THE ROLE OF CLIMATIC FACTORS ON FOREST LANDSCAPE CHANGE IN THE GURGHIU BASIN

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ABSTRACT. - Wind is the main factor involved in changing the natural balance of forest ecosystems from Gurghiu hydrographic basin. Strong winds are responsible for windthrows, especially in spruce arboretums, the most representative of the wood species form the studied area. Trees can be partially (bending of trunks, branches and broken tops) or totally (pulling the roots) damaged. Windthrows occurrence is closely related to the climatic factors, physical-geographical conditions (slope, soil characteristics) and arboretum characteristics (structure, age, consistency) are also important. The imbalance induced by those phenomena is emphasized by pest invasions (especially *Ips Typographus*) which are quite frequent after windthrows.
Our study represents a detailed analysis of the way in which the structure and the balance of the forest ecosystems of Gurghiu basin undergo major changes, because the climatic factors (wind, snow) action. Case study is the windthrow occurred on June 2010, when 200,000 m³ of wood was windthrowed, over a total area of 5,953 ha in P.U. II Isticeu (Fâncel Forest Range) and partially in P.U. I Glăjărie (the same forest range). The methodology used includes the analysis of climatic data, statistical data processing, GIS techniques for mapping the areas vulnerable to windthrows, synthesis.

Keywords: wind speed, windthrows, Gurghiu hydrographic basin, forest ecosystem, vulnerability.

1. INTRODUCTION

Wind represents the climatic factor affecting most frequently the forest ecosystems in the Gurghiu basin, with direct consequences on the balance of forest ecosystems, but also indirect consequences on the local economy. In forestry, windthrow is defined as "any mechanical injury affecting a tree or a stand as a result of the action of the wind" (Popa, 2007).

Current climate changes have increased the frequency of wind disasters at the level of the European continent. Violent storms have determined the fall of great woody masses on large areas. During the last decades, in Europe, at least five wind disasters (Collin, Jourez, Hébert, 2006) were identified, and the most significant were those occurred in France, in 1999 (144 million m^3) and in Sweden,

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in 2005 (75 million m^3). In Romania, the most significant windthrows occurred in 1947-1948, 1964, 1969, 1974-1975, 1995, 2002, of which the most destructive were recorded between the years 1947-1948 and 1974-1975, when the total volume of the wood was of more than 30 million m^3 (Popa, 2007). In the area under study, the most significant windthrows occurred in 1975 (500,000 m^3) (Cronica O.S. Gurghiu and O.S. Fâncel, 1968-2004) and 2010 (over 200,000 m^3) (Lots auctioned list - provided by the Fâncel Forest Range).

Beside the climate, the occurrence of windthrows is greatly influenced by other factors such as: relief (slope, altitude, soil characteristics), stands characteristics (the essence of the trees, the structure of the stand, the density of trees, the stand composition), biometric and biophysical characteristics of the trees (rooting system, age, height, trunk diameter, shape of the crown, slender index, presence of diseases), forestry techniques (creation of pure spruce stands, instead of mixed ones) anthropogenic (pollution, deforestation, lack of reforestation). The most vulnerable are spruce stands because of the shallow root, which does not provide stability to the tree.

Taking into account the affected area, windthrows are classified in: *large windthrows* (produced on a surface of more than 0.5 ha), *isolated windthrows* (covering an area of less than 0.25 ha) and *dispersed windthrows* (when are affected isolated trees on area less than 1 acre) (Barbu, 1985, in Popa, 2007).

2. METHODOLOGY

The methodology used for this study focused on the synoptic analysis of weather conditions in which the windthrow of June 2010 occurred. Also, a qualitative analysis of the induced effects on forest ecosystems was made. To achieve a forecast, a map of forests vulnerability to windthrows in the Gurghiu basin was made, using GIS techniques.

3. CASE STUDY: THE WINDTHROW OF 14th-15th JUNE 2010 IN THE GURGHIU HYDROGRAPHIC BASIN

Spruce (*Picea excelsa*) is the dominant species in the forests of the Gurghiu basin (50% of the total species). This, unlike other species (fir, beech, and oak) has a higher vulnerability to windthrows due to rooting system (shallow root).

