Uprooting as a disturbance factor affecting natural regeneration conditions

Vývraty jako faktor ovlivňující podmínky pro přirozenou obnovu

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Abstract

One of the most visible disturbing processes of upper part of soil is shaping of excavated mounds derived from tip-up tree roots created by windthrows within the mature stand. This process diversifies forest floor conditions affecting either emergence or survival of seedlings. There were investigated conditions onto and around existing tip-up mounds in the three mixed mature stands in the Orlické hory Mts., the Czech Republic. The numbers of both seedlings and saplings were recorded in relation to percent cover of litter there. Even though the exposition of mineral soil has been considered as suitable measure to promote emergence of tree species seedlings, the tip-up mounds are likely to play rather marginal role in regeneration process under conditions of nearly closed canopy within the stands investigated. Considering that just a brief investigation has been done, the paper brings preliminary information on the topic of interest. The article aims to point the mentioned process out; to evaluate state of regeneration based on the investigation; and to gather information on the topic from literature sources.

Keywords: natural regeneration, tip-up mounds, soil disturbance

Abstrakt

Z hlediska diverzifikace stávajících půdních poměrů je opticky nejvýraznějším jevem tvorba vývratů jako důsledek přirozeného vypadávání jedinců mateřského porostu v důsledku větrných polomů. Tyto procesy mění výrazně poměry půdního povrchu a tím také podmínky vzniku přirozené obnovy. Poměry stavu přirozené obnovy na a v okolí pařezových vývratů byly sledovány v rámci tří smíšených porostů v Orlických horách. Hodnocen byl především počet semenáčků a jedinců z přirozené obnovy ve vazbě na výskyt krytu povrchového humusu. Ačkoli je odkrytí minerální půdy považováno za vhodné opatření k podpoře vzcházení semenáčků dřevin, jeví se role vývratů v procesu vzniku obnovy pod krytem mateřského porostu vzhledem k jejich četnosti výskytu ve sledovaných porostech spíše okrajová. S ohledem na orientační charakter provedených šetření považuji závěry studie za předběžné. Cílem příspěvku je tedy upozornit na existenci popisovaného jevu v lesních porostech, zhodnotit stav obnovy na základě vlastního šetření a studiem odborné literatury shromáždit již dříve publikované informace.

Klíčová slova: přirozená obnova, vývraty, narušení půdy

Introduction

The forest soil should not be considered an intact profile from long-term point of view. Among many types of natural forest-soil disturbances, a process called floralturbation is one of the most visible processes causing local alterations of forest floor conditions. For example, whole profile may be strongly influenced by tree falls. When the individuals of mature stand fall down, an uprooting base of tree creates local disturbance of soil profile (Schaetzl et al. 1989). Roots dislodged from the ground usually excavate part of mineral soil over the ground creating

Fig. 1: A mound of exposed soil created by treefall; the tree had fallen downwards the slope. Seedlings and saplings emerged especially on the lower parts of the mound covered with litter recently; there is still obvious bare mineral soil presence on the top of tip-up mound. This tip-up mound is situated under conditions of nearly closed canopy of mature stand at lower elevations. The bare soil is likely to remain because of lower precipitation (consequent lack of moisture). In case of better moisture supply, the unstable surface of mineral soil may be stabilized by cover of mosses.
Val odkryté minerální půdy vzniklý po vývratu; strom padl směrem po svahu. Semenáčky a nárosty vzešly zejména ve spodní části valu, v současnosti pokryté opadem; navrchu je dosud zřetelná přítomnost odkryté minerální půdy. Val na obrázku se nachází v podmínkách téměř neporušeného zápoje mateřského porostu v podhůří. Odkrytá minerální půda na vrchu valu zůstává pravděpodobně vzhledem k nižším srážkám a sezónnímu nedostatku vlhkosti. V případě vyšší vlhkosti je nestabilní povrch brzy stabilizován například porostem mechů.

such a disturbance typical mainly of not-intensively managed forests. This phenomenon appeared especially, when the trees had fallen downwards the slope. Whole formation is usually composed of soil mound derived from a root-plate material and an associated pit (Burslem 2004, Schaetzl et al. 1989) between the mound and slope (fig. 1). If remaining wood is thoroughly decayed, almost no sign remembers what process are the mounds derived from. These disturbed soil patches were found not only as isolated windthrows within stands, but in many cases an original array of horizons was altered due to catastrophic blowdown within large areas (Reed, Mroz 1997). Thus the tip-up-mound forest floor covered with mature stand is indicative of past wind damages on shallow soil profiles.

