OPERA CORCONTICA 38: 123–148, 2001

VEGETATION DYNAMICS IN DWARF PINE ECOSYSTEMS IN THE EASTERN GIANT MTS.

Dynamika vegetace kosodřeviny v ekosystémech východních Krkonoších

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The relationship between *Pinus mugo* and several species (*Carex bigelowii*, *Hieracium alpinum* agg., *Pulsatilla scherfelii* and *Calluna vulgaris*) was studied in the alpine tundra localities reforested by dwarf pine in eastern part of the Giant Mts. The young dwarf pine plantations grow relatively fast and become vital under favourable conditions. Annual increase in shrub width varies in range 12 to 35 % in stands of age to 35 years. Dwarf pine stands are relatively open, the size of the vacant gaps is sufficient for an original plant microcoenose development. Changes in the plant coenoses were described by the repeated relevés use. They documented a decrease of cover or a disappearing set of species, including protected ones (e.g. *Primula minima, Huperzia selago, Hypochoeris uniflora, Gentiana asclepiadea, Arnica montana, Diphasiastrum alpinum*) mainly in the closed *Pinus mugo* stands.

Carex bigelowii is species with low coverage under dwarf pine and in the nearest belt around the shrubs. Number of plants increased with the distance from the nearest pine shrub.

A light ecotonal effect by *Hieracium alpinum* agg. is shown by the dwarf pine periphery. It can be marked within a close belt – the species indicate an accumulation of individuals and flowering plants in the shrub surroundings. The highest number of plants occurs on places with distance of 25–100 cm from the nearest shrub. The maximal accumulation of flowers was within places of distance to 150 cm. The share of browsed plants increases gradually with distance from the nearest pine shrub. There are only a few plants as undergrowth in shrubs of dwarf pine. The parallel plots without dwarf pine show more plants comparing plots of pine plantation.

There is an ecotonal effect within a radius of 50 cm from dwarf pine by *Pulsatilla scherfelii*. The species show a lower dependence of occurrence on the pine shrub-plant distance, nevertheless it is statistically significant. A low accumulation of plants was visible within the distance of 1 m around shrubs. The highest number of flowers can be found in low dwarf pine stands with gaps or in a close peripheral belt of the pine shrubs. Number of browsed plants was higher in free plot comparison with dwarf pine undergrowth.

Calluna vulgaris is a species often occurring together with young dwarf pine shrubs. The most vital heather grows in radius of 50–75 cm from pine shrubs. The highest coverage of flowering heather was on places with distance bigger than 125 cm from shrubs.

It is suggested to adapt management of the dwarf pine stands with regards to the results: it is necessary to guarantee a sufficient free space (gaps) among individual shrubs of dwarf pine. The gaps give the opportunity for development of shade (and other pine influences) intolerant species.

Keywords: alpine tundra, *Calluna vulgaris*, *Carex bigelowii*, dynamics, *Hieracium alpinum* agg., horizontal growth, management, *Pinus mugo*, *Pulsatilla scherfelii*, shrub-herb influence, spatial structure

INTRODUCTION

The relationship between dwarf pine (*Pinus mugo*) and several herb species after reforestation of high mountains tundra ecosystems was studied in the eastern Giant Mts. by similar approach as in the western part of mountains (see PAŠŤALKOVÁ et al. 2001). Following results are a part of the project of Ministry of Environment under notation VaV/620/4/97 solved by the Department of biology at the University of Hradec Králové. In this field two thesis (KRTIČKOVÁ 1999; ZIKMUND 1999) were prepared under the leadership of J. Málková (MÁLKOVÁ et WAGNEROVÁ 1999).

The dwarf pine influence on the plant communities of subalpine and alpine altitudinal zone was evaluated within permanent research plots (PRP's) on the base of coenological relevés, micro-mapping and documentation of the horizontal growth of dwarf pine with its influence on selected autochthonous herb species. Single dwarf pine shrubs and selected species (*Hieracium alpinum* agg., *Pulsatilla scherfelii, Calluna vulgaris* and *Carex bigelowii*) on the PRP were monitored. A goal of the study consists of documentation of the actual state, changes and their cause. It can be a base for suggestion in the management to protect the biodiversity in the tundra ecosystems.

As far as to the geographical and climate differences of eastern and western part of Giant Mts. (e.g. altitude higher by 100 m) are concernet, results are published separately using the same methods used by PAŠŤALKOVÁ et al. (2001).

We thank M. Kociánová, J. Štursa (Administration of Krkonoše National Park) and S. Vacek (Forestry and Game Management Research Institute, Opočno Research station) for useful comments.

ENVIRONMENTAL CONDITIONS OF THE EASTERN GIANT MTS.

From geologic point of view the bedrock on Modrá stráň is from muscovite – albitic schist or phyllite combined with polygenetic colluvial and fluviocolluvial deposits, on Studničná hora it is muscovite – albitic schist or phyllite and the bedrock on Stříbrná pláň is created from medium grained biotitic granite (CHALOUPSKÝ 1968). Soil type is mostly montane humic podzol and immature soils are on the highest places of the area (TOMÁŠEK et ZUZKA 1983).

The investigated area (Fig. 1.) pertains to the catchments of Úpa and Bílé Labe. Climate region is cool with average annual temperature varying between 0 and 2.3°C and amount of precipitation from 1200 to 1500 mm (HLADNÝ, SÝKORA 1983). The study plots are located in the anemo-orographic system of Bílé Labe (JENÍK 1961).

The vegetation consists of a mosaic of communities. *Juncion trifidi* Krajina 1933 (assoc. *Cetrario-Festucetum supinae* Jeník 1961) constitute community of the highest altitude (above 1470 m a.s.l.). The plateau vegetation obtains predominantly growths of alliance *Nardo-Caricion rigidae* Nordhagen 1937 (prevailing assoc. *Carici fyllae-Nardetum* (Zlatník 1928) Jeník 1961) and *Calamagrostion villosae* Pawlowski in Pawlowski, Sokolowski et Walisch 1928 occurring in eutrophic parts (assoc. *Crepido-Calamagrostietum villosae* (Zlatník 1925) Jeník 1961. A mosaic of communities classified within alliance *Pinion mughi* Pawlowski in Pawlowski, Sokolowski et Walisch 1928 (assoc. *Myrtillo-Pinetum mughi* Hadač 1956) grows as a part of uninfluenced natural stands except the highest localities of ridges.

Particular description of environment of arctic-alpine tundra was published by KOCIÁNOVÁ et al. (1995) and SOUKUPOVÁ et al. (1995).

METHOD

The species composition of communities on all plots was registered using repeated relevés (the Braun-Blanquet's scale for abundance and dominance was applied). Similarity among vegetation of all plots was evaluated on the base of the hierarchic agglomerative clustering (average linkage method with Euclidean distance as a measure of dissimilarity; Fig. 2.). Values on representation of species of herb and

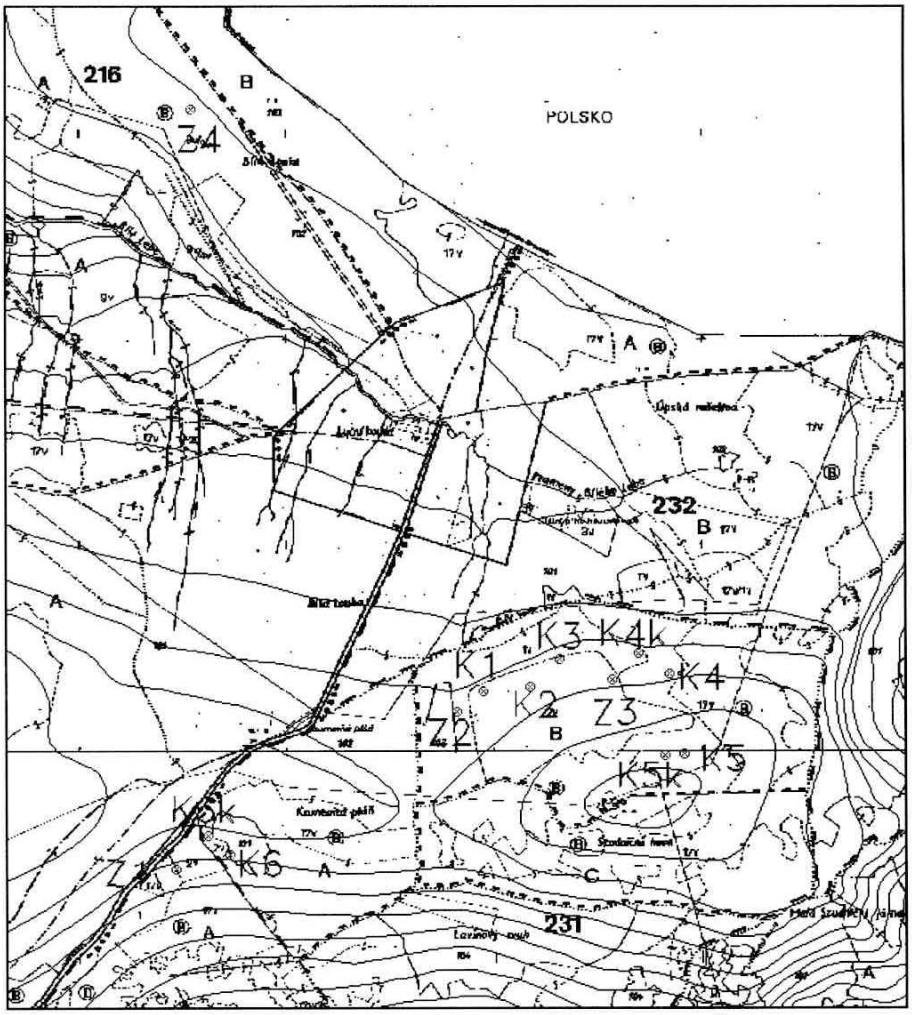


Fig. 1. Localisation of the permanent research plots (PRP's) in eastern part of the Giant Mts.

moss layer were used. The species representation corresponds to an average cover (in per-cents) by the respective grade of the Braun-Blanquet's scale.

The periphery lines of all *Pinus mugo* shrubs were mapped as an upright projection of free branches. Plants or closed groups of plants (clumps) of selected species (*Pulsatilla scherfelii, Hieracium alpinum* agg., *Calluna vulgaris, Carex bigelowii*) were registered as points (clump centroids) – they are called "points of occurrence". One occurrence point corresponds to one or several plants (the same approach was used by PAŠŤALKOVÁ et al., 2001). Each occurrence point has registered number of individual plants, number of flowers (flowering plants) and browsed plants.

