RISCURI ŞI CATASTROFE, NR. XII, VOL. 13, NR. 2/2013

THE RISK OF CLIMATE CHANGES ON ROMANIAN FORESTS

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ABSTRACT**.- **The risk of climate change on Romanian forests. This work covers the influence of climate warming vertically in the Romanian Carpathians space, over the vegetation floors in general and the forest floors in particular, and the reaction of its feedback to climate warming. Thermal parameters are analyzed in two major reference periods that exceed the limits of the beginning (1896-1915, 1921-1955) and the end (1961-2010) of the twentieth century (table 1) and highlight the climate warming in the second period. However, the decade analysis of these parameters for 1961-2010, during the first three decades indicates negative deviations from the average period and positive deviations during the last two decades, which indicates that vertical heat is felt with delay. After positive deviations of mean annual temperature of +0.6...+0.7˚C (table 3) in all forest floors, all forest ecosystems that are vulnerable to climate change, but the most vulnerable are those at higher altitudes (of conifers and shrubs dwarfs) in the warm half of the year and especially in the warmer months, when the disturbances reach +1.3˚C (tables 3f., and 3g), while the half cold, especially in the colder months, where these deviations vary between +0.5 and +1.0˚C (tables 3d and 3e), the most vulnerable are forest ecosystems of lower altitudes (oak and beech). If the warming continues, there is a risk of their degradation, occurring both naturally and anthropogenic. Under these conditions, the forest will not fulfill the role of climate equilibrium, CO_2 storage in biomass and forest soils, so that the response to climate change is reverse,to cede CO_2 to the atmosphere and other greenhouse gas emissions and to enhance the process of pollution, respectively, a warming climate, which requires a National Strategy for sustainable development of the forestry industry.

Key words: climate changes, global warming, vegetation floors, forest ecosystems, feedback reaction.

Introduction

One of the great problems mankind is facing in the contemporary period is the climate change, whose consequences are reflected on all environmental

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components, among which human and human activities are included (Valeria Velcea, Octavia Bogdan, 2008).

The main way of manifestation of climate change is the ***global warming*** that affects all the elements of Earth's climate system, of which there are many positive feedback reactions that lead to the intensification of this process, as well as negative feedback that delays it, tending to stabilization (Busuioc and collab., 2010, Bogdan, 2012).

1. The evolution of climate warming process

Climate warming is a process which occurred since the advent of the atmosphere and is generated by astronomical causes, primarily by solar activity, a process favored by the presence of CO_2 in its composition, the fourth gas as a volume proportion according to WMO, and other greenhouse gases. The role of CO_2 in the warming process is particularly great, because it absorbs the infrared radiation with long wavelength emitted by the Earth and the Sun, thereby ensuring the heat balance of the Earth: in its presence, the temperature of our planet is 15˚C, while in his absence, it would be -18˚C, so that life would be impossible (Bogdan, 2009).

It should be noted that the biggest CO_2 concentration is located at the lower limit of the atmosphere up to a height of 20-30km, above from which, it disappears, obviously affecting the climate warming.

By the beginning of the industrial era (1850), the heating was mainly due to cosmic and astronomical factors rather than the telluric (higher contributions are due to volcanic eruptions, mineral springs, organic decomposition, early farming practicing, Rudiman, 2005).

After 1850, ***due to the industrial revolution*** began the atmosphere rich in CO_2 as a result of the consumption of conventional fuels, a process that has continued to increase ***after 1960***, with the ***scientific and technical revolution*** until today. This led to the increasing pollution of the atmosphere, contributing as a catalyst to global warming (Bogdan, 2005).

According to *the fourth report of the IPCC* (2007), in the pre-industrial period, the total CO_2 amount was of 280 ppm and from 1850 until 2005, only a century and a half later, it increased to 370 ppm.

In line with the above, it follows that in the period before 1850, global warming was mostly ***a slow process*** that took place, while after this year, global warming was caused ***mainly through anthropogenic due to greenhouse gases*** (CO_2, CH_4, NO_2, SO_2, NH_3, O_3, CFCs, water vapor etc.), of which CO_2 has the biggest role, recording particularly rapid growth and continuous upward trend.

In this way, pollution has become a major threat, both directly, through geosystem land health, and indirectly, through the influence it has on global warming.

It is now widely accepted that global warming, by its impact on the environment, has a ***global character***.

What is hard to prove, is that so far it is not known how long this process will take (if it is of the geological eras) and that will be his strength.

Worldwide, during the same period of half a century (1850-2000) as well as pollution, ***air temperature increased*** by 0.76˚C compared to the start of the industrial era in 1850, by 0.6˚ C over the last century (1901-2000) and by 0.74˚C over the past 100 years (1906-2005), (according to the fourth IPCC report, in 2007, quoted by Sandu Mateescu, Vătămanu 2010, Busuioc and collab., 2010), which confirms the upward warming trend.

