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STAND CONDITIONS AFTER HEAVY STORM WINDTHROW IN NORTHEAST ESTONIA

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Abstract

The heavy storm damaged thousands of hectares of forest in Estonia in 2001. The permanent experiment was established to study the stand development after heavy disturbance. Amount of dead wood in damage area reaches 662 m^3 ha^{-1}. The properties of dead wood depend on the species composition and stand structure of former forest. The mechanical details of forming dead wood are important: uprooted trees or broken stems. There is varying number of advance regeneration of Norway spruce in many cases on plots. Advance regeneration growth depends on soil surface changes, ground vegetation and damage status by falling trees. In addition ground coverage by stems and branches creates shelter and seedbed variances. The living trees area affected by storm: the root systems have been under heavy pressure of physical forces.

Introduction

Heavy storm winds are important damage factors in boreal forests. The prediction and planning the preventive measures is quite complicated because of irregular intervals between storms in many cases (Lässig and Mocalov 2000).

The effect of storms on the forests depend on many stand and ecosystem variables: species vulnerability, depth of soils, stand age and composition etc. (Ruel 2000). Also management of the stands produces highly variable stand structures possessing different behaviour patterns under wind pressure (Smith *et al.* 1997).

This study presents descriptive stand characteristics comparatively from areas with different damage status. The formation of pitmounds and considerable amount of dead wood creates very specific conditions for regeneration. Permanent sample plots provide an opportunity to plan investigations for a longer period. Long term dynamics can be studied using permanent sample ares.

Material and methods

The permanent experiment was established to study the stand development after heavy disturbance. The set of sample plots was established in Northeast of Estonia (Tudu Forest District) in 2002.

Table 1. Dominant species proportions in sample plots with total stand destruction after storm.

Tree species	Plot No. 1	Plot No. 5	Plot No. 9
Picea abies (L.) Karst.	65	70	60
Populus tremula L.	24	4	33
Betula pendula Roth	11	19	5
Alnus glutinosa (L.) Gaertn.		8	2

Table 2. Sample plots and calculated wood volumes (both living and dead).

Plot No.	Estimated wood volume, m^3ha^{-1}	Treatment (variant)
1	602.8	100% damage
2	497.5	Control
3	382.4	Control
4	247.8	Salvage cutting
5	387.3	100% damage
6	238.0	Salvage cutting
7	509.6	Partial damage
8	385.0	Control
9	661.5	100% damage
10	302.5	Salvage cutting

Sample plots were situated in forests of different treatments. Three plots were situated in areas of salvage cuttings: the extent of damage was more than 50% in all of those areas. Next three plots were established in completely destroyed forest where all the wood was left in site. In addition three control plots were established in stands with all trees standing. The attempt was also made to find areas with 50% damage but only one stand was suitable for this purpose. All plots were located randomly within the mapped area of different damage classes.

Thus, ten sample plots (40 x 20 m) were established. The coordinates of all tree stems standing were measured. The coordinates of laying stems were determined as beginning and end of the stem within the plot. The measuring tape was placed at the central axis of the plot and distances to stem positions were determined using VERTEX system.

All species were recorded. The breast height diameters were measured for standing and laying trees which stump (also uprooted) was in the plot. The height of the standing part of the snapped stem was measured. The diameter of thickest side of the stem was determined for trees whose stump was outside of the plot. Two diameters were measured for parts of stems and stems whose stump and top were outside of the plot. The height of the mound was measured for uprooted trees. All trees in plot 9 were tagged with metal labels to follow the decomposition during longer period.

The wood volumes were calculated using models based on breast height diameter equations (Laasasenaho 1982). The damage types were analysed for different species.

The measuring was analogous to determine stump positions in plots of salvage cuttings. Stump diameters were measured. Tree volumes were calculated using coefficients for transforming root collar diameters to breast height diameter (http://www.envir.ee).

Results and discussion

The main tree species in sample plots heavily damaged was Norway spruce (*Picea abies* (L.) Karst.). Also European aspen (*Populus tremula* L.) and silver birch (*Betula pendula* Roth) had significant proportion (Table 1).

Amount of dead wood in damage area reaches 662 m^3 ha^{-1} (Table 2). The properties of dead wood depend on the species composition and stand structure of former forest. The mechanical details of forming dead wood are important: uprooted trees or broken stems. The high volumes of dead wood were caused by aggregation of fallen stems in plot.