Isolated and dispersed windthrows are very frequent (those phenomena can produce every year) in the forests of the Gurghiu basin (Neagu, Irimuş, 2011). Their occurrence is based mostly on climate causes, often represented by violent storms with high wind speeds, with a maximum frequency in the spring and early summer. The other causes that should be taken into account are the biotic, geomorphologic and anthropogenic causes.

3.1. Weather conditions

The most recent event occurred on the night of 14th to 15th June 2010 during a squall, associated with prefrontal squall line. Meteorologically, on June 14th a cold front of low pressure center originated in Atlantic, affected the Northwestern Romania coming from the north of the continent (Scandinavia) (fig. 1) and centered over the Central and Eastern Europe. Inside the squall line a sudden increase of the wind speed occurred, surpassing the meteorological warning thresholds for the wind speed. The 500 hPa isobaric surface was quite high over Romania at that time, reaching 576-580 gpdm. The surface was raised up by the North African warm air moving from South (fig. 2).

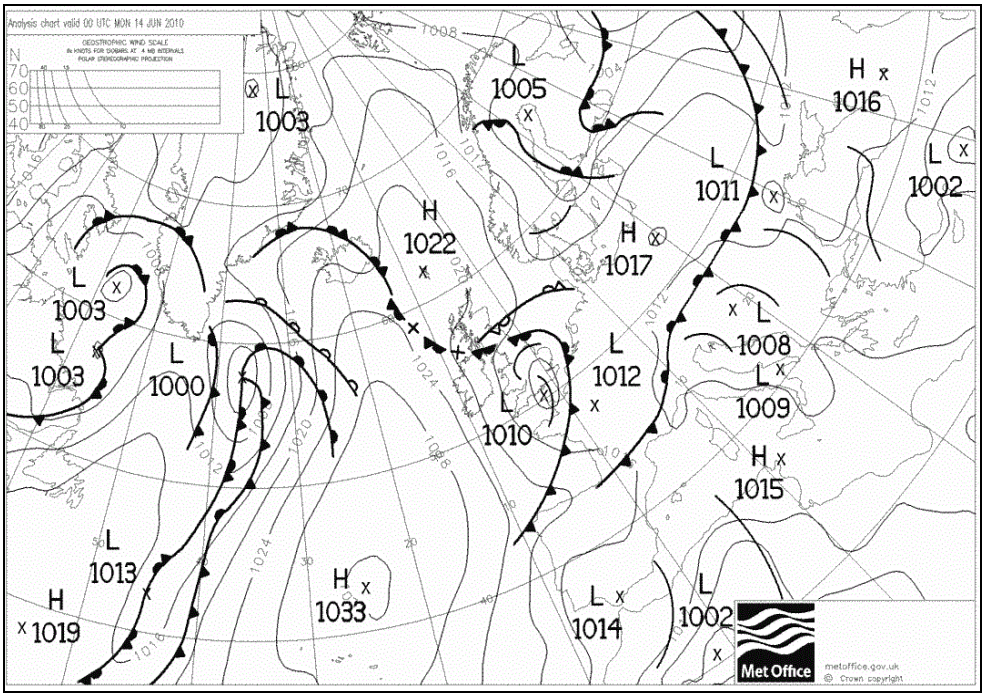

Fig. 1. ***The atmospheric pressure front on 14.06.2010, at 00.00, at sea level (source: www.wetterzentrale.de)***

Because of the absence of a weather station in the studied area, we used for the present analysis, the wind speed recorded to the nearest two weather stations to the studied area: Bucin Weather Station, located at 1282 m altitude and Batoş Weather Station, located at 449 m altitude (fig. 3). Thus, analyzing the evolution of wind speed presented in figure 3, one may conclude that the cold front squall line crossed the region in only few hours. An increase of the wind speed between 14th and 15th June 2010 can be observed. The wind gust speed exceeded 15 m/s in the western part of the area, at Batoş (during both days), and 10 m/s on 15th June at Bucin – in the eastern part of the basin, overreaching the warning/aggravation thresholds for wind.

