Production and humus form development in forest stands established on agricultural lands – Kostelec nad Černými lesy region

V. Podrázský[1], J. Remeš[1], V. Hart[1], W. Keith Moser[2]

[1]*Faculty of Forestry and Wood Sciences, Czech University of Life Sciences in Prague, Prague, Czech Republic*
[2]*USDA, Forest Service, Northern Research Station, St. Paul, U.S.A.*

ABSTRACT: The afforestation of agricultural lands was carried out under different site and ecological conditions, including lower and medium elevated localities. The present study documents the rapidity of accumulation of surface layers and their characteristics in stands of Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), birch (*Betula verrucosa*) and Douglas fir (*Pseudotsuga menziesii*) in the territory of the Training Forest Enterprise in Kostelec nad Černými lesy, at the altitude 430 m a.s.l., on the site of nutrient-poor gleyed soils. The plots were compared with the neighbouring continuously forested site covered with old pine-spruce stand and with near-situated arable field. During the first roughly 40 years, considerable changes were documented on the afforested plots. Forest-floor humus layers in the coniferous stands have already been formed, the humus forms being more favourable compared with the old forest site. Acidification and loss of nutrients run in the upper mineral horizons. These processes were also responsible for the less favourable character of the forest soil in the old stand. Birch showed minor shifts of soil properties in the mineral horizon compared to the conifers; the surface humus accumulation was not observed there yet. The lowest degradation among conifers was shown in Douglas fir, intensively taking up deficient nutrients on the other hand.

Keywords: afforestation; agricultural lands; tree species; forest-floor humus; soil characteristics

Afforestation and reforestation of agricultural land were a common feature in different historical periods in the Czech lands, they were carried out under the most diversified site as well as socio-economical conditions. Besides the marginal mountain and piedmont lands, the abandoned areas were also reforested at the middle and lower altitudes (Klasna 1976). The experimental plantations as well as the practical and commercial ones were established in the whole Czech Republic including neighbouring countries (Sarvaš, Lalkovič 2006; Špulák 2006; Hatlapatková et al. 2006). The aim of these activities was to increase forest cover in the landscape, sometimes fulfilling special functions such as windbreaks, bio-corridors (Tichá 2006), but the most common expected function was production and stabilization of the lands. There are more publications available as for the growth and other tree species aspects on the former agricultural lands. What has been missing up to now, it is the quantification of the effects of new stands on the soil, on the restoration of its forest character – with some exceptions from the last time (Hagen-Thorn et al. 2004; Kacálek et al. 2006; Novák, Slodičák 2006; Novák et al. 2007).

The aim of the paper is to increase the knowledge concerning the afforestation effects at the middle and lower altitudes, particularly in the territory of the Training Forest Enterprise in Kostelec nad

Supported by the Ministry of Agriculture of the Czech Republic, Research Project No. QG 50105.

Černými lesy, so the comparison with results of other site conditions. To this moment, the authors' team evaluated the tree species effects on the humus form establishing in the area of Český Rudolec (Podrázský, Štěpáník 2002), at the higher altitudes of the Krušné hory Mts. (Podrázský et al. 2006), possibly in combination with different thinning regimes (Podrázský 2006). This paper documents the effects of particular tree species (Norway spruce – *Picea abies*, Scots pine – *Pinus sylvestris*, birch – *Betula verrucosa* and Douglas fir – *Pseudotsuga menziesii*) on soil properties on the reforested agricultural land and compares their status with the soils of neighbouring forest stands at permanently forested localities as well as with arable soil.

MATERIAL AND METHODS

Experimental plots were established in the territory of the Training Forest Enterprise, close to Krymlov village within the Kostelec Forest District. All plots were established by planting in 1967. The altitude of the study locality is ca 430 m a.s.l., mean annual precipitation is 600 mm, and mean annual temperature is 7.5°C. The forest site was classified as 4Q (nutrient-poor gleyic soil; fir with oak natural species composition). The study was performed in the stands of four tree species on afforested agricultural lands, in a neighbouring forest stand on continuously forested land (mixed Scots pine – Norway spruce stand) and in a near field – arable soil.

The first plot was established in the stand of Scots pine (*Pinus sylvestris*), the plot area is 0.25 ha. The total stand area is 2.50 ha.

