VOLUME GROWTH LOSSES FOR TREES AND FOREST STANDS IN THE ROMANIAN INTENSIVE MONITORING SYSTEM

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The health of forest ecosystems is mainly influenced by the negative action of air pollution and climate changes of different biotic and abiotic factors, and other disturbances. Tree growth and stand dynamics were considered as the main synthetic indicators on stability, functionality and productivity of forest ecosystems. Consequently, the results obtained by auxological research in the intensive monitoring network of forest ecosystems, in our country (Level II), based on information provided by successive inventories made in 1996 and 2006 (for a period of 10 years) showed different average annual growth in volume, among different tree species, due to specific conditions of vegetation, climate and site, and between the groups of defoliation classes (0-1 and 2-3), evidently, the healthy trees (defoliation classes 0-1 group) recorded higher values than those damaged (group defoliation classes 2-3), differences between 0.09 $m^3yr^{-1}ha^{-1}$ (Ştefăneşti - oak) and 6.44 $m^3yr^{-1}ha^{-1}$ (Sinaia - beech), respectively. In determining the loss of annual growth in volume per year and per ha, the processing of information identified cases where the trees migrating in different classes of defoliation and the error estimation during the reporting period were significantly reduced by taking into account the trees communities that had the same damage class, both at the beginning (1996), during the period, and at the end of the period (2006). The mean growth losses reached up to 45%, for the damaged trees compared to the healthy trees.
These results obtained for the first time in our country contribute to the improvement and development of specific scientific information for forest monitoring system applied in Romania, with special reference to the growth component.

Key words: forest growth, crown condition, air pollution, climate changes, forest monitoring, growth monitoring.

INTRODUCTION

Declining state of forest ecosystems caused by the action of pollution, climate change, the different biotic and abiotic factors, and other disturbing causes, was highlighted with high fidelity through national and international research on the dynamics of trees, stands and forest ecosystems growth. This synthetic indicator has been investigated by conducting experiments located in different pollution intensity locations[1]. The results in this area have clearly shown that pollutants have negative influence on growth, resulting in high mortality rates of trees and forest decline. Where concentrations of pollutants are very high, growth declining is often accompanied by visible symptoms, *e.g.* the process of abnormal physiological defoliation of individual trees.

Based on these results and in the United Nations Convention on Long-Term Effects of long-range Transboundary Pollution (1979), in USA, Canada and virtually in all European countries have implemented the investigations on long-term research of forest ecosystems under the action of various stress factors, especially air pollution and climate change, through special programs of investigation (*i.e.* ICP-Forests, the EU Scheme, the Forest Focus Scheme, Life +).

Advanced researches conducted in the main forest ecosystems in accordance with the objectives of ICP-Forests and the EU Scheme were initiated by Patrascoiu and Badea in 1989 and developed in 1991 and 1992. First results[2] showed the cumulative effect of atmospheric pollution of biotic and abiotic factors on normal growth trend. This research continued with studies that were undertaken based on information relating to: crown condition of trees, growth, state of forest soils, the chemical content of leaves and needles, dry and wet atmospheric deposition[3–6].

In terms of intensive monitoring of forest ecosystems, in our country there have been undertaken a series of researches and studies since the first symptoms of forest decline. The intensity of this phenomenon was investigated by special researches of the impact of air pollution on forests[7,8]. During 1979 – 1990, Alexe *et al.* have conducted research on the causes of oak sudden death and developed measures to restore the ecological stability in forests of oak[9–13].It may also worth mentioning the research on the phenomenon of silver fir sudden death phenomenon[14,15].

The results obtained in forest growth monitoring system applied in Romania revealed the distribution of the radial increment and basal area increment established by periodic measurements in relation to the percentage of defoliation of trees and respectively, the uniformity of the biomass accumulation registered to the healthy trees compared to the damaged trees. On this basis, growth losses due to injury losses caused by various disturbing factors were determined[3].

METHODOLOGY

The research was carried out in the intensive monitoring network, located in the vicinity of stations of the National Meteorological Administration (ANM) in representative forest ecosystems (Fig. 1).