Graphical data processing (digitalisation of hand-made plans of plots and database filling) was carried out by the TopoL software. Main information was obtained by computing of distance single

occurrence points from the nearest dwarf pine shrub (PAŠŤALKOVÁ et al., 2001). Particular evaluation is available by plots K1 – K6. Each plot of size 20 x 10 m consists of two adjacent square sub-plots. A regular network of points with step of 0.25 m was generated. The frequency of points of this network according to the distance of point from the nearest dwarf pine shrub is an estimate of such frequency for a random point. Dependencies of the studied species on dwarf pine were analysed using graphs of cumulative differences calculated according to the equation

$$d = \sum_{i=1}^{k} (f_i/t - F_i/T)$$

where f_i is actual i-th frequency, F_i is relevant expected frequency, t is total number of occurrences, T is number of the generated network points, k is a limit interval of distance (these intervals were chosen with breadth of 0.25 m starting at 0 m to the last interval of distance >4 m; distance equal to 0 m corresponds to points within an area of a pine shrub). For interpretation of these graphs see PAŠŤALKOVÁ et al. (2001).

It is possible to obtain the significance of the curve of cumulative differences on the base of test of goodness of fit the actual distribution of objects (occurrence points, plants, flowering plants, browsed plants, respectively; distribution according to distance from the nearest shrub) and expected distribution of random points (generated as a point network). The χ^2-test was employed.

In the *Calluna vulgaris* micro mapping, the emphasis was laid on the registration of extent of the vitality classes (A – more than 60 % of heather cover is in flower; B – 30–60 % of heather cover is in flower; C – less than 30 % of flowering heather; D – dead heather; E – heather overgrown by grass). This classification is similar to PAŠŤALKOVÁ et al. (2001). An analogical scale was used by *Carex bigelowii*. The grades (density classes) are defined according to number of the plant individuals in the square of the side size of 50 cm: A – 1–5 plants; B – 6–10; C – 11–15; D – 16–20; E – 21–25; F – more than 25 plants per square.

The nomenclature of higher plants follows ROTHMALER et al. (1990), for moss species is consistent with CORLEY et al. (1981). The plant community nomenclature follows MORAVEC et al. (1995). Following pairs of species were not distinguished: *Anthoxanthum odoratum* and *A. nipponicum*, *Senecio fuchsii* and *S. hercynicum*. Species *Campanula bohemica* and *Pulsatilla scherfelii* were determined according to DOSTÁL (1989).

PLOT LOCALISATION

Totally ten PRP's of 20 x 10 m in size were established in the area of eastern Giant Mts. Each plot intended for monitoring of the dwarf pine growth and of relation between pine and selected herb species consists of two containing subplots of 10 x 10 m. Three parallel plots (10 x 10 m) without dwarf pine were fixed for comparing both qualitative and quantitative attributes of the selected herb plant distribution (plots are marked with "k").

All PRP's in the eastern Giant Mts. are found in arctic-alpine tundra of the first zone of the Krkonoše National Park. The major part of plots lies on the northwest and north slopes of Studniční hora (plot K5 with the higher altitude of 1545 m a.s.l.). The most southeastern plot occurs in locality of Modrá stráň (1480 m a.s.l.), the most northern PRP's were fixed in the area of Stříbrné návrší (1400 m a.s.l.) – see Fig. 1. ZIKMUND (1999) has observed (since 1996) plots marked with the first character "Z". "K" is used for plots studied by Krtičková since 1997 (KRTIČKOVÁ, 1999). The plot localisation was not accidental but it had to meet a condition of a sufficient plant frequency by selected species for statistical processing. There is no parallel plot to the Z4 PRP with *Calluna vulgaris* because of a lack of adequate communities without dwarf pine plantation.

All studied plots except Z4 lay in area of the forest enterprise Horní Maršov, forest administration Pec pod Sněžkou. The mentioned plot is localised in the area of Vrchlabí forest enterprise (Špindlerův Mlýn administration).

For particular plot characterisation:

1. The Modrá stráň locality (1480 m a.s.l.): 200 m from the monument "Památník obětem hor", 50 m under road to the Výrovka Chalet – the plot Z1 lays by an end of *Senecio fuchsii* growth, plot K6 is with distance of 30 m. Both plots are designated for studying the relation between *Pinus mugo* and *Pulsatilla scherfelii* (Photo 1). The parallel plot K6k is localised in southeastern direction with distance of 20 m from K6.

2. Northern and northwestern slopes of the Studniční hora (mountain): There are 7 plots with dwarf pine and two parallel plots here. *Pinus mugo* and *Carex bigelowii* were mapped in the plot Z2 (altitude 1485 m) in the surroundings of two autochthonous dwarf pine shrubs. The other plots were used to monitoring of allochthonous plantations of age lower than 35 years. Five PRP's were fixed to study the relationships between dwarf pine and *Hieracium alpinum* agg. The plot Z3 (to study of *Hieracium alpinum* agg. and *Calluna vulgaris*) is situated on the slopes of Studniční hora, too.

3. The Stříbrné návrší locality: A plot to study relationships between dwarf pine and heather complements the set of PRP's (the plot Z4 is located 50 m to the left from the winter tourist path Luční bouda – Špindlerova bouda, 850 m from Luční bouda at 1400 m a.s.l.).

All plots occur at 9th (dwarf pine) forest altitudinal zone. 9Z8 is the most frequent forest type (plots Z2, Z3, Z4, K1 – K4 and K4k). Forest type 9Z9 is mapped within plots Z1, K6 and K6k. Plots K5 (type 9Z6) and K5k (type 9Y1) are of different property.

RESULTS

Relevés (Tables 1.–3.) document properties of plant communities in the eastern Giant Mts. They are comparable with relevés from the western part of the mountains (PAŠŤALKOVÁ et al. 2001). A set of heliophilous species (see indication values for light condition; ELLENBERG et al. 1992) shows a cover decrease or extinction. The set partly consists of protected species – *Primula minima* (plot K5k), *Huperzia selago* (extinction in the plot K1B, decreased representation in K5 and K5k; this situation is equivalent to the western Giant Mts., plots P1 and P4). Coverage of *Veratrum album* subsp. *lobelianum* has decreased in plots K1A, K4A, K4B and K3A (total extinction). Analogical situation appeared in plots P1 and P2 in the western Giant Mts. Plots J1, J2, N1, K1, K2 and P3 showed a cover increase by this species on the contrary. The representation of further protected species in plots of the eastern Giant Mts. did not change unlike the plots of the other mountain part – it was extinction (P2, P3) or a cover decrease (P1, P4) of *Hieracium alpinum* agg. in older stands with high dwarf pine cover (cover was unchanged in the young pine plantations). Species *Hypochoeris uniflora* dies out within older stands (P1 – P4) in the western Giant Mts., another plots of this area show no important change. In the group of limited species it is possible to include *Gentiana asclepiadea* (within plots P1 – P4) and *Diphasiastrum alpinum* (plot P2).

An increase of coverage was registered by *Homogyne alpina* (Z1, K1A, K1B, K2A, K4k, K5k, K6A, K6B, K6k), *Polygonum bistorta* (K5B, K5k, K6A), *Solidago virgaurea* subsp. *minuta* (e.g. Z2, K2A, K6A, analogically in several plots of the western area). Cover of *Calamagrostis villosa, Galium harcynicum* increased lightly within sunlit gaps among pine shrubs of age of 35 years in the western Giant Mts. This dynamics is not possible to generalise because of a short period of observation.

The relevé classification (Fig. 2.) exemplifies small variance among (sub-) plots. It is adequate to fact that all plots are situated in 9th forest altitudinal zone. There are a homogenous groups of plots K1, K4 and K5 with the *Hieracium alpinum* agg. observation. Similar status of plots K6 and Z1 (to study of *Pulsatilla scherfelii*) was documented. Some subplots show most important differences comparing a pair of plots (example of K2 and Z3 plots). The parallel plots are similar to the plots with dwarf pine plantation in the species structure.

Tab. 1. Relevés from plant communities of plots Z1, Z2, Z3, and Z4. Plant species representation according to the Braun-Blanquet's scale with intermediate grades.

Plot	Z1A	Z1B	Z3A	Z3B	Z2A	Z2B	Z4A	Z4B
slope [°]	20	20	15	10	10	10	15	15
orientation	SE	SSE	N	N	N	N	SW	SW
number of species E_2	1	1	2	1	1	1	1	2
number of species E_1	21	26	13	14	9	9	4	4
E_2 cover [%]	13(22)	6(11)	9(18)	8(16)	4(9)	46(53)	16(24)	13(24)
E_1 cover [%]	85 (87)	92 (94)	100	95	95 (97)	80	95 (97)	90 (92)
E_0 cover [%]	0	0	10	5	0	5	5	5
E_2:								
Picea abies	.	.	+	.	.	.	.	r
Pinus mugo	2	2	2	2	1	3(4)	2(2-3)	2(2-3)
E_1:								
Anthoxanthum odoratum agg.	1	1	+	.	2	1	.	.
Calamagrostis villosa	+	+	1-2	1	1	.	.	.
Calluna vulgaris	.	.	3	4	1	1	4	4
Carex bigelowii	+	2	1(1-2)	2	3	3	2	2
Campanula bohemica	.	1	.	.	.	.	.	.
Coeloglossum viride	+	+	.	.	.	.	.	.
Deschampsia cespitosa	2	1	.	.	.	.	.	.
Deschampsia flexuosa	1	2	2(3)	2	3(3-4)	3	2	2
Festuca aizoides	.	1	1	1	.	.	.	.
Geum montanum	.	1	.	.	.	.	.	.
Hieracium alpinum agg.	.	1	1	+	1	r(+)	.	.
Homogyne alpina	1(1-2)	1	.	+	.	+	.	.
Hypochoeris uniflora	1	1	.	.	.	.	.	.
Huperzia selago	.	.	+	+	.	.	.	.
Leontodon hispidus	.	+	.	.	.	.	.	.
Luzula sudetica	.	+	.	.	.	.	.	.
Molinia caerulea	2	+	.	.	.	.	.	.
Nardus stricta	1	2-3	+	2	.	2	1(2)	1
Phleum rhaeticum	.	1(+)	.	.	.	.	.	.
Polygonum bistorta	2	1	1	2	1	.	.	.
Potentilla aurea	1	1	.	.	.	.	.	.
Potentilla erecta	1-2	.	.	.	.	.	.	.
Pulsatilla scherfelii	1	2-3	.	.	.	.	.	.
Rumex alpestris	+	1	.	.	.	.	.	.
Senecio fuchsii	1	1	.	.	.	.	.	.
Silene dioica	+	+	.	.	.	.	.	.
Solidago minuta*	1	2	1	+	+(1)	+	.	.
Trientalis europaea	+	.	.	.	.	.	.	.
Vaccinium myrtillus	+	1	r(+)	1	.	.	.	.
Vaccinium vitis-idaea	.	.	+	+	.	.	.	.
Veratrum lobelianum*	+	+	.	+	1	1	.	.
E_0:								
Cetraria islandica	.	.	1	1	r	+	.	.
Cladonia sp.div.	.	.	1	1	.	R	.	.
Dicranella cerviculata	.	.	.	+	.	.	.	.
Dicranella heteromalla	.	.	+	+	.	.	+	+
Dicranum scoparium	.	.	.	+	.	+	.	.
Pohlia nutans	.	.	.	+	.	+	.	.
Pohlia sp. div.	.	.	+	.	.	.	+	+
Polytrichum formosum	.	.	.	.	.	+	+	+

Tab. 2. Relevés from plant communities of sub-plots K2, K3, K6, and K6k of 10x10 m in size.