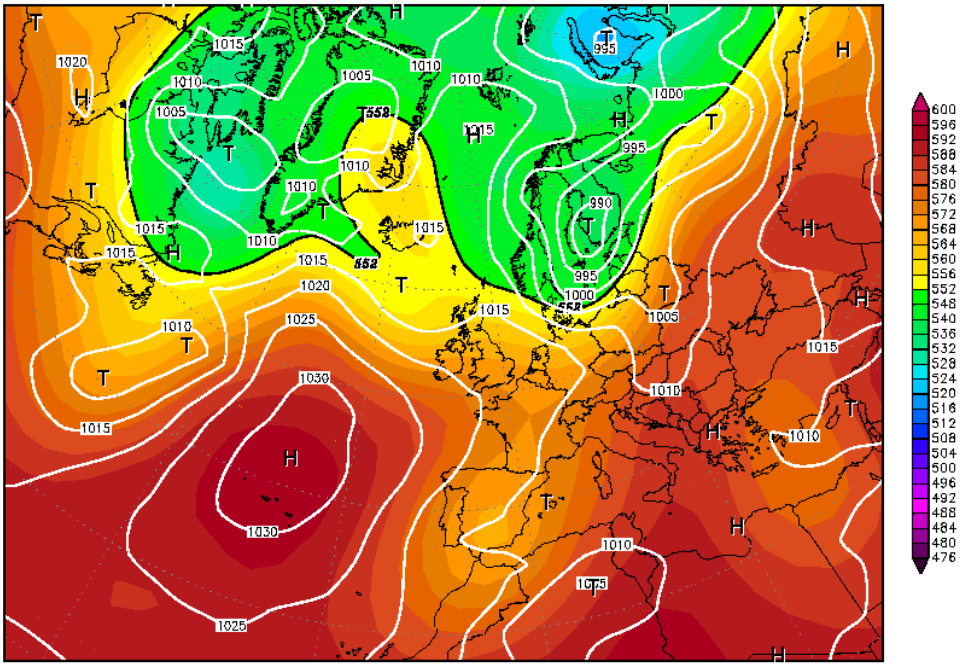

Fig. 2. ***The atmospheric pressure front on 15.06.2010, at 00.00, at sea level and 500 hPa isobaric surface level (source: www.wetterzentrale.de)***

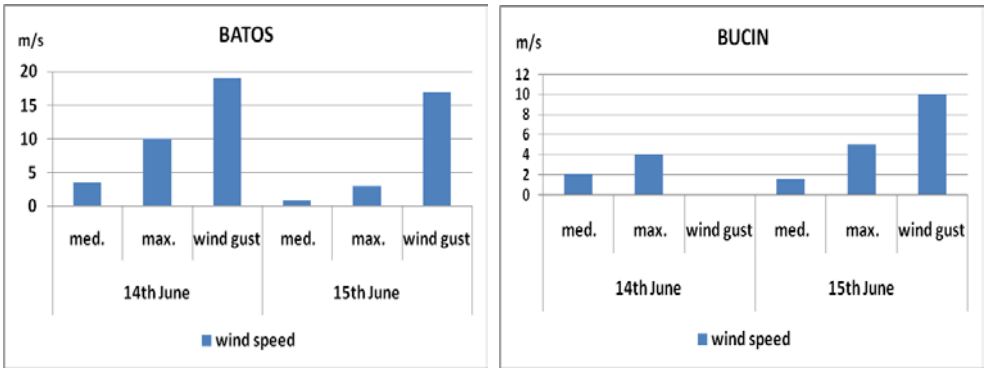

Fig. 3. ***Wind speed at the meteorological stations Bucin and Batoş on 14th and 15th June 2010 (archives Regional Meteorological Centre Transylvania South)***

The maximum wind speed and wind gusts occurred at the Batoş station, located to the west of the analyzed area on 14.06.2010, between 21.00 - 24.00 h, while at the Bucin station records indicated the maximum values of wind speed and wind gusts in the early hours on June 15, 2010. Location of stations in the western part and in the eastern part of the studied area (fig. 4) is very useful as it could be

located, in temporal terms, the moment of the passage of the squall line over the studied region. Thus, it appears that it crossed the area between June 14, 21.00 h and June 15, 03.00 h. In the same period, the largest quantity of wood was windthrowed.

