6,9,15
41*	*C. disperma* Dewey	9	73	Circumpolar	SW	HP			3,4
42	*C. glareosa* Wahlenb.	7	20	Arctic and arctic-alpine	S	HR	2	3	8,13
43	***C. ligerica*** Gay	1	3	European	NE	HR	2	3	1,6,14
44	*C. mackenziei* V.I. Krecz.	5	15	Circumpolar coastal	S	HR	2	3	8,13
45	*C. muricata* L.	8	17	Euro-Siberian		HR			6,13,15
46	*C. paniculata* L.	15	48	Euro-Siberian		HR			4,9,10
47	*C. remota* L.	13	25	Euro-Siberian	N	HP			3,4,5
48	***C. rhizina*** Blytt ex Lindblom	3	7	Eurasian	W	HP	1	2	1,2
49	***C. umbrosa*** Host	1	1	Eurasian continental	SW	HP		5	1,6
50	***Centunculus minimus*** L.	6	11	Discontinous circumpolar	NE	AN		3	18,19
51	*Cephalantera longifolia* (L.) Fritsch	17	26	Euro-Siberian	NE	HR	2	3	1,6,15

Appendix 1. Continued.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
52	***Cerastium alpinum*** L. subsp. ***lanatum*** (Lam.) Asch. & Graebn.	1	1	Arctic and arctic-alpine	S	HP	1	1	12
53	*C. pumilum* Curtis subsp. *glutinosum* (Fr.) Jalas	11	22	European	NE	HR	2	3	6,14,15,18
54	***Ceratophyllum submersum*** L.	2	2	Euro-Siberian	NE	HR		1	17
55	*Chaerophyllum aromaticum* L.	22	27	Euro-Siberian	NW	AP			1,7,15,18,21
56	***C. temulum*** L.	1	1	Euro-Siberian		HR	2	3	1,15
57	*Chenopodium hybridum* L.	13	15	Circumpolar	N	AP			13,18,20
58	*C. polyspermum* L.	13	14	Euro-Siberian		AP			18,19,20
59	***Cinna latifolia*** (Trevir.) Griseb.	5	15	Circumpolar	SW	HP	2	3	2,3
60	***Circaea lutetiana*** L.	2	3	Discontinous circumpolar	N	HP	2	3	1
61	*Cochlearia danica* L.	2	2	European coastal	SE	HR	2	3	12,13
62	*Coeloglossum viride* (L.) Hartm.	10	25	Circumpolar		HR	2	1	6,8,15
63	*Colchium autumnale* L.	6	6	European	N	AP	3	2	6,15,20
64	*Conioselinum tataricum* Hoffm.	3	4	Circumpolar	NW	HP		5	2,15
65	*Cornus suecica* L.	23	32	Discontinous circumpolar	S	HP			3,4,9
66	*Corydalis intermedia* (L.) Mérat	6	10	European		HR	2	3	1,15,20
67	*Cotoneaster niger* (Wahlb.) Fr.	14	15	Eurasian continental	NW	HR	3	5	1,6,12,15
68*	***Crepis mollis*** (Jacq.) Asch.	2	11	European	NE	AP	2	2	7,15
69	*Cruciata glabra* (L.) Ehrend.	1	1	Eurasian continental		AP	2	2	1
70*	*C. laevipes* Opiz	1	4	Eurasian continental		AP		3	1,14,15
71	***Cyperus fuscus*** L.	4	13	Euro-Siberian	N	HR	2	4	8,9,13
72	***Cystopteris sudetica*** A. Braun & Milde	1	1	Eurasian	N	HP	1	3	1
73	*Dactylorhiza incarnata* (L.) Soó subsp. *ochroleuca* (Boll) P.F. Hunt & Summerh.	8	15	Eurasian continental		HR	3	3	9,10
74	***D. praetermissa*** (Druce) Soó	1	1	European	NE	HR	1	1	6
75	***D. ruthei*** (M. Schulze ex Ruthe) Soó	1	1	Northern Europe	NE	HR	1	1	8