Plot	K2A	K2B	K3A	K3B	K6A	K6B	K6k
slope [°]	5	5	10	10	15	10	
orientation	N	N	N	N	SE	SE	SE
number of species E_2	2	2	1	1	1	1	0
number of species E_1	13(13)	9(9)	11(12)	12(12)	22(21)	14(14)	19
E_2 cover [%]	8(19)	9(18)	8(16)	11(19)	22(36)	15(26)	0
E_1 cover [%]	90(92)	87(93)	95(96)	96(97)	97	100	100
E_0 cover [%]	3	3(6)	4	3(6)	0	0	0
E_2:							
Pinus mugo	2	2	2	2	2(3)	2(3)	.
Picea abies	+-1	+	.	.	.	.	.
E_1							
Anthoxanthum odoratum agg.	1(r)	.	1-2	+-1(+)	1	2(1-2)	1
Calluna vulgaris	2-3	3-4(4)	2-3(2)	2-3	.	.	.
Campanula bohemica	.	.	.	.	+	1	1
Carex bigelowii	2	2	2	2	1	1	1-2
Deschampsia cespitosa	.	.	.	.	1-2	1	1
Deschampsia flexuosa	3	2	3(2-3)	3(2-3)	3	2-3	3
Hieracium alpinum agg.	2	2	2	2	+	R	+
Homogyne alpina	r(+)	.	.	.	1(1-2)	1(1-2)	+(1)
Huperzia selago	r	+	+	+	.	.	.
Hypericum maculatum	.	.	.	.	r	.	.
Hypochoeris uniflora	.	.	.	.	.	.	+
Luzula luzuloides	.	.	.	.	r	.	.
Luzula sudetica	.	.	.	.	+	.	.
Maianthemum bifolium	.	.	.	.	+	.	.
Molinia caerulea	.	.	.	.	.	1	1-2
Nardus stricta	1-2	1	1-2(2)	1-2(2)	+(1)	.	2
Polygonum bistorta	1	1	1	1	1(1-2)	1-2	+
Potentilla aurea	.	.	.	.	1	1(1-2)	.
Potentilla erecta	.	.	.	.	.	.	+
Pulsatilla scherfelii	.	.	.	.	2	1	2
Rumex alpestris	.	.	.	.	r	.	.
Silene vulgaris	.	.	.	.	1	.	+
*Solidago * minuta*	r(+)		+	+	+(1)	1	r
Trientalis europaea	.	.	.	.	r	+	r
Vaccinium myrtillus	1(+)	+-1	+-1	+	1(+)	.	1
Vaccinium uliginosum	.	.	.	.	.	.	+
Vaccinium vitis-idaea	+	+	.(+)	r(+)	+(r)	.	.
*Veratrum * lobelianum*	+	.	+(.)	+	1	1	1
E_0:							
Cetraria islandica	(+)1	1(2)	1	1(1-2)	.	.	.
Cladonia sp. div.	r	.	1	1	.	.	.

Comment: Sampling date 31st July, 1997 (main values), repeated at 3rd September, 2001 (values in parenthesis are given in the case of cover difference)

←

Comment: Sampling date 27th July, 1996 (main values), repeated at 30th July, 1998 (values in parenthesis are given in the case of cover difference)

Tab. 3. Relevés from plant communities of sub-plots K1, K4, K4k, K5, and K5k.

Plot	K1A	K1B	K4k	K4A	K4B	K5A	K5B	K5k
slope [°]	5	5	10	10	10	15	15	15
Orientation	N	N	N	N	N	N	N	N
number of species E_2	2	2(1)	1	2	1	2	1	1
number of species E_1	15(15)	12(11)	11(12)	14(14)	14(14)	10(11)	9(10)	12(14)
E_2 cover [%]	18(19)	32(33)	1(3)	12(13)	12(13)	23(26)	26(29)	1(2)
E_1 cover [%]	90(92)	87(90)	97(95)	95(94)	96(95)	87(85)	77(80)	85
E_0 cover [%]	2	7	5	9	10	10	12	10
E_2:								
Pinus mugo	2	3	+(1)	2	2	2-3(3)	2-3(3)	+(1)
Picea abies	+	+(.)	.	+	.	+	.	.(+)
E_1								
Anthoxanthum odoratum agg.	1(+)	.	.	1(+)	+-1(+)	.	.	.
Calamagrostis villosa	1	1-2(1)	1	+	+	.	.	.
Calluna vulgaris	2	2(3)	3(4)	2(3)	2-3(3)	2	2	2
Campanula bohemica	.	.	.	.	.	.	.	.
Carex bigelowii	1-2	1-2	1-2	2	2	2	1	2
Deschampsia cespitosa	+(r)	.	.	.	.	.	.	.
Deschampsia flexuosa	2	2	2(1-2)	3	3-4(3)	2-3(2)	1-2	2(2-3)
Festuca aizoides	.	.	.	+	1	1-2(1)	1	+(1)
Hieracium alpinum agg.	1-2	1	2	1-2	2	2	2	2
Homogyne alpina	r(+)	.(+)	.(+)	.	.	.	.	.(+)
Huperzia selago	r	+(.)	.	+	+	1-2(+)	1(+)	2(1-2)
Nardus stricta	1-2	2	1	1-2(1)	1-2(1)	.(+)	.(+)	1
Polygonum bistorta	1	1	+	1	1	1	+(1)	+(1)
Primula minima	.	.	.	.	.	.	.	1(+)
*Solidago * minuta*	+	+	+	+	+	+(r)	.	+(r)
Trientalis europaea	.	.	.	.	.	.	.	+(r)
Vaccinium myrtillus	1	+-1	+	1	+	1(+)	+	+(1)
Vaccinium vitis-idea	+	+(r)	r(+)	+	+	+	+	.(r)
*Veratrum * lobelianum*	1(r)	.	.(+)	+(r)	+(r)	.	.	.
E_0:								
Cetraria islandica	1	2	1-2	2	2	2	2	2
Cladonia sp.div.	r(+)	.	.(+)	1(+)	1	1	1-2	1-2

Comment: Sampling date 26th August, 2000 (main values), repeated at 3rd September, 2001 (values in parenthesis are given in the case of cover difference)

Young dwarf pine plantations grow rapidly under favourable conditions and show sufficient vitality (Tables 4. –5.). A pine dying off was observed at locality Stříbrné návrší (including PRP Z4) in years 1999–2000 as the consequence of a condition set (winter freezing, pest gradation) – see Photo 3. An annual increase in the shrub width by young stands (of old to 35 years) varies from 12 to 35 % (average 29 %) counting in years 1997, 1999 and 2000. Important changes in the growth can be found from year to year probably as a result of varying climate conditions and/or dwarf pine health status worsening. Similar results – average annual increase about 27 % – are found by PAŠŤALKOVÁ et al. (2001).

The outline maps of plots K1 – K6 in 1999 are a content of Figs. 3.–8. The total area of dwarf pine shrubs (first following column; in m^2 per plot of 200 m^2 in size) and the most frequent distance of a random point from the nearest pine shrub was according to separate plots in 1999 as follows:

K1	32,772	25–50 cm
K2	21,622	25–75 cm
K3	19,201	50 cm
K4	13,730	75–125 cm

K5	31,274	25–50 cm
K6	38,973	0–75 cm

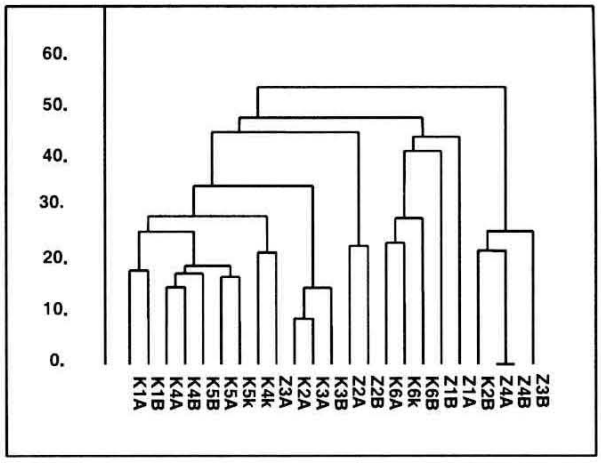


Fig. 2. Classification of relevés (from sub-plots of size 10 x 10 m) using average linkage hierarchical clustering with Euclidean distance as a dissimilarity measure.

An unclose character of the stands is visible by comparing similar plots in the western part of the Giant Mts. (PAŠŤALKOVÁ et al., 2001). Size and properties of gaps are manifested by Fig. 9. with the graph of random point frequencies according to their distances from the nearest pine shrub.

Carex bigelowii had low coverage under pine shrubs and within narrow surroundings of shrubs. Number of plants has increased with distance from the dwarf pine shrubs. Details, graphs and another matter were collected in ZIKMUND (1999). The PRP Z2 is overgrown by healthy vital individuals of *P. mugo* of height about 60 cm with relative low density. The herb layer is shaded only a little. Density class A in the sub-plot Z2A had the highest frequency under shrubs and within narrow surroundings, a decrease was observed dependently on the distance from the shrubs. A high frequency of the medium class C was expected not so high as in reality. The class B varied with two peaks (distance lower than 50 cm and greater than 150 cm). The class D grows with distance up to 100 cm. The class E was observed only with distances lower than 150 cm (a maximum at 100 cm). The class F had a maximum about distance 50–150 cm. All graphs obtained during the period of study are similar – it is an evidence of a stable growth situation by this species. Analogical results were found in the sub-plot Z2B which is specific with presence of a big dwarf pine shrub of height above 120 cm and coverage ca 50 %. The sedge cover of A category was found as undergrowth or within narrow surroundings. On the contrary, the cover class F was more frequent with bigger distance from the nearest pine shrub.

