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Disturbance history in a stone-pine (*Pinus cembra*) multicentury tree-ring chronology from Călimani Mountains (Eastern Carpathians)

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Abstract. The population of trees from the superior limit of forest vegetation can offer important information about the tree's answer to disturbance factors. The research is based on 636 individual stone-pine (*Pinus cembra*) growth series from Calimani Mountains. The growth change method was used to investigate the disturbances produced in mountain forest ecosystem in a 1000 years period. Comparing an average growth sequence for 10 years periods was possible to detect the growth response determined by stand structure modifications. Thus was possible to reconstruct the historical dynamics of disturbance from the last millennia. From the researches, results a minimal threshold imposed by 25 % of radial growth value, which related to the previous year's growth can establish the growth change with a disturbance effect for open areas trees or for low consistency stands. About the normal consistency stands the percentages included between 50 – 100 %. The disturbance taken as ecological issues identified by a dendrochronology approach, indicates periods with major disturbs, without an obvious periodicity.
Key words: Forest disturbance, dendroecology, growth change analysis.

Rezumat. Populațiile de arbori aflați la limita superioară a vegetației forestiere pot oferi informații valoroase cu privire la răspunsul arborilor la acțiunea factorilor perturbatori. Cercetările au presupus prelevarea de carote de creștere de la un număr de 636 arbori de zâmbru (*Pinus cembra*). Metoda aleasă, „growth change", s-a folosit pentru a investiga perturbările pe o perioadă de 1000 de ani produse în ecosistemele forestiere montane. Comparând secvențe de creștere medie pentru perioade de câte 10 ani a fost posibilă evidențierea răspunsului auxologic indus de modificările structurale din arboret. Astfel a fost posibilă reconstituirea dinamicii istorice a perturbărilor din ultimul mileniu. Din cercetări rezultă un prag minim impus prin procentul de 25 % din valoarea creșterii radiale, care raportat la creșterea anilor precedenți poate stabili modificarea creșterii cu efect de perturbare pentru arborii aflați în zone deschise sau arborete cu consistență redusă. În cazul arboretelor cu consistență normală procentul este cuprins în intervalul 50 – 100 %. Perturbările privite ca aspecte ecologice identificate prin abordarea dendrocronologică, indică perioade cu perturbări majore, fără o periodicitate evidentă.
Cuvinte cheie: Perturbări forestiere, dendroecologie, analiza modificării creșterii.

Introduction. The information's included in dendrochronological series with a large temporal coverage are important both for climate reconstruction and dendroecological studies. Very important are the disturbance dynamics studies witch highlights important issues about the time evolution of the forest ecosystem (Nowacki & Abrams 1997). The tree-rings offer the possibility to investigate the history of the forest ecosystem in the perspective of disturbance occurrence from different causes (Hart et al 2012).

Historical natural disturbances, especially the larger ones, are difficult to study directly. Therefore, various methods of identifying effects of disturbances are widely applied in forest ecology (Lorimer & Frelich 1989; Fraver et al 2009). In temperate forests, dendroecology seems to be the most efficient technique to reconstruct the past disturbance dynamics (Splechtna et al 2005; Gratzer et al 2004; Black et al 2009).

The adjustment of actual management methods of forest ecosystems from mountain area, region in which the disturbance action of environment factors (wind, snow, insects etc.) is more and more frequent, to a durable strategies close to nature, represent a base objective of the long term strategies in the domain of forestry and environment. To achieve these objectives it is necessary a profound knowledge of the effects of disturbance factors on forest structure, dendroecological techniques offering a modern and efficient instruments for reconstruction of historical dynamics of structural modifications, and implicit the frequencies and the intensity of these natural risk factors.

Material and Method. The study is localized in the Calimani National Park (47°06'41"N, 25°15'44"E), national interest protected area. In the study region natural mixed stone pine (*Pinus cembra*) and Norway spruce (*Picea abies*) stands can be found with very low human intervention. The altitude where the samples were taken is between 1400 and 1750 m. Basic vegetation associations are represented by Norway spruce with stone pine and acidophilic flora (*Vaccinium* spp.). An important percentage of stone - pine's area is located in "Jnepenis Scientific Reservation with Pinus Cembra". The climate of the research area is continental with north influences.