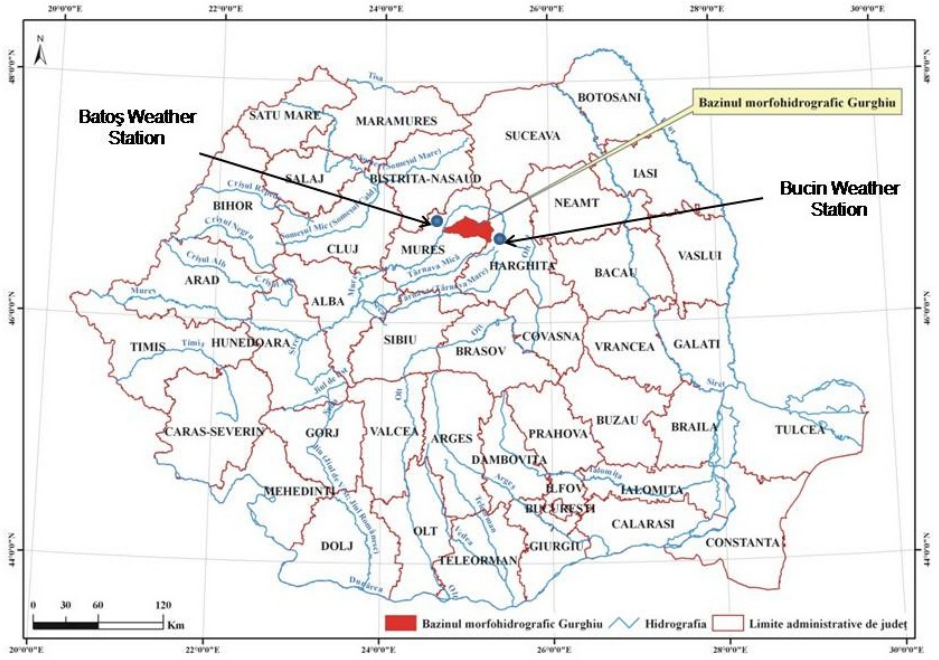

Fig. 4. ***Location of the analyzed area***

The wind speed is very likely to have been much higher in the windthrow area because the air drained up-slope on the valley.

3.2. Effects on the forests ecosystems

Both the older stands, resinous and broadleaf stands, as well as the younger stands, including the 20-30 years old beech stands, were throwed. The total affected surface was 5,953 ha in the production unit II Isticeu (Fâncel Forest Range) and partially in the production unit I Glăjărie (same Forest Range). The damaged volume was over 200,000 m³. The damages to the trees were various: *uprooting, stem bending, broken branches and broken tops* (fig. 5).

Windthrows represent a major risk for forests because of the possible invasions, in the woodsides, of bark beetles, particularly *Ips Typographus* (also known as the great spruce bark beetle). Those beetles attack spruce bark, decreasing the economic value of the tree (Mihălciuc et al, 1995). The most vulnerable are the damaged trees (Wichmann and Ravn, 2000). Thus, following windthrows, cleaning the affected areas is absolutely necessary to prevent the attacks occurrence.

Fig. 5. ***Windthrow effects in P.U. II Isticeu (Fâncel Forest Range) in June 2010***

3.3. Forests vulnerability from the Gurghiu basin to windthrows

Forests vulnerability of Gurghiu basin to windthrows was calculated considering the following aspects:

- woodsides resulted after windthrows occurred during the winter of 2006 and the spring of 2010 offer favorable conditions for new events (imbalance state of forest ecosystems);
- geomorphologic factors like steep slope in the mountain area of the basin, slope orientation favor the occurrence of the phenomenon;
- altitude influences the windthrows dynamic: trees situated at higher altitude (Seaca massif) have lower slender index (growing season is shorter), so their vulnerability to wind hazards is reduced;
- stands structure: the resinous forests (especially the spruce ones) are more vulnerable than the broadleaf ones;
- the age of the stands – the older they are, the more vulnerable they are.