Also, according to these sources, global air temperature increase was not uniform, as states and the General Secretary of WMO, Michel Jerraud the occasion of World Meteorological Day, 23 March 2011: *"The strongest warming felt in the last 50 years of the twentieth century, when there was an increase in average global temperature of 0.13˚/decade is nearly double the 0.74˚C/decade in the century from 1906 to 2005; the warmest years in the history of meteorology have been since 1988 and the warmest decade was 2001-2010, when the average global temperature was 0.5˚C higher than the average of the period 1961-2010, this being the highest average a decade since the beginning of instrumental observations, and the warmest year was 2010, standing at the same level as 1988 and 2005".*

The same source indicates also ***in perspectiv***e, that by the end of the XXI century, ***the average global temperature*** will increase with 1.8-4.0˚C (Busuioc and collab., 2010 Sandu et al., 2010, p. 16) even if the pollution level shall be limited. The calculations made by Busuioc and collab. (2010, p. 18) for different time periods, using A_1B scenario of the IPCC (2007), indicate that compared to the 1961-1990 interval, for the period 2021-2050, an average annual air temperature increase by +1.4˚C (±0.4˚C), for Romania and for 1971-2100, an increase to 3.1˚C (± 0.7˚C), depending on the level of pollution.

At this ascending rate, ***the climate warming will have very large consequences***, among which we quote: overall increase of air circulation in the troposphere, of cyclonic and anticyclonic activity, of thermal & pluviometric contrasts (rain showers, excessive rainfall, or rather hot days and long drought) and lightning, storms, forest fires, snags and wind-blown trees etc. (Bogdan, 2005, Bogdan, Marinică, 2007, Giurgiu, 2010, Bogdan, Coşconea, 2011 et al.).

At a global scale, ***given that the consumption of conventional fuels, respectively, the pollution process will not be limited***, global warming will lead to a slight ***horizontal translation*** to the north of the thermal Equator and ***climatic zones*** of the Northern Hemisphere (where the land occupies the largest surface) and vertically in the mountainous regions and along with them the translation of areas/floors of vegetation in the same direction, which will generate important mutations.

Thus, the temperate and subpolar areas will be invaded by plant species adapted to warmer climates in the south, which will expand the area to the north, and the lower floors will climb to altitude in similar ecological conditions. All these consequences will destabilize the entire social and economic life on Earth, ***global warming proving to be the greatest natural hazard***.

One of the natural factors that contribute to regulate the climate is ***the vegetation in general*** and ***the forest in particular***, which assimilates CO_2 through photosynthesis and releases O_2, having a dual role: refreshes the atmosphere with O_2, and stores CO_2 in vegetal mass and in the forest soil, thus limiting the pollution.

Over time, ***the pre-industrial period***, when the heating was slower, ***the forest has adapted to certain environmental conditions*** (Giurgiu, 2010), while ***in the present circumstances***, it began to suffer and will suffer even more in the perspective of continuing the climate warming and diminishing the moisture resources. Thus, there will be ***extremely large ecological consequences*** on the supply of nutrients to trees and dry soil will increase their vulnerability against strong winds and wind-blown trees (Barbu, Popa, 2005, Giurgiu, 2010, Bogdan, Coşconea, 2011 and collab.).

All this led us to study more closely the manifestation of global warming on forest ecosystems on the floors of vegetation, on which there are little information.

2. Climate change on vegetation floors in Romania

2.1. Metodology

The data presented on global warming, in the current period and in perspective, are global average including a large variability of active surface types, developed both horizontally and vertically. In this case, the data were divided vertically, on vegetation floors specific for Romania, which results in significant altitude differences, with different impacts on forest ecosystems.

In this paper we addressed the ***air temperature***, the main element of the climate system, which highlights global warming, leaving ***atmospheric precipitations***, directly correlated with temperature, as subject to other works.

Thus, ***8 thermic parameters were studied based on meteorological stations located on different floors of vegetation***, as follows: annual air temperature mean, hot semester air temperature mean, cold semester air temperature mean, as well as the average temperature of the coldest months (January and February) and the hottest months (July and August) for two great periods, exceeding the limits of the beginning (1896 to 1955 ─ with a five years break, from 1916 to 1920 due to suspension of work during World War I.) and end (1961-2010) of the twentieth century.

The objective was to determine the thermal differences between the two periods, in order to highlight global warming, as well as the evolution of those parameters from one decade to another from the second period, 1961-2010, when the heat was felt the most.

In this regard, investigations were carried out on two levels, both between ***meteorological stations*** located in different floors of vegetation for which were calculated the average values of the ***8 thermal parameters*** for each period of observation and the differences between them (table 1) as well as between vegetation floors only for the 1961-2010 period (table 2), when the means were calculated by floors and by decades, as well as their deviation from the annual mean (tables 3a-3g).

In the first case (table 1), 9 meteorological stations were selected, with parallel and almost equal rows of the two intervals. For the period 1896-1955 (about 55 years) the climate data published in RSR, vol II, 1966 were used and for the period from 1961 to 2010, they were calculated by us. ***In the second case*** (table 2), covering the floors of vegetation, we selected 22 stations (including the 9 mentioned above) from the ANM database, Bucharest[*].