76	*D. sambucina* (L.) Soó	2	2	European	E	HR	1	1	6
77*	***Dianthus arenarius*** L. subsp. ***arenarius***	2	9	Euro-Siberian	NW	HR			1,6,14
78*	*Diphasiastrum tristachyum* (Pursh) Holub	5	21	Discontinous circumpolar		HP	3		1,14,21
79	*Draba muralis* L.	14	25	European	E	HR	2	3	12,13,15,18
80	***Dracocephalum ruyschiana*** L.	10	16	Eurasian continental	N	HR	2	3	1,6
81	*Drosera intermedia* Hayne	14	24	Discontinous circumpolar		HR			10,11
82	*Dryopteris dilatata* (Hoffm.) A. Gray	9	11	European		HP		5	1,2,3,4
83	*Elatine hydropiper* L.	2	7	Euro-Siberian		HR		3	16,18
84*	*Eleocharis mamillata* (H. Lindb.) H. Lindb. ex Dörfl.	8	36	Eurasian continental		AP			10,16
85	*Eleocharis parvula* (Roem. & Schult.) Link ex Bluff, Nees & Schauer	15	27	Circumpolar coastal	SE	HR			8,13
86	***Elymus farctus*** (Viv.) Runemark ex Melderis subsp. ***boreali-atlanticus*** (Simonet & Guin.) Melderis	13	15	European coastal	NE	HR	2	3	13,14
87	*Elymus farctus* × *E. repens*	5	16	European		HR			13,14
88	*Epilobium tetragonum* L.	12	16	Euro-Siberian	N	HR		3	7,13,21
89	***Epipogium aphyllum*** (F.W. Schmidt) Sw.	7	20	Eurasian		HP	1	1	1,3
90	*Equisetum* × *litorale* Kühlew. ex Rupr.	1	1	Circumpolar		HR			7,9,13
91	***Equisetum* × *moorei* Newman**	3	3	Circumpolar		HR	2	2	1,13
92	***Equisetum* × *trachyodon*** A. Braun	1	2	European	E	HR	1	3	1,3
93	*E. scirpoides* Michx.	4	10	Circumpolar	S	HP	2	1	1,7,9
94*	*Eriophorum gracile* W.D.J. Koch ex Roth	5	22	Circumpolar		HR		3	9,10
95	***Eryngium maritimum*** L.	14	17	European coastal	NE	HR	2	3	13
96	*Euonymus europaea* L.	6	6	European	N	HR	2	3	1,2,3,7,20
97	*Fallopia dumetorum* (L.) Holub	13	15	Euro-Siberian		HR			2,13,15

Appendix 1. Continued.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
98	***Festuca altissima*** All.	8	23	European	NE	HP	2	3	1,2,3
99	*F. trachyphylla* (Hackel) Krajina	16	17	Eurasian continental		HR			6,14,18
100	*Filago minima* (Sm.) Pers.	1	2	European	N	AP		5	1,6,18
101	*Galium mollugo* L.	8	20	Euro-Siberian		AP			1,6,9,15
102	*G. rivale* (Sibth. & Sm.) Griseb.	14	32	Euro-Siberian	N	HR			2,7,15
103*	*G. trifidum* L.	1	7	Circumpolar	S	HR		5	10,11
104	*G. triflorum* Michx.	10	25	Discontinous circumpolar	S	HR		4	1,3,21
105	*Gentiana pneumonanthe* L.	8	25	Euro-Siberian	NW	HP	2	3	7,9,10
106*	*Geranium bohemicum* L.	1	4	Euro-Siberian		AP		5	15,21
107	*G. lucidum* L.	4	9	European	NE	HR	2	3	12,13,15
108	*G. molle* L.	11	17	Circumpolar	E	AP			18,19
109*	*Geum aleppicum* Jacq.	3	21	Circumpolar	NW	AP			1,2,15,18,20,21
110	*Gladiolus imbricatus* L.	18	20	Euro-Siberian	N	HR	3	4	3,7,9
111*	*Glyceria lithuanica* (Gorski) Gorski	3	40	Eurasian	W	HP			3,4,21
112	***Gymnadenia odoratissima*** (L.) Rich.	12	15	European	NE	HP	2	3	3,9,10
113	*Gymnocarpium robertianum* (Hoffm.) Newman	13	46	Circumpolar		HR	2	4	1,12,10
114	*Gypsophila muralis* L.	12	15	Euro-Siberian		AP			14,18,19,20,21
115	***Halimione pedunculata*** (L.) Aellen	13	21	Eurasian	NE	HR	2	3	8,13
116	*Hammarbya paludosa* (L.) Kuntze	24	57	Circumpolar		HP	2	3	4,9,10
117	*Hedera helix* L.	12	18	European	NE	HP	2	3	1,3,20
118	*Helichrysum arenarium* (L.) Moench	24	32	Euro-Siberian	N	HR	2	4	1,6,14,15,18
119	*Holcus mollis* L.	2	4	Euro-Siberian		HR	2	5	15
120	*Hydrocotyle vulgaris* L.	7	8	European	NE	HP	2	3	9,10,13,16
121	*Hypericum hirsutum* L.	19	27	Euro-Siberian	NE	HR			1,6,15