In the analyzed area, very high vulnerability to windthrows is characteristic to the stands included in the I and II production units (P.U.) of Fâncel Forest Range and P.U. VIII of Gurghiu Forest Range, where resinous are dominant and trees average age is around 85 years. This indicates a high degree of instability to the wind action. The average trees consistency is at 0.5, and the II and III production class are dominant (according to the Forest Planning of Gurghiu and Fâncel Forest Ranges). Very low vulnerability is characteristic to areas where mixed stands (spruce, beech, fir) prevail and to high mountain area where, although the spruce

stands are dominant, trees have a low slender index and are younger (recent plantations).

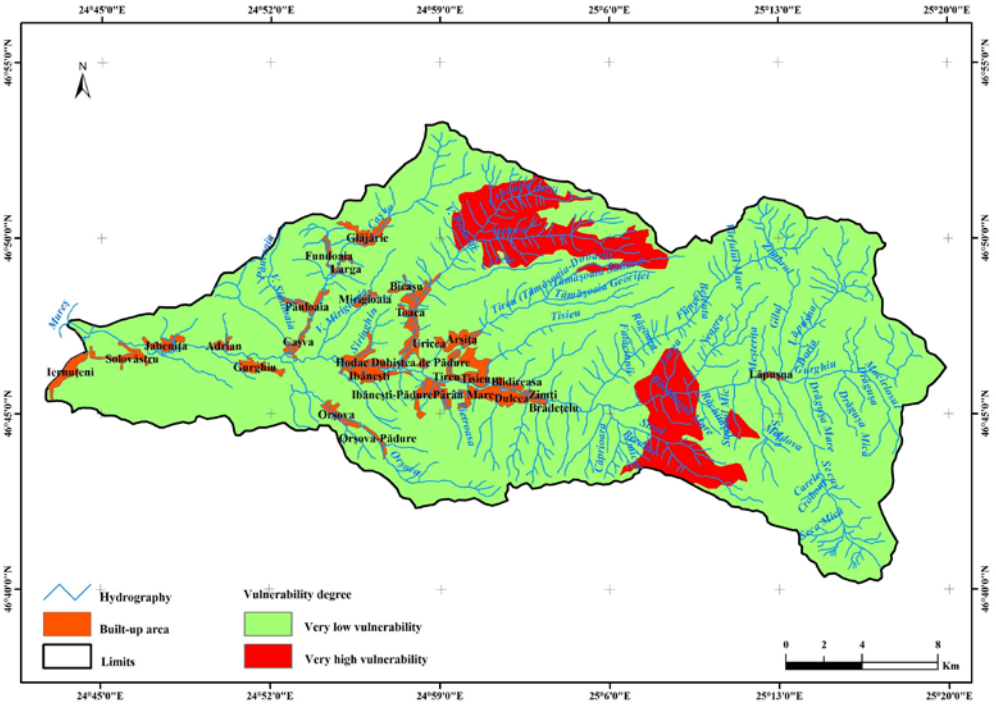

Fig. 6. ***Forests vulnerability to windthrows***

These phenomena do not directly affect man, not setting life-threatening or human health, but indirect losses are significant. Windthrows are a disturbing factor, both from ecological and economical point of view – of the forests bio-production (Popa, 2007).

4. CONCLUSIONS

Windthrows represent a current issue whose importance increases and grab the attention of other field scientists, along with the traditional ones (forestry). Specialists emphasis on finding solutions to implement forest planning techniques in full accordance with the natural environment: the so-called rational forestry, ecological based, which is primarily aimed at forest conservation and protection (Ichim, 1990, in Popa, 2007; Dorog, 2007; Gardiner and Quinne, 2000). Forests protection to natural disasters such as windthrows involves the application of appropriate forestry techniques that follow the entire evolution of the tree, from planting to maturity (Balleaux, 2006).

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