The second plot is located in the stand of Norway spruce (*Picea abies*) of total area 3.98 ha, the plot area is 0.191 ha.

The third plot is situated in the birch stand (*Betula verrucosa*) of total area 0.7 ha, the measured area is 0.134 ha. The last plot encloses the stand of Douglas fir (*Pseudotsuga menziesii*), the whole stand was included (0.125 ha – Table 1). For comparison, the neighbouring areas were included – mature pine-spruce stand on forest land and arable land – raps field. No stable plots were established here.

The plots on former agricultural land were delimited and their plot was quantified. The trees were pruned (dead branches) to the height enabling free access to measurements: indexing, registration, dbh measurement. The diameters were determined with callipers within 1 cm intervals. Two cross-measurements were done; 4 cm diameter classes were used. The height was measured in two trees from each tree class (Field-Map technology). dbh and height measurements were used for the volume calculations using Volume Tables (LESPROJEKT 1952).

Soils, i.e. holorganic layers and the uppermost part of the mineral soil body (Ah horizons), were sampled in October 2006. In the coniferous stands, the forest-floor layers were sampled using the iron frame 25 by 25 cm. In the birch stand and on the arable soil, the surface humus was not present. The samples were taken from the depths 0–10 and 10–20 cm. The mineral soil horizons were not sampled quantitatively. The analyses of individual samples were performed. Number of replications was 4 in all plots.

These characteristics were determined:

- amount of dry matter (D.M.) of holorganic horizons at 105°C and calculation per 1 ha area,
- total carbon content (humus content) using the Springel-Klee method, total nitrogen content using the Kjeldahl method,
- soil reaction (pH) in water and 1 N KCl, potentiometrically,

Table 1. Comparison of the production potential of particular tree species in stands established on former agricultural land

Species	Scots pine	Norway spruce	Birch	Douglas fir
Plot (ha)	0.25	0.191	0.134	0.125
Age	39	39	39	39
N (trees)	352	221	59	116
Trees/ha	1,408	1,157	440	928
Mean height (m)	20.6	20.1	24.0	21.6
Mean diameter (cm)	19.5	19,5	21.4	23.8
Volume/plot (m^3)	88.2	66.7	21.1	54.6
V (m^3/ha)	352.1	349.4	157.1	438.6

– characteristics of the soil adsorption complex according to the Kappen method: S – base content, T-S (H) – hydrolytical acidity, T – cation exchange capacity, V – base saturation,
– plant available nutrients using the Mehlich III solution. The P-content was determined spectrophotometrically, the other nutrients by AAS,
– characteristics of the exchangeable acidity in the KCl solution,
– total nutrient content in the holorganic horizons, after mineralization by the mixture of sulphuric acid and selenium. The analyses were done by the Tomáš Laboratory in Opočno. Only a limited set of the most indicative results is documented in the present paper.

The statistical evaluation was performed using the statistical software S-PLUS by the analysis of variance method. The results were evaluated by Scheffe's method by multiple comparisons on the 95% significance level. The horizons of the same type were compared.

RESULTS AND DISCUSSION

a) Stand volume

Particular tree species showed largely differentiated growing potentials. Table 1 documents the results of dendrometric measurements in a comprehensive form. The pine stand has the highest density, the birch one the lowest. Birch reached the maximum height, but its stand was very sparse to show a large standing volume. Douglas fir showed the second height, which together with maximum dbh and relatively high density resulted in the largest standing volume. The highest production and relatively high density were documented for this tree species in this way, confirming the position of this tree species as the most productive in the temperate zone with convenient soil and site conditions (Remeš, Hart 2004). This assumes also the maximum nutrient uptake and related effects on the soil environment (Podrázský, Remeš 2006; Kantor 2008).

