SOIL EROSION AND PLANT SUCCESSION AT CLEAR-CUT AREAS IN THE JIZERA MOUNTAINS, CZECH REPUBLIC

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Abstract

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Plant vegetation plays an important role in the protection of hillslopes exposed to overland flow and soil erosion. After the clear-cut of mature spruce stands in the Jizerka experimental catchment (the Jizera Mts, North Bohemia), the significant rill erosion was found namely in skid-roads originated by skidding the harvested timber. Significant loss of soil was related to the length of erosion rills.

The relationship between vegetation characteristics (plant cover, species richness, percentage of plants representing particular life and growth forms), and attributes of erosion rills (age, depth, and slope) was studied.

Positive effect of rill age on species diversity was found, but the main factor affecting plant cover and species richness is erosion intensity (the depth of erosion rill). We conclude that rising erosion intensity causes: lower percentage cover of vegetation, lower species richness, lower proportion of hemicryptophytes, and higher proportion of plants forming clusters or bunches, which may form 100% of plant species present.

Key words: forest harvest, skid-roads, rill erosion, plant succession, species richness, plant cover, catchment hydrology, Jizerské hory Mts

Introduction

Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. Berger and Iams (1996) reported that human activities have degraded some 15% (2000 million ha) of the Earth's land surface between latitudes 72° N and 57° S. Traditionally, the soil cover endangered by water erosion has been related to agriculture activities (Pasák, 1984), while forests are generally considered as an effective land-use to control both erosion and sedimentation (Shaw, 1991). However, in the last decades, the intensive forest harvest has already caused an important soil loss in several mountain regions of the world (Goudie, 2000; Price, Butt, 2000).

The Protected Headwater Area of the Jizera Mts was proclaimed in 1978 to support benefits of local mountain catchments in the conservation of soil and water. Unfortunately, in the 1980s, headwater basins of the Jizera Mts were deteriorated by consequences of the acid atmospheric deposition (acidification of both terrestrial and aquatic ecosystems, defoliation, die-back of spruce plantations), and commercial forestry practices (planting spruce stands of low ecological stability, non-effective control of insect epidemics, extensive clear-cut, use of heavy machinery, skidding timber by wheeled tractors, and difficult reforestation). Forest plantations of Norway spruce (*Picea abies*) have been replaced by large areas overgrown by the communities *Junco effusi-Calamagrostietum villosae* (Sýkora, 1983) dominated by the invasive grass *Calamagrostis villosa*, very competitive in the process of reforestation.

Since 1982, the processes of overland flow, soil erosion and sedimentation were studied in the Jizerka experimental catchment (Křeček, Pretl, 1992). In 1984–1988, the basin was affected by a massive clearcut of mature spruce stands. The heavy mechanization deteriorated directly about 10% of the soil surface. Skidding the timber (wheeled tractors) enlarged the density of existing network of skidroads and periodical drainage from 1.3 to 4.7 km/km^2.

The main aim of this study is to evaluate the role of plant vegetation in the protection of exposed cleared slopes in the Jizera Mts. The study focused namely on changes of plant vegetation with the morphology of erosion rills (cross section, depth and slope), and on the impact of rill age on the spontaneous succession.

Methods

Since 1982, the erosion processes were studied in the highest part of the Jizera Mts: in the Jizerka experimental catchment (area of 1.0 km^2, 860 to 980 m a.s.l.), and over the adjacent slope to the Souš reservoir (area of 0.5 km^2, 880–980m a.s.l.). In both sites, *Junco effusi-Calamagrostietum villosae* with a dominant grass *Calamagrostis villosa* spreads fast over the clearcut areas.

Erosion and sedimentation was monitored in the catchment scale (area of 1.0 km^2 instrumented by climate station, four standard raingauges, V-notch weir and sedimentation pond) as well as on two unit run-off plots (30x30 m, homogeneous slope of 10 and 20^o). The model WEPP (USDA-ARS, 2005) were applied to predict the soil erosion at the disturbed sites.