Hieracium alpinum agg. (PRP's Z3, K1 – K5 and two parallel plots) shows an accumulation of plants and flowers in dwarf pine surroundings (Fig. 10.). The most specimens were with distances of 25–100 cm. The higher accumulation of flowers occurred from 100 to 150 cm distantly. As distance from shrub had grown so a share of browsed plats increased. Figs. 11.–12. present examples of the plot Z3A for number of plants and flowers according to distance from dwarf pine shrub. PAŠŤALKOVÁ et al. (2001) found a few plants inside dwarf pine and a maximum with distance of 50–100 cm. Krtičková documents higher number of plants in the parallel plots comparing the plots with *P. mugo* plantation under similar environmental conditions (Tab. 6.).

An ecotonal effect by hawkweed on the *P. mugo* periphery is developed poorly. It can be found within a radius 50 cm (plot K1) or more (frequently) – it was by distance of 75–150 cm in the plot K4.

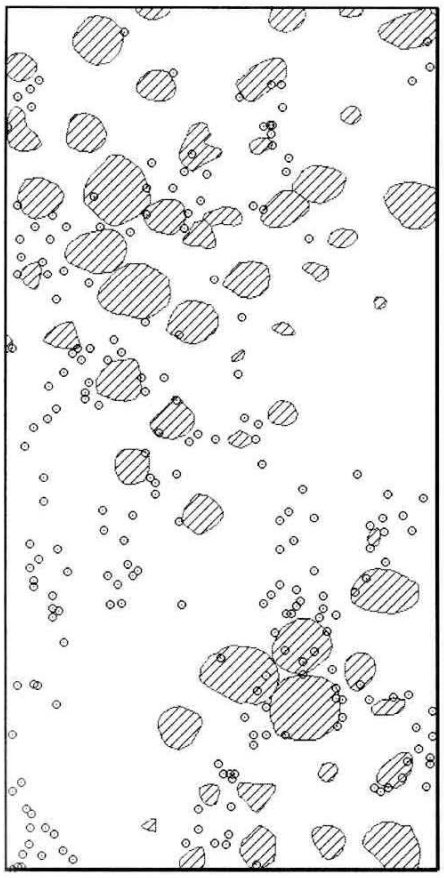


Fig. 3. Plot K1 with *Hieracium alpinum* agg. in 1999. Plot size is 10 x 20 m (in Figs. 4–8 like that).

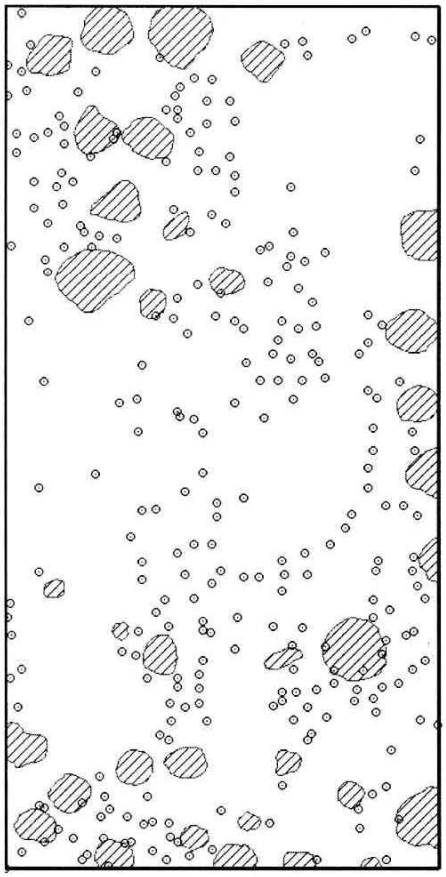


Fig. 4. Plot K2 with *Hieracium alpinum* agg. in 1999.

A few plants occur as undergrowth. The share of flowering plants was lower inside of shrubs in all plots of the eastern Giant Mts. Results of statistical testing for dependence between number of all/flowering plants and distance from the nearest shrub were significant by all plots (Table 7.).

Dependence of *Pulsatilla scherfelii* occurrence on distance from pine shrub was weak (comparing *H. alpinum* agg.) nevertheless significant (Table 7.; plots Z1, K6, parallel plot K6k). A flat accumulation of plants within a radius to 100 cm (maximum varies between 25–50 cm) was observed in the plot K6 (Fig. 13.). The browsed plants are frequent out of dwarf pine stands, 100 cm and more distantly from shrubs. See a map of plot Z1 on Fig. 14., distribution of plants regarding to dwarf pine on Fig. 15.

Number of occurrence points by *P. scherfelii* inside dwarf pine shrubs is reduced but total number of plats is equal to gaps. Share of flowering plants is significantly reduced inside shrubs (to 3.5 % comparing 7.2 % in gaps). It may not be true under thin shrubs with sufficient lighting of ground. An important ecotonal effect was registered in the plot K6 within the radius of 50 cm from shrubs. Numbers of plants in plots K6 and K6k are compared in Table 8.

Coverage of *Calluna vulgaris* in plots within the eastern Giant Mts. is higher comparing the western area. Heather grows in three study sub-plots with 4th grade of the Bran-Blanquet's dominance scale and one sub-plot with 3rd grade. Heather as undergrowth inside of young dwarf pine shrubs was common in both parts of the Giant Mts. The highest heather vitality was documented in the shrub surroundings with radius of 50–75 cm. Increasing occurrence of heather was found to distance of 1 m from the nearest dwarf pine shrubs.

An analyse of the *C. vulgaris* vitality in 1996 has documented that the highest coverage of full healthy (flowering) heather (vitality class A) was found with distance from the nearest shrub more than 125 cm. It is possible to see increasing cover of dead (not flowering) class D with distance from pine shrubs to 75 cm (more than 60 %) during next years. The area increase of the class D (+25 % in 1997, +16 % in 1998) passed to the exclusion of classes A and E (heather overgrown by grass). There were several places of dead heather overgrown by *Deschampsia flexuosa* as change of the class D into E.

Very important increase of extension of dead heather was observed during short period of three years (Photo 4). There is a set of conditions influencing vitality changes by C. vulgaris. It is not only

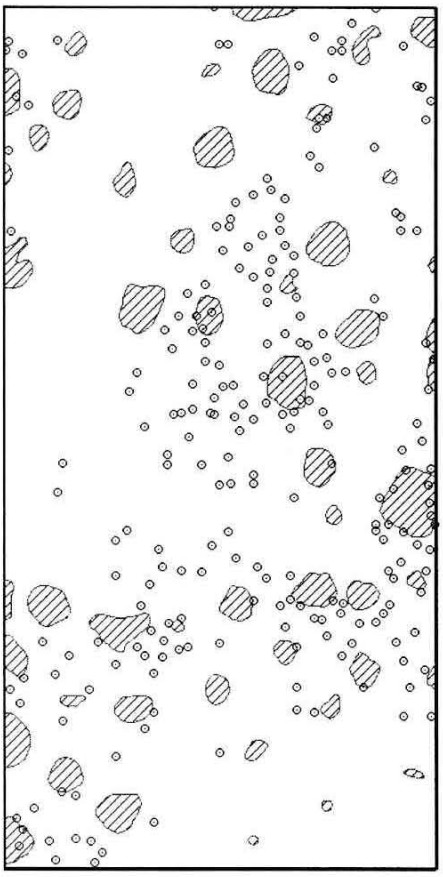


Fig. 5. Plot K3 with *Hieracium alpinum* agg. in 1999.

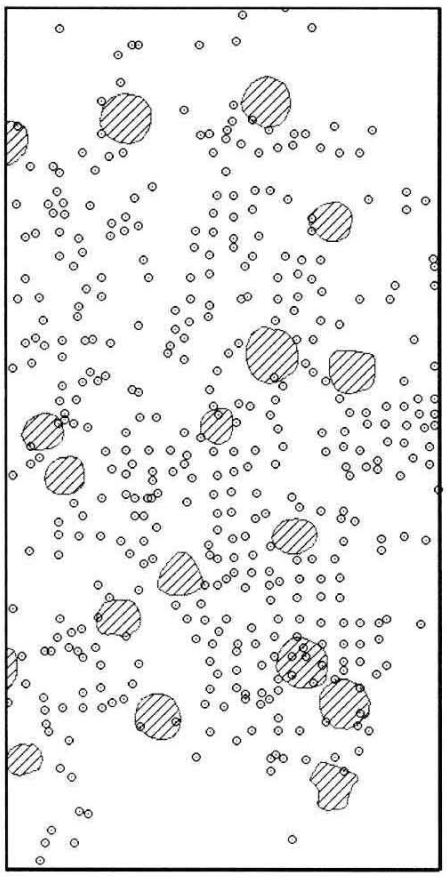


Fig. 6. Plot K4 with *Hieracium alpinum* agg. in 1999.

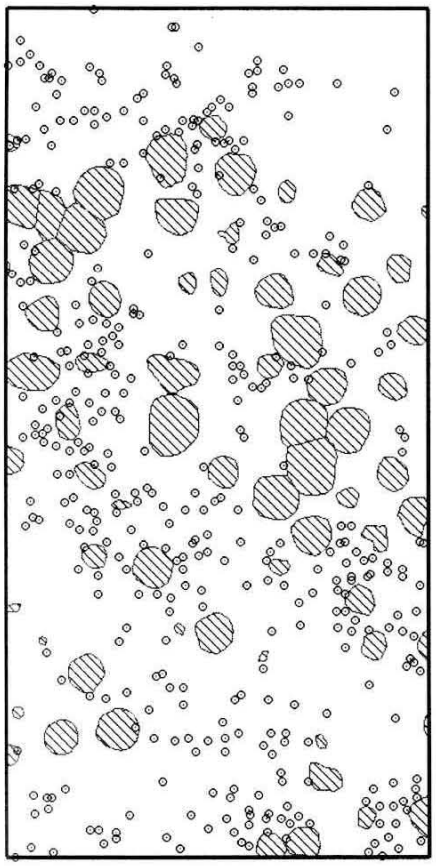


Fig. 7. Plot K5 with *Hieracium alpinum* agg. in 1999.

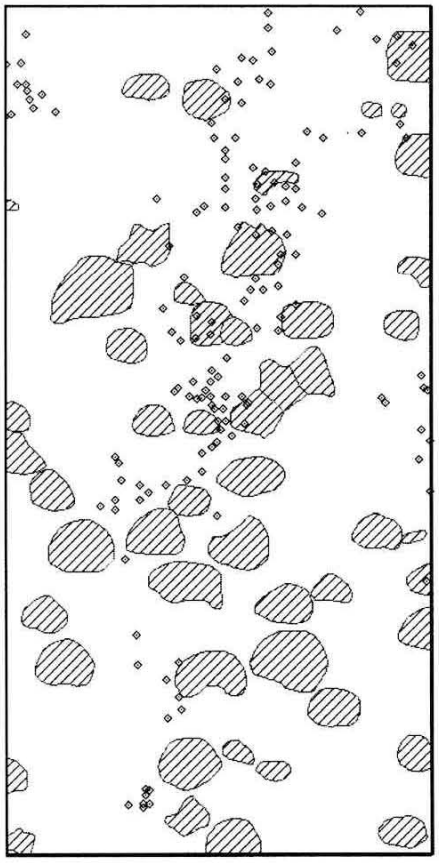


Fig. 8. Plot K6 with *Pulsatilla scherfelii* agg. in 1999.

microclimate influence of dwarf pine shrubs. The mesoclimate conditions can vary from year to year (temperature, precipitation, snow cover height and duration etc.; KOCIÁNOVÁ et al. 1995; SPUSTA 1995; HARČARIK et al. 2001). The species ontogenesis contains more complex facts (e.g. mycorrhiza; JAHODOVÁ 2001) and oscillations – it can be a topic of a further study (compare PAŠŤALKOVÁ et al. 2001).