Table 2. Basic characteristics of both forest-floor humus and topsoil horizons in particular stands

Plot / Species	Horizon	Mass (t/ha)	pH (H_2O)	pH KCl	S (mval/100 g)	T (mval/100 g)	V (%)	Total humus (%)	Total N (%)	C/N
Scots pine	L + F1	9.44	4.3	3.8	21.0ab	57.7ab	36.4	65.8	1.6	24
	F2 + H	22.58a	3.9b	3.2b	33.2ab	76.8	43.1b	57.3ab	1.5	22
	Ah	**32.02**	4.5c	3.7b	5.4b	12.5	43.3cd	4.1b	0.20b	12
Norway spruce	L + F1	11.57	4.4	4.1	43.4b	74.2a	58.1	58.3	1.5	22
	F2	8.74	4.1	3.8	38.1	80.7	47.1	59.6	1.6	27
	H	17.49a	3.7b	3.2b	23.8b	66.0	36.3b	49.4b	1.3	22
	Ah	**37.80**	4.3c	3.7 b	5.8b	13.2	43.7cd	3.8ab	0.17ab	13
Birch	0–10		5.7b	4.7a	9.1a	12.0	74.9b	3.5ab	0.20b	10
	10–20		5.8	4.7	7.4	9.3	78.7	1.9	0.1	11
Douglas fir	L + F1	13.40	4.8	4.5	30.3ab	50.7bc	59.4	57.8	1.5	22
	F2 + H	20.51a	4.4a	3.9a	47.6a	75.1	63.0a	48.8b	1.4	20
	Ah	**33.91**	4.5c	3.8b	5.6b	11.8	47.9c	2.7ab	0.15ab	10
Old stand of pine and spruce	L + F1	9.71	4.4	4.0	15.2a	34.3c	36.4	54.7	1.3	24
	F2	16.46	3.8	3.3	31.6	73.7	41.7	70.6	1.6	26
	H	112.12b	3.4c	2.5c	25.7b	88.8	28.5b	64.6a	1.4	27
	Ah	**138.29**	4.0c	3.3b	4.4b	13.6	32.6d	3.8ab	0.12a	18
Field	0–10		6.7a	5.1a	10.3a	11.2	92.5a	1.8a	0.15ab	7
	10–20		7.0	5.4	11.0	11.5	95.3	1.8	0.1	10

Different indexes indicate statistically significant differences on the 95% level, the same indexes and their absence indicate data homogeneity

b) Soil state

Individual stands showed visible effects on the state and development of the studied soils. Soil reaction (active) showed statistically significant changes in the whole humus form profile (Table 2). In the litter layer, no statistically significant differences were registered, despite the fact that the values are the highest in the Douglas fir stand and similar ones in stands of the other conifers. The sampling of surface humus was not possible in the birch stand (and on arable soil) because of its lack. In F and H layers, the significantly highest values were registered in the Douglas fir stand again, visibly lower in the pine and spruce stands on the agricultural lands and the lowest on the old forest soil. In the mineral horizons, the arable soil showed the highest pH value around 7.0, slightly lower in the case of birch and lower in the stands of conifers, the insignificantly lowest in the spruce stand.

Similar dynamics was shown by the soil reaction measured in 1 N KCl. Very low acidity of the arable soil is documented, on the contrary, a distinct decrease in the old stand was registered. Birch showed a relatively good state, the comparison of Douglas fir and spruce was in favour of the former species. The comparison of these two species in other cases showed a similar relation (Podrázský, Remeš 2005).

The exchange base content was slightly higher (L + F horizons) in the spruce stand on the former arable soil and then in the Douglas fir one, lower in the pine stand and especially lower in the older stand on forest land. In the mineral soil, the highest values were in the field soil, followed by birch stand, the situation in the conifer stands was quite comparable – with a tendency of the lowest values in the old forest stand. In this stand, the base losses and leaching took place for the longest period. The relatively high content of bases in spruce litter is interesting, probably reflecting a higher content in the mineral soil and, on the contrary, the slight decomposition of litter in the L and/or F1 layer.