In 1992, 1995, 1996, 2002, and 2003, the detailed botanical inventory was carried out in the field. Phytosociological relevès (4x4m each) were taken. To include the impact of all species abundance, the data were transformed from Braun-Blanquet scale to 9-point scale according to van der Maarel (1979).

For each relevè, the following data were listed:

- Year of logging,
- Slope criteria (less than 5^o, 5–10^o, more than 10^o),
- Depth of erosion rills, classified into three cattegories: shallow (under 25 cm), middle (25–50 cm), deep (more than 50 cm).

The corresponding data were collected at stands representing clearings and forest dieback. In total, 53 relevès of deep rills, 33 of middle rills, 38 of shallow rills, 15 of dead forests, and 17 of clearings, were collected.

Within each group of investigated stands, following characteristics were evaluated using data on higher plants only:

- Percentage cover of herb layer,
- Species richness (total species number per relevè),
- Life forms by Raunkiaer (Raunkiaer, 1934, according to Ellenberg, 1979):
  - hemicryptophytes (Hkf),
  - chamaephytes (Chf),
  - geophytes (Gf),
  - therophytes (Tf),
  - phanerophytes (Ff).
- Growth types:
  - plants forming above and/or underground tillers,
  - plants with simple stems or forming clusters or bunches.

The statistical approach of ANOVA was used to test the differences in above mentioned vegetation features among the groups of particular stand and age. Then correlations among these characteristics were studied, and regression of particular variables with the age of rills determined. CANOCO (Ter Braak, 1988) was used to analyse the relations among stand and plant demands for the environmental characteristics (RDA analysis). The nomenclature of plant taxa follows Rothmaler (1982).

Results

Erosion and sedimentation

The model WEPP ((USDA-ARS, 2005) simulated processes of soil erosion and sedimentation on the disturbed S-shape hillslope at Jizerka (Fig. 1). Thus, the scenario of forest dieback, degradation and disturbance by logging operations produced erosion up to 3.9 t/ha (in the upper segment of 975 m) and sedimentation of 1.9 t/ha (in the bottom of 325 m). The erosion culminates (0.9 kg/m^2) between 286 and 351 m of the slope length from the top.

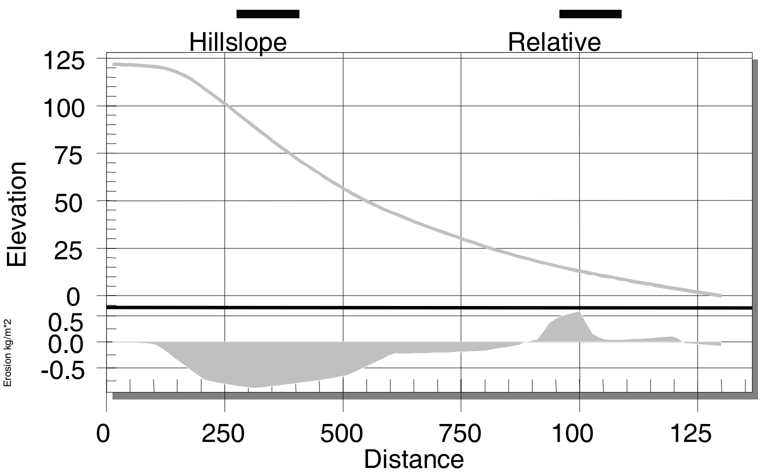

Fig. 1. Processes of erosion and sedimentation in the disturbed forest stand at the S-shape hillslope profile at Jizerka.

Negligible sheet erosion was measured at both run-off plots representing "forest dieback" (declined mature spruce stand) and "clearing" (harvested stand invaded by grass). However, the significant loss of soil was related to the length of erosion rills produced by skidding the harvested timber. In the catchment scale, the erosion increased from 0.01 to 1.34 mm/year.

