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THE COMPARATIVE ANALYSIS OF THE CARBON STOCKING POTENTIAL BY THE EUROPEAN AGRICULTURAL AND FORESTRY SYSTEMS

TOMA CAMELIA¹

Abstract: *The goal of the present paper resides in the comparative analysis of the statistical FAOSTAT data and information in the last 25 years, for the EU countries and other European countries, completed with data and information from the well known literature and from webographics, referring to the multi-functionality, evolution, dynamics and importance of the potential of grasslands and forests as reservoirs of carbon absorption and stocking from the greenhouse gases, respectively atmosphere CO₂, and its stocking into organic carbon from the soil and from the live bio-mass of the forestry vegetation. In the paper, we made a short summary of the natural and artificial processes, biological, physical, and chemical ones, to which the researchers are working experimentally for the capture and stocking of the atmosphere carbon from the natural or anthropic emissions in agriculture, industry, transports or circular economy. Data and information utilized have evidenced that the cultivated land areas and some zones with peatlands are big transmitters of CO₂. At Europe Continent's level and by geographical regions, we can see that in the period 1995-2017/2018 there diminished the permanent grasslands and that only in the Scandinavian states and in the Russian Federation these ones increased their areas. In dynamics, the area of the European forests increased by almost 2%, but it could have increased by another 7%, if they had not been destroyed in fires, their highest share being produced in the Russian Federation (96%). Nevertheless, half of the live forest bio-mass quantity owned is to be found in the Russian Federation, which is champion by the area owned, being four times bigger than the rest of the European states. With all this, the carbon from the live forest bio-mass per area unit is the biggest in the forests in the West and East of the continent, the rest of the regions and the Russian Federation having a value of the indicator almost equal to average.*

Key words: *permanent grasslands, forests, CO₂ emissions, soil, live bio-mass*

JEL Classification: *O13, O52, Q23,, Q24, Q54, R11*

INTRODUCTION

In order to limit the global heating of the Planet to 1.5 Celsius degrees, considered a safe threshold from the point of view of the Intergovernmental Group for Climate Changes (IPPC/GISC), it is essential to reach to the neutrality of the carbon dioxide emissions up to 2050 year.

This objective is set also in the Agreement from Paris for the climate (COP21) in December 2015, which was signed by 195 countries, including by the EU.

United Nations Organisation launched at the COP25 meeting in Madrid a Framework Convention for Climate Changes, within which, the European Council launched European Green Deal.

The agreement provides an "European climate law", a juridical framework to reach the objective of CO₂ emissions reduction and proposes itself to make Europe neutral from the climate point of view until 2050.

Article 4 from the Paris Agreement provides: "*...., the parts are proposing themselves to reach as soon as possible the global maximum value of greenhouse gas emissions And then take measures to rapidly reduce it according the best available scientific knowledge in order to obtain a balance between the anthropic emissions through sources and absorptions through absorbants of the greenhouse gases in the second half of this century*"²

European Green Deal or the European Ecological Pact has in view 7 action zones at the level of public policies to reach the neutrality of CO₂ until 2050 year:

-Biodiversity; Agriculture; Clean energy; Sustainable Mobility, Industry, Constructios; Polution elimination.

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² <https://www.europarl.europa.eu/news/ro/headlines/priorities/schimbarile-climatice/20200618STO81513>

MATERIAL AND METHOD

Neutrality of dioxide carbon emissions means net zero emissions, which means all greenhouse gases emissions at world level will have to be counterbalanced through sequestration of carbon dioxide.

The long term, absorbants are the soils of certain agricultural and forestry systems, the forests' biomass and the oceans. According to estimations these natural absorbants are sequestering between între 9.5 and 11 Gt CO₂ per year, while the global emissions in 2019 reached to 38 Gt.³

Up to the present, no absorbent- natural or artificial – is able to eliminate enough carbon dioxide in order to fight with the global heating. There were proposed different methods based on *biological*⁴, *physical*⁵ and *chemical processes*⁶.

