INFLUENCE OF MICRORELIEF AND DOMINANT SPECIES ON THICKNESS OF HUMUS LAYERS ON SELECTED PLOTS IN NP ŠUMAVA[*]

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This study describes character of humus layers in Modrava and Plechý areas (Šumava Mts.), especially thickness of humus layers in relation to microhabitat conditions, in particular dominant species and microrelief types. The research was carried out on six permanent research plots; three of them are located in Forest District Modrava and three in Forest District Plechý. Influence of mentioned factors was assigned using the analysis of variance and multiple comparison. Our data suggest that statistically important differences between individual humus layers can be only rarely confirmed – our data shows large variability.

humus layers; microhabitat; mountain forests; Norway spruce

INTRODUCTION

The surface humus component represents an important element of the organic matter dynamics, as well as of the nutrient cycle and energy flow (Podrázský, 2006). Character of humus forms has significant impact on the nutrient cycle, humidity and temperature (Green et al., 1993). The humus layers compose the base for root system thereby determining the seedlings quality. In general the bare surface humus layers seem to be very important factor for appearance and quality of seedlings (Kozlowski, 2002), but this factor could not be only positive, like results of Hunziger and Brang (2005), but also negative in decreasing numbers of seedlings in comparison to other microsite types (Šerá et al., 2000). The surface humus evaluation based on visual assessment seems to be good indicator to predict the stand character. Similar results give Ponge and Chevalier (2006). Their study describes e.g. Humus Index (based on the classification of humus forms) that proved to be significantly correlated with some important ecological parameters of forest ecosystems such as topsoil physical and chemical properties and plant and soil animal communities.

The influence of gap creation on the formation of humus layer has been intensively studied and well understood in ecosystems dominated mainly by beech (Muys et al., 1988; Podrázský, Vieweg h, 2005; Pontallier et al., 1997). In mountain spruce ecosystems often driven by large developmental cycle with destruction of woody compartments on larger areas, characteristics of humus layers may differ significantly. Except these changes the formation of surface humus is influenced by many factors related to microsite. Two of them are described in this study – ground vegetation cover and microrelief. The aim of this study is to evaluate the character of surface humus layers on specific plots in Modrava and Plechý area in Šumava Mts. The main research question was how do selected microsite conditions (dominant species of ground vegetation cover, microrelief) determine the thickness of humus layers. Further we tried to evaluate methodology for assessment of microrelief characteristic in the scale of whole research plot.

MATERIAL AND METHODS

Permanent research plots (PRP) are located in Modrava and Plechý area in National Park Šumava. The altitude varies from 1120 to 1370 m a.s.l., precipitation varies between 900 – 1380 mm per year and average annual temperature is 3.5–5 °C. Three PRP are located in Modrava area (labeled Mo 1, Mo 3, Mo 4), another three PRP are located in Plechý area (labeled Pl 18, Pl 19, Pl 20). The first three PRP represent three different site and stand conditions: Mo 1 – stand on expressed slope with living woody compartment, Mo 4 – mature stand disrupted by bark beetle on flat area, Mo 3 – adjacent stand with living woody compartment. PRP in the Plechý area are established in altitudinal gradient from 1200 m to 1350 m a.s.l. (Pl 18 in the lowest and Pl 20 in the highest position) in predominantly vital stands with limited bark beetle attack. Main plant species under growing stands are: *Vaccinium myrtillus*, *Calamagrostis villosa*, *Avenella flexuosa* and *Athyrium distentifolium*. They are followed by *Trientalis*

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europea, *Homogyne alpina*, *Oxalis acetosella*, *Lycopodium annotinum* and *Maianthemum bifolium*. Plant society under stands disrupted by bark beetle is dominated by *Chamaerion angustifolium*. Dominant moss species in stands in higher altitude are *Polytrichum formosum, Dicranum scoparium a Sphagnum sp*. The dominant soil type is podzol with humus form mor. The detailed description of PRPs is given in Table 1.

The investigation was carried out on transects 50m long and 5m wide oriented down the slope or parallel to the border of the stand in flat areas. In regular matrix always two sample plots (SP) on one running meter were established (100 SP per transect). For each SP we reported the type (shape) of microrelief (elevation, depression, slope, flat) and the dominant species of the ground vegetation cover (blueberries, moss, ferns, grass, no vegetation). On each SP also the depth of humus layers L, F, H was measured (according to Němeček, 2001). SPs, where the parent rock was reaching the surface of the soil, were not involved in the evaluation (abount 10% of established SPs on each transect). Microrelief types were specified by relative change of the surface height along the circle (radius $r = 50$ cm) around the middle of the SP. As relevant bound was taken the relative change of at least 5 cm on more than one half of the circle.