Characterisation of investigated stands

1. Dead forests
The cover of herb layer reaches 100% (due to high light income). Species richness is very low (maximum to 6 species per relevè), usually only a few resistant hemicryptophytes are present (e.g. *Calamagrostis villosa, Deschampsia flexuosa*).
2. Clearings
Percentage cover is 95–100. Species richness is higher (5-10), besides hemicryptophytes (*Calamagrostis villosa, Deschampsia flexuosa*, etc.), chamaephytes (*Vaccinium myrtillus, V. vitis-idaea, Galium harcynicum*), geophytes (*Trientalis europaea* etc.), and young phanerophytes are also present.
3. Shallow erosion rills
Plant cover is 25–98%. Species richness varies between 4–10, mainly hemicryptophytes (*Agrostis stolonifera, Deschampsia caespitosa, D. flexuosa, Juncus effusus*; in older successional stages, *Calamagrostis villosa* as well) and young phanerophytes are common.
4. Middle erosion rills
Plant cover ranges between 20 and 75%. Species richness is 4–9, mainly hemicryptophytes (*Agrostis stolonifera, Deschampsia caespitosa, D. flexuosa, Juncus effusus, Calamagrostis villosa*), and seedlings of *Salix caprea* are frequent. Plants forming clusters prevail.
5. Deep erosion rills
Plants cover only 1–30% of the soil surface. Species richness is 1–9, mainly hemicryptophytes (as listed above) are widespread, but annual plants with shallow root system were also found (*Sagina procumbens, Spergularia rubra*). Plants forming clusters represent in average 71% of species present.

Mean values of vegetation characteristics are given in Table 1. We listed 48 plant species in all relevès. Constancy of vascular plants found in particular stand types (% of localities where the species were found) presents Table 3.

Differences within stand groups

The highest percentage of the plant cover (96–98%, Table 1) was found at relatively not disturbed stands. While both parameters (percentage cover and species richness) were lowest in deep rills, followed by middle (percentage cover only) and shallow rills (both characteristics). Differences were statistically significant ($r = -0.65$, $p < 0.05$, Table 2).

The depth of rills significantly affects plant cover ($R^2 = 0.42$). Few species were present noticeably rarely in middle and deep rills in comparison with other stands, e.g. *Calamagrostis villosa, Galium harcynicum, Vaccinium myrtillus* (Fig. 2, Table 3).

T a b l e 1. Mean values of vegetation characteristics in particular stand types with different erosion intensity: % cover of herb layer, S – species richness, % of plants forming clusters, % of plants forming tillers, % of particular life forms (Hkf – hemicryptophytes, Ff – phanerophytes, Chf – chamaephytes, Tf – terophytes, Gf – geophytes)

	% Cover	S	Clusters	Tillers	Hkf	Ff	Chf	Tf	Gf
Deep rills	19.1	5.4	71.1	28.9	76.5	11.5	7.4	1.4	1.2
Middle rills	45.9	5	69.2	30.8	78.6	11.9	3.2	5.3	0.7
Shallow rills	67.5	6.6	66.8	33.2	79.6	12.5	5.2	2	0.9
Dead forests	98.6	5.9	62.1	37.9	73.5	5.6	17.5	0	3.3
Clearings	96.4	6.4	60.3	39.7	59.8	17.9	13.4	0	6

T a b l e 2. Regression of species richness and % cover of herb layer on rill characteristics (depth, slope, and age). Bold – statistically significant results

	Rill depth			slope			rill age		
	Correl. coef.	R^2	p	Correl. coef.	R^2	p	Correl. coef.	R^2	p
% cover	**- 0.65**	**0.42**	**0.000**	0.05	0.004	0.46	0.08	0.006	0.359
S	- 0.17	0.03	0.053	0.21	0.02	0.091	**0.54**	**0.30**	**0.000**