Those parameters were calculated first on stations for the entire period (1961-2010) and on the floors of vegetation (table 2) and then on decades and vegetation floors for each climatic parameter (tables 3a-3g).

2.2. Deviation of thermal parameters mean during 1961-2010 compared with 1896-1955

By comparing the 9 meteorological stations with parallel rows located in different climate floors, some conclusions resulted (table 1) that we will present below.

Air temperature increased during the twentieth century, aspect highlighted by higher values recorded in the second period, 1961-2010, compared to the first, 1896-1955, marked by positive deviations of thermal parameters.

Such ***positive deviations were recorded in all floors of vegetation***, which means that heating propagated from below throughout the vertical, but ***not with the same intensity***; quantitative deviations are reduced as the altitude increases.

The largest positive deviations in all parameters analyzed were carried at the weather stations situated below 500m altitude, plains and low hills, the area of oak trees.

● During the year ***warming was higher in the cold half of the year, especially in January and February and lower in the warm semester, especially in July and August***.

[*] Maria Coşconea (2011), *Climate risks causing wind blown trees in Romania,* PhD thesis held at the Institute of Geography of the Romanian Academy, under the supervision of Prof. Univ. Dr. Octavia Bogdan

● ***In the cold semester of the year***, the deviations were of +0.5...+0.8˚C at the weather stations below 500m altitude and of +0.1˚C to those in coniferous level (1200-1800m) in alpine area (>2000m altitude).

● ***In the actual winter months, January and February***, the deviations were also higher, as follows:

− ***In January***, these deviations ranged between +0.6 and +1.4˚C in the oak level, +0.3˚C at weather stations on beech level and +0.2˚C in the alpine area (except the coniferous level with +0.7˚C);

− ***in February***, the heating peaked throughout the vertical: +0.8˚C...+1.6˚C at the stations in the oak floor, +0.6˚C in the beech floor, +0.5˚C in the alpine area (except the coniferous level with -0.2˚C);

To note that ***in some large depressions,*** as in the case of Braşov Depression, deviations recorded average temperatures in cold semester (-0.5˚C) in January (-0.4˚C) and February (-0.7˚C) were negative, which means lower temperatures in the period 1961-2010 compared with the period 1896-1955, justified by the high frequency of temperature inversions.

● ***Weakest warming*** occurred in the warm semester of the year, but was observed in all meteorological stations located in different climatic floors: +0.2...+0.3˚C on the oak floor and +0.2˚C on the hardwood floors and conifers, and +0.3˚C in the alpine area.

● ***in the warm summer months, July and August, the positive deviations were as small***, but stood out at all the stations, as follows:

− ***in July***, they were +0.1...+0.2˚C at stations in the oak floor, +0.2...+0.3˚C in the beech floor, +0.2˚C at the conifers level and +0.3˚C in the alpine area;

− ***in August***, their sequence was: +0.1...+0.3˚C in the oak floor, +0.1...+0.4˚C on the beech level, +0.3˚C on the conifers floor and +0.2˚C in the alpine area;

● The differences between the two periods, 1896-1955 and 1961-2010 lead to relatively small deviations of the ***mean annual temperature***, they vary between +0.1 and +0.5˚C at the stations on the oak floor, dropping to +0.1˚C on the beech floor, but increase with altitude (+0.2˚C) at stations in the upper floors.

Table 1. Deviation (ΔT°C) of the thermal parameters (P°C), average for the period 1961-2010 (T_1°C)* compared to the average for the period 1896-1955 (T_2°C) ** from various meteorological stations located in each vegetation floor.