This network was intended to Level II forest monitoring (intensive) and consists of 12 sites located during 1989–1992, along the initiation of complex researches on the evolution of main forest ecosystems in our country, under the action of different stress factors[16].

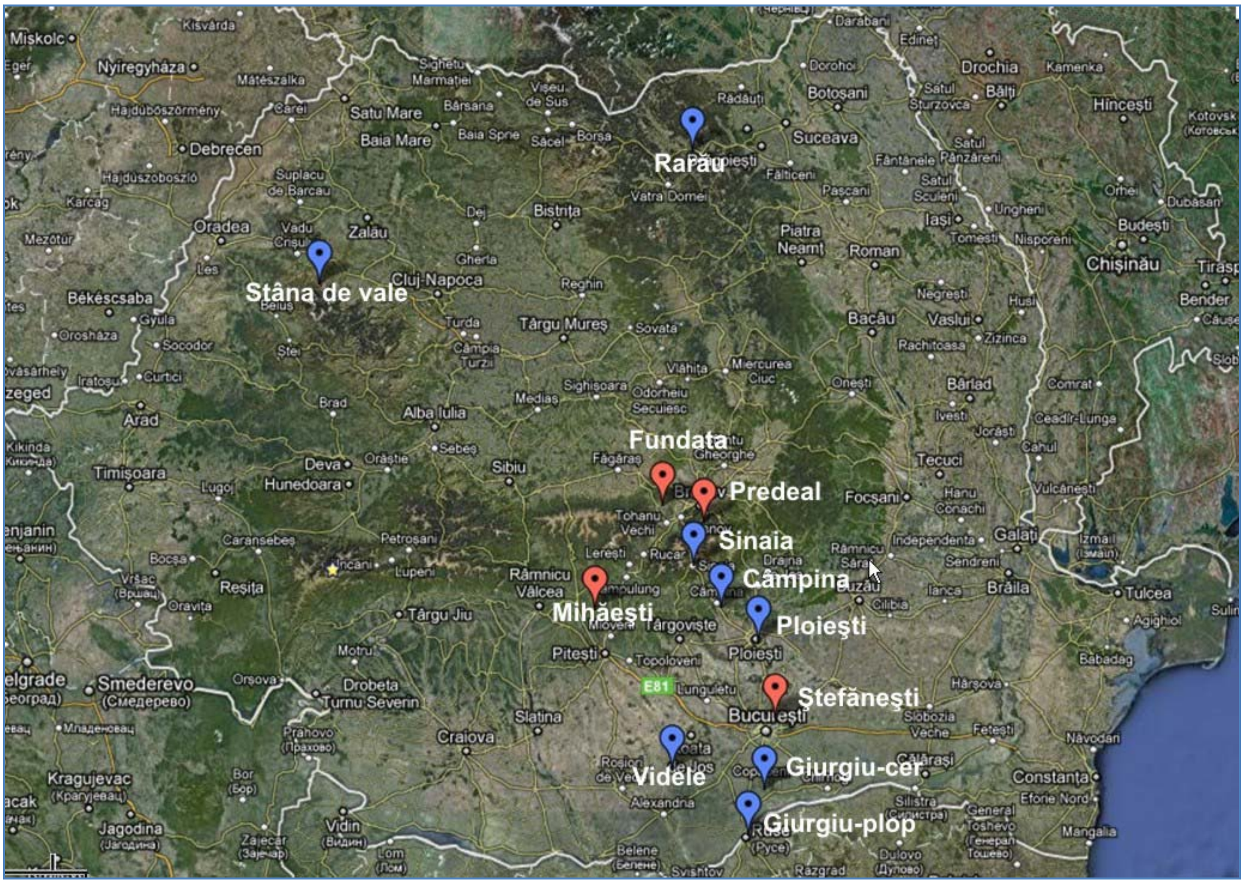

Fig. 1. Intensive monitoring plots (Level II plots placed in representative forest ecosystems.