These tip-up mounds with exposed subsoil diversify forest floor conditions within the stands. Consequently, the altered soil patches may have affected both species composition and density of naturally regenerated seedlings and saplings. The question is whether these disturbed soil patches affect regeneration adversely or not, and what is a principal factor in both success and failure of naturally regenerated new generation. In fact the paper answers, whether the tree species seedlings and saplings under particular site and stand conditions may have emerged and survived.

Methods

The objective of paper is investigation of natural regeneration within the three near-natural forest stands related to naturally disturbed forest floor conditions. All

localities are situated in the Orlické hory Mts., East Bohemia. including adjacent foothills. All of these stands are typical of their more or less natural tree species composition, but either space or age structure of forests could be changed by human activities during the past. Localities are situated within the Protected Landscape Area (CHKO Orlické hory), established in 1969 (tab. 1). A foothills locality (No. 2) mature stand is composed mainly of broadleaves; especially beech (55%) and sycamore maple (20%) mixed with spruce (12%) and other broadleaves (12%). Another locality (No. 1) mature stand is composed mainly of spruce (32%) and beech (52%) mixed with fir (12%). The last one (No. 3) mature stand is composed mainly of spruce (64%) and beech (29%) mixed with sycamore maple (7%).

Tab. 1: Natural conditions of localities investigated.
Přírodní podmínky sledovaných lokalit.

Locality [1)]	Altitude (m a.s.l.) [2)]	Aspect [3)]	Slope (%) [4)]	Age of mature stand (yr) [5)]	Bedrock [6)]	Soil type [7)]
No. 1	800	SE	20	180	gneiss	podzol
No. 2	560	NW	50	120	Permian breccia	cambisol
No. 3	930	NNW	35	180	mica schist	entic podzol

Vysvětlivky: [1)] lokalita; [2)] nadmořská výška; [3)] expozice; [4)] sklon svahu; [5)] věk mateřského porostu; [6)] mateřská hornina; [7)] půdní typ

Localities were chosen to satisfy following conditions:

- potential ability of forest stand to regenerate naturally itself;
- tree species composition was representative of the near-natural mixed forests in accordance with particular site conditions;
- no intensive management measures have been done in last decades;
- occurrence of relatively fresh tip-up mounds changing forest floor conditions.

The investigation was focused on state of natural regeneration (especially saplings) under different conditions of forest floor patches with exposed mineral soil. Following site characteristics occurred were investigated: presence of forest-floor humus, occurrence of exposed subsoil, abundance of vascular plants and mosses. Numbers of both seedlings and saplings per square meter were recorded. Considering the site diversity onto disturbed surface and around tip-up mounds, the sample plots were divided into three groups in order to investigate the state of natural regeneration there. Group A – base part of tip-up mound including pit and adjacent disturbed soil (up to 0.5 m height from undisturbed ground); group B – top part of tip-up mound including elevated sides; group C – undisturbed forest floor surrounding tip up mound. From the data recorded were calculated: averages of both percent coverage and number of individuals per square meter; standard deviations and confidence intervals to estimate statistically significant difference among variants. This brief investigation has not been done in terms of number of

tip-up mounds per hectare yet, since the relatively fresh, but regeneration-overgrown mounds are quite rare in the localities where the investigation has been conducted. Thus the article brings just "preliminary" results from the fieldwork referred to publications related.