No. Crt.	Weather station	P°C	T°C annual	T°C Σ warm	T°C Σ cold	T°C January	T°C February	T°C July	T°C August
ALPINE AREA (>2000m)									
1	Omu Peak	**T_1°C**	-2.4	2.4	-7.2	-10.3	-10.6	5.7	5.9
		T_2°C	-2.6	2.1	-7.3	-10.5	-11.1	5.4	5.7
		ΔT°C	**+0.2**	**+0.3**	**+0.1**	**+0.2**	**+0.5**	**+0.3**	**+0.2**
CONIFERS AREA (1200…1750-1800m)									
2	Parâng	**T_1°C**	3.6	9.1	-1.8	-5.1	-5.0	12.6	12.6
		T_2°C	3.4	8.9	-1.9	-5.8	-4.8	12.4	12.3
		ΔT°C	**+0.2**	**+0.2**	**+0.1**	**+0.7**	-0.2	**+0.2**	**+0.3**
BEECH FLOOR (500-1200m)									
3	Predeal	**T_1°C**	5.0	11.0	-0.8	-4.8	-4.0	14.7	14.3
		T_2°C	4.9	11.0	+1.2	-5.1	-4.6	14.5	14.2
		ΔT°C	**+0.1**	**0.0**	-0.4	**+0.3**	**+0.6**	**+0.2**	**+0.1**
4	Braşov	**T_1°C**	7.7	14.6	0.7	-4.3	-2.5	18.1	17.6
		T_2°C	7.8	14.4	1.2	-3.9	-1.8	17.8	17.2
		ΔT°C	-0.1	**+0.2**	-0.5	-0.4	-0.7	**+0.3**	**+0.4**
OAK FLOOR (<500m)									
5	Cluj	**T_1°C**	8.5	15.5	1.6	-3.6	-1.3	19.1	18.5
		T_2°C	8.2	15.3	1.1	-4.4	-2.3	18.9	18.2
		ΔT°C	**+0.3**	**+0.2**	**+0.5**	**+0.8**	**+1.0**	**+0.2**	**+0.3**
6	Bistriţa	**T_1°C**	8.7	15.4	1.2	-4.2	-1.9	19.0	18.3
		T_2°C	8.2	15.4	1.0	-4.4	-2.7	19.1	18.5
		ΔT°C	**+0.5**	**0.0**	**+0.2**	**+0.2**	**+0.8**	-0.1	-0.2
7	P. Neamţ	**T_1°C**	8.9	15.9	1.9	-2.7	-1.3	19.6	19.0
		T_2°C	8.4	15.6	1.3	-3.3	-2.5	19.5	18.9
		ΔT°C	**+0.5**	**+0.3**	**+0.6**	**+0.6**	**+1.2**	**+0.1**	**+0.1**
8	Tg. Jiu	**T_1°C**	10.3	17.4	3.1	-1.8	+0.5	21.3	20.6
		T_2°C	10.2	17.5	3.0	-2.5	-0.4	21.6	20.7
		ΔT°C	**+0.1**	-0.1	**+0.1**	**+0.7**	**+0.9**	-0.3	-0.1
9	Bucureşti-Filaret	**T_1°C**	11.4	18.9	3.9	-1.4	0.9	23.0	22.4
		T_2°C	10.9	18.7	3.1	-2.8	-0.7	22.9	22.3
		ΔT°C	**+0.5**	**+0.2**	**+0.8**	**+1.4**	**+1.6**	**+0.1**	**+0.1**

*) After *ANM Archive*, calculated data
**) After *Clime RSR*, vol. II, 1966

Table 2. Mean air temperature parameters during 1961-2010 at weather stations in each vegetation floor and the floor mean

No. crt	Weather station	T°C Annual mean	T°C Σ warm	T°C Σ cold	T°C January	T°C February	T°C July	T°C August
ALPINE AREA (>2000m)								
1	Vf. Omu	-2.4	2.4	-7.2	-10.3	-10.6	5.7	5.9
2	Ţarcu	-0.5	4.4	-5.3	-8.4	-8.6	7.8	8.0
	Mean	**-1.4**	**+3.4**	**-6.3**	**-9.3**	**-9.6**	**6.8**	**7.0**
SUBALPINE AREA (1750-1800...2000m)								
3	Vlădeasa	1.2	6.4	-4.0	-7.2	-7.1	9.7	9.9
4	Iezer	1.5	6.8	-3.8	-6.9	-6.8	10.2	10.1
	Mean	**1.4**	**6.6**	**-3.9**	**-7.1**	**-7.0**	**10.0**	**10.0**
CONIFERS FLOOR (1200...1750-1800m)								
5	Lăcăuţi	1.4	6.9	-4.2	-7.7	-7.6	10.4	10.4
6	Parâng	3.6	9.1	-1.8	-5.1	-5.0	12.6	12.6
7	Sinaia	3.9	9.4	-1.7	-5.1	-5.0	12.9	12.7
8	Semenic	3.7	9.4	-2.0	-5.4	-5.2	13.0	12.9
9	Fundata	4.5	10.3	-1.4	-5.1	-4.7	13.8	13.7
10	Băişoara	5.0	10.5	-0.6	-3.9	-3.7	13.9	13.9
	Mean	**3.6**	**9.3**	**-1.9**	**-5.4**	**-5.2**	**12.8**	**12.7**
BEECH FLOOR (500...1200m)								
11	Predeal	5.0	11.0	-0.8	-4.8	-4.0	14.7	14.3
12	Întors.Buzăului	6.3	13.0	-0.4	-5.2	-3.5	16.6	15.3
13	Miercure Ciuc	5.6	12.9	-1.7	-7.1	-5.0	16.6	15.7
14	Tg. Secuiesc	7.0	14.1	-0.1	-5.2	-3.4	17.7	17.2
15	Braşov	7.7	14.6	0.7	-4.3	-2.5	18.1	17.6
16	Polovragi	9.3	16.0	2.5	-1.8	-0.4	19.9	19.3
	Mean	**6.8**	**13.6**	**0.0**	**-4.7**	**-3.1**	**17.3**	**16.6**
OAK FLOOR (<500m)								
17	Cluj	8.5	15.5	1.6	-3.6	-1.3	19.1	18.5
18	Bistriţa	8.7	15.4	1.2	-4.2	-1.9	19.0	18.3
19	Piatra Neamţ	8.9	15.9	1.9	-2.7	-1.3	19.6	19.0
20	Oraviţa	11.2	17.5	4.8	0.1	1.9	21.0	20.9
21	Tg. Jiu	10.3	17.4	3.1	-1.8	0.5	21.3	20.6
22	Bucureşti-Filaret	11.4	18.9	3.9	-1.4	0.9	23.0	22.4
	Mean	**9.8**	**16.8**	**2.8**	**-2.3**	**-0.2**	**20.5**	**20.0**