Among the *biological natural and artificial processes* proposed to be newly created or improved and extended, we can enumerate: Peatlands and ameliorated moors; Afforestation of new areas; Urban silviculture; Restoration of the humid tropical zones; Agriculture, agriculture of carbon, bamboo agriculture; Stocking of the carbon at a bigger depth in the land; Fertilization with iron and/or urea of the oceans; Creation of farms to crop and process sea algae etc.

The physical processes reside in different methods experimented to capture by the biomass of the carbon dioxide from thermo-centrals; deposit of carbon dioxide in oceans by injecting liquified gases at high pressures on the bottom of oceans or in place of oil field, and salt depleted, with a stocking capacity estimated from 675 up to 10000 Gt CO₂.

The chemical processes reside in the mineral carbonation, chemical methods, new technologies in the cement industry and of other construction materials, which could produce materials with absorbtion of CO₂ qualities; utilization of chemical substances cleaning the air while chemical reactions etc.

The financial costs and energy consumptions for the implementation at global level are until present real obstacles, the projects remaining for the moment in the phase of laboratory or punctual experimental at low scale.

Nevertheless, the danger of global heating over the limits admitted is determining the states, governments, and science people in the whole world to search and experiment new solutions, such that the future gives us hopes, that at least the emissions produced by the anthropic activities diminish themselves, if natural processes cannot be stopped at Planet level.

The goal of the present paper resides in the comparative analysis of statistical FAOSTAT data and information in the last 25 years, for the states of European continent, completed with data and information from the well known literature and from webography, referring to the importance and potential of the grasslands and forests as reservoirs for absorbing and stocking of the carbon from the greenhouse gases, respectively CO₂ atmosphere and organic carbon in the soil.

RESULTS AND DISCUSSIONS

As we mentioned above, one of the main absorbants of CO₂ is the **soil**.

”Two thirds of the terestrial carbon is averagely to be found, in the first 10-20 cm depth from the surface of the soil (soil and roots), being a much more protected part agains decomposition (it is estimated 1500 Gt of C organic world widde).

The C reserve situated under the soil in the forests, permanent grasslands and other eco-systems in the mountain zones remains almost intact, as much as the eco-system does not suffer transformations.

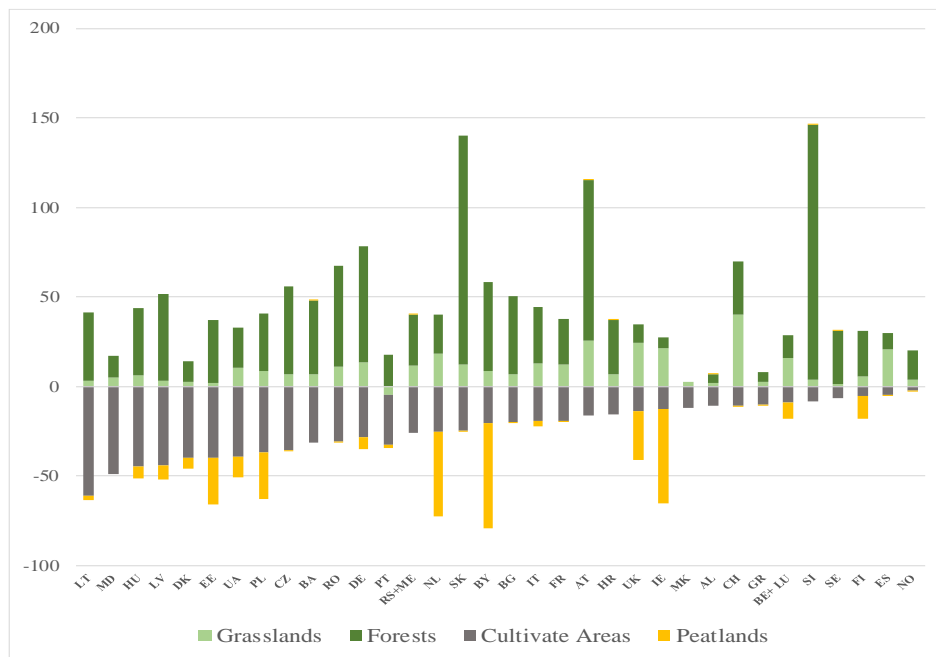
³ Neier, H et all, 2018, ”International Climat Negotiations – Issues at stake in view of the COP 24 UN Climate Change Conference in Katowice and beyond”, study requested by the ENVI committee.