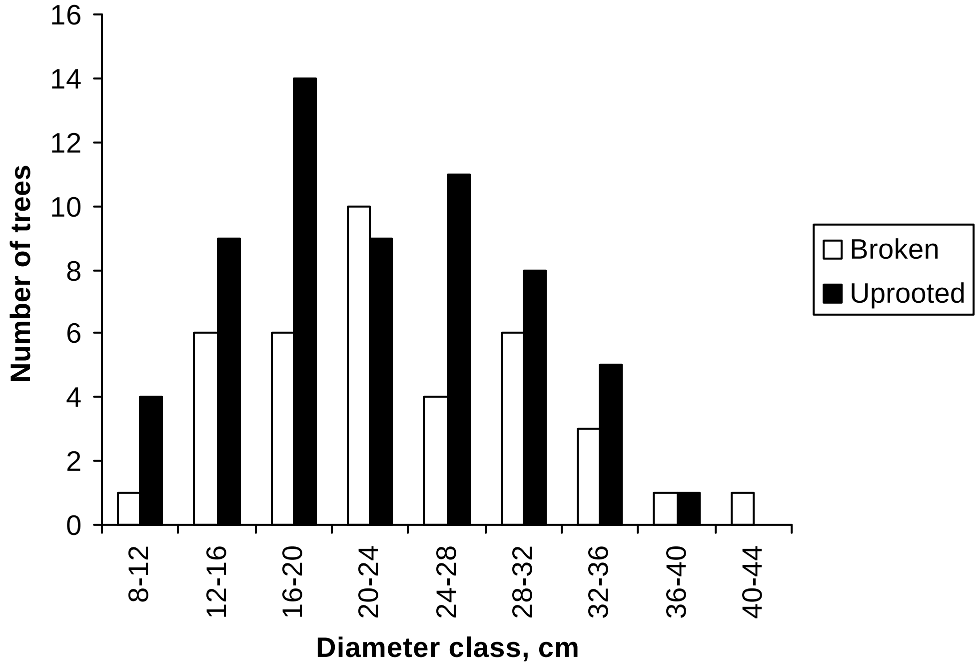

Fig. 1. Number of spruce trees in plots with completely destroyed stands (plots no. 1, 5 and 9). Broken and uprooted stems are separated.

The ground vegetation and advance regeneration growth conditions have been changed to a high degree. The occurrence of heavy storms with local impact has increased during last decades. Disturbance status has great variation in quite a fine spatial scale.

Damaged Norway spruces are uprooted (Fig. 1). Only diameter class 20-24 cm has higher number of broken stems. It is possible that this tree generation was damaged by root rot fungus. European aspens demonstrates quite different pattern: smaller trees have been broken whereas bigger stems are uprooted (Fig. 2).

There is varying number of advance regeneration of Norway spruce in many cases on plots. Advance regeneration growth depends on soil surface changes, ground vegetation and damage status by falling trees. In addition ground coverage by stems and branches creates shelter and seedbed variances.

One of the main conclusions by Charlton and Bazzaz (1998) was the high heterogeneity of resource levels in experimental blowdown areas. For instance there was a drastic variation in light levels between such microsites as pits and ground vegetation (fern) patches. The same conclusion can be reached on the basis of our observations.