Source: Data processed from ANM Archive, Bucharest

2.3. The decade evolution of the thermal parameters by vegetation floors and their deviation from the multiannual mean for the period 1961-2010

Based on decades of data on the evolution of all thermal parameters during 1961 - 2010 (tables 3a-3g), some conclusions resulted, that we will present in the following paragraphs.

● Although climate warming was felt globally since 1961, as shown in table 1, the vertical heat transfer in the Romanian mountain area was delayed so that ***the first three decades (1961-1970, 1971-1980 and 1981-1990) were characterized by the predominance of negative deviations*** from the mean for the period 1961-2010 made by each thermal parameter analyzed (tables 3a-3g), which signifies a colder period compared to the next two warmer decades (1991-2000 and 2010).

● ***The coldest decade*** was different from one parameter to another:

─ for the ***mean temperatures of January***, the coldest decade was 1961-1970 the respective deviations ranged from -2.0˚C and -1.0˚C oak floor in the alpine area, gradually decreasing with altitude (table 3d).

─ for the ***mean annual temperature*** (table 3), the ***warm semester*** (table 3b) of ***July*** (table 3f) and August (table 3g), the coldest decade was 1971-1980 for all forest floors; in these cases, the largest negative deviations were recorded in the hottest months, July (-0.9...-1.2˚C) and August (-1.1...-1.2˚C) in all forest floors (see tables 3f and 3g).

─ for the ***mean temperatures of the cold semester*** (table 3c) ***and February*** (table 3e), the coldest decade was 1981-1990 for all floors. For the ***cold semester*** (values are averaged over several months), deviations are smaller, ranging from -0.4˚C in the oak and the beech floor, at -0.3˚C at -0.2˚C of coniferous and subalpine and alpine areas (table 3c), compared to those of ***February***: -0.9˚C in oak floor, -1.1˚C at the beech level and then increasing to -0.5˚C in the subalpine dwarf shrubs, table 3e).

● Of the three cold decades, ***the coldest decade for all forest floors*** was the first, 1961-1970, in which all negative deviations of the ***mean temperature in January*** compared to the mean of the period 1961-2010 were the largest: -2.0˚C in the oak floor, -1.9˚C in the beech floor, from -1.4˚C in that of conifers, of -1.2˚C in the dwarf shrubs floor and -1.0˚C in the alpine area (see table 3d).

● Since 1991, the climate has been in a continuous heating process, highlighted by the positive decade deviations from the mean per period, increasingly higher, phenomenon noted in all thermal parameters analyzed.

Table 3. The decade evolution of the deviations (Δ**T°C**) of the thermal parameters (T°**C**) by vegetation floors and their deviation from the multiannual mean for the period 1961-2010 (**M°C**).

Table 3a Mean annual temperatures

Reference period	**Alpine area (>2000m)**		**Subalpine area (1800-2000m)**		**Coniferes floor (1200-1800m)**		**Beech floor (500-1200m)**		**Oak floor (<500m)**	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	M°C=-1.4		M°C=+1.4		M°C=+3.6		M°C=6.8		M°C=+9.8	
1961-1970	-1.5	**0.1**	+1.2	**-0.2**	+3.5	**7.5**	+6.8	**0.0**	+9.7	**-0.1**
1971-1980	-1.7	**-0.3**	+1.0	**-0.4**	+3.3	**-0.3**	+6.5	**-0.3**	+9.4	**-0.4**
1981-1990	-1.6	**-0.2**	+1.2	**-0.2**	+3.3	**-0.3**	+6.6	**-0.2**	+9.8	**0.0**
1991-2000	-1.4	**0.0**	+1.5	**+0.1**	+3.7	**+0.1**	+6.8	**0.0**	+9.8	**0.0**
2001-2010	-1.0	**+0.4**	+2.0	**+0.6**	+4.3	**+0.7**	+7.4	**+0.6**	+10.4	**+0.6**

Table 3b Mean temperatures of the warm semester

Reference period	**Alpine area (>2000m)**		**Subalpine area (1800-2000m)**		**Coniferes floor (1200-1800m)**		**Beech floor (500-1200m)**		**Oak floor (<500m)**	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	M°C=3.4		M°C=6.6		M°C=9.3		M°C=13.6		M°C=16.8	
1961-1970	3.5	**+0.1**	6.7	**+0.1**	9.2	**-0.1**	13.6	**0.0**	16.9	**+0.1**
1971-1980	2.8	**-0.6**	5.8	**-0.8**	8.5	**-0.8**	12.9	**-0.7**	16.0	**-0.8**
1981-1990	3.3	**-0.1**	6.4	**-0.2**	9.2	**-0.1**	13.6	**0.0**	16.6	**-0.2**
1991-2000	3.5	**+0.1**	6.8	**+0.2**	9.4	**-0.1**	13.7	**+0.1**	17.0	**+0.2**
2001-2010	4.2	**+0.8**	7.5	**+1.1**	10.2	**+0.9**	14.3	**+0.7**	17.5	**+0.7**