⁴ https://ro.qaz.wiki/wiki/Carbon_sequestration

⁵ ibidem

⁶ ibidem

There are big differences between the arable soils, the soils of the grasslands and those of the forestry areas, as regards their capacity to deposit the carbon. (Figure1)



Source : Lanssens et al., 2005, cited by Huyghe, C., et al, 2014, author's processings

Figure 1. Structure of cumulative carbon balances specific for each European country, by the sequestering sources (+) /loss (-) (g. C/sq.m /year in the soil)

In case of grasslands there are: permanent covering; zones with roots containing big quantities of nitrogen and organic carbon; a longer period of growing and photosynthesis; bigger water retention; possibility of grazers presence (more emissions of different greenhouse gases); more organic substance (roots) etc.

The arable lands cropped are recognised by their specific character: plants cropped annually; crops rotations and perturbing the soil's life; mechanical and manual works of the soil; acceleration of the process of soil compaction by the heavy machines within the conventional technological works; the smoothing of the fertilizers, mainly the nitrogen and potassium; erosion produced by water and wind.

Permanent grasslands. On area of pastures and hayfields, the first 10 centimeters depth from the underground level are important for the levels of organic Carbon. When there are made works on the soils of the grasslands for their turning into arable soils, in the first years after conversion it is lost almost half of the C reserve. Transformation of an arable soil into grassland, needs more than 50 years to come back to the same level of the organic Carbon content from a permanent grassland. Different researchers demonstrated clearly that the first 10 cm from the underground of a grassland contains a percentage almost double of C in comparison with the arable soil." (Carlier, L., et al, 2009)

In the last century, in many European regions, the grassland management have suffered important modifications, through giving up to the traditional model from the previous centuries.

The authors of a paper (Huyghe, C. et al, 2014) bring to attention the fact that intensification of the grasslands utilization through the high supply of chemical fertilizers, the frequent defforestations, the seeding of grasslands or their conversion into arable lands lead to major changes in West of Europe, and at present, they are a real concern for the new states Members from the East of Europe, which are not willing to repeat the past errors of those in the West.

Together with the intensification and/or abandonment of grasslands, reduction of the area threatens all aspects of European biodiversity: the genetic diversity, landscapes, and especially, the functions afferent to the eco-system.

Grasslands are offering many functions to the eco-system of which many are linked to the soil ecosystem and to the role which they have in balancing the greenhouse gases and the reduction of soil erosion and pollution. (Table 1)

Table 1. Multi-functionality of grasslands

Type of grassland	Practices	Biodiversity	Effect upon the landscape	Water quality	Prevention of soil erosion	Carbon sequestration	Yield quality
Annual fodders	1	*	*	*	*	*	*
	2	*	*	**	*/**	*	*
Temporary grassland	3	*	**	*/**	**	**	**
	4	*/**	**	***	***	**	***
Permanent grasslands	3	**	***	**	**	***	**
	4	***	***	***	***	***	***
Grasslands with ecological value	5	*/***	****	***	***	****	****

Note : 1 = Corn without crop rotation; 2 = corn with crop rotation ; 3 = intensive management; 4 = rational fertilization; 5 = wet or dry pastures; * small impact; **** big impact.