The Pressler drill was used for taking samples of core growth from the living trees and the saws to extract slices from the trunk of dead trees. In the lab all cores were prepared and measured according with standard dendrochronological procedures. The LINTAB equipment and TSAP software were used for measuring the annual ring-widths with a precision of 0.01 mm, as well as for cross-dating the growth series by graphical comparison (Rinntech 2005). The dated process was made both visual, with TsapWin program, and statistic being used parameters like t value as in Baillie & Pilcher (tBP) (Baillie & Pilcher 1973) and Gleichläufigkeit coefficient (GLK %) (Eckstein & Bauch 1969). The quality of dating process was tested with COFECHA software (Holmes 1983) which eliminates the measures mistakes, the missing or the fake rings. The total data sets consist on 636 trees: 274 cores were taken from living trees and 362 cores from dead wood.

The identification of disturbance using tree-ring width information can be difficult because the growth process is related to many factors (Schweingruber 1996). When gaps occur in the forest stands due to windthrow or insect attacks the remaining trees react by increasing significantly the radial growth. Forest disturbance identification was based on individual tree ring series applying the growth change method (Hart et al 2012; Hart & Grissino–Mayer 2008; Nowacki & Abrams 1997).

The identification of the tree growth release is the primary criterion for the disturbance reconstruction (Nowacki & Abrams 1997). The growth changes are established using the formula:

$$GC\ \% = [(M_2 - M_1)/M_1] \times 100$$

Where: GC % = the growth change percentage; M_1 = the average of 10 previous tree rings width; M_2 = the average of 10 subsequent tree-rings width.

Growth change was classified as release events when the values of GC are over 25 % for minor events and over 50 % for major events (Hart et al 2012).

Results and Discussion. A number of 636 cores were taking, from trees with ages between 39 and 701 years. The data set cover a period of 1014 years. More than 10 individual tree ring series was registered after 1174, and after 1325 the chronology replication is over 25 series.

From the total data set 96.06 % (610 cores) shows at least one release event identified by growth change methods. The highest number of events for an individual series is 121. Release events were not detected in 26 samples, a small percentage which reflects homogeneity of signal induced by disturbance (Black & Abrams 2005). From the total number of events statistically detected in the tree ring series (15705), 10333 - 65.79 % are moderate and 5372 (34.29 %) are major. Only 14.05 % of trees show multiple release events (Figure 1).