122	*H. montanum* L.	4	8	European	NE	HR	2	3	1,6,15,21
123	*Hypochaeris radicata* L.	20	25	European	NE	AP			1,6,15,18,20,21
124	*Isoetes echinospora* Durieu	1	1	Discontinous circumpolar		HP	1	1	16
125	*I. lacustris* L.	14	20	Discontinous circumpolar		HP	2	2	16
126	*Jovibarba globifera* (L.) J. Parn.	16	25	Euro-Siberian	NW	HR	2	4	1,6,14,15,20
127	*Juncus bulbosus* L.	13	26	Discontinous circumpolar		HR		5	8,9,10,13
128	***J. inflexus*** L.	1	1	Euro-Siberian	NE	HR		1	15,18
129	*J. squarrosus* L.	4	13	Discontinous circumpolar	N	HP	2	1	4,9,10
130	*J. stygius* L.	2	6	Discontinous circumpolar		HR		5	4,10,11
131	***J. subnodulosus*** Schrank	3	5	European	NE	HP	2	3	9,10
132	***Koeleria macrantha*** (Ledeb.) Schult.	4	8	Circumpolar	N	HR	2	3	1,6,14
133*	***K. pyramidata*** (Lam.) P. Beauv.	1	5	European		AN		5	1,6,18
134	*Lactuca sibirica* (L.) Maxim.	4	4	Eurasian	SW	HR	2	3	13
135	*Lamium maculatum* L.	11	15	Euro-Siberian	N	HP		3	15
136	*Lappula squarrosa* (Retz.) Dumort.	16	49	Circumpolar		AN		4	13,14,18,19,21
137	*Laserpitium latifolium* L.	21	32	European	NE	HR			1,2,6,15,21
138*	***L. prutenicum*** L.	1	4	Euro-Siberian	N	HP	2	1	6,15
139*	*Lathyrus linifolius* (Reichard) Bässler	1	7	Euro-Siberian	E	HR	2	1	1,15
140	*L. niger* (L.) Bernh.	6	18	European		HP	2	3	1,6,15,21
141	***L. pisiformis*** L.	8	23	Eurasian continental	NW	HR			1,6,15
142	*Leersia oryzoides* (L.) Sw.	3	9	Discontinous circumpolar	NW	HP		3	16
143	*Lemna gibba* L.	7	9	Euro-Siberian	NE	AP	2	3	16,17
144	*L. turionifera* Landolt	3	3	European		AP			16
145	*Leonurus cardiaca* L. subsp. *cardiaca*	15	20	Euro-Siberian		AN			18,20
146	***Ligularia sibirica*** (L.) Cass.	8	17	Eurasian	NW	HR	1	2	7,9,10,15
147	*Limosella aquatica* L.	6	12	Discontinous circumpolar		HR		5	13,16,17
148	*Lithospermum officinale* L.	13	17	Euro-Siberian	N	HR			1,6,13,15
149	*Littorella uniflora* (L.) Asch.	2	3	European	E	HP	1	2	13,17
150	*Lobelia dortmanna* L.	8	13	Discontinous circumpolar		HP	2	2	16
151	*Lotus arvensis* Pers.	6	22	Distribution unclear		HR			6,18,19
152	*L. callunetorum* (Üksip) Miniaev	7	13	Baltic	endemic	HP		3	1,6,14,15,18