Source: Sarzeaud et al., 2008, French Livestock Institute (2007), cited by Huyghe et al., 2014

Also, natural and semi-natural grasslands are supplying services to the eco-system, as well as goods and benefits, as:

- they supply fodder products for animal raise; they are stocking water and recharge aquifers with edible water, having a purifying role through retaining pollutants; it results clean water, fresh air and clean soil;

- from cultural point of view, they offer to the eco-system: parameters of environment and are agricultural and archeological patrimony, distinctive species and habitats, grazing for rare animal species and regulate the genetic diversity of the plants;

- offer much ecological knowledge and instruction zones, the society benefits of physical and psychological health, social cohesion, leisure and tourism, biological research basis etc.;

- ecosystem benefits by the climate regulation through GES sequestration and stocking of organic carbon in soil, avoiding climate perturbation.

In the last 25 years, at the level of the European continent (without Russian Federation⁷), we can observe a reduction of the areas with permanent grasslands by 10.5 mill. Ha, (12%)., reduction of which, half was produced in the South region, and the other half is divided between West and East regions, equally.

The South Region has lost over one fifth of the own areas with grasslands (5.8 mill. Ha), which led to a huge loss (22%) of the stock of organic carbon in the soil, accumulated in the 23 years. Only in the states of the North region it was produced an increase by 4% of the grasslands' area and an increase of the Carbon retained in the soil by 3%.

Also, the regions in the East and West of Europe were affected, beside the cumulated loss of area (24%) of grasslands, but also a diminution by 23% of the total organic carbon stock in the soil.

One of the most important causes of affecting the European pastures it seems to be the drought which appears most frequent lately, with more and more hot years and the South states are

⁷ The statistical analysis in table 2 and in figure 1 was made without including Russian Federation and some very small states as area, only from size considerations of extreme data, which distort the graphic representation.

confronted, except drought also with the presence of the arid and calcareous soils etc. In the drought years, in some states, the balance is viceversa, such as, pastures can become transmitters of greenhouse effect gases(GEG). (Table 2)

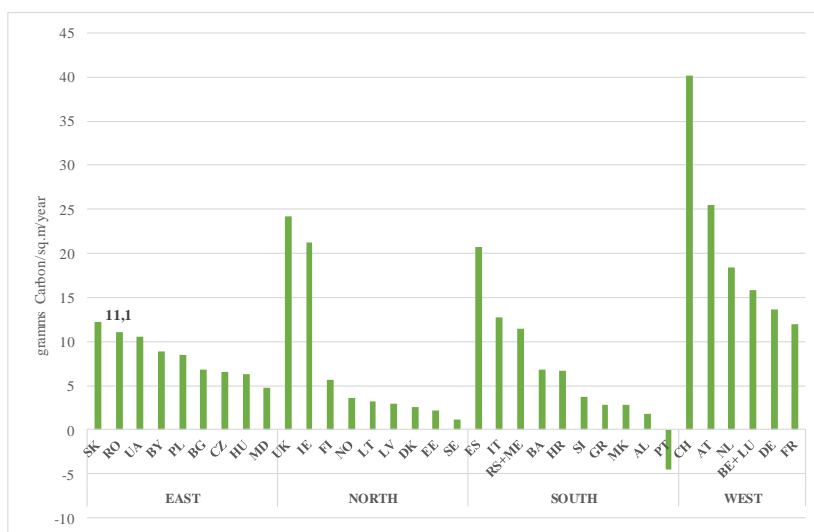
Table 2. Evolution of permanent grasslands area and the balance (stock) of Carbon in the period 1995-2017, in Europe and by geographical regions