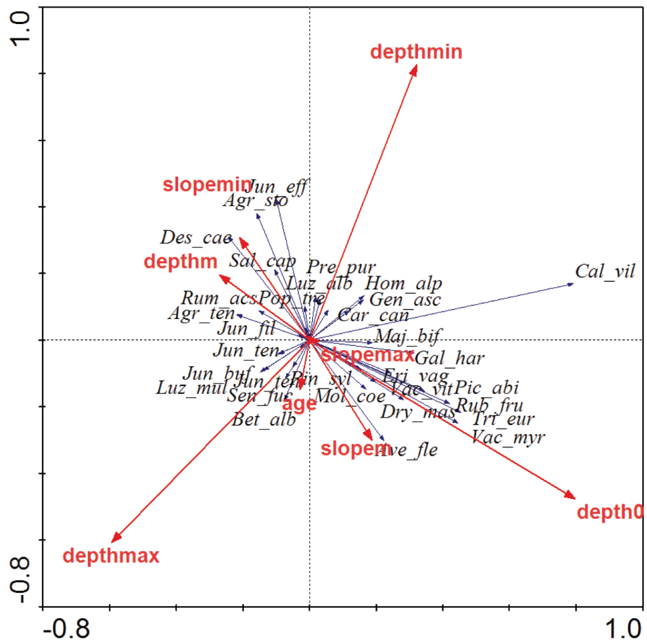

Fig. 2. RDA (depth 0 = no erosion rill, depthmin = minimum rill depth, depthm = middle depth, depthmax = maximum depth, slopemin = minimum slope, slopem = medium slope, slopemax = maximum slope).

T a b l e 3. Constancy of vascular plants (%) in stand groups: SF, SS – shallow rills in terrain up to 5° – more than 5°, MF, MS – middle rills in terrain up to 5° – more than 5°, DF, DS – deep rills in terrain up to 5° – more than 5°, C – clearings, DT – dead forests

	SF	SS	MF	MS	DF	DS	C	DF
Agrostis stolonifera	100	60	100	53	87	53	7	.
Athyrium filix-femina	.	13	7	7	.	.	13	47
Betula pendula juv.	13	13	13	.	.	13	13	.
Calamagrostis villosa	100	87	40	87	40	47	100	100
Carex canescens	.	7	.	.	.	7	.	.
C. leporina	7	7	7	.	7	.	.	.
C. nigra	.	.	.	7	.	.	.	.
C. pairae	.	13	.	7	7	.	.	.
Cerastium arvense	.	7	.	.	.	.	.	.
Deschampsia caespitosa	87	73	93	47	60	73	20	.
D. flexuosa	40	53	33	67	60	80	93	87
Digitalis purpurea	.	.	.	.	.	.	.	7
Dryopteris filix-mas	.	.	.	.	.	.	7	.
Epilobium angustifolium	.	7	7	.	.	7	60	13
E. montanum	.	7	.	.	7	7	.	.
Eriophorum vaginatum	.	.	.	.	.	.	13	.
Galium harcynicum	20	20	7	7	7	13	53	33
Gnaphalium sylvaticum	.	7	.	.	.	.	.	.
Holcus mollis	.	.	.	.	.	.	7	.
Homogyne alpina	.	.	.	.	.	.	7	7
Juncus bufonius	.	.	.	.	7	.	.	.
J. squarrosus	.	13	.	13	7	7	.	.
J. effusus	100	73	87	73	33	33	20	.
J. filiformis	.	.	.	7	.	.	.	.
J. tenuis	.	13	.	13	.	20	.	.
Larix decidua juv.	.	.	.	.	.	.	7	.
Luzula luzuloides	.	7	.	.	.	.	.	.
L. multiflora agg.	20	.	7	7	7	7	7	.
Molinia caerulea	.	.	.	.	.	.	7	7
Picea abies juv.	.	13	.	7	.	.	40	27
P. pungens juv.	.	.	.	.	.	.	7	.
Plantago major	.	7	.	.	.	.	.	.
Poa annua	7	.	.	7	.	.	.	.
Populus tremula juv.	.	.	7	.	.	.	.	.
Rubus fruticosus agg.	.	7	.	.	.	.	27	.
Rumex acetosella	27	.	27	20	13	13	.	.
Sagina procumbens	.	.	.	.	7	.	.	.
Salix caprea juv.	73	40	53	40	7	27	13	.
Scleranthus perennis	7	.	.	.	.	.	.	.
Senecio fuchsii	.	.	.	.	.	.	.	7
Sorbus aucuparia juv.	7	.	.	.	.	.	7	.
Spergularia rubra	.	.	.	7	7	.	.	.
Stellaria nemorum	.	.	.	.	.	.	.	.
Taraxacum officinale	.	13	.	.	.	.	.	.
Trientalis europaea	.	.	.	7	.	.	53	7
Tussilago farfara	.	.	.	.	7	7	.	.
Vaccinium myrtillus	.	7	.	13	7	7	80	47
V. vitis-idaea	.	.	.	.	.	.	7	.

