THE EFFECT OF THE FOREST VEGETATION ON SNOW DEPOSITION: CASE STUDY, THE FORESTS AT THE FRINGE OF NOJORID AND PAUSA LOCALITIES

S.L. DOROG

University of Oradea, Faculty of Environmental Protection
26 Gen. Magheru St., 410048 Oradea; Romania, E-mail: dorogs@yahoo.com

Abstract: The presence of the snow layer plays important energetic, hydrological and ecological roles upon forest vegetation. Snow deposition is highly influenced by dominant wind direction during the snowing episode and also by the presence or absence of obstacles (forest stands, vegetation debris on cultivated lands, various types of constructions). The present paper presents the results of the snow layer thickness measurements within the forest and in the nearby area. The measurements were performed in 16-18 February 2012, after a heavy snowing episode during 14-15 February 2012. Data processing was performed with Kyplot software for the comparison of snow depositions within the forest, outside the forest and between these situations. The variations of the snow depositions thickness were not significant within the forest and extremely significant nearby the forest. In most occasions, the forest played the role of a wall diminishing the wind speed therefore the snow was deposited preponderantly outside the forest where various obstacles were intercepted. Tree windbreaks have beneficial roles: decrease the damaging effect of the dry winds, increase water contents of the soil and, at last but not at least, protect communication routes within and between localities. Within forest stands playing the role of windbreaks, the snow layer is deposited more or less in a non-uniform manner depending on the wind speed and direction also, the windbreak orientation. It is necessary to take into consideration as priority for local and central administrations for long term planning of the tree windbreaks designed to protect communication routes and localities respectively in areas affected by hard winds during the winters due to increased incidence of extreme meteorological events. Risk analysis in exposed areas and the application of correct measures should become priorities at national level in order to decrease the unfavourable effects of the extreme meteorological events.

Key words*: *Sow layer, distribution, forest vegetation effect,comparative analysis

INTRODUCTION

Snow cover plays important energetic, hydrological and ecological role upon forest vegetation. The presence of the snow cover influences the incident energy input by reflectance modification and influences also the regeneration and seedling growth. Slow snow melting sheltered by the forest leads to gradual water accumulation in the forest soil which preserves in a better waythe water as compared to cultivated soils (VASILESCU M.M., 2003). Beneath snow cover, frequently the soil does not freeze or freezes only superficially which helps tree roots to develop during the cold season (VASILESCU M.M., 2004).

During the last period of time, among other effects of the global climatic change, the increased incidence of extreme phenomena is observed: intermittence of abundant rains and prolonged droughts, intermittence of relatively warm periods during the winter without snow cover and abundant snowing (DOROG S., 2003). All these events head toward serious effects affecting human society (DOROG S. et all., 2006).

For the next years, due to the increased incidence of extreme meteorological events measures to be taken are considered: the identification and mapping of risk areas and the implementation of concrete measures for the diminution of risks and the produced unfavorable effects. For the limitation of uneven and abundant snow deposition in risk areas, tree windbreaks must be reconstructed. These were destroyed by different agents meaning that the reconstruction must be targeted toward destroyed or inexistent windbreaks in places exposed to aforementioned risk (DOROG S. et all., 2005).

The present paper presents results of the study on snow deposition inside and outside a forested area due to wind high intensity and the presence of various obstacles on the place.

Tree windbreaks (LUPE I, 1952) determine the accumulation of snow within the protected space they establish taking the shape of a wave or a dune. The width of the dune depends on the width of the tree windbreak and its penetrability which are positively correlated meaning that a wide windbreak will harbor a wide snow dune and a narrow windbreak will harbor a narrow snow dune (LUPE I., 1943).

Tree windbreaks playa double role from the point of view of humidity distribution in soil: decrease the damaging effect of dry winds which has a beneficial effect on surrounding cultivated areas and increase soil water content by retaining and accumulating a significant snow layer (VASILESCU M.M., 2007). Within the studied forest stands, several successive, narrow snow dunes were formed, usually two or three parallel dunes smaller than the first one which can be called tails (VASILESCU M.M. et all., 2007) which intercept partially the wind dislodged snow.

