A STATISTICAL ANALYSIS OF DISTRIBUTION AND EVOLUTION OF FOREST POTENTIAL IN ROMANIA, BETWEEN 1990-2010, ESPECIALLY FOR SUCEAVA COUNTY

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Abstract

Romanian forest covers 6.37 millions ha (about a quarter of the country area). From this, 6.23 millions ha are covered by forests, representing 26.7% of the country area. In the early years, forests used to cover 80% of the country, but the need for practicing agriculture or other economic interests consistently reduced the area, decreasing the ratio below European average of 33%. Forest management has become even more unbalanced because of the economic interests which were promoted instead of a rational management, leaving aside biodiversity's conservation.
Catastrophic floods that swept the whole country have shown how seriously the ability of hydrological and anti-erosion protection of our forest has been reduced. The major threatens for the forests are the uncontrolled cuttings for timber and the appropriation of former owners. This phenomena will increase if no measures are taken. The forests play an ecological part, so that 50% of Romanian forests are classified into categories of water, soil and climate protection. So, the way forests are managed significantly affects environment's quality.
The choice of statistical data is motivated by the fact that deforestation is one of the main risk factors favoring the occurrence of climatic and geo-morphological risk phenomena.
The goal of this paper is the achievement of a complete statistical analysis of the forests in our country, with general applicability for all Romanian counties and particularly for Suceava county. To avoid "distortion" of analysis and representation, Bucharest was not taken into account.

Key words: Romanian forest, risk phenomena, forest management, statistical analysis, residual maps

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In the first part of the paper, we determined the basic statistical indicators. Then, in the second part of the paper, we concentrated on the correlation establishment between the forest potential on three different years, at a statistically significant distance, i.e. ten years (1990, 2000 and 2010). For a better view of statistical distributions we chose the graphical representation, using histograms and maps. We first analyzed the comparison between forest values by counties, for the years 1990 and 2010. We find that, during this 20 years period, there are no significant changes on forest distribution in Romania. It also noted that the counties with highest forest value are Suceava and Caras-Severin, while the largest deforested areas are located in Calarasi and Braila counties.

MATERIAL AND METHOD

Based on the data on forest area distributed by county, we initially set the number of classes, but also relative and cumulative frequencies for each of these years, 1990, 2000 and 2010. Table 1 presents the frequency classes with their relative frequencies. The number of frequency classes was calculated using the Huntsberger formula:

$$k = 1+3.332*\log(n) \quad (1),$$

where k represents the number of classes and n, that here has the value 41, represents the number of counties.

As it can be seen from the table, the number of classes is almost identical for each year. Exceptions are the classes [75-150] and [150-225] from the year 2000. This shows a constant for both deforestation and forestation in the country. The next step was the computing and graphical representation of relative and cumulative frequencies for each of the three years, in order to develop the histograms that give the relative frequency curves. These allow us to locate the concentration and dispersion area of distribution and also their discontinuities.

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Table 1

The classes for t he years 1990, 2000 and 2010

Year 1990		Year 2000		Year 2010	
Class	The effective of the class	Class	The effective of the class	Class	The effective of the class
0-75	12	0-75	12	0-75	12
75-150	8	75-150	8	75-150	8
150-225	11	150-225	11	150-225	11
225-300	7	225-300	7	225-300	7
300-375	1	300-375	1	300-375	1
375-450	2	375-450	2	375-450	2

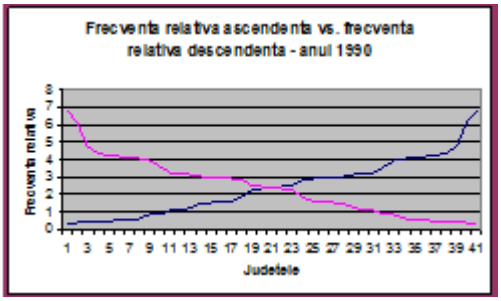


Figure 1a **Ascendant relative frequency vs. Descendant relative frequency - 1990**

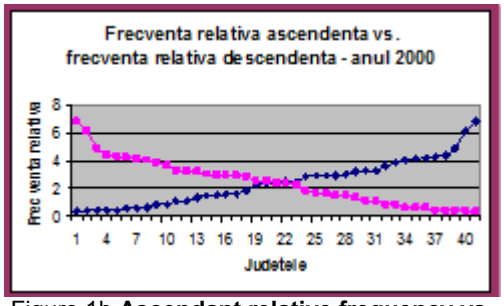


Figure 1b **Ascendant relative frequency vs. Descendant relative frequency - 2000**