Tab. 4. Development of total cover of planted dwarf pine in the plots Z1 – Z4 during 1996-98, and pine growth as mean of the relative shrub area increase. All values in per-cents.

Plot	Coverage 1996	Coverage 1997	Coverage 1998	Relative increase 1996–97	Relative increase 1997–98
Z1A	13,2	17,0	21,7	22,4	21,7
Z1B	6,5	10,2	11,5	36,3	11,3
Z2A	3,6	6,5	9,5	44,6	31,6
Z2B	46,0	49,0	52,6	6,1	6,8
Z3A	8,8	12,9	18,0	31,8	28,3
Z3B	8,0	11,7	16,0	31,6	26,9
Z4A	16,5	19,3	24,2	14,5	20,2
Z4B	13,2	17,4	23,3	24,1	25,3

Tab. 5. Development of total cover of planted dwarf pine in the plots K1 – K6 during 1997–2001, and pine growth as mean of the relative shrub area increase. All values in per-cents.

Plot	Coverage 1997	Coverage 1999	Coverage 2000	Coverage 2001	Relative increase 1997–99	Relative increase 1999–2000	Relative increase 2000–01
K1A	9	14	18	19	35	22	7
K1B	17	22	32	33	27	29	4
K2A	8	11	16	19	26	29	14
K2B	9	13	17	18	29	22	4
K3A	8	11	15	16	26	26	6
K3B	11	13	18	19	19	26	2
K4A	7	9	12	13	24	28	6
K4B	7	10	12	13	30	16	8
K5A	12	16	23	26	25	30	10
K5B	14	21	26	29	32	22	10
K6A	22	29	33	36	24	12	9
K6B	15	20	25	26	23	20	3

Tab. 6. Number of all plants, flowering and browsed plants of *Hieracium alpinum* agg. in the study plots. All values was calculated per plot area of 100 m^2.

plot	year	number of plants	flowering plants	browsed plants	flowering share [%]	browsed share [%]
K1	1997	955	278	105	19,16	11,05
K1	1999	786	100	10	12,78	1,34
K2	1997	1035	203	23	19,65	2,27
K2	1999	958	91	3	9,55	0,37
K3	1997	542	135	37	24,88	6,82
K3	1999	564	59	2	10,46	0,44
K4	1997	1687	408	131	24,18	7,79
K4	1999	1531	166	22	10,84	1,47
K5	1997	941	360	84	38,29	8,98
K5	1999	835	278	57	33,27	6,82
K4k	1997	510	121	65	23,73	12,75
K4k	1999	481	111	1	23,08	0,21
K5k	1997	1231	380	103	30,87	8,37
K5k	1999	1270	265	76	20,87	5,98

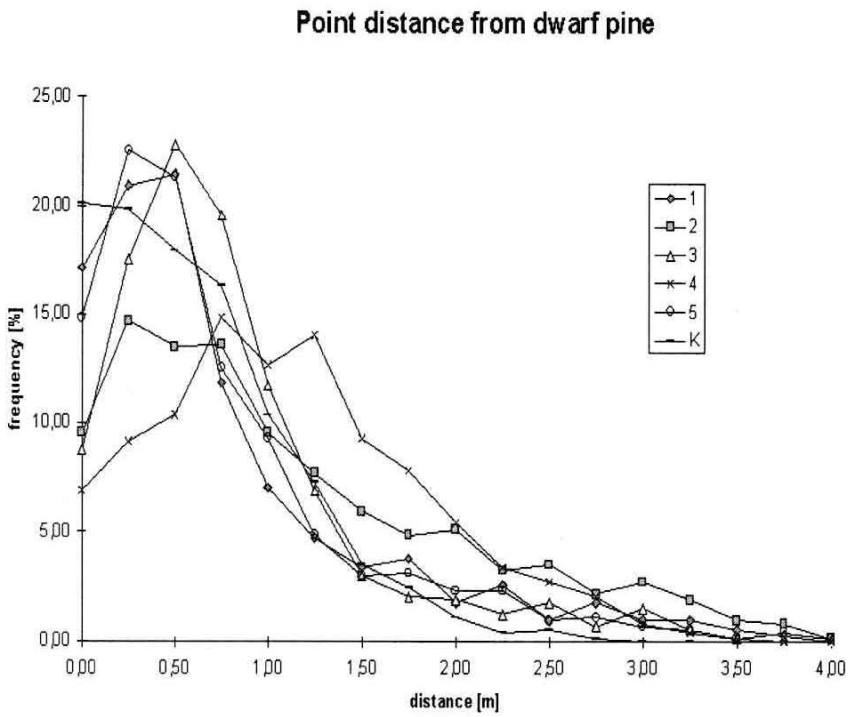


Fig. 9. Relative frequencies of distances of random point from the nearest dwarf pine shrub in the plots with *Hieracium alpinum* agg. – K1 – K5 (signed 1–5) and *Pulsatilla scherfelii* – K6 (K).

Tab. 7. χ^2-test of goodness of fit comparing occurrence point-pine (B), plant-pine (R), flowering plant-pine (K) and browsed plant-pine (O) distances with generated random point-pine distances within plots of the K series in 1999. Compared values are results of the χ^2-test: **bold** faced values significant at level α<0,1 %, insignificant values at level α = 5 % are written in *italics*. Number of degrees of freedom (n–2) is presented.

		n-2	B	R	K	O
K1	Hieracium	14	**65,1**	**444,9**	**85,2**	*12,2*
K2	Hieracium	14	31,8	**515,1**	**56,3**	*21,8*
K3	Hieracium	13	*14,2*	**130,6**	**67,9**	**119,3**
K4	Hieracium	13	*21,9*	**323,5**	**99,4**	26,6
K5	Hieracium	14	**73,6**	**345,5**	**151,2**	**83,2**
K6	Pulsatilla	10	**91,1**	**530,8**	**49,2**	

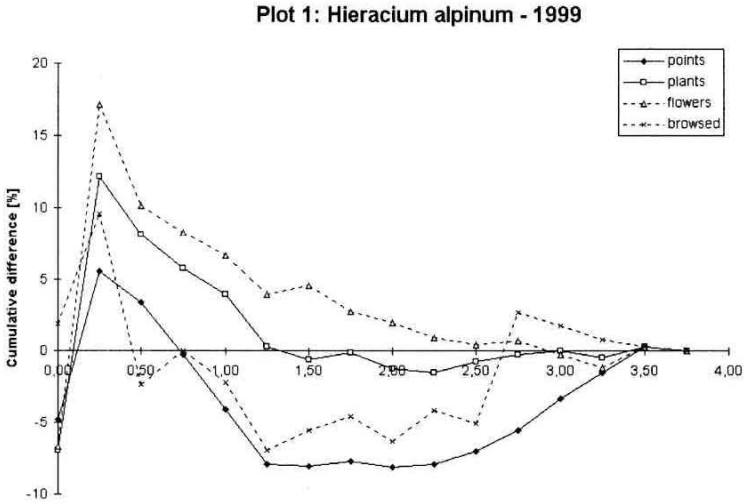


Fig. 9. Relative frequencies of distances of random point from the nearest dwarf pine shrub in the plots with *Hieracium alpinum* agg. - K1 - K5 (signed 1 - 5) and *Pulsatilla scherfelii* - K6 (K).

A

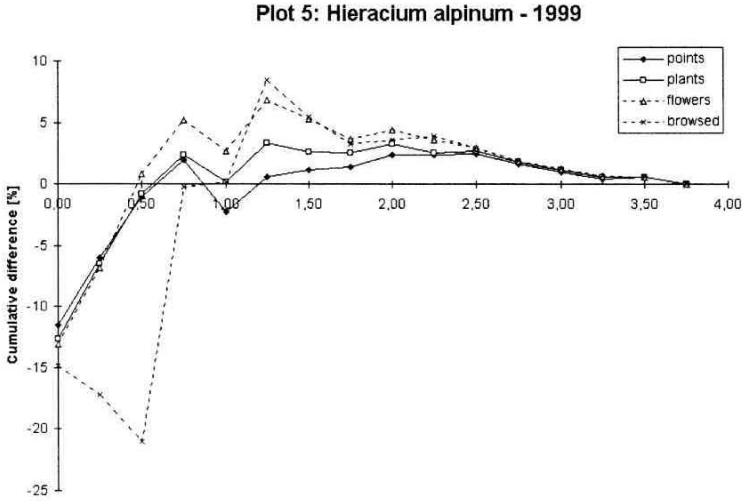
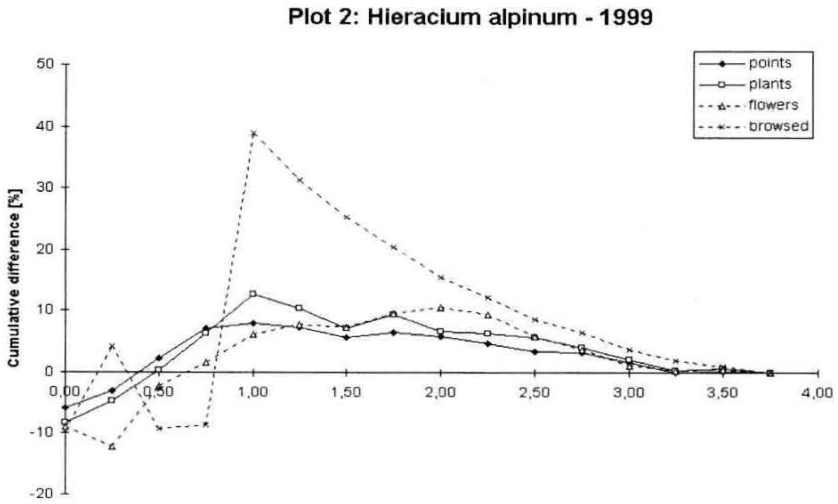
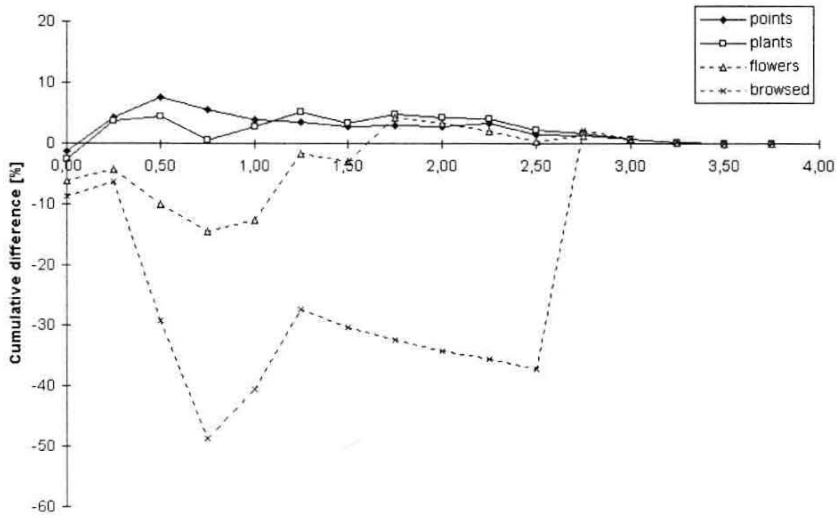