Appendix 1. Continued.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
153	***Lotus ruprechtii*** Miniaev	5	9	Baltic	endemic	HP		3	8,13
154	*Lunaria rediviva* L.	14	23	European	N	HP	3	4	1,2,3
155	*Luzula sudetica* (Willd.) DC.	4	6	Arctic and arctic-alpine	S	HR			6,9,21
156*	*Lycopodiella inundata* (L.) Holub	6	34	Discontinous circumpolar		HP	2	2	9,10,11,18
157	***Melilotus dentatus*** (Waldst. & Kit.) Pers.	4	6	Euro-Siberian	N	HR			8,13
158	*Mentha longifolia* (L.) L.	6	6	Euro-Siberian	N	HR			3,4,10,15
159	***Moehringia lateriflora*** (L.) Fenzl	1	2	Eurasian	W	HP	2	1	1,15
160	*Montia fontana* L. subsp. *fontana*	6	10	Discontinous circumpolar	SE	HR			10,13,16
161	*Myosotis laxa* Lehm. subsp. *baltica* (Sam. ex Lindm.) Hyl. ex Nordh.	14	17	Northern Europe	E	HR			4,10,13
162	*M. sparsiflora* J.G. Mikan ex Pohl	5	5	Euro-Siberian	NW	AP			12
163	*Myriophyllum alterniflorum* DC.	4	5	Discontinous circumpolar	SE	HP	2	2	16
164	*M. verticillatum* L.	9	29	Circumpolar		HR			16
165	*Najas marina* L. subsp. *intermedia* (Wolfg. ex Gorski) Casper	5	10	Circumpolar		HR	2	3	17
166	*Neslia paniculata* (L.) Desv.	17	21	Circumpolar	N	AN			18,19,20
167	*Odontites verna* (Bellardi) Dumort. subsp. *verna*	1	3	Eurasian continental		HR		3	8,13
168	***Onobrychis arenaria*** (Kit.) DC.	6	14	Eurasian	N	HR	2	3	1,14,15,18
169	*Orchis morio* L.	6	9	European	NE	HR	2	3	6
170	***Orobanche bartlingii*** Griseb.	12	20	Euro-Siberian	N	HR		4	6,15
171	***O. elatior*** Sutton	11	20	Eurasian	N	HR		4	6,15,18,19
172	***O. pallidiflora*** Wimm. & Grab.	14	21	European	N	HR		4	1,15,18,19
173	***Oxytropis campestris*** (L.) DC. subsp. ***sordida*** (Willd.) C. Hartm.	1	2	Arctic and arctic-alpine	S	HR	1	3	14,18
174	***O. pilosa*** (L.) DC.	8	22	Eurasian continental	N	AP	2	3	1,6,13,15,18,21
175	*Peplis portula* L.	7	13	Euro-Siberian		HR			3,9,16,18,19

176	***Peucedanum oreoselinum*** (L.) Moench	3	6	European	N	HR	2	1	1,6,15,21
177	*Phyteuma spicatum* L.	20	32	European	NE	HP	3		1,2,15,20
178	*Picris hieracioides* L.	7	12	Eurasian	NW	AP			1,6,15,18,21
179	***Pinguicula alpina*** L.	6	7	Arctic and arctic-alpine	S	HP	2	3	10
180	***Pleurospermum austriacum*** (L.) Hoffm.	4	5	Eurasian	N	HR	2	3	1
181	*Poa alpina* L.	6	7	Arctic and arctic-alpine	SE	AP	2	3	6
182	*P. crispa* Thuill.	2	2	Euro-Siberian	N	AN		5	6,18,20
183	*Polemonium caeruleum* L.	21	33	Eurasian continental		HR			7,9,10,15,19
184	*Polygonum bistorta* L.	23	32	Eurasian	NW	HR			7,9,10,15
185*	***P. oxyspermum*** C.A. Mey. & Bunge ex Ledeb.	3	14	Northern Europe	SE	HR	2	3	13
186	***Polystichum braunii*** (Spenn.) Fée	1	1	Discontinous circumpolar	N	HP		3	1
187	***P. lonchitis*** (L.) Roth	2	5	Arctic and arctic-alpine	SE	HP	1	1	1,12,15
188	***Potamogeton* × *meinshausenii*** Juz.	10	10	Eurasian continental		HR		3	16
189	*P. rutilus* Wolfg.	20	24	European		HR			16
190	***P. trichoides*** Cham. & Schltdl.f.	3	6	European	N	HR		5	16
191	*Potentilla* × *mixta* Nolte ex Rchb.	2	6	European		AP			6,18
192	***P. fruticosa*** L.	7	9	Circumpolar	N	AP	3	4	6,20
193	*P. intermedia* L.	5	10	Euro-Siberian		AN			15,18,19,20
194	*Prunus spinosa* L.	7	15	Euro-Siberian	NE	HR	2	3	6,15
195	***Pulmonaria angustifolia*** L.	2	6	European	N	HR	1	1	1
196	***Pyrus pyraster*** (L.) Burgsd.	15	16	European		AP	3	4	1,6,15,19,20
197	*Radiola linoides* Roth	1	2	European	N	AP	1	2	6
198	***Ranunculus arvensis*** L.	2	4	European		AN			18,19
199	***R. lanuginosus*** L.	5	6	European	N	HP	2	3	1,3
200	*R. serpens* Schrank subsp. *nemorosus* (DC.) G. López	8	17	European	N	HR	2	3	1,6,7,9,15,21
201	***Rhinanthus rumelicus*** Velen. subsp. ***osiliensis*** Ronniger & Saarsoo	7	8	Endemic	endemic	HP	2	3	9,10