The cation exchange capacity was the highest in both stands with the spruce occurrence, lower in the holorganic layers of other conifers – this indicates a

Table 3. Contents of plant available nutrients according to Mehlich III method in particular horizons in different stands

Plot / Species	Horizon	P	K	Ca	Mg
		(mg/kg)			
Scots pine	L + F1	57.0	983.5a	2,923.5a	455.0a
	F2 + H	29.6	418.0a	2,784.0b	328.8a
	Ah	15.3b	87.8c	264.0c	29.5b
Norway spruce	L + F1	44.0	471.5b	3,588.5a	299.5ab
	F2	54.0	402.5	4,223.5a	307.0
	H	50.5	320.0ab	3,107.0ab	230.5a
	Ah	9.8b	72.3c	341.0c	35.0b
Birch	0–10	20.3b	146.0b	791.5b	94.0a
	10–20	11.5	95.8	659.8	77.3
Douglas fir	L + F1	51.0	519.5b	2,946.5a	248.0ab
	F2 + H	43.5	345.0a	3,568.0a	259.0a
	Ah	4.3c	79.8c	383.5c	51.5b
Old stand	L + F1	42.0	505.5b	1,456.5b	194.0b
	F2	34.0	473.0	2,039.5b	252.0
	H	22.0	201.5b	893.0c	134.0b
	Ah	1.0c	46.5c	205.0c	37.0b
Field	0–10	36.5a	188.8a	1,364.0a	80.5a
	10–20	40.8	189.8	1,439.3	82.8

high share of organic acids (high hydrolytic acidity) in the spruce stand and subsequently formed humus forms. This trend continued down to the mineral layers, the highest T values were documented in Ah horizons of both spruce stands. A similar state was documented in all other stands.

The complex indicator of the soil adsorption complex is represented by the adsorption complex saturation (base saturation – V value). The most favourable state was observed in the Douglas fir stand and the less favourable one in the old conifer stand. The long-lasting effects of acidification processes can be supposed there. Full base saturation was observed in the agricultural soil (mineral horizons) and slightly lower in the birch stand. The state was quite comparable in the conifer stands on the former agricultural lands, significantly lower values were documented on the old forest sites.

The total humus content also showed very high variability, the highest values of this characteristic were determined in well-developed holorganic horizons on the forest site. Higher contents were documented also in the pine stand and lower ones in the spruce stand on afforested agricultural soil. Low contents were proved for Douglas fir. Highly significantly lower values were documented in the arable soil (mineral horizon), low values were also in the Douglas fir and birch stand. The litter of both these species is decomposed and mineralized very quickly; mineralization prevails upon humification – at least compared to the other studied species. Surface humus accumulation did not occur in the birch stand yet. This is a consequence of the high-quality site as well as of the fact that the canopy is not closed due to relatively sparse stand. On a less favourable site and with full canopy, the formation of distinct surface humus is possible (Podrázský, Štěpáník 2002), relatively massive under mountain conditions (Podrázský et al. 2006).

Total nitrogen content also indicates the quality of the humus form. Low values were documented in the holorganic layers of the older stand on the forest site, in the mineral layer total N-content was the significantly lowest there. The concentration of this macronutrient was comparable in the humus forms in other conifer stands. In the organomineral Ah horizon, the highest Nt content was registered in the birch and pine stands, probably due to the effect of the ground vegetation, intensively recycling this macronutrient.

The plant available phosphorus content showed considerable variability, this is probably the reason for insignificancy of the lower content of this nutrient in the forest soil. In the mineral horizons, the significantly highest concentrations were documented in the arable soil, lower contents in the birch stand. On the contrary, the significantly lower contents were registered in the Douglas fir stand and especially in the old forest soil – the major portion of this nutrient was fixed in the biomass, so it was depleted from the soil.

On the contrary, the plant available potassium content was the highest in the pine stand, where the effect of the ground vegetation was reflected similarly like in the birch stand. Herb and especially grass vegetation recycles this macroelement very effectively. In the mineral horizon, the highest K content was documented on the arable (agricultural) soil, the effects of the litter rich in potassium were detected both in the birch as well as in the pine stand. This characteristic was similar in the other stands. An approximately half content was found in the soil of the former forest site. Considerable losses and sequestration of the nutrients in the biomass can be supposed there – in the holorganic horizons as well as in the stand biomass.

Plant available calcium obviously showed a significant tendency of the highest content in holorganic layers in the spruce stand on the agricultural soil. The low degree of litter decomposition is reflected by the lower leaching in the subsoil. The opposite feature is detected in the Douglas fir stand, low Ca contents are documented in pine and in the stand on the former forest soil. In the mineral soil, the clearly higher Ca content is analyzed in the birch stand and especially in the arable soil.