Fig. 10 (A-E). Relative cumulative difference in the frequency of occurrence points, plants, flowering plants (flowers) and browsed plants by *Hieracium alpinum* agg. in the plots K1 - K5. Horizontal axis - distance from the nearest dwarf pine shrub (in m). Significance of difference of a curve from the zero line was tested (see Table 7 for results)

B



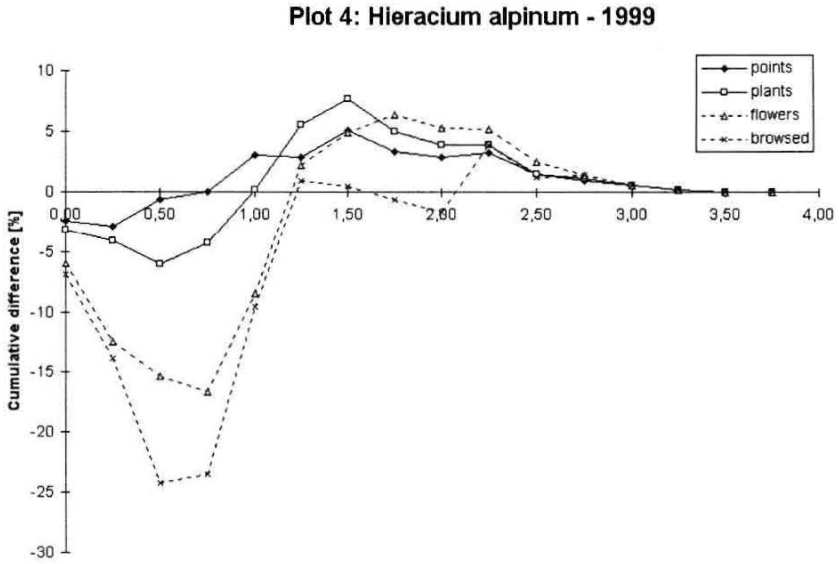
C



Tab. 8. Number of all plants and flowering plants of *Pulsatilla scherfelii* in the study plots. All values was calculated per plot area of 100 m².

plot	year	number of plants	flowering plants	flowering share [%]
K6	1999	416	26	6,25
K6k	1999	262	49	18,70

D



E

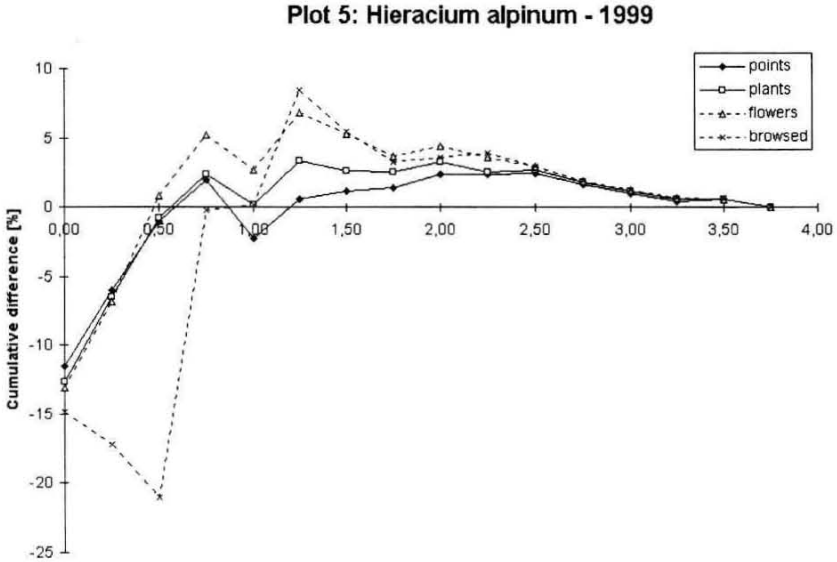


Fig. 10 (A-E). Relative cumulative difference in the frequency of occurrence points, plants, flowering plants (flowers) and browsed plants by *Hieracium alpinum* agg. in the plots K1 - K5. Horizontal axis - distance from the nearest dwarf pine shrub (in m). Significance of difference of a curve from the zero line was tested (see Table 7 for results).

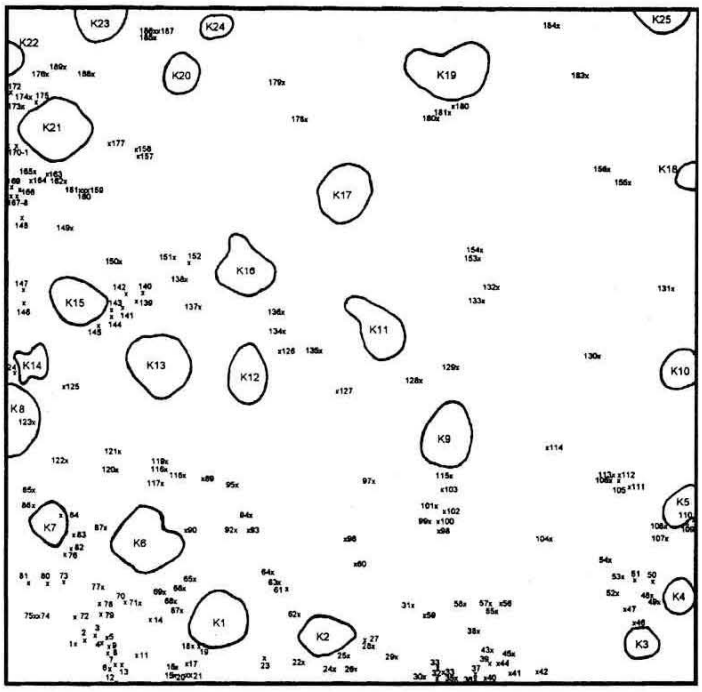


Fig. 11. Spatial arrangement of the *Pinus mugo* stand and *Hieracium alpinum* agg. within PRP Z3A (plot size 10 x 10 m). Polygons (K1– K25) – dwarf pine shrubs, points (1–189) – hawkweed plants (ZIKMUND 1999).

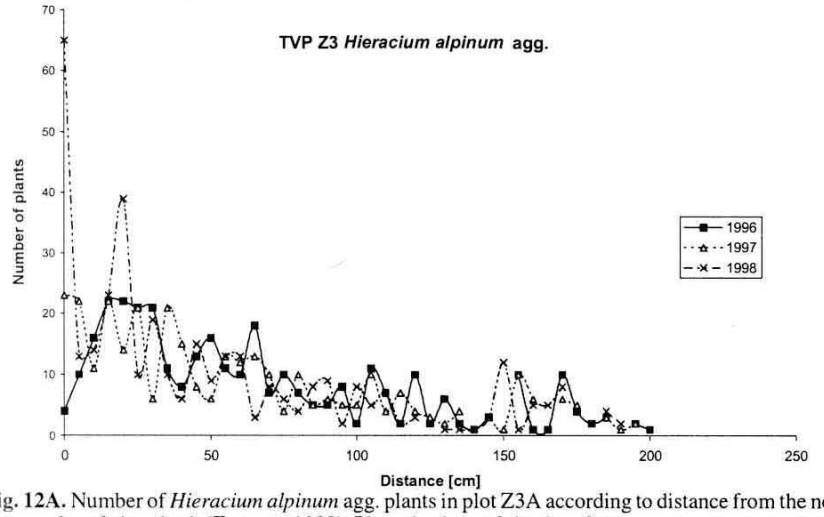


Fig. **12A.** Number of *Hieracium alpinum* agg. plants in plot Z3A according to distance from the nearest dwarf pine shrub (ZIKMUND 1999). Plotted values of absolute frequency are necessary to evaluate regarding to the frequency of positions with the same distance from shrubs.

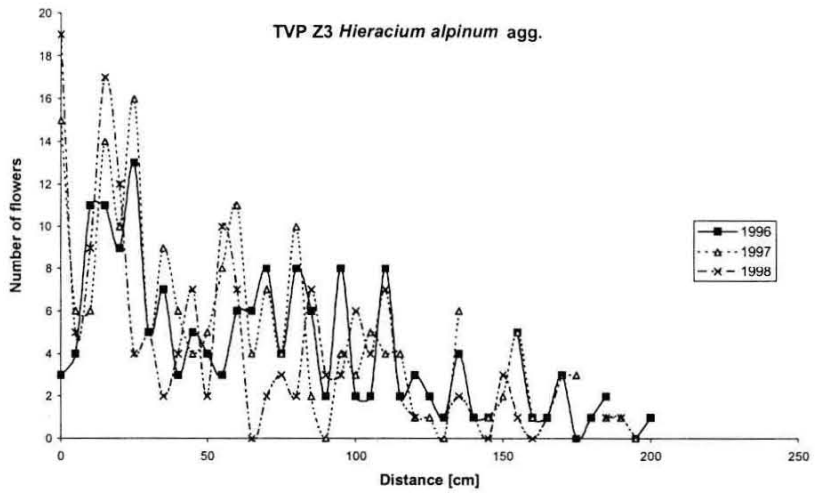


Fig. 12B. Number of *Hieracium alpinum* agg. flowers in plot Z3A according to distance from the nearest dwarf pine shrub (ZIKMUND 1999).