Appendix 1. Continued.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
202	*Rhynchospora fusca* (L.) W.T. Aiton	5	16	Discontinous circumpolar	SE	HR	2	3	3,9,10
203	*Rorippa* × *anceps* (Wahlenb.) Rchb.	2	5	European		HR			7,9,10,13
204	*R. sylvestris* (L.) Besser	1	2	Euro-Siberian	N	AN			2,7,9,10,13,18
205	*Rosa ciesielskii* Blocki	4	4	Eurasian continental	NW	HR		3	15,18,19,20
206	*R. pomifera* Herrm. subsp. *glandulosa* (Schmalh.) Šmite	3	6	Eurasian continental	NW	HR			12,15,18,19,20
207	*R. rubiginosa* L.	4	15	European	NE	HR			6,12,18,19,20
208	*R. sherardii* Davies	2	2	European	NE	HR		3	6,15,18,19,20
209	*Rubus arcticus* L.	7	18	Eurasian	S	HR	2	1	3,4,9,10,15
210	*Rumex* × *maximus* Schreb.	5	6	European		HR			2,3,4,8,9,10,20
211	*R. pseudonatronatus* Borbás	17	21	Eurasian continental	W	HR			7,13,18
212	*Ruppia cirrhosa* (Petagna) Grande	11	14	Circumpolar coastal	E	HR		3	17
213	*Sagina maritima* G. Don	8	8	European coastal	E	HR	2	3	13
214*	*Salix myrtilloides* L.	17	106	Eurasian	W	HP			3,4,10,15
215*	*S. purpurea* L. subsp. *purpurea*	3	14	European	NE	AP			7,9
216	*S. repens* L. subsp. *arenaria* (L.) Hiitonen	2	4	Euro-Siberian	E	HR	2	2	8,13
217	*S. repens* L. subsp. *repens*	3	7	Eurasian	E	HR	2	2	8,13
218*	***Saxifraga adscendens*** L.	2	17	Arctic and arctic-alpine	SE	HR	2	2	6,12
219*	***S. hirculus*** L.	8	68	Circumpolar		HP	2	2	9,10,11
220	***Schoenus nigricans*** L.	8	15	European	NE	HR	2	3	8,9,10
221	*S. ferrugineus* × *S. nigricans*	5	5	European	NE	HR			8,9,10
222	*Scirpus radicans* Schkuhr	8	17	Eurasian	NW	HP	2	4	7,9,10,13
223	*Selaginella selaginoides* (L.) P. Beauv. ex Schrank & Mart.	13	31	Arctic and arctic-alpine	S	HP	2	3	7,8,9,10
224	***Senecio fluviatilis*** Wallr.	4	5	Eurasian continental		HR			9,10,15