MATERIAL AND METHODS

The sampling area is pace in the Southern fringe of the city of Oradea, the forests edging localities Păuşa and Nojorid, near the county road 671 which links Oradea and the Southern part of Bihor County. The variability of the snow cover from Păuşa and Nojorid was studied between 16 and 18 February 2012 after the heavy snowing event of 14-15 Febraury. The heavy snow deposition induced traffic perturbation due to non uniform deposition. Measurements were performed between 16 and 18 February 2012.

Measurements were performed on transects of 150-200 m 100m apart within forest stands and outside the forest. Transects were placed perpendicular to forest edge, the depth of the snow cover being measured every 5 m. The total number of depth measurement points was 372.

Forests where sampling was performed are composed of Turkey oak (*Quercus cerris*) as a dominating species and other mixed species such as *Prunus avium* and *Acer campestre*. Areas situated outside the forest where also sampling was performed, are community pastures at the fringe of Nojorid and cultivated land near Păuşa.

Under both situations, snow depth was influenced by wind speed and direction which was SW-NE, the speeds reported by the meteorological station Oradea being of 45-50 km/h.

Data processing was performed using Kyplot software. Analysis of comparisons was applied on the snow depth data within the forest, outside the forest and between the two situations.

RESULTS AND DISSCUTIONS

Statistical analysis of data concerning the comparison of snow depth within and outside the forest is summarized in the tables presented below.

Table 1 shows two situations; high significance level of the snow deposition differences outside and within the forest and low level of significance of the same situations. In the case of extremely high significance, the difference of snow depth was in the range of 7-9 cm, in the case of low significance, snow depth varied in the range of 2-3 cm. Situations when a fraction of the deposited snow was dislodged by wind were correlated with extremely high significance of the differences between snow depth within the forest and outside the forest.

Table 1

Comparisons of snow depth within and outside the forest

Sampling area	Position	Average	Variance	Comparisons	
				T test value	Significance level
Nojorid 1	Forest	25,1	15,05	-6.52653	*** (P<=0.001)
	Outside the forest	16,4	22,79		
Nojorid 2	Forest	24,5	8,45	-5.11542	*** (P<=0.001)
	Outside the forest	18,9	16,03		
Păuşa 17.1	Forest	23,6	7,09	-0.10301	N.S. (P>0.05)
	Outside the forest	23,4	31,81		
Păuşa 17.2	Forest	28,6	13,40	-3.65545	*** (P<=0.001)
	Outside the forest	23,7	12,74		
Păuşa 17.3	Forest	30,0	22,82	-3.98641	*** (P<=0.001)
	Outside the forest	23,8	14,88		
Păuşa 17.4	Forest	26,1	3,85	-1.30818	N.S. (P>0.05)
	Outside the forest	24,5	15,51		
Păuşa 17.5	Forest	27.2	7,16	-4.32393	*** (P<=0.001)
	Outside the forest	21.7	13,71		
Păuşa 18.1	Forest	28,1	6,25	1.564906	N.S. (P>0.05)
	Outside the forest	31,0	33,73		
Păuşa 18.2	Forest	28,8	24,5	0.453705	N.S. (P>0.05)
	Outside the forest	30,1	64,5		
Păuşa 18.3	Forest	28,2	6,51	1.432288	N.S. (P>0.05)
	Outside the forest	31,3	46,11		
Păuşa 18.4	Forest	27,1	24,36	0.209362	N.S. (P>0.05)
	Outside the forest	27,4	11,48		
Păuşa 18.5	Forest	27,3	17,11	1.517922	N.S. (P>0.05)
	Outside the forest	30,4	36,21		
Păuşa 18.6	Forest	27,5	29,77	-1.27759	N.S. (P>0.05)
	Outside the forest	25,3	18,98		

Micro depressions in the outside forest areas can accumulate snow within snow which is dislodged from areas with positive terrain topography and harbour more superficial snow layer (or no snow cover). Within the forest the amplitude of variation of snow depth is diminished as compare with outside forest areas due to protection effect of the forest vegetation.