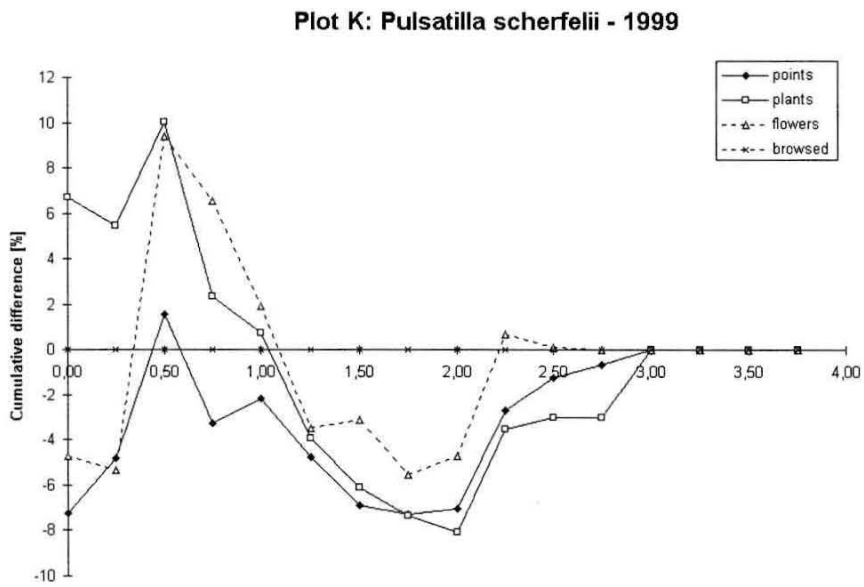


Fig. 13. Relative cumulative difference in the frequency of occurrence points, plants, flowering plants (flowers) and browsed plants by *Pulsatilla scherfelii* in the plot K6. Horizontal axis - distance from the nearest dwarf pine shrub (in m).

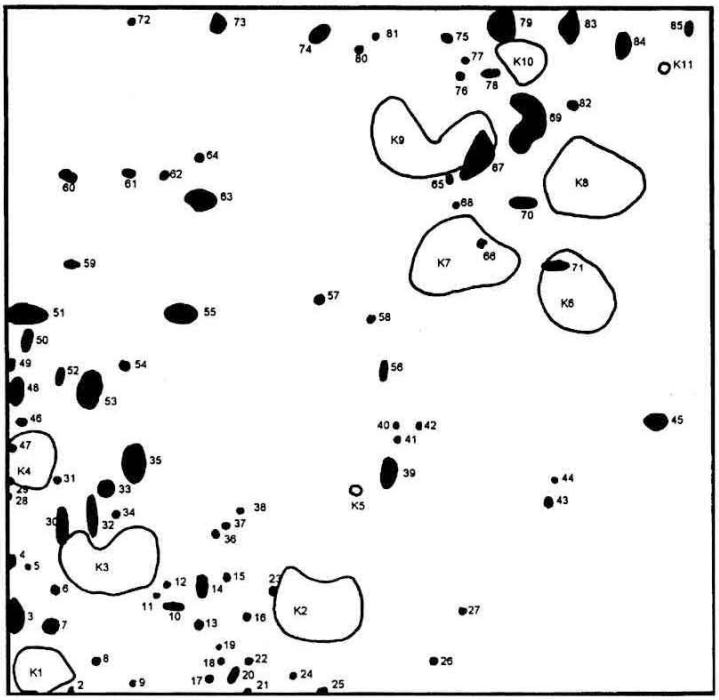


Fig. 14. Spatial arrangement of the *Pinus mugo* stand and *Pulsatilla scherfelii* within PRP Z1B (plot size 10 x 10 m). Empty polygons (K1–K10) – dwarf pine shrubs, black polygons (1–85) – pasque-flower plant clumps (ZIKMUND 1999).

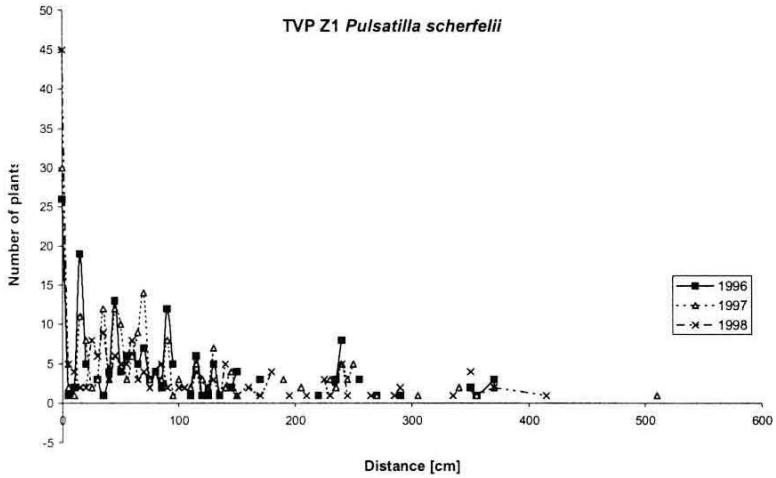


Fig. 15. Number of *Pulsatilla scherfelii* plants in plot Z1B according to distance from the nearest dwarf pine shrub (ZIKMUND 1999).

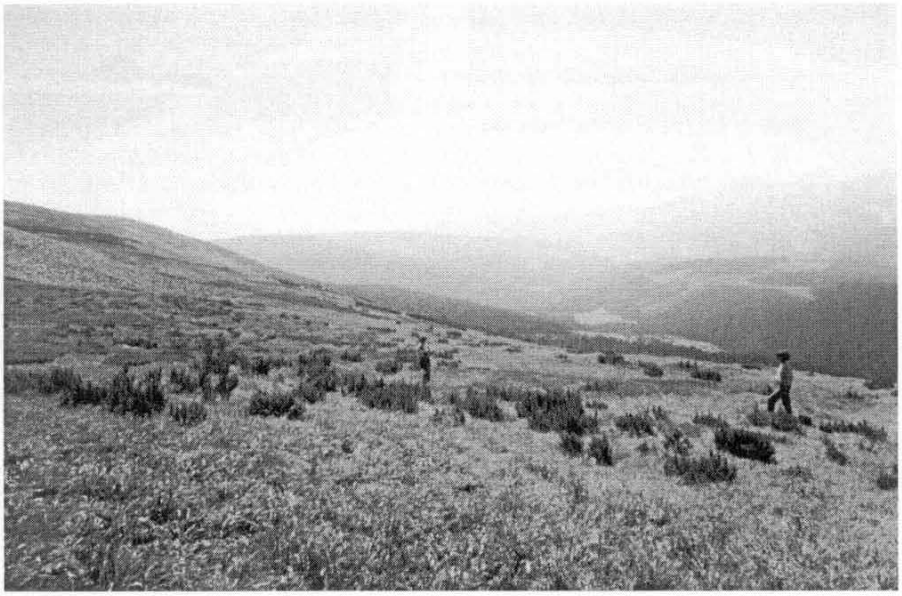


Photo 1. Plots K6 and Z1 in the area of locality Modrá stráň. Spatial relationship between dwarf pine and *Pulsatilla scherfelii* were monitored. (J. Málková)

Photo 2. Spatial relationships *Pinus mugo, Hieracium alpinum* agg. and *Calluna vulgaris* were studied in the plot Z3 (area of the Studniční hora). (J. Málková)

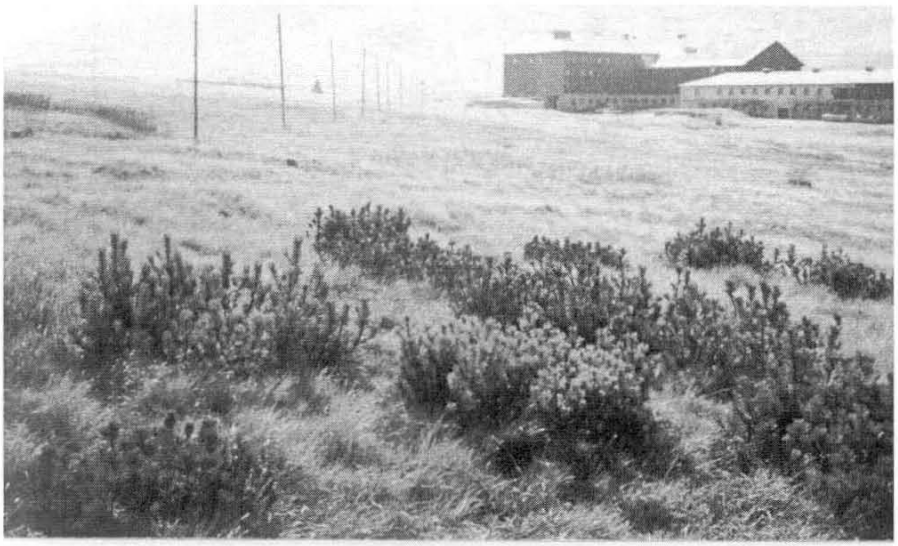


Photo 3. The young plantation of dwarf pine was died off in the plot of Stříbrné návrší in 1999. (J. Málková)

Photo 4. Heather dying off in the plot Z3 in the locality of Studniční hora. (J. Málková)

CONCLUSION

Frequencies and vitality were evaluated for several species – hawkweed (*Hieracium alpinum* agg.), pasque flower (*Pulsatilla scherfelii*), heather (*Calluna vulgaris*) and sedge (*Carex bigelowii*) with spatial relation to growing dwarf pine (*Pinus mugo*) shrubs. Evidence for ecotonal effect within surroundings of the pine shrubs with width about 60-100 cm (approximately equal to height of shrubs) was obtained. The effect is specific according to separate species (PAŠŤALKOVÁ et al., 2001). The ecotonal effect is significant by increase of vitality of hawkweed and pasque flower, particularly by increase of flowering intensity. The open dwarf pine canopy is a reason of this situation when that herb species grows under sufficient light condition with using favourable microclimate impact of dwarf pine shrubs. We can talk about a temporal ecological lee-effect. The pine surroundings show lower browsing by ungulate game. The study plots have more open dwarf pine stands with greater gaps compared with those in the western Giant Mts. (PAŠŤALKOVÁ et al., 2001).

On the base of obtained data, the size of gaps is insufficient for some heliophilous species (e.g. *Hieracium alpinum* agg., *Pulsatilla scherfelii, Hypochoeris uniflora, Arnica montana, Primula minima, Lycopodium clavatum, Diphasiastrum alpinum* subs. *complanatum*) from point of species survival. These plants do not grow inside of mature dwarf pine shrubs (MÁLKOVÁ, 2001).

The extent of vital *Calluna vulgaris* patches has decreased (especially in the locality of Stříbrné návrší).

Comparing PRP's with *P. mugo* stand and plots without pine plantation, more plants of *Hieracium alpinum* agg. and *Carex bigelowii* occur in the free plots. Possible differences of the community structure (see relevé classification) are necessary to take into account.