In both stands with spruce occurrence the lowered content of magnesium was documented in the forest-floor horizon. The significantly highest Mg concentration was found in the Douglas fir stand and especially in the pine one. Interspecific demands of particular tree species are probably demonstrated in this way, as well as the inherited soil characteristics. Similar trends were observed in the mineral horizons, in this case, the contents were high, especially high in the birch stand and in the arable soil and low in spruce and in pine.

The obtained results can hardly be compared with other authors, the references are totally missing in the domestic literature, with some exceptions (Kacálek et al. 2009), not dealing with all compared aspects. Despite the different character of studied sites the foreign sources are in coincidence with our results (Hagen-Thorn et al. 2004). In similar studies, the comparable species-specific differences were documented as well (Podrázský, Remeš 2005). The selective uptake of e.g. phosphorus and nitrogen by broadleaves was documented compared to conifers, as well as the effects of the ground vegetation of the litter character in incompletely closed stands (Podrázský et al. 2006).

CONCLUSIONS

The results confirmed different effects of particular tree species on the state and development of afforested agricultural soils. There were obvious differences in the conifer effects, further in the effects of birch, as well as in the former and actual land use.

Soil of the agricultural land origin showed the higher content of nutrients, including the bases. The former fertilization was detectable in this way and it was reflected by the full base saturation of the adsorption complex, base content and soil reaction values. On the other hand, the contents of humus and consequently also of nitrogen were the lowest there. It was a result of different dynamics of organic matter in the agricultural soils compared to the forest sites.

In the birch stand, the formation of surface humus is still missing due to incomplete canopy and low density of the stand. Soil chemical characteristics were less favourable compared to agricultural land, on the contrary, more favourable compared to organomineral horizons of the studied conifers.

The closed canopy of coniferous stands resulted in the progressive formation of surface humus with highly favourable characteristics – of higher quality in comparison with continuously forested land. The effects of the agricultural use of land, i.e. the fertilization and supply of nutrients, are still visible. In the continuously forested land, the acidification trends are detected – especially the nutrient uptake and leaching.

The differences among particular coniferous species are also visible. The effects of Douglas fir were reflected in the formation of litter with good decomposition as well as transformation. On the other hand, this species takes up a lot of nutrients from the soil. The reforested agricultural soils showed considerable changes in their character and largely incline to the typically forest character during the first 40 years after afforestation.

References

HAGEN-THORN A., CALLESEN I., ARMOLAITIS K., NIHLGÅRD B., 2004. The impact of six European tree species on the chemistry of mineral topsoil of forest plantations on former agricultural land. Forest Ecology and Management, *195*: 373–384.

HATLAPATKOVÁ L., PODRÁZSKÝ V., VACEK S., 2006. Výzkum v lesních porostech na bývalých zemědělských půdách v oblasti Deštného a Neratova v PLO 25 – Orlické hory. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 185–192.

KACÁLEK D., BARTOŠ J., ČERNOHOUS V., 2006. Půdní poměry zalesněných zemědělských pozemků. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 169–178.

KACÁLEK D., NOVÁK J., DUŠEK D., BARTOŠ J., ČERNOHOUS V., 2009. How does legacy of agriculture play role in formation of afforested soil properties? Journal of Forest Science, *55*: 9–14.

KANTOR P., 2008. Production potential of Douglas fir at mesotrophic sites of Křtiny Training Forest Enterprise. Journal of Forest Science, *54*: 321–332.

KLASNA J., 1975, 1976. První generace smrkových porostů na bývalých nelesních půdách. Sborník Vědeckého lesnického ústavu Vysoké školy zemědělské v Praze, *18–19*: 259–287.

LESPROJEKT, 1952. Hmotové tabulky ÚLT. Brandýs nad Labem, Lesprojekt.

NOVÁK J., SLODIČÁK M., 2006. Opad a dekompozice biomasy ve smrkových porostech na bývalých zemědělských půdách. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 155–162.

NOVÁK J., KACÁLEK D., PETR T., 2007. Properties of humus and upper soil horizons under 66-year-old spruce stand on former agricultural land. In: Management of Forests in Changing Environmental Conditions, Zvolen 4.–6. 9. 2007. Zvolen, TU: 90–95.