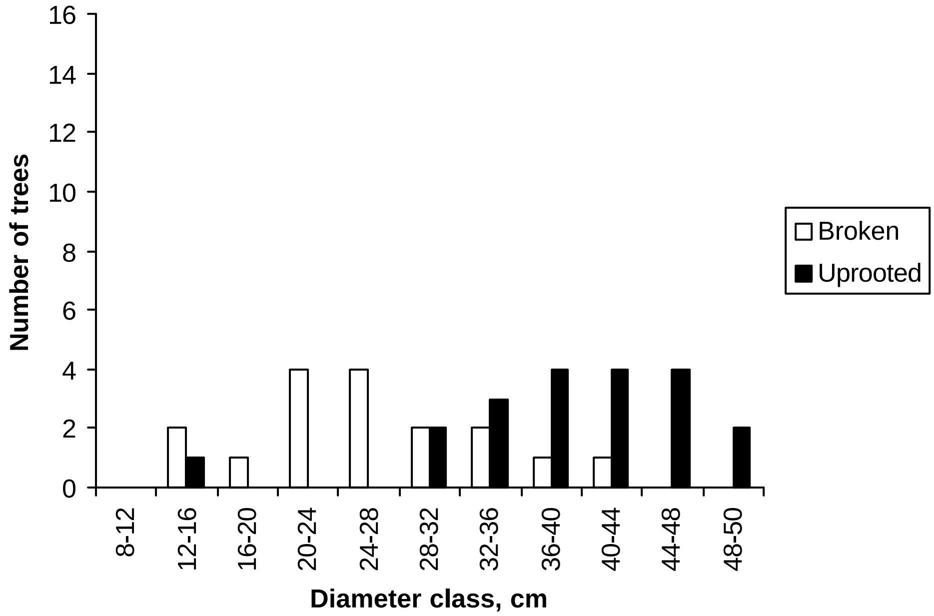

Fig. 2. European aspen in plots with total stand destruction. The number of broken and uprooted trees is given

However, the gradual development of edaphic conditions changes regeneration patterns imposed by climatic (light, temperature) factors. Erosion of soil from mounds into pits may severely inhibit establishment of regeneration trees (Charlton and Bazzaz 2000, Bazzaz 1996). Simlar descriptions can be found in Ulanova (2000) and Bormann *et al.* (1995). Winter conditions create additional variance in temperature regimes and introduce snow pressure effect (Figure 3).

The living trees area affected by storm: the root systems have been under heavy pressure of physical forces.

The forest ground without damages is an important place for regeneration. The proportion of ground changed by pitmounds could reach 10% (Charlton and Bazzaz 1998). The rest is covered with ground vegetation and advance regeneration or exposed for gradual regeneration.

Future work in the frame of the present project is focused on regeneration patterns on different microsites: pits, mounds, fallen logs, open ground and ground covered by vegetation.

Fig. 3: Sample plot with heavy damage. Also winter conditions and snow pressure affect the state and development of windthrow areas.

Storm impact and windthrows are important disturbance factors in many places in Estonia. It must be stressed that the nature of heavy winds has changed: the wind impact has more local nature causing destruction areas of relatively small size. At the same time the severity of destruction seems to be higher compared to historical data.

The scale of disturbance must be considered. The gap dynamics on the costal areas of Estonia is highly dependent on wind. At the same time the stand structure has certain acclimation features to resist the constant high speed wind pressure.

The shade intolerant species are favoured by disturbances of bigger scale like windthrows. Main reason is the altered light conditions. However, the blowdown areas accommodate sites with rather poor light environment. An example is provided by Carlton and Bazzaz (1998). The uprooted trees change considerable area of former forest ground into vertical plate of decomposing material. If the vertical level is not exposed to the sun the light conditions can be more convenient for shade tolerant species.

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References

Bazzaz, F.A., 1996: Plants in Changing Environments: Linking physiological, population, and community ecology. Cambridge University Press, Cambridge, England

Bormann, B.T., Spaltenstein, H., McCellan, M.H., Ugolin, F.C., Cromack, K.,Jr., Nay, S.M., 1995: rapid soil development after windthrow disturbance in prostine forests, Journal of Ecolgy, Vol. 83, pp. 747-757

Carlton, G.C., Bazzaz, F.A., 1998: Resource congruence and forest regeneration following an experimental hurricane blowdown, Ecology, Vol. 79, pp. 1305-1319

Laasasenaho, J., 1982: Taper curve and volume function for pine, spruce and birch, Communicationes Instituti Forestalis Fenniae, Vol. 108.

Lässig, R., Mocalov, S.A. 2000. Frequency and characteristics of severe storms in the Urals and their influence on the development, structure and management of the boreal forests, Forest Ecology and Management, Vol. 135, pp. 179-194

Ruel, J.-C., 2000: Factors influencing windthrow in balsam fir forests: from landscape studies to individual tree studies, Forest Ecology and Management, Vol. 135, pp. 169-178

Smith, D.M., Larson, B.C., Kelty, M.J., Ashton, P.M.S., 1997: The practice of silviculture. Applied forest ecology. Ninth edition. John Wiley & Sons, Inc., New York

Ulanova, N.G., 2000: The Effects of windthrow on forests at different spatial scales: a review, Forest Ecology and Managemanet, Vol. 135, pp. 155-167