Table 2 summarizes the comparisons of the snow depth variation within the forest in the study sites as follows:

- The comparisons of snow depth within forest (13 sampling units) show the relative uniformity of the distribution of snow cover, significance test indicating not significant differences in eleven cases out of thirteen.

- In the other case, differences were extremely significant (sampling unit Păuşa 17.3 as compared to Nojorid 1 and significant differences as compared with Nojorid 2 and Păuşa 1. the situation is due to snow accumulation in this micro depressionary area, the depth of which was constantly over the average value calculated for sampling areas. In this area tree density varies at a greater extent, stand consistency being situated around 0.65-0.7.

- Marginally significant differences characterizing the sampling unit Păuşa17.2 are explained by similar causes already presented with the observation that the average snow depth is closer to the average of other sampling units.

Tabel 2

Comparisons of the snow depth variation within the forest in the study sites

Study site	Comparisons of the snow depth within the forest. Significance level			
	Nojorid 2	**Păuşa 17.1**	**Păuşa 17.2**	**Păuşa 17.3**
Nojorid 1	0.115347 N.S.(P>0.05)	0.46139 N.S.(P>0.05)	3.66227 * (P<=0.05)	4.55622 *** (P<=0.001)
Nojorid 2	-	0.34604 N.S.(P>0.05)	3.54693 * (P<=0.05)	4.44087 ** (P<=0.01)
Păuşa 17.1	-	-	3.20089 N.S.(P>0.05)	4.09483 ** (P<=0.01)
Păuşa 17.2	-	-	-	0.89394 N.S. (P>0.05)
-	**Păuşa 17.4**	**Păuşa 17.5**	**Păuşa 18.1**	**Păuşa 18.2**
Nojorid 1	2.076253 N.S. (P>0.05)	2.768337 N.S. (P>0.05)	3.345074 N.S. (P>0.05)	3.806463 * (P<=0.05)
Nojorid 2	1.960905 N.S. (P>0.05)	2.65299 N.S. (P>0.05)	3.229727 N.S. (P>0.05)	3.691116 * (P<=0.05)
Păuşa 17.1	1.614863 N.S. (P>0.05)	2.306948 N.S. (P>0.05)	2.883684 N.S. (P>0.05)	3.345074 N.S. (P>0.05)
Păuşa 17.2	- 1.58603 N.S. (P>0.05)	- 0.89394 N.S. (P>0.05)	- 0.31721 N.S. (P>0.05)	0.144184 N.S. (P>0.05)
Păuşa 17.3	- 2.47997 N.S. (P>0.05)	- 1.78788 N.S. (P>0.05)	- 1.21115 N.S. (P>0.05)	- 0.74976 N.S. (P>0.05)
Păuşa 17.4	-	0.692084 N.S. (P>0.05)	1.268821 N.S. (P>0.05)	1.730211 N.S. (P>0.05)
Păuşa 17.5	-	-	0.576737 N.S. (P>0.05)	1.038126 N.S. (P>0.05)
Păuşa 18.1	-	-	-	0.46139 N.S. (P>0.05)
-	**Păuşa 18.3**	**Păuşa 18.4**	**Păuşa 18.5**	**Păuşa 18.6**
Nojorid 1	3.402748 * (P<=0.05)	2.162763 N.S. (P>0.05)	2.826011 N.S. (P>0.05)	2.970195 N.S. (P>0.05)
Nojorid 2	3.2874 N.S. (P>0.05)	2.047416 N.S. (P>0.05)	2.710663 N.S. (P>0.05)	2.854848 N.S. (P>0.05)
Păuşa 17.1	2.941358 N.S. (P>0.05)	1.701374 N.S. (P>0.05)	2.364621 N.S. (P>0.05)	2.508805 N.S. (P>0.05)
Păuşa 17.2	- 0.25953 N.S. (P>0.05)	- 1.49952 N.S. (P>0.05)	- 0.83627 N.S. (P>0.05)	- 0.69208 N.S. (P>0.05)
Păuşa 17.3	- 1.15347 N.S. (P>0.05)	- 2.39346 N.S. (P>0.05)	- 1.73021 N.S. (P>0.05)	- 1.58603 N.S. (P>0.05)
Păuşa 17.4	1.326495 N.S. (P>0.05)	0.086511 N.S. (P>0.05)	0.749758 N.S. (P>0.05)	0.893942 N.S. (P>0.05)
Păuşa 17.5	0.634411 N.S. (P>0.05)	- 0.60557 N.S. (P>0.05)	0.057674 N.S. (P>0.05)	0.201858 N.S. (P>0.05)
Păuşa 18.1	0.057674 N.S. (P>0.05)	- 1.18231 N.S. (P>0.05)	- 0.51906 N.S. (P>0.05)	- 0.37488 N.S. (P>0.05)
Păuşa 18.2	- 0.40372 N.S. (P>0.05)	-1.6437 N.S. (P>0.05)	- 0.98045 N.S. (P>0.05)	- 0.83627 N.S. (P>0.05)
Păuşa 18.3	-	- 1.23998 N.S. (P>0.05)	- 0.57674 N.S. (P>0.05)	- 0.43255 N.S. (P>0.05)
Păuşa 18.4	-	-	0.663247 N.S. (P>0.05)	0.807432 N.S. (P>0.05)
Păuşa 18.5	-	-	-	0.144184 N.S. (P>0.05)