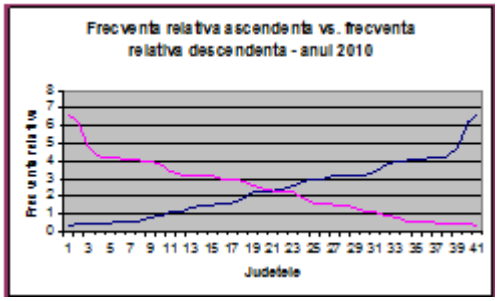


Figure 1c **Ascendant relative frequency vs. Descendant relative frequency - 2010**

Since we worked with three sets of data, corresponding for the years 1990, 2000 and 2010, the representation of three different graphs was necessary, as it shown below (*fig. 1 a, b, c*).

In the next stage we calculated the central values and the dispersion parameters for the three considered years. We first made the calculations for all counties and then we concentrated only on Suceava. The computing of the mean values was required to determine the central tendency in the evolution of the forest and also to determine deviations from the mean. The tables below show the basic statistical indicators for these three years which were taken into account:

Table 2

Central values for the three years considered

Central measure	Year 1990	Year 2000	Year 2010
Mean	155.3902439	155.2707317	158.3780488
Median	152,8	152,4	149,5
Mode	-	-	-

Table 3

Dispersion parameters for the three years considered

Dispersion parameters	Year 1990	Year 2000	Year 2010
Minimum value	21.3	21.3	22
Maximum value	436.1	434.8	435.3
Amplitude	414.8	413.5	413.3
Variance	10753.1104	10730.79812	11055.37726
Standard deviation	103.6972054	103.5895657	105.1445541
Quartile 1	68.6	68	72.5
Quartile 2	152.8	152.4	149.5
Quartile 3	208.3	208	219.4
Interquartilic dist.	139.7	140	146.9

Table 4

The central values and dispersion parameters for Suceava county

Mean	435.2476
Median	435.2
Mode	435,3
Minimum value	434.8
Maximum value	436.1
Amplitude	1.3
Standard deviation	0.326526
Quartile 1	435
Quartile 2	435.2
Quartile 3	435.3
Interquartilic distance	0.3

RESULTS AND DISCUSSIONS

The determination of the central values and variance parameters was done after we put the data in ascending order. We noticed that Calarasi county has the smallest area covered by forest, a trend maintained throughout the period, pointing out a very slight increase in the year 2010, at a value of 22000 hectares.

Regarding the mean of the entire area for these three years, there is an increase trend for the year 2010. The median is very close to the mean value, so that the data are normally distributed, i.e. their distribution is Gaussian (most values are very close to the mean value).

The standard deviation is high for each of these three years which is normal considering the fact that the observed values for each of the 41 counties are not closed to each other: e.g. there are counties where forest areas are between 20000-50000 hectares (Călăraşi, Brăila, Ialomiţa, Ilfov, Teleorman, Galaţi, Constanţa, Giurgiu) and also there are counties where forest area covers 300000 hectares (Hunedoara, Caraş-Severin şi Suceava). Thus, for these counties that have large deviations from the mean, the *z* score is also high. So:

- for Calarasi: -1.293094095;
- for Braila: -1.265128057;
- for Ialomita: -1.249698518;
- for Suceava: 2.707013705.

Figure 2 (*a* and *b*) represent the maps for standard deviations for the years 1990 and 2000. These maps ware realized in PhilCarto program:

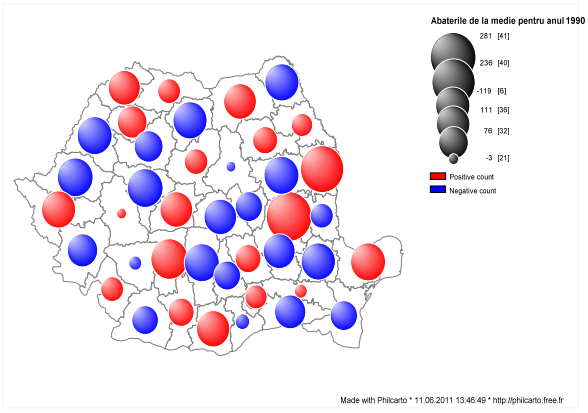
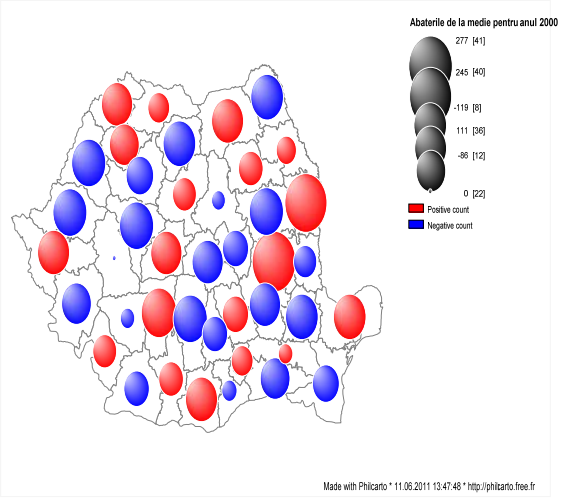


Figure 2a **The standard deviations for the year 1990**

Suceava county has an important forest potential, with an average forest area of 435.2476 hectares. There was a decrease in the year 2000 compared to the year 1990, following the disastrous effects resulting from deforestation. In recent years, forest area has a slight expansion, registering a standard deviation of 0.052381.



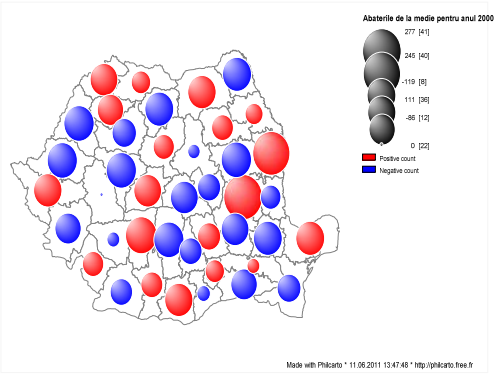


Figure 2b **The standard deviations for the year 2000**

This variation is graphically represented in the figure 3:

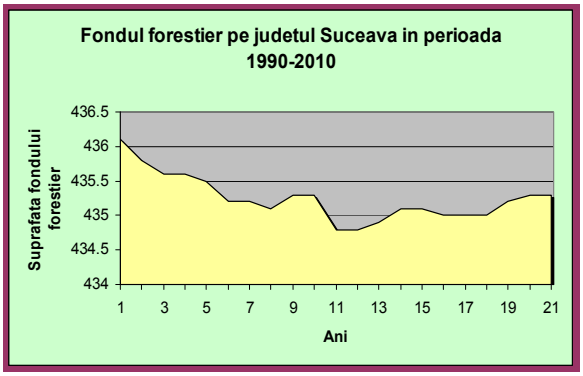


Figure 3 **The distribution of forest for Suceava county between the years 1990-2010**

To see the interdependence between the values of these three distributions of data, we made three correlations: between total areas covered with forest in 1990 and 2000, 2000 and 2010, 1990 and 2010.

As we expected, the random variables, two by two, represented by these three years take into account, are almost perfectly positively correlated, i.e. the correlation result, *r*, is very close to 1 in all of these three cases. The Figures 4 (*a* and *b*) demonstrates this:

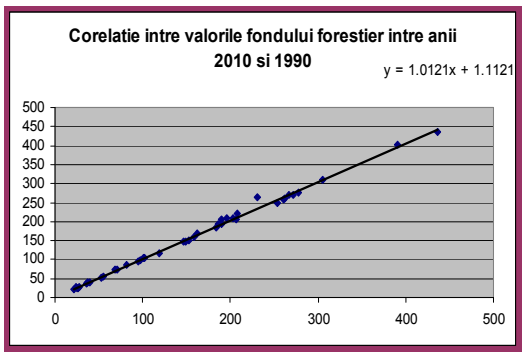


Figure 4.a The regression line for correlation between the years 1990 and 2010

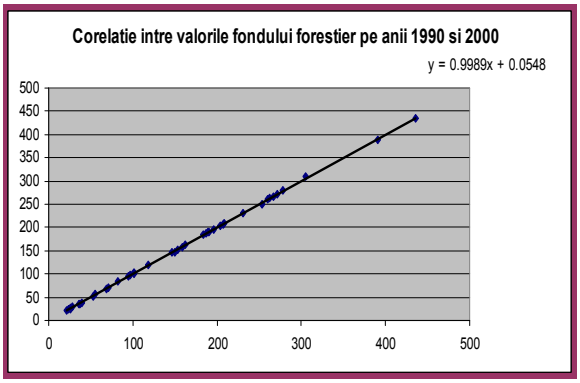


Figure 4.b The regression line for correlation between the years 1990 and 2000

In the table below we presented the values of r coefficients (the empirical correlation coefficient) and r^2 (the determination coefficient) as well as the slope and the intercept of regression line. These four values are the most important correlation and regression factors:

Table 5

The values of regression coefficients

Years/Values	r coeff	r^2 coeff	slope	intercept
1990 -2000	0.999916378	0.998832763	0.998878446	0.054766371
2000 -2010	0.998139317	0.996443249	1.013204374	1.05706492
1990 -2010	0.998739317	0.996282097	1.012070798	1.112120568

So, for these three cases we got the following results:

- 99.98% of forest area values for the year 2000 are influenced by the forest area values for the year 1990;
- 99.64% of forest area values for the year 2010 are influenced by the forest area values for the year 2000;
- 99.62% of forest area values for the year 2010 are influenced by the forest area values for the year 1990.

From the figure 4 (a, b) we can see that the points are very close to the regression line, proving the correlation strength. The relationships for regression lines are as they follow:

- for the years 1990 and 2000: $y = 0.9989x + 0.0548$;
- for the years 2000 and 2010: $y = 1.0132x + 1.0571$;
- for the years 1990 and 2010: $y = 1.0121x + 1.1121$.

The residuals maps are presented below:

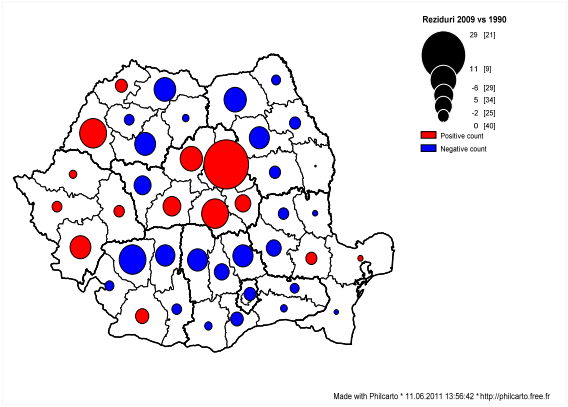


Figure 5a **The residuals map for the years 1990 and 2010**

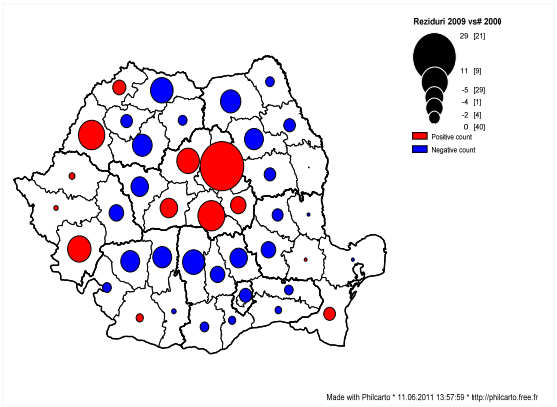


Figure 5b **The residuals for the years 2000 and 2010**

CONCLUSIONS

In this paper we've made a complete statistical analysis, for three representative years, 1990, 2000 and 2010, of our country's forest potential, a problem that become more serious, because of intensive deforestation in the last 20 years. This was the main reason for choosing these data, and following the analysis it can be drawn some conclusions: there is an increase of forest potential for the year 2010 compared to the period of 2000's, a period when the deforestation took a peak value; the correlation between the values of forest potential, taken two by two, is, as we expected, very strong, denoting a limitation regarding the deforestation; the correlation between the years 1990 and 2010 is lower than the other two correlations; this highlights a significant forestation process for some counties as well as an increasing deforestation process for others.

The use of statistics for geographical problems is very important in order to track and visualize numerous geographical factors that underlie a natural balance. The main goal of using these correlations is to highlight some links or differences between various parameters or to show how much a geographical factor is influenced by others factors.

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