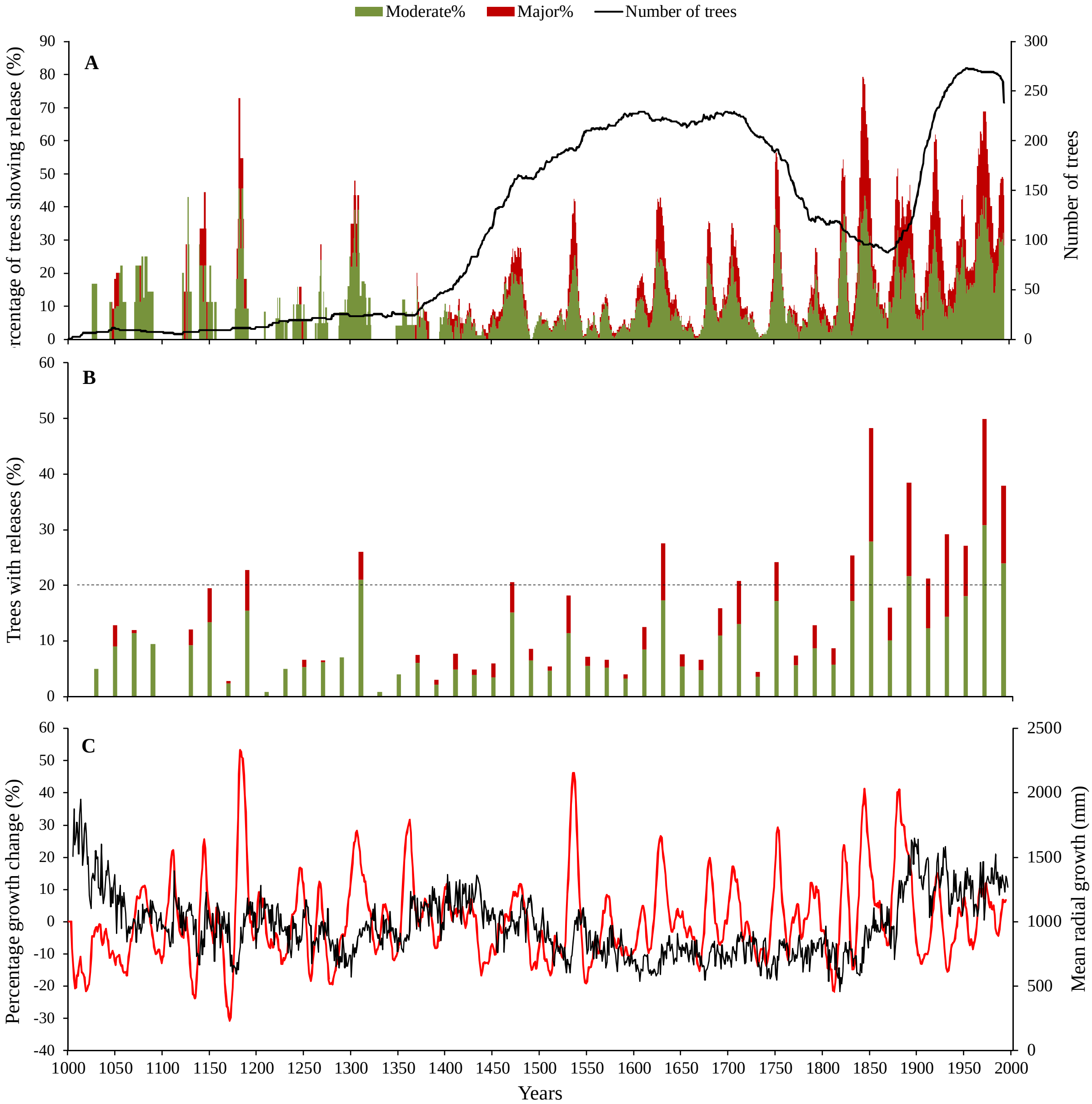

Figure 1. Dynamics of growth change percentage (GC %) in Calimani Mountains. (A – release events and sample replication; B – release events by decade; C – black line – mean growth series (mm/year^{-1}), red line – mean growth change percentage).

The 20 % of trees with release is taken as threshold to identify disturbances. The most important sustained growth release was noticed for a 15 years period, from 1839 until 1853, this event been described as a major disturbance. The longest period between two consecutive events is noticed between 1321 and 1461, 141 years, where the medium average of the moderate release is 3.58 % and the major release is 1.25 %. The mean growth change percentage during this period show hard suppression processes, explained by the strong competition between trees. At that moment the stand have a maximum structural stability being resistant to disturbances.

We identify sixteen disturbances during the thousand years or record (Figure 1). These episodes occurred from 1983 – 1992, 1964 – 1978, 1943 – 1953, 1911 -1924, 1873 – 1899, 1840 – 1855, 1816 -1829, 1786 – 1792, 1747 – 1761, 1695 – 1711, 1677 – 1685, 1621 – 1634, 1603 – 1606, 1531 – 1541, 1462 – 1483, 1297 – 1305. Only fourteen of these disturbances exceeded the limit required by the 20 % of tree with release: 1980 (37.83 %), 1960 (49.81 %), 1940 (27.03 %), 1920 (29.08 %), 1900 (21.13 %), 1880

(38.34 %), 1840 (48.17 %), 1820 (25.37 %), 1740 (24.06 %), 1700 (20.77 %), 1620 (27.51 %), 1460 (20.50 %), 1300 (25.96 %), 1180 (22.72 %).