Table 3c Mean temperatures of the cold semester

Reference period	**Alpine area (>2000m)**		**Subalpine area (1800-2000m)**		**Coniferes floor (1200-1800m)**		**Beech floor (500-1200m)**		**Oak floor (<500m)**	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	M°C=-6.3		M°C=-3.9		M°C=-1.9		M°C=0.0		M°C=+2.8	
1961-1970	-6.4	**-0.1**	-4.2	**-0.3**	-2.2	**-0.3**	0.0	**0.0**	+2.5	**-0.3**
1971-1980	-6.1	**+0.2**	-3.9	**0.0**	-1.9	**+0.0**	+0.1	**+0.1**	+2.7	**-0.1**
1981-1990	-6.5	**-0.2**	-4.1	**-0.2**	-2.2	**-0.3**	-0.4	**-0.4**	+2.4	**-0.4**
1991-2000	-6.4	**-0.1**	-3.9	**0.0**	-2.0	**-0.1**	-0.1	**-0.1**	+2.8	**0.0**
2001-2010	-6.1	**+0.2**	-3.6	**+0.3**	-1.4	**+0.5**	+0.5	**+0.5**	+3.4	**+0.6**

Table 3d Mean temperatures of January

Reference period	**Alpine area (>2000m)**		**Subalpine area (1800-2000m)**		**Coniferes floor (1200-1800m)**		**Beech floor (500-1200m)**		**Oak floor (<500m)**	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	M°C=-9.3		M°C=-7.1		M°C=-5.4		M°C=-4.7		M°C=-2.3	
1961-1970	-10.3	**-1.0**	-8.3	**-1.2**	-6.8	**-1.4**	-6.6	**-1.9**	-4.3	**-2.0**
1971-1980	-9.2	**+0.1**	-6.7	**+0.4**	-5.4	**0.0**	-4.6	**+0.1**	-2.2	**+0.1**
1981-1990	-9.3	**0.0**	-7.4	**-0.3**	-5.3	**+0.1**	-4.6	**+0.1**	-2.1	**+0.2**
1991-2000	-8.6	**+0.7**	-6.4	**+0.7**	-4.7	**+0.7**	-4.1	**+0.6**	-1.5	**+0.8**
2001-2010	-9.2	**+0.1**	-6.6	**+0.5**	-4.9	**+0.5**	-3.9	**+0.8**	-1.3	**+1.0**

Table 3e Mean temperatures of February

Reference period	Alpine area (>2000m)		Subalpine area (1800-2000m)		Coniferes floor (1200-1800m)		Beech floor (500-1200m)		Oak floor (<500m)	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	**M**°C=-9.6		**M**°C=-7.0		**M**°C=-5.2		**M**°C=-3.1		**M**°C=-0.2	
1961-1970	-9.9	**-0.3**	-7.7	**-0.7**	-5.8	**-0.6**	-3.4	**-0.3**	-0.8	**-0.6**
1971-1980	-8.7	**+0.9**	-6.1	**+0.9**	-4.5	**+0.7**	-2.2	**+0.9**	+0.4	**+0.6**
1981-1990	-10.2	**-0.6**	-7.5	**-0.5**	-5.8	**-0.6**	-4.2	**-1.1**	-1.1	**-0.9**
1991-2000	-9.7	**-0.1**	-6.7	**+0.3**	-5.1	**+0.1**	-3.4	**-0.3**	0.0	**+0.2**
2001-2010	-9.5	**+0.1**	-6.8	**+0.2**	-4.8	**+0.4**	-2.6	**+0.5**	+0.5	**+0.7**

Table 3f Mean temperatures of July

Reference period	Alpine area (>2000m)		Subalpine area (1800-2000m)		Coniferes floor (1200-1800m)		Beech floor (500-1200m)		Oak floor (<500m)	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	**M**°C=6.8		**M**°C=10.0		**M**°C= 12.8		**M**°C=17.3		**M**°C=20.5	
1961-1970	6.5	**-0.3**	9.7	**-0.3**	12.3	**-0.5**	17.0	**-0.3**	20.4	**-0.1**
1971-1980	5.9	**-0.9**	8.8	**-1.2**	11.8	**-1.0**	16.3	**-1.0**	19.4	**-1.1**
1981-1990	6.4	**-0.4**	9.6	**-0.4**	12.5	**-0.3**	17.1	**-0.2**	20.2	**-0.3**
1991-2000	7.1	**+0.3**	10.3	**+0.3**	13.2	**+0.4**	17.7	**+0.4**	20.9	**+0.4**
2001-2010	8.2	**+1.4**	11.1	**+1.1**	14.1	**+1.3**	18.3	**+1.0**	21.6	**+1.1**