In growth forms, percentage of plants forming tillers declined gradually from clearings and dead forests (almost 40%) to shallow (33%) and deep rills (29%), in the same direction, the proportion of plants forming clusters increased from 60 to 71%.

Considering the life forms, hemicryptophytes are the most common here. They form 70–80% of species present in rills and dead forests, in comparison with only 60% in clearings. Besides them, seedlings and juvenile woody species (Ff, espec. *Salix caprea, Betula pendula, Sorbus aucuparia*) and chamaephytes are occasionally present. Therophytes (small annuals) were found only in rills (= stand with open soil surface supports their accession). On the other hand, dead forests and clearings harbour higher proportion of chamaephytes (espec. *Vaccinium myrtillus, V. vitis-idaea*) (Table 1).

In "slope" groups, only weak positive correlation was found with species richness ($r = 0.21$, $p = 0.091$) (Table 2).

The role of rill age

The year of forest harvest was registered, and used in this study. Moreover, forest tractors occasionally re-entered the area in the following years too, just to cut few remaining individuals or to transport seedlings for replanting. Anyway, the dominant disturbance is related to the year of main logging. Thus, the period after the clear cut represents the period of possible plant succession.

Evaluating the vegetation features in particular age groups regardless of the other stand attributes, ANOVA revealed only some significant among-site differences, which are important for soil protection against erosion:

- Life forms: Chamaephytes found only in rills older than 10 years, occurrence of phanerophytes tends to grow with rill age (Fig. 3).
- Growth forms: differences between groups are not significant, but some trends are apparent. The percentage of species forming tillers is lower in older rill. On the other side, the age increased the proportion of plants forming clusters (Fig. 4).
- Species richness (S): statistically significant tendency that older rills harbour more plant species ($r = 0.54$, $p < 0.005$) was found.
- Plant cover: Plant cover is higher in older rills, but the correlation is very weak and not significant ($r = 0.08$). In rills up to 3 years of age, the cover was the lowest (10–15%), in older rills, there was no impact of rill age and the cover ranged between 26 and 80%.

Discussion and conclusions

The area disturbed by forest logging has been overgrown by *Calamagrostis villosa*. The richness of plant species occurred in investigated stands is rather low: only 48 species of vascular plants were found in all our relevès. Zelená (1996) reported that the composition of species found in forest clearings is related mainly to the type of harvested forest, namely to the species of its original herb layer.

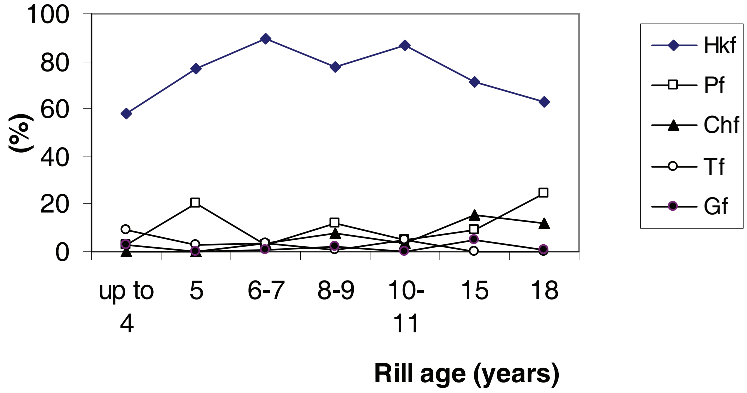

Fig. 3. Proportion of growth forms in age groups: hemicryptophytes (Hkf), phanerophytes (Pf), chamaephytes (Chf), therophytes (Tf), geophytes (Gf).