Regions of Europe	Permanent grasslands Mill. Ha		Permanent grasslands	Emissions – absorbtions equiv.CO2	Permanent grasslands	Carbon stock, equiv.CO2
	1995	2017	2017/1995* 100-100 (%)	2017/1995 *100 -100 (%)	2017-1995 mil. ha	2017-1995 mii. tone
North	17.3	17.9	4	Abs +3	0.7	Abs+123
West	20.3	17.9	-12	-12	-2.5	Abs-340
East	24.6	21.7	-12	-11	-2.9	Abs-261
South	27.4	21.7	-21	-22	-5.8	Abs-744
Total Europe*)	89.7	79.2	-12	-10	-10.5	Abs-1253
Russian Fed.	87.0	92.0	2.6	Emis. +0.2	5.0	Emis. + 0.63
TOTAL Europe	176.7	171.2	-3.1		-5.5	Abs. -1252

*) Witout Russian Federation

Source: FAOSTAT, 2019, author’s processings

Following the studies made by the researchers in the field (Huyghe, C., 2014), the quantity of organic carbon stocked in the soil (COS), calculated in grams/year per square meter of grasslands in different European country, puts into evidence a very big variability infunction of: latitude and altitude, temperatures and rainfalls, types of soil, composition of live vegetal bio-mass, systems of maintenance and exploitation etc. (Figure 2)



Source : Lanssens et al., 2005, citat de Huyghe, C., et all, 2014, author’s processings

Figure 2. Balance of Carbon (absorbtions – emissions) specific for each European country, grouped by geographical regions (g C/sq.m/year of pastures)

The biggest quantities of carbon stocked in the soil (COS) were determined by the pastures in Switzerland (40 g), Austria (25 g), United Kingdom (24 g), Ireland and Spain each with 21 g, Netherlands, Belgium and Luxembourg (16-18 g), Germany, Italy, Slovakia and France (12-13 g), Serbia, Montenegro, Romania and Ukraine (11 g) and the other states under 10 grams. Only Portugal had a loss of COS of 4.5 g/sq.m/year.

Directing principles of the Eu strategy for forests and forestry sector are the following:

- sustainable administration of forests and their multifunctional role, which could permit the supply of many goods and services in a balanced manner and to guarantee the forests’ protection;

- efficient utilization of resources, in view of optimizing the contribution of the forests and forestry sector to the sustainable development, to the creation and multiplication of jobs;
- responsibility towards forests at world level in order to promote the sustainable production and consumption of forestry products.

Science people are saying that the re-forestation and a better administration of the forests can ensure 18% of the reduction in the climate changes until 2030. But studies can be divided.

”While the young forests are tending to absorb more carbon in general, as the density of the young trees is higher, the absorption rate of carbon of a tree is accelerating as it gets older. This means that the forests made of high trees and old- as tropical and temperate forests on the Coast of Pacific in North America- are some of the biggest carbon deposits of the Planet.

But when the forests are exploited, their huge carbon deposits are wasted rapidly.

Researchers are asking the exploitation and processing industry for wood to help the climate changes by doubling the age of harvest of the trees from 40 to 80 years old and tell the governmental agencies which are administrating forests to impose their own restrictions at harvesting.”⁸

In the last 25 years, in Europe (without Russian Federation) the area of forest lands increased by 11.7 mill. ha (6.2%). (Table 3)

Table 13. Evolution of forestry land areas and the balance (stock) of Carbon in the period 1995-2017, in Europe and by geographical regions

Regions of Europe	Forestry land areas Mill. Ha		Forestry land areas	(Emissions – bsorbptions) echiv.CO2	Forestry land areas	Stock of Carbon, equiv.CO2
	1995	2017	2017/1995* 100-100 (%)	2017/1995 * 100 -100 (%)	2017-1995 mill. ha	2017-1995 mill. To.
North	73.8	75.2	1.9	-35.4	1.4	Abs.-41,1
West	32.3	34.8	7.8	30.3	2.5	Abs.+34,4
East	42.8	45.7	6.7	-23.1	2.9	Abs.-40,5
South	40.2	45.1	12.1	-23.6	4.9	Abs.-28,2
Total Europe without Russian F.	189.1	200.8	6.2	-14.4	11.7	Abs.-75,4
Russian Federation	809.1	815.3	0.8	abs +273	6.2	Abs.+93
Total Europe	998.2	1016.1	1.8		17.9	
Forest fires cumulated 95-2017					76.1	
d.c. Russian Fed.					73.0	
Europe- Russian Fed.					0.90	