The young dwarf pine plantations grow relatively fast, consequently with decrease of size of free gaps. The average annual increase in shrub width is equal to 29 %. Decrease of cover or total extinction of heliophilous species (ELLENBERG et al. 1982) e.g. *Pulsatilla scherfelii, Hypochoeris uniflora, Hieracium alpinum* agg., *Arnica montana, Primula minima, Lycopodium clavatum, Diphasiastrum alpinum* are running as dwarf pine grows. The size of gaps is insufficient for survival species *Hieracium alpinum* agg. and *Pulsatilla scherfelii*.

Management of closed dwarf pine stands is necessary to guarantee a sufficient spacing of single pine shrubs for development of protected and endangered heliophilous species within gaps of satisfactory size.

SUMMARY

The relationship between an shrub species (*Pinus mugo*) and *Carex bigelowii, Hieracium alpinum* agg., *Pulsatilla scherfelii* and *Calluna vulgaris* was studied in the tundra ecosystems reforested by dwarf pine in eastern part of the Giant Mts. The young dwarf pine plantations grow relatively fast and become vital under favourable conditions. Annual increase in shrub width varies in range 12 to 35 % in stands of age to 35 years. Dwarf pine stands are relatively opened, size of the vacant gaps is sufficient for an original plant microcoenose development. Changes in the plant coenoses were described by the repeated relevés use. It was a way to describe decrease of cover and/or extinction of several plant species including some protected herbs during the period of the study.

Carex bigelowii is a species with low coverage under dwarf pine and in the nearest belt by the shrubs. Number of plants increased with the distance from the nearest pine shrub.

A light ecotonal effect by *Hieracium alpinum* agg. is shown within the dwarf pine periphery. It can be marked within a close belt – the species indicates an accumulation of individuals and flowering plants in the shrub surroundings. The highest number of plants occurs on places with distance of 25–100 cm from the nearest shrub. The maximal accumulation of flowers was within places of distance to 150 cm. The share of browsed plants increases gradually with distance from the nearest pine shrub. There are only a few plants as undergrowth in shrubs of dwarf pine.

There is an ecotonal effect within a radius of 50 cm from dwarf pine by *Pulsatilla scherfelii*. The species show a lower dependence of occurrence on the pine shrub-plant distance, nevertheless it is statistically significant. A low accumulation of plants with distance from shrubs to 1 m was visible. The highest number of flowers can be found in low dwarf pine stands with gaps or on a close peripheral belt of the pine shrubs. Number of browsed plants was higher in free plot comparing dwarf pine undergrowth.

Calluna vulgaris is a species often occurring together with young dwarf pine shrubs. The most vital heather grows in radius of 50–75 cm from pine shrubs. The highest coverage of flowering heather was on places with distance above 125 cm from shrubs.

It is suggested to adapt management of the dwarf pine stands with regards to the results: it is necessary to guarantee a sufficient free space (gaps) among individual shrubs of dwarf pine. The gaps enable development of shade (and other pine influences) intolerant species.

SOUHRN

Vztah mezi klečí horskou (*Pinus mugo*) a vybranými druhy bylinného patra po vysokohorském zalesňování v tundrových ekosystémech byl řešen ve východní části Krkonoš na katedře biologie Univerzity Hradec Králové. Na řešení se pod vedením a za spolupráce Málkové podíleli po dobu 3–6 let v rámci diplomových či doktorandských prací Krtičková (1999) a Zikmund (1999).

Ve východních Krkonoších bylo vytyčeno 10 trvalých výzkumných ploch 10 x 20 m (dále jen TVP), každá složená ze dvou subploch velikosti 10 x 10 m (vzájemně se dotýkají) ke sledování vlivu rozrůstající se kleče na vybrané druhy rostlin. Dále byly fixovány tři kontrolní plochy bez klečových porostů (velikost 10 x 10 m) pro porovnání kvalitativních a kvantitativních znaků růstu vybraných cévnatých rostlin (dále kontrola – k). Veškeré sledované TVP leží v arkto-alpinské tundře v I. zóně KRNAP. Většina ploch byla fixována na SZ a S úbočí Studniční hory (nejvýše leží v 1545 m n.m.). Nejjižněji se nachází TVP na Modré stráni (1480 m n.m.), nejseverněji jsou TVP na Stříbrném návrší (1400 m n.m.) – obr. 1. Písmenem Z jsou označeny čtverce, v nichž prováděl výzkum od roku 1996 Zikmund (1999), písmenem K plochy sledované od roku 1997 Krtičkovou (Krtičková 1999). Umístění ploch ve výsadbách kosodřeviny stáří do 35 let nebylo náhodné, ale muselo splňovat podmínku výskytu dostatečného počtu jedinců vybraných rostlinných taxonů, aby bylo možné výsledky jejich dynamiky statisticky zpracovat.

V trvalých výzkumných plochách (dále jen TVP) byl hodnocen vliv kleče na rostlinná společenstva subalpínských a alpínských poloh na základě opakovaných fytocenologických snímků, mikromapování a zejména studia horizontálního rozrůstání kleče a jeho vlivu na vybrané autochtonní druhy bylinného patra. V TVP byla monitorována vitalita, fertilita, početnost a pokryvnost i výška klečových porostů. U vybraných původních druhů *Hieracium alpinum* agg., *Pulsatilla scherfelii*, dále *Calluna vulgaris*, *Carex bigelowii* bylo přesně zakreslováno umístění, počet rostlin, květů a okousaných květů. Pro *Calluna vulgaris* byla vytvořena speciální stupnice na základě pokryvnosti a stupně kvetení.

Klasifikace fytocenologických snímků (obr. 2.) dokládá poměrně malé rozdíly mezi jednotlivými lokalitami resp. plochami/subplochami. Opakované fytocenologické snímky zachycují tab. 1–3.

Při hodnocení počtu a vitality jestřábníků, koniklece, vřesu a ostřice Bigelowovy ve vztahu k rozrůstajícím se mladým porostům kleče bylo zjištěno, že v okolí zkoumaných mladých výsadeb působí tzv. ekotonální efekt v šíři okolo 60–100 cm (přibližně odpovídal výšce kleče), přičemž vliv na jednotlivé druhy se projevuje specificky. Průkazné bylo positivní působení ekotonálního efektu na vitalitu jedinců jestřábníku a koniklece a zejména na intenzitu jejich kvetení. Důvodem je skutečnost, že vysázená kleč má dosud relativně nízký zápoj a studované druhy rostlin dosud netrpí nedostatkem světla, naopak využívají často příznivějšího mikroklimatu v závětří kleče. Lze tedy hovořit o dočasném efektu ekologického krytí. Sledované plochy měly oproti obdobným plochám ze západních Krkonoš (Pašťalková et al. 2001) podstatně rozvolněnější porost kleče s většími volnými plochami mezi jednotlivými keři. V blízkosti kleče byl také zjištěn nižší okus květů spárkatou zvěří.

Pro *Carex bigelowii* byla prokázána nízká pokryvnost v kleči a v její těsné blízkosti. Počet rostlin stoupal se vzdáleností od kleče.

Hieracium alpinum agg. (TVP Z3, K1 až K5 a dvě plochy kontrolní) jeví určitou kumulaci jedinců i květů v okolí kleče. Obr. 3.–7. znázorňují rozmístění keřů kleče a rostlin druhu *Hieracium alpinum* agg. v plochách K1–K5, prostorové uspořádání v ploše Z3A je na obr. 11. Nejvíce exemplářů bylo v intervalu 25–100 cm. Frekvence počtu náhodných bodů podle jejich vzdálenosti od nejbližšího keře kleče na plochách K1–K5 znázorňuje obr. 9. Kumulativní diference počtu bodů výskytu, počtu rostlin, květů a okousaných rostlin v závislosti na vzdálenosti od nejbližšího keře kleče na plochách K1–K5 je zobrazena na obr. 10. Obr. 12. znázorňuje počty jedinců a květů u *Hieracium alpinum* agg. v Z3A v závislosti na vzdálenosti od kleče. Největší kumulace květů byla do 150 cm od kleče. V kontrolách bylo více rostlin než na blízkých 12 TVP založených v nedalekých klečových porostech, tedy ve srovnatelných stanovištních podmínkách (tab. 6.). Tab. 7. zahrnuje statistickou významnost odchylky jednotlivých křivek od nulových hodnot diferencí (test dobré shody). Pod vlastní klečí roste jen nízký počet rostlin. Procento kvetení v kleči bylo sníženo. Závislost výskytu počtu jedinců i kvetoucích jedinců na vzdálenosti od kleče byla vysoce statisticky průkazná.

Pulsatilla scherfelii měl proti *H. alpinum* agg. nižší, přesto statisticky průkaznou závislost výskytu na vzdálenosti od kleče, patrná je mírná kumulace rostlin do 100 cm od kleče, maximum jedinců v intervalu 25–50 cm (obr. 13., 15.). Prostorové uspořádání keřů kleče a druhu *Pulsatilla scherfelii* v K6 zachycuje obr. 8. a v ploše Z1B obr. 14. Počty rostlin na studijních plochách K6 a K6k jsou v tab. 8.

Druh *Calluna vulgaris* byl proměřován ve třech plochách s hodnotami abundance a dominance 4, jednu plochu s hodnotou 3. Největší vitalita vřesu byla prokázána v průměru v intervalu 50–75 cm od kleče. Z hodnocení vitality *Calluna vulgaris* v roce 1996 vyplynulo, že největší pokryvnost zdravého (kvetoucího) vřesu (kategorie A) byla ve vzdálenosti nad 125 cm od kleče. V následujících letech lze pozorovat zvětšující se pokryvnost odumřelé kategorie D (do 75 cm od kleče více než 60 %), tedy během krátké časové periody tří sezón bylo zjištěno výrazné zvýšení pokryvnosti odumřelého vřesu.

Mladé výsadby kleče se poměrně intensivně rozrůstají (v průměru o 29 % za rok) a zmenšuje se velikost volných ploch mezi keři kleče. Přírůstky vysázené kleče v TVP východních Krkonoš jsou v tab. 4. a 5. S rozrůstáním *P. mugo* dochází k úbytku heliofilních druhů (např. *Pulsatilla scherfelii*, *Hypochoeris uniflora*, *Hieracium alpinum* agg., *Arnica montana*, *Primula minima*, *Lycopodium clavatum*, *Diphasiastrum alpinum*) a při dalším vzrůstu zápoje kleče může dojít až k úplnému vymizení těchto druhů. Pro tyto druhy jsou některé volné plochy již nedostatečné vzhledem k možnosti jejich přežití. Pod vzrostlou zapojenou klečí tyto taxony nebyly již nalézány (viz fytocenologické snímky PAŠŤALKOVÁ et al. 2001).

Při managementu plně zapojených klečových porostů je potřebné především zajistit dostatečný odstup jednotlivých keřů tak, aby volné plochy umožňovaly zdárný vývin chráněných a ohrožených druhů, které jsou většinou heliofilní.

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