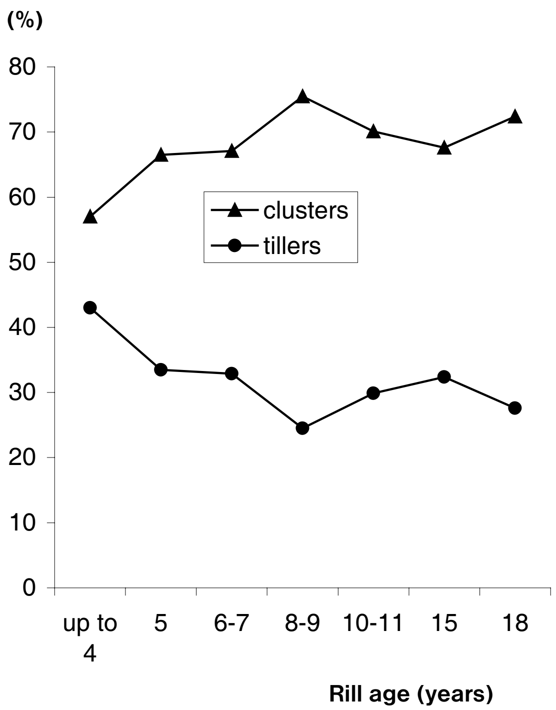

Fig. 4. Proportion of plants forming tillers and clusters in age groups.

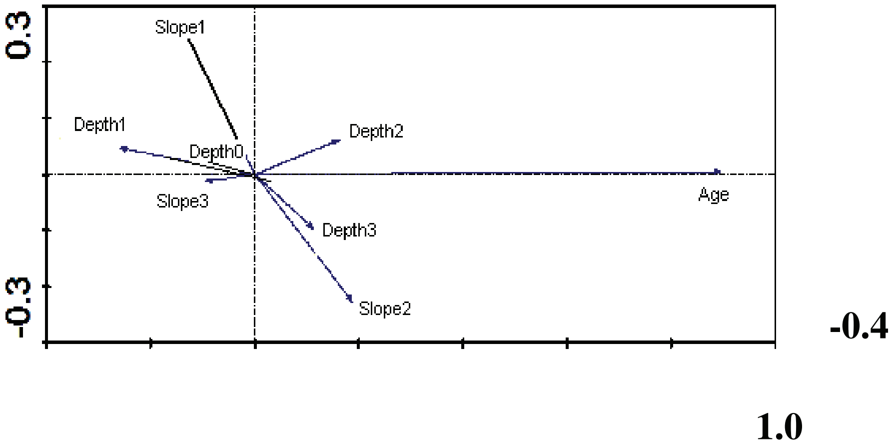

Fig. 5. PCA with stand characteristics (depth 0 = no erosion rill, depth1 = minimum rill depth, depth2 = middle depth, depth3 = maximum depth, slope1 = minimum slope, slope2 = medium slope, slope3 = maximum slope).

At the harvested forest slopes, the rill form of soil erosion dominates while the sheet erosion is negligible. The erosion of soil in rills is characterised by their crossection; the depth relates to their slope, length, skidding techniques and weather situation during skidding (Modrý, Hubený, 2003). The removal of the organic topsoil reduces the nutrient availability and also the soil seed bank, both highly required by the recovery of rills. Besides the soil seed bank and seed rain (Urbanska, Fattorini, 2000), the succession depends on the viability of seeds. Generally, in the Jizera Mts, flora (total number of plant species) is rather poor. Moreover, the seed germinability of the species dominating in the clearings – *Calamagrostis villosa* – is very low and rarely reaches 10% (Morávková-Lipnická, 1996). Elmarsdottir et al. (2003) stressed the effect of soil surface on plant succession – gravel can „catch“ seed rain and keep the soil moist.