Source: FAOSTAT 2020, author’s calculations

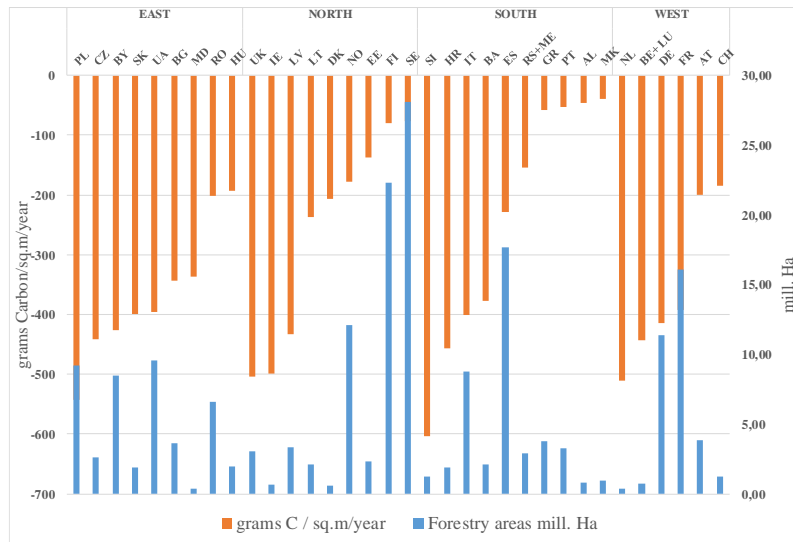
But, the total quantity of carbon stocked, existent in the year 2017, was with over 75 mill. tones equiv.CO2 smaller, representing in dynamics a decrease by 14.4% towards the year 1995.

By geographical regions, it is to be remarked the West region with an increase of the Carbon stock by 34.4 mill. tones equiv.CO₂, but in the regions North and East, stocks were smaller by 40 mill. tones of carbon opposed to the year 1995.

Analysing the FAOSTAT data regarding the areas with forests destroyed in fires, cumulated in 23 years, we can see that the present area with forests should have been by 7% bigger, (76.1 mill. ha). The greatest loss of forestry area was registered in the Russian Federation (96%), and 4% were forests destroyed by fires in the rest of the Continent.

Analysing the quality of the forestry soils through the content stocked by carbon/sq.m /year, we can observe, also, very big variabilities. (Figure 3)

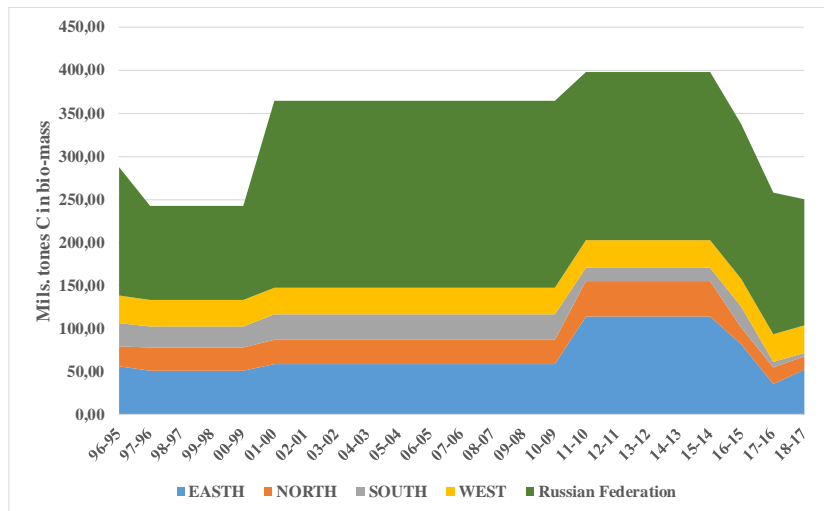
⁸https://news.mongabay.com/2019/05/tall-and-old-or-dense-and-young-which-kind-of-forest-is-better-for-the-climate/?fbclid=IwAR2kSt7liwpVlShTcPw_TnSz4Ozky5ZvFacesI9-j3B9YL_br0_8ruxWrU4