A permanent sample plot of intensive monitoring (SSI) has 5 permanent sample subplots (SPP) in cross direction of the main cardinal directions (N, E, S and V) and in the centre, located at a distance of 30 m from it. The SPP's are circular in shape, the size of area of 500 m^2 (radius being equal to 12.62 m). Given their spatial distribution (Fig. 2), corresponding to a surface area that exceeds 0.7 ha, it provides sufficient statistical coverage, for scientific investigations.

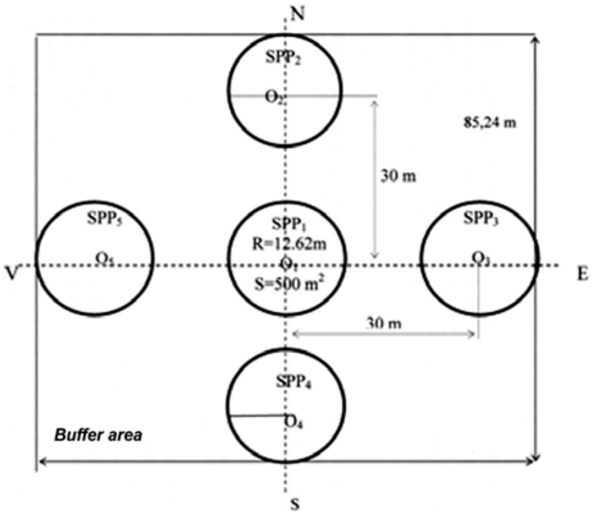

Fig. 2. Permanent sample plot design.

The actual inventory consisted of measuring and estimating the main dendrometric features of trees across all SPP, *e.g.* diameter at breast height (DBH), height (H), positional class, grade, etc.

DBH of trees was measured uphill on sloped terrains or against the SPP' centre, the measuring position being marked with paint for chronological comparison. Since 1991, there have been other periodic measurements in the years 1996, 2001 and 2006.

Crown condition was assessed each year for all trees across the SSI, during the same period of each growing season (Fig. 3), with defoliation as the main criteria, and two main defoliation group classes: healthy tress with defoliation under 30% (defoliation classes 0-1) and damaged trees with defoliation above or equal to 30% (defoliation classes 2-3). The dead trees (100% defoliation-class 4) were measured the DBH and the height, in order to correctly account for their contribution in the forest stands' growth balance, between two periodic measurements. These records allow accurate determination of the volume of dead trees and/or extracted (cut) (V_E) between two successive inventories (over a period of 5 or 10 years), a particularly important element in determining the volume growth (I_V).

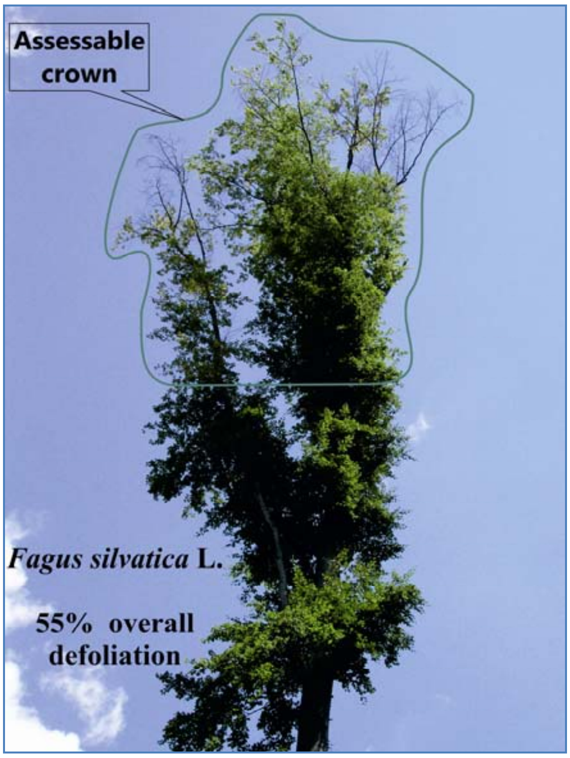

Fig. 3. Assessment of tree crown defoliation.

RESULTS AND DISCUSSION

The method of periodic measurements was used to measure the volume growth of the forest stands, based on regular records made in 1996 and 2006 (Badea *et al.*, 2008).