Table 3g Mean temperatures of August

Reference period	Alpine area (>2000m		Subalpine area (1800-2000m)		Coniferes floor (1200-1800m)		Beech floor (500-1200m)		Oak floor (<500m)	
	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C	T°C	ΔT°C
1961-2010	**M**°C=7.0		**M**°C=10.0		**M**°C= 12.7		**M**°C=16.6		**M**°C=20.0	
1961-1970	6.7	**-0.3**	9.6	**+0.4**	12.3	**-0.5**	16.5	**-0.1**	19.8	**-0.2**
1971-1980	5.8	**-1.2**	8.8	**-1.2**	11.8	**-1.0**	15.5	**-1.1**	18.8	**-1.2**
1981-1990	6.7	**-0.3**	9.7	**-0.3**	12.5	**-0.3**	16.4	**-0.2**	19.7	**-0.3**
1991-2000	7.5	**+0.5**	10.7	**+0.7**	13.2	**+0.4**	17.0	**+0.4**	20.5	**+0.5**
2001-2010	8.1	**+1.0**	11.3	**+1.3**	14.1	**+1.3**	17.8	**+1.2**	21.0	**+1.0**

Source: Data processed after ANM Archive, Bucharest

● ***The warmest decade***, highlighted by most of the thermal parameters for all forest floor ***was 2001-2010*** (including the ***annual mean temperature***, as noted by Sandu, Mateescu, Vataman, 2010 for this parameter all over the country); exception is the ***January mean temperature*** for which the warmest decade was 1991-2000, also for all floors of vegetation.

● ***But the greatest warming of the decade*** 2001-2010 occurred during the ***warm semester of the year***, when positive deviations from the annual average ranged between +0.7˚C and +1.1˚C (table 3b) and in ***the warmest months, July and August***, when the deviations were ≥1.0˚C in ***all vegetation floors***, the largest of +1.1...+1.4˚C being the upper floors, conifers, dwarf shrubs in alpine area (see tables 3f and 3g).

● After the positive deviations of ***annual mean temperature*** registered in the last decade, in all forest floors of +0.6...+0.7˚C (table 3), as great as that of the twentieth century, it follows that ***all forest ecosystems of all these floors are vulnerable to climate change***.

● ***In the warm semester of the year*** and respectively in the summer months (July and August) when such deviations are ≥1.0˚C, all forest ecosystems are vulnerable to climate change, ***but the most vulnerable are those at higher altitudes, conifers and dwarf shrubs*** where these deviations reach +1.3˚C (see tables 3f and 3g).

● ***In the cold semester of the year***, respectively in the coldest months (***January and February***), all forest ecosystems are vulnerable to climate change, especially those at ***lower altitudes, oak and beech mixed with other deciduous***, where the deviations are by +0.8˚C+1.0˚C in January (table 3d) and by +0.5...+0.7˚C in February (Table 3e), while above, they are smaller.

● If ***decades deviations were calculated during the period 1961-2010 and from 1896-1955***, these deviations would be ***even higher***, as the average of all thermal parameters of this period were lower than in the period under review (see table 1).

Considering, however, that the analyzed period was quite long, five decades, the results are inconclusive. Maybe if the altitude of the Carpathians would be higher and weather stations (to which I had access) separately in each forest floor would have been more numerous, these deviations would be distributed better, and their vertical variation would have been more uniform. However, in these conditions, such deviations are an example of ***regional climate variation***, altitude dependent, the orientation of the air advection with different thermal characteristics etc.

● We note that, although undergone a period of warming, negative deviations appear as large and positive, confirming the presence of thermal contrasts specific to this period.

● If global warming continues, two main conclusions are imposed: on one hand, ***the forest ecosystems will degrade*** (as well as other plant ecosystems), on the other hand, ***some will adapt*** based on the selection of trees and shrubs resistant to high temperatures to be used in afforestation.

● They should be seen as an adaptation and a ***possible vertical translation floors of vegetation in general***, as we have already anticipated, detailed in the context of Romania by Acad. Giurgiu V. (quoting Botzan, 1996), which states: it is possible to "*shift the semi-desert steppe, forest steppe to steppe plains of the steppe forest area, and a slight altitudinal translation of spruce forests with a rising trend to upper the limit of forest vegetation* " (Giurgiu, 2004, 2005, 2010, p. 7).

3. The feed-back reaction of the forest ecosystems to climate change

It is known that forests show a significant role in the climate, both by CO_2 storage in biomass and forest soils within them and by releasing O_2 in the atmosphere through photosynthesis. After Giurgiu (2010), Romanian forest soils sequester approximately half of the total carbon, respectively 700 million tons of the total 1.2 billion tons/year derived from organic matter mineralization, thereby helping to reduce pollution and thus to reduce warming process. Unfortunately, however, the percentage of forest cover in the country has decreased, according to the same information sources, from 60%, as it was two centuries ago, to about 27%, Romania being considered among the E.U. countries poor in forests (the EU average being 42%), due to massive deforestation, which currently reaches 12 million ha per year, which substantially decreases the role of forests in reducing pollution process.