Further we tried to propose methodology for assessment of microrelief characteristic in the scale of whole research plot by evaluating Index of Relief Variability (IRV). This was developed for the assessment of the microrelief variability on particular transects. The index takes values from 0 to 1 such describing the distribution of particular microrelief types on each transect. The highest value of IRV (IRV = 1) means the equable distribution of microrelief types. The lowest value (IRV = 0) indicates the presence of only one microrelief type within transect (practically it can be only the flat or the slope) type.

Index of Relief Variability is defined as follows:

$$IRV = \frac{1}{\sqrt{a^2 + b^2 + c^2 + d^2}} - 1$$

Where: a, b, c, d – area proportions of each microrelief type, $\sum (a, b, c, d) = 1$

The dependent variable (thickness of humus horizons) was distributed normally. Leven's test of homogeneity of variance showed that the variances of the dependent variables are approximately equal in microrelief and dominant species types. Further One-Way ANOVA was used searching for differences within microreliefs and dominant species types. For multiple comparison between data sets we used the Tukey method. For all analyses, results were considered significant when $P \leq 0.05$.

RESULTS AND DISCUSSION

Thickness of aboveground humus horizons

The average thickness of aboveground humus horizons in relation to microrelief and dominant species describe Table 2 and 3. The average values of the thickness of total humus layer in microrelief and dominant species types ranged from 9.4 cm (PL 18, elevation) to 37.7 cm (Mo 1, depression) and from 11.5 cm (Mo 4, grass) to 26.7 cm (Mo 1, blueberries) respectively.

The highest values are reached in depressions and on sample plots with the dominance of ferns, on the contrary the lowest values are reached on elevations and on plots with the dominance of grasses. The average thickness of the L horizon on particular PRPs ranged from 2.0 to 9.6 cm, of the F horizon from 1.4 to 6.3 cm and of H horizon from 3.6 to 22.5 cm in relation to microsite conditions. The average thickness of the L horizon is 4.5 cm, of F horizon 3.9 cm and of the H horizon 9.9 cm. Even on particular plots within the same microsite type high variability of data distribution was observed. These results correspond with research conduced by Svoboda (2003) in the locality Trojmezná, where the thickness of particular humus horizons L, F, H reached following values: 0.0–1.5 cm (L), 5.0–15.5 cm (F) and 5.5–25.0 cm (H). Even here the author stated high variability of the thickness of total humus horizons in relation to microsite conditions. Differences between particular PRPs are not significant. The highest difference was expected on PRP Mo 4 where the tree layer was heavily disintegrated already in 1996; nowadays the PRP and surrounding area are without living shelterwood. Other PRP are covered by mature stands with stocking reaching values at least 0.6. Even more than one decade of development under the declined forest stand did not result in significant changes in thickness of aboveground humus horizons. This observation is in accordance with the research conduced by Svoboda and Podrázský (2005) in the near locality Smrčiny, where no significant difference between thickness of humus layers under living and dead mature stand

Table 1. Identification and basic description of permanent research plots (source: Vacek, Krejčí et al., 2009)

PRP	Stand	Forest type	Altitude	Exposition	Age (2009)	Characteristic
Mo 1	68B4	8Y1	1140	E 60°	144	vital, frequent bark beetle attack
Mo 3	68A7	8K7	1120	flat	148	vital, occasional bark beetle attack
Mo 4	68B	8K7	1120	flat	lastly130 (1996)	declined
Pl 18	4A6/2/1	1S1	1245	SE 25°	203	vital, frequent bark beetle attack
Pl 19	5A3/1	8Y1	1313	SE 40°	163	vital, occasional bark beetle attack
Pl 20	5A3/1	8N1	1361	flat	163	vital, occasional bark beetle attack

was stated several years after stand decline. On the other hand after longer development decades in mountain spruce stands, changes of the quality of top-soils as reaction on changes of stand density (including complete disruption of woody compartment) are to be expected (cf. Podrázský et al., 2005). Similar results give Nilsen and Strand (2008): the differences in the litter fall between stands with low and height biomass density (after 30 years) were small and not significant – there were only a tendency towards this. Decrease of aboveground humus store due to thinning after 30 years development showed also Podrázský et al. (2005). Also tending in spruce stands resulted in faster decomposition of soil humus and its lower accumulation mainly in H horizons.

Relief variability

Table 4 gives general overview of microrelief types and the values of Index of Relief Variability (IRV). The relative cover of particular microrelief types varies significantly. The highest ratio reached the slope, followed by flat type, depression and elevation.