Under this method, the increase in volume (I_V) was determined using the relationship:

$$I_V = V_B + V_E - V_A - V_S;$$

where, V_B represents volume of all trees inventoried at the end of study period (2006)

V_E – volume of all dead/cut trees during the period 1996-2006

V_A – volume of all trees inventoried at the beginning of the period (1996)

V_S – volume of all trees inventoried in 2006 which had in 1996 a DBH lower than 80 mm (ingrowths).

Determination of volumes V_B, V_E, V_A and V_S was performed using the two-way logarithmic regression equation (Giurgiu, 2004), based on DBH and height correlation:

$\log v = a_0 + a_1 \log d + a_2 \log^2 d + a_3 \log h + a_4 \log^2 h$, where:

a_0, a_1, a_2, a_3, a_4 represent the regression coefficients[17].

d – DBH (mm);

h – tree height modelled based on DBH-height correlation (m).

For establishing average annual forest stand volume growth per ha for 10 years period (1996–2006) was used the following formula:

$$I_V = 0.1 * \left[\frac{(V_{p2006} + V_s) - (V_{p1996} + V_{EI} + V_{EII}) + (V_{EI} + V'_{EII}) - V_s}{S_{SSI}} \right]$$

The volumes were determined at the beginning and at the end of the study period (1996–2006) for all trees present and viable during the period (common trees) (V_{P1996},V_{P2006}) of main species, for those who have been removed or died during the period (1996–2001 and 2002–2006), after stratification at 1996 (V_{EI}) and 2006, respectively (V^1_{EII}), and for the cut or dead trees, after intermediate period 2002–2006,in accordance with stratification made in 1996 (V_{EII}), and for ingrowth (V_S) (representing thin tress under 80 mm in diameter in 1996) (Table 1).

The above mentioned volumes (Table 1) were used to determine the average annual volume growth per hectare for each community separately, and finally, for establishing the growth losses (in % and $m^3yr^{-1}ha^{-1}$) recorded for the damaged trees (defoliation classes 2-3) compared against the healthy trees (defoliation classes 0-1).

On the defoliation group classes 0-1 and 2-3 the volume growth of forest per year and ha (Table 2) was estimated taking into account the stratification of trees by crown condition, both at the beginning ($I_{V0\text{-}1A}$, $I_{V2\text{-}3A}$) and at the end of study period ($I_{V0\text{-}1B}$, $I_{V2\text{-}3B}$), for all common living trees in this period and for living trees which both in 1996 and 2006 were situated in the same defoliation class ($I_{V0\text{-}1}$ and $I_{V2\text{-}3}$) as follows:

$$I_{v0\text{-}1A} = 0{,}1 \left(\frac{V_{0-1BA} - V_{0-1AA}}{S_{SSI}} \right);$$

$$I_{v2\text{-}3A} = 0{,}1 \left(\frac{V_{2-3BA} - V_{2-3AA}}{S_{SSI}} \right);$$

$$I_{v0\text{-}1B} = 0{,}1 \left(\frac{V_{0-1BB} - V_{0-1AB}}{S_{SSI}} \right);$$

$$I_{v2\text{-}3B} = 0{,}1 \left(\frac{V_{2-3BB} - V_{2-3AB}}{S_{SSI}} \right);$$

$$I_{v0\text{-}1} = 0{,}1 \left(\frac{V_{0-1B} - V_{0-1A}}{S_{SSI}} \right);$$

Table 1

Main species tree volumes used for determining the growth balance by means of periodic measurements method, during 1996–2006 period