The highest value was calculated for date 1844, for whom 41.19 % of the tree ring chronologies showed major release. In 16 December 1843, has documented a catastrophic windthrow in Bucovina region, mentioned by Fischer (1899) (cited by Popa 2007). From the data analysis results that this ecosystem disturbance was the largest in the last thousand years in the Calimani Mountains. Between 1746 and 1920 five successive disturbances ware identified. It is important to note that after windthrow outcome in 1843 the ecosystem has become unstable. An important number of stone-pine trees were brought down and new generation of forest, with high percentage of spruce, show up.

Chronology of catastrophic windthrow in northern Romania (Bucovina region) mention the years: 1885 (upwards of 100.000 m^3, after Fischer 1899), 1916, (600.000 m^3, was collected from Bistrita Valley and Ciuc area, after Zeletin 1955), 1948 (4.500.000 m^2 from Bistrita and Moldova Valley, Mures and Ciuc area, after Zeletin 1951), 1971 (the volume is not specified, but the area is roughly the same, after Ichim 1988) cited by Popa (2007).

In cases of less extensive release episodes we can speculate the effect of disturbances are due by local causes and is clear that the frequency of such event it decreased during 1300 – 1620. During the period 1000 and 1300 have not considered appropriate to discuss the results since the number of samples is low. An increase in frequency and intensity of disturbance in the last 200 years is evident.

Conclusions. Based on a large tree ring width data set of stone-pine from Calimani Mountains covering the last millennia, was possible to reconstruct the main disturbances. Using the growth changes methods a significant increase on frequency and intensity in the last 200 years. Description of disturbance (with focus on the impact on stand structure) dynamics is important to understand how this even control the forest ecosystem structure development.

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References

Baillie M. G. L., Pilcher J. R., 1973 A simple cross-dating programme for tree-ring research. Tree-Ring Bulletin 33:7–14.

Black B. A., Abrams M. D., 2005 Dendroecological history and climatic responses of an old-growth hemlock forest in Schall's Gap, central Pennsylvania. Journal of the Torrey Botanical Club 132:103-114.

Black A. B., Abrams M. D., Rentch J. S., Gould P. J., 2009 Properties of boundary-line release criteria in North American tree species. Ann For Sci 66(2):205.

Eckstein D., Bauch J., 1969 Beitrag zur Rationalisierung eines dendrochronologischen Verfahrens und zur Analyse seiner Aussagesicherheit. Forstwissenschaftliches Centralblatt 88(4):230–250. [In German].

Fraver S., White A. S., Seymour R. S., 2009 Natural disturbance in an old-growth landscape of northern Maine, USA. J Ecol 97:289-298.

Gratzer G., Canham C., Dieckmann U., Fischer A., Iwasa Y., Law R., Lexer M. J., Sandmann H., Spies T. A., Splechtna B. E., Szwagrzyk J., 2004 Spatio-temporal development of forests - current trends in field methods and models. Oikos 107(1):3-15.

Hart J. L., Clark S. L., Torreano S. J., Buchanan M. L., 2012 Composition, structure, and dendroecology of an old – growth Quercus forest on the tablelands of the Cumberland Plateau, USA. For Ecol Manage 266:11–24.

Hart J. L., Grissino–Mayer H. D., 2008 Vegetation patterns and dendroecology of a mixed hardwood forest on the Cumberland Plateau: implications for stand development. For Ecol Manage 255:1960–1975.

Holmes R. L., 1983 Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43:69-75.

Lorimer C. G., Frelich L. E., 1989 A methodology for estimating canopy disturbance frequency and intensity in dense temperate forests. Can J For Res 19:651–663.

Nowacki G. J., Abrams M. D., 1997 Radial – growth averaging criteria for reconstructing disturbance histories from presettlement – origin oaks. Ecol Monogr 67:225–249.

Popa I., 2007 Managementul riscului la doboraturi produse de vant. Editura Tehnica Silvica Bucuresti, 235 pp. [In Romanian].

Rinntech, 2005 TSAP User reference. 110 pp.

Schweingruber F. H., 1996 Tree rings and environment. Dendroecology. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research, Vienna, Haupt. 609 pp.

Splechtna B. E., Gratzer G., Black B. A., 2005 Disturbance history of a European old-growth mixed-species forest — a spatial dendroecological analysis. J Veg Sci 16:511–522.

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