The important impact of canopy percentage in reducing overland flow and the loss of soil is widely known (Pasák, 1984; Shaw, 1991; Quinton et al., 1997; Křeček, Hořická, 2001). Maximum values of cover percentage were found in not disturbed sites and in shallow rills. Similar results reported Šilhavý (1991) from the Giant Mts. Mean species richness ranged between 5–7 and was homogenous in particular groups. Differences in species composition were flat, presumably due to low diversity of local flora.

As expected, our study confirmed that older rills harbour more plant species (S depended on rill age by 30%). Gradual increase in species richness during succession is known from most communities. In plant cover, our results were not explicit. The cover increased, but the relationship was not statistically significant. In rills up to 3 years old, the cover was the lowest (10–15%), in older rills, there was no impact of rill age and the cover ranged between 26 and 80%.

An important information provided spectra of life forms and the ratio of growth forms. With rising age of rills, the proportion of plants forming tillers decreased, as well as the percentage of hemicryptophytes. The proportion of both above mentioned plant groups is the lowest in deep rills. We conclude that in the field survey, where it is necessary to sample existing stands, mainly deep and middle old rills were found and studied. Shallow rills were already recovered by vegetation, therefore difficult to recognize (results of RDA analysis in Fig. 5). Age groups differ in number of rills; most of identified shallow rills was 5 years old, while within the deep rills 7–10 year old individuals were the most abundant. On the other hand, these results confirm our conclusion that deep rills regrow very slowly.

It is possible to conclude that the main factor affecting regrowth of erosion rills is the erosion intensity characterised by the crossection (mainly the depth of erosion furrows).

Rising erosion intensity causes: lower percentage cover of vegetation, lower species richness, lower proportion of hemicryptophytes, higher proportion of plants forming clusters or bunches (which may form 100% of plant species present). As the above mentioned plants do not have good ability to cover soil surface and to protect it against erosion, this process may easily continue. Considering the morphology of rills, no significant effect of the slope was found in the research area.

Generally, the shallow rills can regrow quite easy, while in the deep rills, the process of plant succession is very slow or even not possible. Thus, the logging practices producing more, but "shallow rills" are better that practices producing only a few "deep rills".

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References

Berger, A.R., Iams, W.J. (eds), 1996: Geoindicators: Assessing Rapid Environmental Changes in Earth Systems. A.A. Balkema, Rotterdam, 483 pp.

Ellenberg, H., 1979: Zeigerwerte der Gefässpflanzen Mitteleuropas. Göttingen.

Elmarsdottir, A., Aradottir, A.L., Trlica, M.J., 2003: Microsite availability and establishment of native species on degraded and reclaimed sites. J. Appl. Ecol., *40*, 5, p. 815–823.

Goudie, A., 2000: The Human Impact on the Natural Environment. MIT Press, Cambridge, 511 pp.

Křeček, J., Pretl, J., 1992: Soil erosion and sediment transport in a forested catchment. In Křeček, J., Haigh, M.J. (eds): Environmental Regeneration in Headwaters. ENCO, Praha, p. 216–218.

Křeček, J., Hořická, Z., 2001: Degradation and recovery of mountain watersheds in the Jizera mountains, Czech Republic. Unasylva, *37*, p. 247–259.

Maarel, E. van der, 1979: Transformation of cover-abundance values in phytosociology and its effect on community similarity. Vegetatio, *39*, p. 97–114.

Modrý, M., Hubený, D., 2003: Impact of skidder and high-lead system logging on forest soils and advanced regeneration. J. For. Sci., *49*, p. 273–280.