Results and discussion

Excellent review paper gathering information on tree uprooting was written by Schaetzl et al. (1989). They mentioned an importance of tip-up mounds derived from uprooting in terms of affecting soil morphology, surface characteristics, nutrient conditions, regeneration trends and forest age structure. The paper provides a synthesis of knowledge related on the topics of treefall and uprooting from environmental, economical and silvicultural points of view. The results of my investigation confirms the importance of uprooting from aspects affecting soil morphology, surface characteristics, and regeneration conditions, even though uprooting may be of lesser importance from regeneration point of view under conditions of nearly closed canopy of mature stand. If gaps created by windthrows are not large enough, the light conditions do not allow regeneration to escape a ground vegetation layer or no woody regeneration appears onto and around tip-up mounds.

The mounds of exposed mineral soil are shaped not only as derived from individual treefalls within stands; also catastrophic blowdown can cause such a soil disturbance on much more extended areas (Kulakowski, Veblen 2003). The authors found that such disturbances may serve as soil preparation especially under conditions of poorly drained soils, because seedlings of both *Picea engelmanii* and *Abies lasiocarpa* were established preferentially on old fallen logs and tip-up mounds. The tip-up mounds are of great importance in such severe habitats like swamps (Titus 1990), because elevated soil provides both germination and growth substrate for most woody species avoiding temporarily flooded sites there. But there were found only few mounds to support establishment of woody species at least sufficiently.

Quite special role which the tip-up mounds play in relation to growth of hemlock natural regeneration after catastrophic blowdown was found by Long et al. (1998). Despite the xeric and unstable conditions of steep walls of mounds the hemlock seedlings and saplings escaped browsing of deer. Thus the soil disturbance provided better conditions for regeneration, because the individuals of hemlock were found in significantly greater density, were taller and had larger basal diameters on the tip-up mounds than in surrounding areas. On the other hand, if the mounds were not derived from massive treefalls after severe blowdowns, they would not be of such an obvious importance for regeneration and diversification of forest floor conditions. When correlating mound density or percentage of stand area occupied by mounds, Tyrrell and Crow (1994) found no relationship between these characteristics and stand age. They confirmed the main mound-promoting influential factors (e. g. topography, slope, water table, soil type and subsurface pans) summarized by Schaetzl et al. (1989). They also assessed lack of correlation between mound percentage and stand age as attributable to long mound persistence (roughly centuries) in the stands.

The tip-up mounds in old-growth forest in Japan were overgrown with rich communities of pioneer species (Nakashizuka 1989). It seems that uprooting plays an important role in maintaining species diversity in these forests, because soil disturbance promotes germination of species with small, wind-dispersed seeds, while large-seeded, animal-dispersed species were present at sites without soil disturbance. He found neither relation to species composition, nor species diversity between sites under closed canopy and gaps without soil disturbance. Thus, the gap formation without creating tip-up mounds does not contribute substantially to the maintenance of pioneer species population there. Peters et al. (1992) confirmed the importance of creating mounds for successful natural regeneration of these forests composed mainly of *Fagus crenata*. The reason is that regeneration of the beech is strongly prevented by infestation of dwarf bamboo (e. g. *Sasa senanensis*) creating ground floor understorey (height up to 2 m). They found a restriction of sparse beech regeneration to mounds in case of recovered dominance of dwarf bamboo understorey. On the other hand, there were found no vascular plants preventing the regeneration emergence recently in forest stands in the Orlické hory Mts. Seedlings and saplings emerged especially on the lower parts of the mound covered with litter recently; there is still obvious bare mineral soil presence on the top of tip-up mound (locality No. 2). The bare soil is likely to remain there because of lower precipitation (consequent lack of moisture). In case of better moisture supply, the unstable surface of mineral soil is stabilized by cover of mosses (locality No. 3). An emergence and performance of the small-seeded species were examined by Kobayashi and Kamitani (2000) under conditions of different light levels and soil disturbance. They found a greater effect of soil disturbance upon a density and number of species than the effect of high light level.