On PRP Pl 18 and Mo 3 with lowest value of IRV flats and slopes were highly represented. On the contrary on PRP Pl 20 and Mo 4 with highest values of IRV all microrelief types were represented equally. IRV represents easy methodology for assessment of microrelief characteristic which can be used as an indicator to predict some other stand parameters e.g. natural regeneration can be essentially influenced by character of microrelief (Ilisson et al., 2007; Hanssen, 2002; Kuuluvainen, Kalmari, 2003; Diaci et al., 2005), thus IRV seems to be one of useful indicators to predict regeneration pattern.

The influence of microsite and dominant species types on the thickness of humus horizons

Table 5 gives general overview of significance levels as result of comparison of data sets within microrelief and dominant species types. Table 6 shows detailed results of multiple comparing, where One-Way ANOVA showed significant differences between microsites. In two cases (PRP Pl 19 in horizon H and Mo 4 in horizon L) the Tukey test of multiple comparison did not revealed specific pairs of microsites with significant differences.

Table 2. Average thickness of humus layer in relation to microrelief

PRP	Elevation				Depression				Slope				Flat			
	L	F	H	Total	L	F	H	Total	L	F	H	Total	L	F	H	Total
Mo 1	2.6	2.2	12.0	16.8	9.6	5.6	22.5	37.7	4.0	5.3	10.3	19.6	5.3	4.3	13.9	23.5
Mo 3	3.6	3.2	6.4	13.2	2.1	2.7	5.5	10.3	3.6	4.1	10.0	17.7	3.1	3.9	8.9	15.9
Mo 4	3.0	2.1	4.9	10.0	3.6	2.9	7.1	13.6	5.0	3.1	4.6	12.6	4.6	3.0	7.8	15.4
Pl 18	4.4	1.4	3.6	9.4	2.0	3.7	4.3	10.0	5.8	3.6	7.2	16.7	5.0	3.2	5.4	13.6
Pl 19	3.9	4.1	5.7	13.7	6.9	4.5	12.2	23.6	4.1	3.3	12.1	19.5	3.6	4.0	18.4	26.0
Pl 20	6.3	4.0	11.7	22.0	4.6	3.4	14.6	22.6	4.6	2.7	11.6	18.9	4.7	3.3	10.2	18.2

Table 3. Average thickness of total humus horizons in relation to dominant species

PRP	Blueberries				Moss				Ferns				Grass				No vegetation			
	L	F	H	Total	L	F	H	Total	L	F	H	Total	L	F	H	Total	L	F	H	Total
Mo 1	3.5	3.7	19.5	26.7	4.4	5.4	8.4	18.2	X	X	X	X	X	X	X	X	6.5	4.3	14.9	25.8
Mo 3	3.6	3.8	9.3	16.7	3.7	3.9	6.9	14.5	X	X	X	X	3.5	4.0	10.5	18.0	2.8	4.2	8.9	15.9
Mo 4	4.2	3.1	7.8	15.1	4.0	3.0	12.4	19.4	X	X	X	X	4.1	2.5	5.0	11.5	4.7	3.4	5.2	13.3
Pl 18	4.5	4.5	6.6	15.5	2.0	2.0	6.6	10.6	6.3	6.3	5.4	17.9	5.0	5.0	5.0	15.0	6.0	6.0	7.7	19.7
Pl 19	3.8	3.5	9.7	17.1	6.9	4.5	10.0	21.4	X	X	X	X	X	X	X	X	X	X	X	X
Pl 20	6.1	4.5	13.2	23.8	3.0	4.0	12.0	19.0	5.0	4.5	15.7	25.2	4.1	2.5	9.2	15.8	4.8	3.8	12.6	21.2

Table 4. Percentual representation of particular microrelief types and the values of Index of Relief Variability (IRV)

PRP	Plot cover (%)				IRV
	Depression	Elevation	Flat	Slope	
Pl 18	4	3	21	72	0.33
Mo 3	7	9	48	36	0.64
Mo 1	25	6	19	50	0.69
Pl 19	36	12	13	39	0.79
Pl 20	27	14	39	20	0.87
Mo 4	24	19	33	24	0.96

Table 5. Significance levels *P* of One-Way ANOVA – significance lower than 0.05 shows significant differences in thickness of humus layers (in bold)