Morávková–Lipnická, K., 1996: Generative reproduction of *Calamagrostis villosa* in the Jizera Mts (in Czech). Zprávy Čs. Bot. Společ., *31*, p. 101–103.

Pasák, V. 1984: Soil Erosion Control (in Czech). SZN, Praha, 181 pp.

Price, M., Butt, N., 2000: Forests in Sustainable Mountain Development. CABI Publishing, Wallingford, 590 pp.

Quinton, J.N., Edwards, G.M., Morgan, R.P.C., 1997: The influence of vegetation species and plant properties on runoff and soil erosion: Results from a rainfall simulation study in South-east Spain. Soil Use Manag., *13*, 3, p. 143–148.

Raunkiaer, C., 1934: The Life Forms of Plants. Oxford University Press, Oxford.

Rothmaler, W., 1982: Exkursionsflora für die Gebiete von der BRD and DDR. Volk und Wissen Volkseigener Verl., Berlin.

Shaw, E.M., 1991: Hydrology in Practice. Chapman & Hall, London, 539 pp.

Sýkora, T., 1983: *Junco effusi-Calamagrostietum villosae*, a significant community succeeding the spruce forests in Western Sudetes (in Czech). Preslia, *55*, p. 165–172.

Šilhavý, I., 1991: Evolution of erosion in the area of the Krkonoše Mts. National Park within the years 1986-1989 with respect to wood-working. Opera Corcontica, *28*, p. 27–46.

Ter Braak, C.J.F., 1988: CANOCO – a FORTRAN program for canonical community ordination by partial detrended canonical correspondence analysis, principal components analysis and redundancy analysis (version 2.1.). Agr. Math. Gr., Wageningen, 95 pp.

Urbanska, K.M., Fattorini, M., 2000: Seed rain in high-altitude restoration plots in Switzerland. Restor. Ecol., *8*, p. 74–79.

USDA-ARS, 2005: WEPP Hillslope/Watershed Model. Pardue University, West Lafayette, Indiana.

Zelená, V., 1996: Main types of grass communities of deforested areas in the Beskydy Mts. In Fiala, K. (ed.): Grass Ecosystems of the Deforested Areas in the Beskydy Mts. Brno, p. 39–44.

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Nováková J., Křeček J.: **Půdní eroze a rostlinná sukcese na erozních holinách Jizerských hor.**

Rostlinný kryt hraje důležitou roli v ochraně svahů ohrožených povrchovým odtokem a půdní erozí. Po smýcení poškozených smrkových porostů v povodí Jizerky (Jizerské hory, Severní Čechy) zarostly plochy holin společenstvem *Junco effusi-Calamagrostietum villosae* s dominantním druhem *Calamagrostis villosa.* K vytvoření výrazných erozních rýh došlo zejména v místech přibližovacích cest vzniklých při svozu dřevní hmoty kolovými traktory. Ztráta půdní hmoty je úměrná zejména délce erozní rýhy. Studovali jsme vztahy mezi vegetací (pokryvnost, druhová bohatost, podíl druhů jednotlivých životních a růstových forem) a charakteristikami erozních rýh (jejich stáří, hloubka, sklon terénu). Zjistili jsme statisticky průkazný pozitivní vliv stáří rýhy na druhovou bohatost. Hlavním faktorem, který ovlivňuje pokryvnost a druhovou bohatost, však zde byla intenzita eroze (hloubka erozní rýhy). Podáváme rovněž stručný popis jednotlivých kategorií erozních rýh z hlediska charakteru jejich vegetace a soupis zjištěných druhů vyšších rostlin s vyhodnocením jejich stálosti na jednotlivých typech stanovišť. Z našich výsledků vyplývá, že rostoucí intenzita eroze způsobuje: nižší pokryvnost, nižší druhovou bohatost, nižší zastoupení hemikryptofytů a vyšší podíl trsnatých druhů (nevýhodné z hlediska protierozní ochrany).