Concerning the comparisons of the snow depth variations in the sampling units from the outside forest area:

- The differences n snow depth as compared to the other two locations are extremely significant due to the positioning of the two forest stands with respect to wind direction during the snowing episode. In Nojorid, wind direction was tangent to the forest edge while at Păuşa wind direction formed an angle of 30-45 ° to the forest edge. This explains the higher values of snow layer depth from Păuşa, outside the forest.

Tabel 3

Comparisons of snow depth variations outside the forest, at study sites

Site	Comparisons of snow depth within the forest. Significance level			
	Nojorid 2	**Păuşa 17.1**	**Păuşa 17.2**	**Păuşa 17.3**
Nojorid 1	1.632812 N.S. (P>0.05)	4.444878 *** (P<=0.001)	4.656539 *** (P<=0.001)	4.717013 *** (P<=0.001)
Nojorid 2	-	2.812066 N.S. (P>0.05)	3.023726 N.S. (P>0.05)	3.084201 N.S. (P>0.05)
Păuşa 17.1	-	-	0.211661 N.S. (P>0.05)	0.272135 N.S. (P>0.05)
Păuşa 17.2	-	-	-	0.060475 N.S. (P>0.05)
-	**Păuşa 17.4**	**Păuşa 17.5**	**Păuşa 18.1**	**Păuşa 18.2**
Nojorid 1	5.125216 *** (P<=0.001)	3.401692 * (P<=0.05)	9.28284 *** (P<=0.001)	8.678095 *** (P<=0.001)
Nojorid 2	3.492404 * (P<=0.05)	1.76888 N.S. (P>0.05)	7.650028 *** (P<=0.001)	7.045283 *** (P<=0.001)
Păuşa 17.1	0.680338 N.S. (P>0.05)	-1.04319 N.S. (P>0.05)	4.837962 *** (P<=0.001)	4.233217 ** (P<=0.01)
Păuşa 17.2	0.468678 N.S. (P>0.05)	-1.25485 N.S. (P>0.05)	4.626301 *** (P<=0.001)	4.021556 ** (P<=0.01)
Păuşa 17.3	0.408203 N.S. (P>0.05)	-1.31532 N.S. (P>0.05)	4.565827 *** (P<=0.001)	3.961082 ** (P<=0.01)
Păuşa 17.4		-1.72352 N.S. (P>0.05)	4.157624 ** (P<=0.01)	3.552879 * (P<=0.05)
Păuşa 17.5			5.881148 *** (P<=0.001)	5.276403 *** (P<=0.001)
Păuşa 18.1				-0.60475 N.S. (P>0.05)
-	**Păuşa 18.3**	**Păuşa 18.4**	**Păuşa 18.5**	**Păuşa 18.6**
Nojorid 1	9.449145 *** (P<=0.001)	6.999927 *** (P<=0.001)	8.889756 *** (P<=0.001)	5.63925 *** (P<=0.001)
Nojorid 2	7.816333 *** (P<=0.001)	5.367114 *** (P<=0.001)	7.256943 *** (P<=0.001)	4.006438 ** (P<=0.01)
Păuşa 17.1	5.004267 *** (P<=0.001)	2.555049 N.S. (P>0.05)	4.444878 *** (P<=0.001)	1.194372 N.S. (P>0.05)
Păuşa 17.2	4.792606 *** (P<=0.001)	2.343388 N.S. (P>0.05)	4.233217 ** (P<=0.01)	0.982711 N.S. (P>0.05)
Păuşa 17.3	4.732132 *** (P<=0.001)	2.282913 N.S. (P>0.05)	4.172742 ** (P<=0.01)	0.922237 N.S. (P>0.05)
Păuşa 17.4	4.323929 ** (P<=0.01)	1.87471 N.S. (P>0.05)	3.764539 * (P<=0.05)	0.514033 N.S. (P>0.05)
Păuşa 17.5	6.047453 *** (P<=0.001)	3.598234 * (P<=0.05)	5.488063 *** (P<=0.001)	2.237558 N.S. (P>0.05)