The tip-up mounds within the locality No. 2 (fig. 2) are the only ones, where the top surface of mound (group of releves situated over 0.5 m above ground) is not covered with nearly any saplings yet, excepting sparse presence of mosses. Thus the locality is the only one, where the elevated mineral soil affects regeneration adversely. The saplings are composed mainly of beech and sycamore maple; a sparse presence of Norway maple (roughly one individual per square meter) was recorded only in undisturbed soil releves. The saplings of both the other localities are composed of beech and Norway spruce. The numbers of saplings on the top surface of mound were lower than numbers on both the base of mound and surrounding undisturbed ground. Norway spruce number exceeded the number of beech in the top-surface releves from both localities. The number of spruce individuals was highest in locality No. 3 at all. Considering the relatively low number of tip-up mounds within the entire forest stand, there is no doubt that mounding plays a minor role in changes of regeneration conditions.

Conclusion

The investigation of tip-up mounds created by treefals within the mixed stands of the Orlické hory Mts. suggested that this process does not influence the regeneration conditions significantly there. Even though the mounds are quite well-visible within the mixed stands, in accordance with literature sources, their formation un-

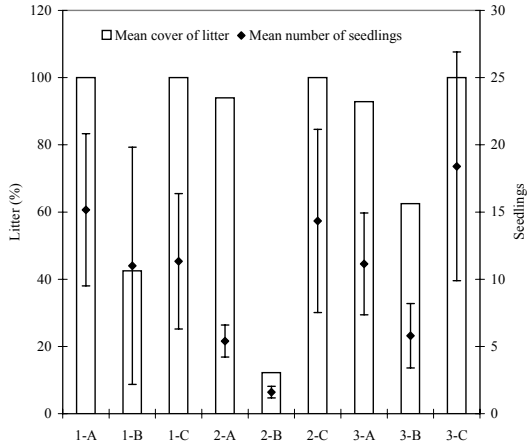

Fig. 2: Percent cover of litter related to mean number of woody seedlings per square meter. Columns represent cover of litter per 1m^2 (Y axis), while points represent mean number of seedlings per 1m^2 (secondary Y axis). Error bars indicate confidence intervals at significance level 0.05. X axis symbols: 1, 2, 3 – three localities investigated; A – base part of tip-up mound including pit and adjacent disturbed soil (up to 0.5 m height); B – top part of tip-up mound including elevated sides; C – undisturbed forest floor surrounding tip-up mound.
Procentický pokryv opadu ve vztahu k průměrnému počtu semenáčků na ploše čtverečního metru. Sloupce představují pokryv opadu (osa Y), zatímco body jsou počty jedinců (sekundární osa Y). Chybové úsečky zobrazují hodnoty konfidenčního intervalu analyzovaných souborů (hladina významnosti 0,05). Symboly na ose X: 1, 2, 3 – tři sledované lokality; A – bazální část vývratiště s narušenou půdou; B – svrchní část valu včetně vyzdvižených stran; C – neporušený půdní povrch v okolí vývratišť.

der conditions of nearly closed mature stand canopy leads to creation of sparsely disturbed patches. On the other hand a catastrophic blowdowns can disturb soil in much greater extent of damage. After that blowdown can such disturbances serve as a "site preparation" to promote emergence of mainly small-seeded (especially pioneer) tree species. But the uprooting can also play more important role under conditions of temporarily flooded sites to promote both emergence and growth of woody species tolerating or nearly avoiding water-logged soils. There was the only locality (2 – situated in foothills; fig. 2) within the stands of interest, where the significant difference among three groups of conditions was proved. There were not nearly any saplings recorded in releves situated on both the top and sides of elevated soil compared to base of mound including pit and undisturbed ground. On the mounds of the other localities was density of saplings in the top-of-mound releves lower than both on the base and surrounding undisturbed soil, but comparison was insignificant. The article brings first insight into the topic of interest under conditions of mixed near-natural forests in the Orlické hory Mts. Hence next investigations, for instance estimating number of tip-up mounds, their age and stage of wood decomposition are needed.