Source : Lanssens et al., 2005, cited by Huyghe, C., et al, 2014, author's processings

Figure3. Area of forestry land owned by the states of Europe and balance (stock)of emissions-absorbtions by grams C/ sq.m/year, grouped by geographical zones of the Continent

It is observed that, the states with the biggest forestry areas in Europe, after the Russian Federation, are Sweden and Finland, scandinavian states which compensate absorbtion of CO2 emissions, not through the sequesteres content in the soil (70-80 g C/sq.m /year), but through the size of owned forestry lands, of 28 and respectively 22 mill. ha.



Source: FAOSTAT, 2020, author's processings

Figure 4. Evolution of annual increase in carbon- sequestered in European forestry live bio-mass in the period 1995-2018, gouped by geographical zones and in Russian Federation

Evolution of the annual increase of C stocked in live bio-mass (1 t C = 1 m³ of wood) followed the same trend in all regions of the continent, but with different shares. (Figure 4)

From the data processed and analysed, in the year 1995, on Europe Continent, the quantity of Carbon in live forestry biomass was estimated at 46,3 billion of tones, to which were added in the last 23 years, 7.7 billion tones of Carbon. From these, 54% were stocked by the forests of the Russian Federation, the area of which is 4 times bigger than the forests of the rest of Europe, followed by the regions in the East by 20%, the North and West, by 9% and region South by 7%.

The average density of carbon in forestry live mass at 1000 hectares of European forest increased in the period 1995-2018 from 46 to 53 thousand tones C, the forests in the East and West of Europe being on first place in 2018 year, each with 93 thousand tones C/1000 ha, and the other

regions, North, South and Russian Federation situating themselves close to the European average, respectively, 49, 54 and 50 thousand tones C/1000 ha.

CONCLUSIONS

In the analysed period (1995-2017/2018), we can observe that at the level of the European Continent, the biggest reservoirs of carbon, forests and permanent grasslands, have a distribution, intensity and capacity for absorption of Carbon in the soil and in live biomass very varied, in function of latitude and altitude, temperatures and rainfalls, types of soil, composition of the live vegetal biomass, systems of maintenance and exploitation etc.

The areas with grasslands have suffered important diminutions, mainly in the states in the South, East and West of Europe, because of the years more frequently with severe droughts, as well as other anthropic causes (abandonment, conversion, overexploitation, soil erosion, etc.), but it was compensated with an increase of the area enlargement with over 50% in Russian Federation and in the states in Northern Europe, which benefited of better climate conditions.

The forestry areas have known an increase dynamics towards 1995 by 2 % at the level of whole continent, but have registered cumulate losses because of fires (7%), which, in case they had not occurred, could have increased forestry areas by 9 %. The growth potential has also been diminished due to intensive exploitation of wood, diseases and pests and drying of trees due to frequent pedological droughts.

From the point of view of the carbon content in live biomass per area unit, the forests in the East and West of Europe are situated on first place, and the rest of regions, inclusively the Russian Federation, are registering values of the indicator close to the Continent's average .

Let us hope, that the new "European law of the climate", within the "European Green Deal" will impose to the member states a legal framework to be respected for the reaching of the objective of reducing the CO₂ emissions and that it will reach the target to make Europe neutral from the climate point of view until 2050.

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