Păuşa 18.1	0.166305 N.S. (P>0.05)	-2.28291 N.S. (P>0.05)	-0.39308 N.S. (P>0.05)	-3.64359 * (P<=0.05)
Păuşa 18.2	0.77105 N.S. (P>0.05)	-1.67817 N.S. (P>0.05)	0.211661 N.S. (P>0.05)	-3.03885 N.S. (P>0.05)
Păuşa 18.3		-2.44922 N.S. (P>0.05)	-0.55939 N.S. (P>0.05)	-3.8099 * (P<=0.05)
Păuşa 18.4			1.889829 N.S. (P>0.05)	-1.36068 N.S. (P>0.05)
Păuşa 18.5				-3.25051 N.S. (P>0.05)

- The snow depth measured in sampling units Păuşa 18.1, 18.2, 18.3 was extremely significant in terms of differences as compared to snow depth measured in sampling units

Nojorid1,2, Păuşa 17.1, 17.2, 17.3, 17.4, 17.5. The situation was due to the wind which displaced the snow in lower parts of the area also containing various obstacles such as ditches along the county road 671 and ditches along the local road linking Păuşa and Şauaieu, shrubby vegetation on the pasture and plant debris on the cultivated land. Locally, in these areas snow depth reached 50-60 cm.

- The extremely significant differences between the sites are determined by the terrain orography: at Nojorid the terrain is a smooth plain while at Păuşa the terrain is wavy.

CONCLUSIONS

The comparisons of snow depth within the forest in 13 sampling units reveal that snow layer distribution is relatively uniform with the exception of two sampling units. This fact demonstrates that tree windbreaks and compact forest stands in plains act as natural protective barriers in the proximity of localities and along the communication routes, against the combined action of snow falling and wind intensification.

The differences in snow depth measured outside the forests are extreme. The causes are various linked to a combination of factors acting simultaneously. Of main importance are wind direction and speed, orientation of stand edges, of secondary importance are stand density and age, the presence or lack of the understory, the terrain orography and the presence of obstacles.

The necessity of the elaboration of medium and long term strategies concerning of areas uneven snow deposition in terms of mapping and the implementation of efficient measures aiming the risk reduction must become a national priority. This implies the reconstruction of the degraded tree windbreaks, planting new ones in places where conditions imply the presence of such barriers under the increased incidence of extreme meteorological events.

The analysis of risk areas and the application of adequate measures should become national priorities in order to reduce the unfavourable effects produced by extreme meteorological events.

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