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Souhrn

Jedním z nevýraznějších procesů narušujících sled genetických horizontů v lesní půdě je přeformování půdních vrstev v důsledku vzniku stromových vývratů. Vývraty obecně nejsou nijak vzácným jevem; objevují se zejména ve stejnorodých smrkových monokulturách, kde často padají celé porosty najednou. Ovšem situace ve smíšených porostech, kde není po dlouhou dobu uplatňováno intenzivní hospodaření, se vyvíjí poněkud jinak. V rámci rozpadu mateřského porostu vypadávají postupně jednotlivé stromy. Mnohé z nich, ať už jehličnany nebo listnáče, jsou vyvraceny, a s částí kořenů se překlopením dostává na povrch část minerální půdy. Později dochází k zetlení ležícího dřeva a již téměř nic neukazuje přímo na původ vzniku výrazných terénních depresí a valů formujících část půdního povrchu jednotlivých lokalit (obr. 1). Můžeme si představit, že v lesích lidskou činností nedotčených tento faktor mechanického převrstvování půdních horizontů mohl být také významným činitelem geneze jednotlivých typů lesních půd. Na půdách s významným podílem skeletu je převrstvení obzvlášť dobře identifikovatelné. Tyto útvary mají strmé čelo směrem po svahu, poměrně úzký hřbet a zadní,

často značně skeletnatou část proti svahu. Na dně deprese dochází k hromadění povrchového humusu. Na jednotlivých zkusných plochách (1 m^2) byly hodnoceny tyto charakteristiky: výskyt minerální půdy, procentický kryt opadu a počty jedinců dřevin z přirozené obnovy. Plošky byly za účelem vyhodnocení rozděleny do tří skupin (obr. 2): A – bazální část vývratu zahrnující porušený půdní profil do výšky 0,5 m nad neporušeným povrchem; B – vrcholová část půdního valu (tip-up mound) včetně vyzdvižených stran; C – neporušená půda v okolí valu. V porostech vyšších poloh (č. 1 – 800 m n. m.; č. 3 – 930 m n. m.) dochází již brzy po vytvoření vývratu k hojnému nástupu přirozené obnovy smrku a buku (varianty 1A, 1B, 3A, 3B), přičemž smrk osidluje často i jejich vrcholové partie. V případě podhorské lokality (č. 2 – 560 m n. m.) byly konstatovány signifikantní rozdíly v denzitě jedinců z přirozené obnovy mezi všemi třemi variantami. Navíc zde vůbec nedochází k obnově smrku (dominují buk a klen), ačkoli je tato dřevina v mateřském porostu také zastoupena. Co se týká vlivu těchto útvarů na přirozenou obnovu, jejich role by neměla být přeceňována v případě výskytu pod slabě porušeným zápojem mateřského porostu. Jiná je situace v případě katastrofických rozvratů porostů větrnými polomy, kdy se rozsáhlá pole vývratišť stávají vhodnou půdou k nástupu pionýrských druhů dřevin s lehkými semeny. Ovšem vždy se nemusí jednat o vysloveně pionýrské druhy, jelikož například smrk má také dostatečně lehká semena a časté semenné roky, aby mohl osidlovat nejen minerální půdy při bázi valu, ale také i vrcholové části vývratiště. Jako důležitý předpoklad však zde pro tento případ uvádím dostatek srážek. Vznik popisovaných útvarů není sice příliš častý (Schaetzl et al. 1989), ovšem z dlouhodobého hlediska v řádu stovek let může význam převrstvení půdních horizontů pod kontinuálním krytem porostu narůstat. Jak vyplývá z již publikovaných studií, význam půdních valů pro nástup a odrůstání přirozené obnovy stoupá také v případě výskytu na podmáčených nebo dočasně zaplavovaných stanovištích nebo na lokalitách se silným zabuřeněním. Troufám si zde odhadnout, že z hlediska nástupu a odrůstání přirozené obnovy jsou nejméně příznivá zejména raná stádia těsně po zformování vývratů. Později, jak postupně dochází k tlení dřeva, sesedání valu a pokryvu minerální půdy opadem, se mohou rozdíly těchto mikrostanovištních narušení a okolní nenarušené půdy stírat. Tento příspěvek přináší první informace týkající se tématu vývratů ve smíšených přírodě blízkých porostech Orlických hor, tudíž k detailnějšímu poznání vlivu zmíněných procesů na přirozenou obnovu jsou nutná pokračující šetření.

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