N°	Name	S_{SSI} ha	V_{p1996} m³	V_{p2006} m³	V_{EI} m³	V_{EII} m³	V^I_{EII} m³	V_S m³
1	Giurgiu-Turkey oak	0.15	33.70	41.36	0.32	0.25	0.25	0.32
2	Videle – Turkey oak	0.25	37.53	49.27	1.45	0.32	0.57	–
3	Videle-Hungarian oak	0.25	37.35	46.64	0.77	1.11	1.11	–
4	Ştefăneşti-oak	0.25	45.14	51.91	3.01	5.54	5.54	–
5	Ploieşti-oak	0.25	37.54	43.40	4.41	3.86	3.86	–
6	Câmpina-sessile oak	0.25	72.96	92.11	2.27	0.58	0.58	–
7	Sinaia-beech	0.25	180.11	186.11	25.73	3.94	4.25	–
8	Predeal-spruce	0.25	179.14	213.17	0.81	8.19	8.19	0.06
9	Rarău -spruce	0.25	56.13	60.85	7.39	2.35	2.35	0.77
10	Fundata-beech	0.17	41.36	53.32	0.19	0.50	0.50	–
11	Stâna de Vale-spruce	0.25	48.26	71.01	1.04	1.15	2.40	1.90
12	Mihăieşti-sessile oak	0.25	69.28	88.50	0.59	0.45	0.45	–

$$I_{v2\text{-}3} = 0{,}1\left(\frac{V_{2-3B} - V_{2-3A}}{S_{SSI}}\right),$$

$I_{V0\text{-}3} = I_{V0\text{-}1} + I_{V2\text{-}3}$, where:

$V_{0\text{-}1AA}$, $V_{2\text{-}3AA}$, $V_{0\text{-}1BA}$, $V_{2\text{-}3BA}$ represent the trees volume for the main species, common in the beginning (A) and at the end of the 1996–2006 period (B), belonging to different groups of defoliation classes (0-1 and 2-3) in the year 1996 (A) (m^3);

$V_{0\text{-}1AB}$, $V_{2\text{-}3AB}$, $V_{0\text{-}1BB}$, $V_{2\text{-}3BB}$ – trees volume for the main species of common in the early (A) and end (B), belonging to different groups of defoliation classes (0-1 and 2-3) in 2006 (B) (m^3);

$V_{0\text{-}1A}$, $V_{2\text{-}3A}$, $V_{0\text{-}1B}$, $V_{2\text{-}3B}$ – volume of main species of trees common in both the early period (A) and at the end (B) were employed in the same group of defoliation classes (0-1 and 2-3) (m^3);

S_{SSI} – area of the permanent sample plot (SSI) (ha).

In order to avoid the errors produced by migration of living trees during the study period in different defoliation classes, it was determined an average of forest volume growth taking into account the stratification of tress by crown condition in 1996 and 2006 (Table 2), as follows:

$$I_{v0\text{-}1AB} = \frac{I_{v0-1A} + I_{v0-1B}}{2};$$

$$I_{v2\text{-}3AB} = \frac{I_{v2-3A} + I_{v2-3B}}{2}.$$

One can notice that the volume growth for common living trees are the same for each plot if they are calculated as an average, taking into account the stratification of trees by crown condition in 1996 and 2006, or only by crown condition of the trees registered at the end of study period (2006).

Analyzing the values of average annual growth in volume, during the period 1996-2006 it is obvious that they are significantly different, ranging from 4.3 $m^3yr^{-1}ha^{-1}$ (SSI Videle-turkey oak) to 15.9 $m^3yr^{-1}ha^{-1}$ (SSI Predeal-spruce). Average annual growth in volume recorded by English oak stands (Ştefăneşti - oak, Ploiesti - oak) was considered low, in areas affected by drought and having a high proportion of mixture species, which to some extent dominates the main species. Low values (4.6 $m^3yr^{-1}ha^{-1}$) were recorded at SSI Rarău-spruce, located in extreme conditions of vegetation (altitudinal upper limit), indicating a low level of productivity and ecosystem integrity, *i.e.*, high intensity of damage factors, mainly the influence of extreme climatic conditions and vegetation.