PODRÁZSKÝ V., 2006. Effects of thinning on the formation of humus forms on the afforested agricultural lands. Scientia Agriculturae Bohemica, *37*: 157–163.

PODRÁZSKÝ V., ŠTĚPÁNÍK R., 2002. Vývoj půd na zalesněných zemědělských plochách – oblast LS Český Rudolec. Zprávy lesnického výzkumu, *47*: 53–56.

PODRÁZSKÝ V., REMEŠ J., 2005. Retenční schopnost svrchní vrstvy půd lesních porostů s různým druhovým složením. Zprávy lesnického výzkumu, *50*: 46–48.

PODRÁZSKÝ V., REMEŠ J., 2006. Important introduced coniferous tree species and their soil forming effect. In: NEUHÖFEROVÁ P. (ed.), Faculty of Forestry and Environment of Czech University of Agriculture Prague, Kostelec nad Černými lesy, 20. 6. 2006. Kostelec nad Černými lesy, ČZU: 93–96.

PODRÁZSKÝ V., REMEŠ J.,ULBRICHOVÁ I., 2006. Rychlost regenerace lesních půd v horských oblastech z hlediska kvantity nadložního humusu. Zprávy lesnického výzkumu, *51*: 230–234.

REMEŠ J., HART V., 2004. Růst douglasky tisolisté na území ŠLP v Kostelci nad Černými lesy. In: Sborník z konference Introdukované dřeviny a jejich produkční a ekologický význam, 10.–11. 11. 2004, Kostelec nad Černými lesy. Kostelec nad Černými lesy, ČZU: 83–90.

SARVAŠ M., LALKOVIČ M., 2006. História a súčasnosť zalesňovania nelesných pôd na Slovensku. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 9–14.

ŠPULÁK O., 2006. Příspěvek k historii zalesňování zemědělských půd v České republice. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 15–24.

TICHÁ S., 2006. Výsadby dřevin na zemědělských půdách – historie a současnost. In: Zalesňování zemědělských půd, výzva pro lesnický sektor. Kostelec nad Černými lesy 17. 1. 2006. Praha, ČZU: 25–32.

Received for publication January 19, 2009
Accepted after corrections April 2, 2009

Produkce a tvorba humusových forem v lesních porostech založených na zemědělské půdě – oblast Kostelce nad Černými lesy

ABSTRAKT: K zalesňování zemědělských půd docházelo v nejrůznějších podmínkách, včetně nižších a středních poloh. Příspěvek dokládá rychlost akumulace holorganických vrstev a jejich pedochemické vlastnosti v porostech borovice lesní (*Pinus sylvestris*), smrku ztepilého (P*icea abies*), břízy bradavičnaté (*Betula verrucosa*) a douglasky tisolisté (*Pseudotsuga menziesii*) na území Školního lesního podniku ČZU v Kostelci nad Černými lesy v nadmořské výšce 430 m, na stanovišti odpovídajícímu SLT 4Q (chudá dubová jedlina). Plochy byly srovnávány se sousedním trvale zalesněným BO a SM porostem a s ornou půdou rovněž v bezprostředním sousedství. Během prvních zhruba 40 let došlo na zalesněných lokalitách ke značným změnám. Došlo ke tvorbě nadložního humusu s příznivějšími charakteristikami ve srovnání s trvale zalesněnou půdou, ve svrchních minerálních horizontech se projevila acidifikace a ztráty živin. Tyto procesy vedly k nejméně příznivému stavu právě na trvalé lesní půdě. Bříza vykazovala nejmenší změny ve srovnání s jehličnany, dosud se v jejím porostu neprojevila akumulace nadložního humusu. Nejméně degradačně se projevila douglaska, která na druhé straně selektivně poutala deficitní živiny.

Klíčová slova: zalesňování; zemědělské půdy; lesní dřeviny; humusové formy; půdní charakteristiky

Corresponding author:

Prof. Ing. Vilém Podrázský, CSc., Česká zemědělská univerzita v Praze, Fakulta lesnická a dřevařská,
165 21 Praha 6-Suchdol, Česká republika
tel.: + 420 224 383 403, fax: + 420 321 610 349, e-mail: podrazsky@fld.czu.cz