225	*S. paludosus* L.	8	22	Euro-Siberian	N	HR			9,10,15
226	*Serratula tinctoria* L.	11	16	European	NE	AP	2	4	6,7,8,9,15
227	***Silene chlorantha*** (Willd.) Ehrh.	7	7	Eurasian continental	NW	HR	2	2	1,14,15,18,21
228	***S. otites*** (L.) Wibel	1	1	Eurasian continental		AP			1,14,18,19,21
229	***Sorbus rupicola*** (Syme) Hedl.	8	9	Northern Europe	E	HR	2	2	1,6,21
230	*Sparganium angustifolium* Michx.	12	22	Discontinous circumpolar	SE	HP	2	3	16
231	*S. glomeratum* Laest. ex Beurl.	8	19	Eurasian	SW	AP		3	16
232*	*S. gramineum* Georgi	2	13	Eurasian		HP	2	3	16
233	***Spergularia media*** (L.) C. Presl subsp. ***angustata*** (Clavaud) Greuter & Burdet	2	3	European	E	HR		1	8
234	*Stellaria uliginosa* Murray	4	9	Euro-Siberian		HR			3,10,15
235	***Swertia perennis*** L.	6	16	Discontinous circumpolar	N	HP	1	2	4,6,9,10,15
236	*Taxus baccata* L.	22	25	European	NE	HP	2	4	1,3,4,6
237	*Teesdalia nudicaulis* (L.) R. Br.	1	1	European	NE	HR		5	14,18
238	***Tetragonolobus maritimus*** (L.) Roth	22	24	European	NE	HR	3	4	6,8,15
239	***Thesium ebracteatum*** Hayne	17	36	Euro-Siberian	N	AP		2	1,6,15
240	*Thymus pulegioides* L.	15	23	Euro-Siberian		AP			1,6,14,15,18
241	***Trifolium alpestre*** L.	8	24	Euro-Siberian	N	HR	2	3	1,6,15
242*	*T. campestre* Schreb.	5	23	Euro-Siberian	E	HR	2	3	6,8,18,19
243	*Trisetum flavescens* (L.) P. Beauv.	14	41	European	NE	AP			6,7,18,20
244	***T. sibiricum*** Rupr.	2	3	Eurasian	W	HR	2	1	7
245	*Utricularia minor* L.	16	36	Circumpolar		HR			10,16
246	***Veronica dillenii*** Crantz	3	3	Eurasian continental	N	HP		5	14,15
247	*V. hederifolia* L.	7	11	European	NE	AN		3	15,18,19,20
248	*Vicia cassubica* L.	20	31	Euro-Siberian	NE	HR	2	4	1,6,15,18,21
249	*V. lathyroides* L.	3	8	European	NE	HR	2	3	6,14,18
250	*V. tenuifolia* Roth	2	2	Eurasian	N	HR	2	3	1,6,15,18,21
251	*V. villosa* Roth subsp. *villosa*	15	28	Euro-Siberian		AN			6,15,18,19
252	*Vincetoxicum hirundinaria* Medik.	8	11	Euro-Siberian	NE	HR	2	3	1,6,12,13,15,18

Appendix 1. Continued.

	Taxon	After 1970	Total	Floristic element	Border	HI	NP	RD	Habitats
253	***Viola elatior*** Fr.	10	26	Eurasian continental	N	AP	2	3	1,3,5,6,9,15
254	*V. hirta* L.	14	18	Euro-Siberian	N	HP			1,6,15
255	***V. pumila*** Chaix	11	21	Euro-Siberian	N	HP		3	6,8,13,15
256	*V. reichenbachiana* Jord. ex Boreau	24	29	European	NE	HP		5	1,2,18,20
257	*V. selkirkii* Pursh ex Goldie	1	1	Circumpolar	S	HR	2	1	1

After 1970 – number of quadrangles with recordings after 1970, Total – number of quadrangles where the species has been recorded after 1900. Border indicates the cardinal point if the species reaches the limit of its distribution in Estonia. HI – sensitivity to human impact: hemerophobe (HP) – species which is disturbed by human activities; hemeradiaphore (HR) – species is indifferent to a certain limit of human activity; apophyte (AP) – an indigenous species preferring moderate to strong human impact; anthropophyte (AN) – introduced species surviving only in communities significantly changed by human activities. NP – under nature protection in Estonia (three categories, 1 – most strictly protected). RD – category in the Red Data Book of Estonia (1998). Habitats lists the habitat types in which the species occurs in Estonia: 1 – dry and fresh forests, 2 – floodplain forests, 3 – paludified forests, 4 – peatland forests, 5 – drained peatland forests, 6 – dry and fresh meadows, 7 – floodplain meadows, 8 – coastal meadows, 9 – paludified meadows, 10 – fens, 11 – bogs, 12 – rocks, 13 – shores, 14 – dunes and sandy plains, 15 – bushes and forest margins, 16 – freshwater, 17 – sea, 18 – open ruderal habitats, 19 – cultivated meadows and fields, 20 – parks and gardens, 21 – burnt-over and clear cut forests. Asterisk in the first column is a sign of severely decreasing species. Taxa in bold print are rare or missing in neighbouring countries (NW Russia, Latvia, Sweden, Åland, Finland).

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