PRP	Significance level *P*					
	Dominant species types			Microrelief types		
	Horizon					
	L	F	H	L	F	H
Mo 1	0.324	0.879	**0.048**	**0.043**	0.694	0.101
Mo 3	**0.006**	**0.01**	0.517	0.104	0.219	0.141
Mo 4	0.851	0.426	**0.001**	**0.031**	0.562	0.192
Pl 18	**0.025**	0.107	0.289	0.143	0.384	0.189
Pl 19	0.104	0.399	**0.013**	0.139	0.739	0.084
Pl 20	0.114	**0.011**	0.067	0.902	0.428	0.359

Table 6. Pairs of microsites with significant differences in thickness of humus horizons (for values see also Table 2 and 3)

PRP	Pairs of microsites					
	Dominant species types			Microrelief types		
	Horizon					
	L	F	H	L	F	H
Mo 1	x	x	v–m	d–e	x	x
Mo 3	g–v, g–m	g–v, g–m, g–n	x	x	x	x
Mo 4	x	x	g–m, n–m	x	x	x
Pl 18	f–m, n–m	x	x	x	x	x
Pl 19	x	x	x	x	x	x
Pl 20	x	f–g	x	x	x	x

Legend: v – *Vaccinium myrtillus*, m – moss, g – grass, n – no vegetation, f – ferns, d –depression, e – elevation, x – no differences

Significant difference in thicknesses of humus horizons in relation to microrelief was stated only on elevations and depressions on PRP Mo 1 in L horizon; probably due to mechanical accumulation of litter in depressions. In relation to the dominant species significant differences in thickness of humus horizons were more frequent (Table 6). Nevertheless, generally high level of variability does not allow concrete conclusions about the influence of particular microsite and dominant species types on the formation of aboveground humus horizons. Thus, the influence of ground vegetation and microrelief on the thickness of humus horizons could be stated only partially. Especially evident is the difference between humus layers under grasses and other vegetation types, but it does not provide the definite result – the litter layer in grass seems to be thinner than in the other types, but this is not the rule.

CONCLUSION

It can be generally stated that the microsite and dominant species of ground vegetation cover play a crucial role in the formation of humus layers (Table 2 and 3), but still more knowledge about other factors is needed in order to predict the future development of top-soils. Designed analyze of microrelief variability can become useful tool in interpretation of selected stand characteristics (mainly of natural regeneration patterns in mountain spruce stands) nonetheless this approach requires further verification on different site and forest stand conditions.

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Vliv mikrostanoviště na tloušťku humusových vrstev na vybraných plochách v NP Šumava.

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Práce se zabývá vlivem mikrostanoviště, konkrétně tvaru mikroreliéfu a dominanty bylinného patra na mocnost humusových horizontů v NP Šumava. Dále byla vytvořena metoda pro hodnocení charakteru plochy z hlediska mikroreliéfu, která může sloužit k predikci a interpretaci některých dalších stanovištních charakteristik (např. úspěšnost přirozeného zmlazení).

Výzkum byl proveden na šesti trvalých výzkumných plochách (dále jen TVP) – TVP 1, 3, 4 v oblasti Modravy a TVP 18, 19, 20 v oblasti Plechého. Vliv výše uvedených faktorů byl zkoumán pomocí analýzy rozptylu a metodou mnohonásobného porovnání (Tukeyova metoda). Mezi různými typy mikroreliéfu byl prokázán významný rozdíl pouze na TVP 1, a to v horizontu L mezi prohlubněmi a vyvýšeninami. Vliv dominanty bylinného patra se ukázal jako významnější, rozdíly zde byly prokázány častěji, přesto však výsledky nedovolují učinit jednoznačný závěr. Nejvíce rozdílů bylo prokázáno na TVP 3, a to mezi travinami a ostatními typy dominant. Data vykazují značnou variabilitu a absolutní hodnoty celkových mocností dosahují velikých rozdílů mezi maximem a minimem (0,5–64 cm). Celková mocnost humusových horizontů na jednotlivých plochách a v jednotlivých typech mikrostanoviště se pohybuje v rozpětí od 9,4 do 37,7 cm. Mocnosti humusových horizontů dosahují nejvyšších hodnot v depresích a na ploškách s dominancí kapradin, nejmenších naopak na vyvýšeninách a na ploškách s dominancí trav. Na základě vyhodnocení mocností jednotlivých humusových horizontů a analýz jejich rozptylů lze s vysokou pravděpodobností konstatovat, že vliv dominanty bylinného patra i mikroreliéfu je sice významným činitelem spoluurčujícím mocnost humusových horizontů, ale predikovat mocnost humusových vrstev pouze na základě typu dominanty a mikroreliéfu s potřebnou mírou jistoty nelze.

humusové vrstvy; mikrostanoviště; horské lesy; smrk ztepilý

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