Table 2

Volume growth ($m^3yr^{-1}ha^{-1}$) for common living trees (total) and for different defoliation group classes (0-1 and 2-3)

Plot name	I_{VAB}	$I_{V0\text{-}1AB}$	$I_{V2\text{-}3AB}$	I_{VB}	$I_{V0\text{-}1B}$	$I_{V2\text{-}3B}$	$I_{V0\text{-}3}$	$I_{V0\text{-}1}$	$I_{V2\text{-}3}$
Giurgiu-Turkey oak	5.75	3.34	2.41	5.74	4.78	0.96	2.32	1.63	0.69
Videle – Turkey oak	5.64	4.76	0.88	5.67	4.97	0.7	4.52	4.19	0.33
Videle-Hungarian oak	4.29	2.74	1.55	4.33	3.45	0.88	2.9	2.02	0.88
Ştefăneşti-oak	4.46	2.27	2.19	4.39	2.42	1.97	2.65	1.37	1.28
Ploieşti-oak	5.9	3.15	2.75	5.9	4.41	1.49	2.97	1.69	1.28
Câmpina-sessile oak	8.8	5.85	2.95	8.8	6.81	1.99	5.61	4.25	1.36
Sinaia-beech	14.58	10.51	4.07	14.57	12.99	1.58	6.72	6.58	0.14
Predeal-spruce	15.93	9.51	6.42	15.88	15.45	0.43	4	3.57	0.43
Rarău -spruce	4.64	3.15	1.49	4.59	3.31	1.28	3.22	2.42	0.8
Fundata-beech	7.49	5.57	1.92	7.48	6.58	0.9	5.21	4.44	0.77
Stâna de Vale-spruce	9.53	7.62	1.91	9.5	8.68	0.82	7.16	6.46	0.7
Mihăieşti-sessile oak	12.06	7.99	4.07	12.06	10.15	1.91	6.71	5.32	1.39

Thus, the highest values (15.9 $m^3yr^{-1}ha^{-1}$) were recorded in Predeal-spruce stand, where it has high productivity in optimal climatic conditions and altitude. Sessile oak, (*Quercus petraea*), both in SSI Campina-sessile oak and in Mihăeşti-sessile oak, had normal values or above the average volume growth (8.8 $m^3yr^{-1}ha^{-1}$ respectively, 12.1 $m^3yr^{-1}ha^{-1}$), which indicates a good ecosystem integrity and high vitality. For the Turkey oak (Quercus cerris) and the Hungarian oak (*Quercus frainetto*) (SSI Giurgiu – Turkey oak and Videle-Hungarian oak), the average annual growth in volume recorded similar values ranging from 5.7 $m^3yr^{-1}ha^{-1}$ (Videle-Turkey oak and Videle-Hungarian oak) and 4.3 $m^3yr^{-1}ha^{-1}$ (Giurgiu - Turkey oak), although considered below normal due to excessive drought conditions recorded in the years 1998, 2000, 2002–2004, these species proving to some extent, considerable resistance to the extreme conditions in southern Romania.

On groups of defoliation classes, the highest values of average annual growth in volume per year and hectare were recorded for the healthy trees SSI Sinaia-beech (14.6 $m^3yr^{-1}ha^{-1}$) and Predeal-spruce (15,9 $m^3yr^{-1}ha^{-1}$) and the lowest for SSI Ştefăneşti-oak (14.4 $m^3yr^{-1}ha^{-1}$) and SSI Rarău-spruce (14.6 $m^3yr^{-1}ha^{-1}$). The damaged trees registered the highest values in the same stands (SSI Sinaia-beech and SSI Predeal-spruce) and the lowest in SSI Videle-Turkey oak and SSI Rarău-spruce.

In cases of the trees that were constantly assessed as healthy (defoliation classes 0-1), the recorded average annual growth was evidently higher than for the damaged trees (defoliation classes 2-3) (Table 2).

The volume growth registered for the trees that remain constantly healthy are particularly relevant and are a reference for calculating the growth losses for the damaged trees.