The phenomenon is not only specific to Romania. The Earth has about 850 million degraded forests with the cleared ones hoarded 17-20% of CO_2 emissions (Giurgiu, 2010, p. 6).

Warming causes degradation of forest ecosystems, both ***directly***, by drying forests and their defoliation and by drying the soil and weaken their resistance, making them vulnerable to wind-blown trees, but also ***indirectly*** by increasing thermal contrasts rainfall, the rain showers accompanied by thunderstorms and hail storms, with more frequent hot days that generate forest fires and thereby, reducing forest cover and diminishing the role of forests in the climate.

Under these conditions, forest degradation by reaction of feedback can contribute to the ***intensification of pollution and greenhouse gas respectively intensification of warming***. It occurs while the physiological functions of forests ***are destroyed and soil structure inside them hoarding CO_2***.

This phenomenon occurs both ***naturally***, by amplifying warming consequences (dryness, drought, thunderstorms phenomena, fire, rain, storms), which causes degradation of forest ecosystems and ***anthropogenic***, by extending massive deforestation and limiting the role of forest hydrology.

Stated above that deforestation at national level took a large scale after the 90's, as a result of forest fund fragmentation, after restoration of old properties (there are currently 800 000 forest owners, Giurgiu, 2010, p. 9), irrational exploitation and the scaling of huge forest land (12 million hectares per year, as shown).

Also, on Earth, 13 million hectares of tropical forests are deforested yearly, which transfer to the atmosphere 6.5 million CO_2/year, after destructuring and washing soil during floods and landslides thus contributing to increased greenhouse effect. Thereto are added two million hectares of degraded or abandoned land, which instead of helping to provide the climatic balance role of the forest, through the processes of mineralization of soil organic mass, it releases huge amounts of CO_2 into the atmosphere with an opposite effect.

According to Brawn (2008) quoted by Giurgiu (2010, p. 11), the deforestation on Earth is responsible for the release of 1.5 billion tonnes per year of carbon that goes into the atmosphere.

It is to be mentioned that ***natural fore**st **fires contribue to increasing greenhouse gas concentrations***. As an example, in E.U. countries in southern Europe amid climate warming, their frequency increased to about 50 000/year, which causes the destruction of 500 000 ha of forest (the regeneration of which takes a long time), (Giurgiu, 2010, p. 8), having as result other greenhouse gases, as well.

The reduction of forest cover, thereby destroying the physiological functions of the forest, ***about anthropogenic can occur in other ways*** such as uncontrolled logging, theft, illegal trade, arson, faulty silvicultural works etc. All these will increasingly diminish forest role in maintaining the climate equilibrium and favours in contrast, the opposite effect, of enhancing the warming process.

Since climate change has become ***a global mankind problem in the contemporary period***, specialized international organizations ***are seeking solutions for improving the administrative and climate system***, ***recognition of the role of forests in maintaining its balance***, for which were drawn various strategies for sustainable development (Bogdan, Costea, 2013).

Thus, Brown (2008), cited by Giurgiu, 2010, page 12, shows that by the afforestation of 170 million ha of of degraded land, in 10 years, it is possible to fix the 950 million tons of carbon, and together with afforestation for soil conservation and combating floods will reach 1,000 million tons of carbon sequestered in biomass and forest soils.

If they add the effect of halting deforestation (1.5 billion carbon / year), the replacement of conventional fuels with non-conventional energy, the transition to electric railways and hybrid cars with improved soil management etc., worldwide CO_2 emissions will decrease in 2020 by 80%, below 2008 levels, and the concentration of CO_2 in the atmosphere will drop below 400 ppm allowing air to limit temperature increase and stabilizing the climate (op. cit.).

In Romania, according to ***the National Afforestation Programme arising*** from the ***National Sustainable Development Strategy***, it provides extension of woodland areas towards 2 million hectares in 2035, by which the forest could absorb through photosynthesis, 10-12 milions of tons of CO_2, thereby as a country, to reducing anthropogenic warming process.

It is therefore necessary, ***appropriate forest management***, in addition to afforestation, and ***other measures*** to implement (Giurgiu, 2010) ***such as reconstruction of deconstructed and cleared forests*** which now totals about 40% and will increase by 30-40 % of the potential of forests to capture CO_2 from the atmosphere and storing it in biomass and forest soils, forest belts extending in the southeast, to mitigate the adverse consequences of climate change, halting deforestation, increasing the resilience of forest ecosystems at different aggressive factors (storms, wind-blown trees, natural fires, various pathogens, insect attacks that reduce CO_2 storage potential of forests in the atmosphere); ban illegal logging, the use of wood as fuel and biomass for energy, proper silvicultural work, degraded land to maintain their CO_2 stored inside and not least, the continuation and deepening of basic scientific research on the impact of climate change on forest ecosystems and their adaptation to new climatic conditions and thus to limit the risk of global warming and feedback reaction to it.

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