The losses of volume growth per year and ha due to damaging process of trees were established with a very high accuracy taking into account for each plot only the population of trees which during the entire period had the same defoliation class:

$$\Delta I^1{}_{0\text{-}1}/I_{0\text{-}3} = I^1_{\mathrm{VO-1}} - I_{\mathrm{VO-2}};$$

$$\Delta I^1{}_{0\text{-}1}/I_{0\text{-}3}\% = \frac{I^1_{\mathrm{VO-1}} - I_{\mathrm{VO-2}}}{I_{\mathrm{VO-1}}} * 100;$$

$$\Delta I_{0\text{-}3}/I_{2\text{-}3} = I_{\mathrm{VO-3}} - I^1_{\mathrm{V2-3}};$$

$$\Delta I_{0\text{-}3}/I^1{}_{2\text{-}3}\% = \frac{I_{\mathrm{VO-3}} - I_{\mathrm{V2-3}}}{I_{\mathrm{VO-3}}} * 100;$$

$$\Delta I^1{}_{0\text{-}1}/I^1{}_{2\text{-}3} = I^1_{\mathrm{VO-1}} - I^1_{\mathrm{V2-3}};$$

$$\Delta I^1{}_{0\text{-}1}/I^1{}_{2\text{-}3}\% = \frac{I_{\mathrm{VO-1}} - I_{\mathrm{V2-3}}}{I_{\mathrm{VO-1}}} * 100,$$

$$\mathrm{I}^1{}_{0\text{-}1} = N_{0-3}\,\frac{I_{0-1}}{I_{2-3}};$$

$$I^1{}_{2\text{-}3} = N_{0-3}\,\frac{I_{2-3}}{N_{2-3}},$$

$N_{0\text{-}3} = N_{0\text{-}1} + N_{2\text{-}3}$, where:

$I^1v_{0\text{-}1}$ represents the volume growth if all trees would have been healthy (defoliation classes 0-1);

$I^1{}_{2\text{-}3}$ – volume growth if all trees would have been damaged (defoliation classes 2-3);

$\Delta I^1{}_{0\text{-}1}/I_{0\text{-}3}$ – volume growth loss due to damage process by comparison with real status of trees (m^3yr^{-1} ha^{-1}, %)

$\Delta I^1{}_{0\text{-}1}/I^1{}_{2\text{-}3}$ – maximum hypothetical volume growth loss ($m^3yr^{-1}ha^{-1}$, %);

$\Delta I_{0\text{-}3}/I^1{}_{2\text{-}3}$ – potential volume growth loss of the existing forest stand, in the hypothesis that all trees would be damaged ($m^3yr^{-1}ha^{-1}$, %);

$N_{0\text{-}1}$ – number of healthy trees (defoliation classes 0-1);

$N_{2\text{-}3}$ – number of damaged trees (defoliation classes 2-3);

$N_{0\text{-}3}$ – number of trees with the same damage class during the study period.

Relative growth loss ($\Delta I_{v\%}$) was calculated both by comparison of healthy trees (in the hypothesis that all trees would have been in defoliation class 0-1 group) with the real status of stand and with damaged trees (defoliation classes 2-3) of the stand (Table 3).

These differences ($\Delta I^1{}_{0\text{-}1}/I_{0\text{-}3}$) vary between 0.05 $m^3yr^{-1}ha^{-1}$ (Videle-Turkey oak) and 0.65 $m^3yr^{-1}ha^{-1}$ (Fundata-beech). As a result, assuming that all trees in these communities would be damaged (defoliation classes 2-3), during the period, then the differences ($I_{0\text{-}3}/I^1{}_{2\text{-}3}$) would vary between 0.3 $m^3yr^{-1}ha^{-1}$ (Giurgiu-Turkey oak) and 2.03 $m^3yr^{-1}ha^{-1}$ (Fundata-beech). Consequently, according to the first hypothesis, that all trees were healthy (defoliation classes 0-1), the percentage of growth losses per hectare and year are ranging from 1.1% (Videle-Turkey oak) and 11.1% (Predeal-spruce).

Table 3

Volume growth losses ($m^3yr^{-1}ha^{-1}$ and %) registered in intensive permanent monitoring plots (Level II) for the living trees with the same defoliation class during the period 1996–2006

Plot name	I_{V0-1} $m^3an^{-1}ha^{-1}$	I_{V2-3} $m^3an^{-1}ha^{-1}$	I_{V0-3} $m^3an^{-1}ha^{-1}$	I^1_{V0-1} $m^3an^{-1}ha^{-1}$	$\Delta I^1_{0-1}/I_{0-3}$ $m^3an^{-1}ha^{-1}$	$\Delta I^1_{0-1}/I_{0-3}$ %	I^1_{2-3} $m^3an^{-1}ha^{-1}$	$\Delta I^1_{0-3}/I_{2-3}$ %	$\Delta I_{0-3}/I^1_{2-3}$ %	$\Delta I^1_{0-1}/I^1_{2-3}$ %
Giurgiu-Turkey oak	1.63	0.69	2.32	2.47	0.15	6.3	2.02	0.3	12.9	18.3
Videle-Turkey oak	4.19	0.33	4.52	4.57	0.05	1.1	3.99	0.53	11.8	12.7
Videle-Hungarian oak	2.02	0.88	2.90	3.05	0.15	4.8	2.61	0.29	9.9	14.2
Ştefăneşti-oak	1.37	1.28	2.65	3.00	0.35	11.8	2.35	0.3	11.2	21.7
Ploieşti-oak	1.69	1.28	2.97	3.32	0.35	10.6	2.61	0.36	12.3	21.6
Câmpina-sessile oak	4.25	1.36	5.61	5.85	0.24	4.1	4.98	0.59	11.3	14.9
Sinaia-beech	6.58	0.14	6.72	6.75	0.03	0.5	5.43	1.29	19.2	19.6
Predeal-spruce	3.57	0.43	4.00	4.02	0.02	0.5	3.85	0.15	3.8	4.3
Rarău-spruce	2.42	0.80	3.22	3.44	0.22	6.5	2.69	0.53	16.3	21.8
Fundata-beech	4.44	0.77	5.21	5.86	0.65	11.1	3.18	2.03	39.0	45.7
Stâna de Vale-spruce	6.46	0.70	7.16	7.22	0.06	0.8	6.66	0.50	7.0	7.7
Mihăieşti-sessile oak	5.32	1.39	6.71	6.94	0.23	3.3	5.95	0.76	11.3	14.3

According to a second hypothesis, that all trees would have been injured, the registered growth would be higher (as an “additional yield”) ($\Delta I_{0-3}/I^1_{2-3}$) with 7.0% (Stâna de Vale-spruce) to 39 % (Fundata-beech).

Finally, according to a third hypothesis that all trees would have been healthy (defoliation classes 0-1) or all tress would have been damaged (defoliation classes 2-3), the relative differences of volume growth ($\Delta I^1_{0-1}/I^1_{2-3}$) would range between 7.7% (Stâna de Vale-molid) and 45.7% (Fundata-fag).

Knowing the volume growth losses due to damage processes of trees through cumulative negative action of various stress factors (climate, pollution, anthropogenic, fire, etc.), along with other biotic and abiotic factors, allow to anticipate the effects of these factors on forests’ growth, and the development of reliable prognosis and strategies, based on information provided by the monitoring system forestry at regional and national level.

CONCLUSIONS

1. Developing and improving of the specific methods for establishing of volume growth and growth losses due to damaging process of trees and stands;

2. Testing of methods in order to reduce errors due to migration process of trees in different defoliation classes on the values of the volume growth, taking into consideration forest health status of trees at the beginning and the end study period and only the population of trees which had the same defoliation class during the entire period in order to obtain good quality of the results;

3. The values of volume growth losses (%) for the studied forest ecosystems due to damaging process are between 1-12%, and they are very important scientific information for prognosis on real estimation of forest growth and on allowable cuttings volume at local, regional and national level.

4. Elaboration of scenarios on increasing intensification of the proportion of damaged trees (defoliation classes 2-4) up to 90-100%, by comparing with the real health situation or with the best situation (defoliation classes 0-1) of trees, the values of the growth losses (%) will increase up to 40-45%.

5. Calculating the average of forest volume growth is the optimal solution for avoiding errors due to the tree migration process in different defoliation classes during the entire period. In addition, it is recommended to take into consideration for stratification the crown condition of trees at the end of the period.

6. The results obtained for the first time in our country will have a very good scientific contribution in developing of the forest monitoring system, with special focus on forest growth monitoring component and in Romanian forest policy and strategy.

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