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Forest areas from Forestry Administration County Suceava that contain certain values that are of critical conservation priority in the forest certification process

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Abstract: Established on the FSC Principles and Criteria in 1999, the concept of High Conservation Value Forests (HCVF) has provided a useful new approach for defining and managing forest areas of critical conservation significance. This concept is flexible enough to be applied in a variety of contexts not only in the forest certification. As a result it has been applied in a range of settings, and has been used outside forest certification as well as within it.

The FSC standard contains 10 conservation principles, related by several areas. Principle 9 (which is related of the HCVF identification) asks the forest manager to take a wider view, and to consider conservation issues as a high priority or significance on a national, regional or global scale.

In the assessment process of HCVF from Forestry Administration County (FAC) Suceava, there was find an area of 18,543.63 ha with forest areas with high conservation values, which represent 8% of the total area with HCVF identified at national level. From this surface area, the highest percent is represented by forest areas from protected areas (31%), forests with critical seasonal use (23%) and of forests that are critical for erosion control (20%).

In all 24 forest districts (FD) were identified HCVF, the highest percent of the total area with HCVF from FAC Suceava, being in FD Crucea (16%), Dorna Cândreni and Stulpicani (12%).

After the identification of the HCVF, there must be a decision making process that determines what form of management will be consistent with maintaining or enhancing of these values.

It must be noted that the FSC standard does not require that an area of forest classified as HCVF becomes a protected area. In some cases, it may be possible to achieve commercial use of the forest while maintaining the value. Only forest areas from protected areas (National or natural parks, natural reserves, etc) will be completely protected.

Keywords: assessment, criteria, conservation values, forest areas.

1. Introduction

In the last years Romania has implemented the EU Birds and Habitat Directive (NATURA 2000), therefore, an important percent of the country's forests are under some form of protection. Thus in Romania are13 national parks, 14 nature parks and 382 protected areas (Ioja et al., 2010). Most of Romania's protected areas and all of national and nature parks are managed by the National Forest Administration (NFA) Romsilva (Abrudan et al., 2009).

Now, in the context of the Forestry certification, the areas managed by National Forest Administration Romsilva, containing environmental and social values, such as unique biodiversity, watershed protection, soil stabilization or an archaeological site will become High Conservation Value Forests (Jennings et al., 2003; Rouget et al., 2006; Schnooret al., 2010) .

The concept of High Conservation Value (HCV) was used first in 1998, when the Forest Stewardship Council (FSC) adopted it to define forest areas of outstanding and critical importance whose attributes should be maintained or enhanced (FSC 1996; Jennings et al., 2003; Blackman et al., 2011; Brown et al., 2013;). In this context, High Conservation Value Forests (HCVF) are evaluated by a process that identify them using a particular set of values (Stewart et al., 2008; Tollefsonet al., 2008; FSC 2012;):

- **HCV1- Species diversity**. Concentrations of biological diversity including endemic species, and rare, threatened orendangered species, that are significant at global, regional or national levels;

- **HCV2- Landscape-level ecosystems and mosaics**. Large landscapelevel ecosystems and ecosystem mosaics that aresignificant at global, regional or national levels, and contain viable populations of great majority of the naturally occurring species in natural patterns of distribution and abundance;

- **HCV3 - Ecosystems and habitats**. Rare, threatened, or endangered ecosystems, habitats or refugia

- **HCV4 - Critical ecosystem services**. Basic ecosystem services in critical situations, including protection of water catchments and control of erosion of vulnerable soils and slopes;

- **HCV5 - Community needs**. Sites and resources fundamental for satisfying the basic necessities of local communities (for livelihoods, health, nutrition, water, etc.);

- **HCV6 - Cultural values.** Sites, resources, habitats and landscapes of global or national cultural, archaeological or historical significance, and/or of critical cultural, ecological, economic or religious/sacred importance for the traditional cultures of local communities.

The use of the HCVF concept is an important step towards better forest management and protection and complements other tools for forest conservation such as forest certification and the designation of protected areas (Van Kootenet al., 2004; Rietbergen-McCrackeret al., 2007;Kujiket al., 2009; McCormicket al., 2009; Pena-Claros et al., 2009).

This process can be considered as complementary to political planning processes such as Natura 2000 and it is very useful for NFA Romsilva and for private forest owners too, to manage forests to sustain and enhance the environmental services.

The aim of this article is to identify the HCVFs of the Forest Administration County Suceava to make a better forestry management and to maintain and to enhance the values of critical importance.

2. Materials and methods

The study was conducted in the Forestry Administration County (FAC) Suceava, on the range of 24 Forest Districts (FD), managed of National Forest Administration Romsilva, respectively: Adâncata, Breaza, Brodina, Broșteni, Cârlibaba, Crucea, Dolhasca, Dorna, Falcău, Fălticeni, Frasin, Gura Humor, Iacobeni, Marginea, Mălini, Moldovița, Pătrăuți, Pojorâta, Putna, Râșca, Solca, Stulpicani, Vama and VatraDornei.

Suceava County covers an area of 8,553.5 km^2, representing 3.6% of the country area. It is located in the north-eastern part of Romania, between Pietrosul Călimani (2.022 m altitude) and the Siret river bed (233 m). In a landscape dominated by central and north-eastern European bioclimatic elements, which creates a unique landscape harmony, on the geographical coordinates 24˚57‘‘-26˚40‘‘ east longitude and 47 ˚4‘‘55”-47˚57‘‘31” north longitude, with an amphitheatric settlement.

The main forms of relief are hills, slopes and plains. Overall, the county has two major units of relief: the mountain region - 65.4% mountains with heights between 800 and 2.100 m and the plateau region - 34.6% sub-Carpathian plateau and hills.

The heights decrease gradually from west to east, highlighting thus the leveling and diversification of the other components of the natural environment.

The geographical space of Suceava County falls almost equally within the continental climate sector (in the eastern side), having a continental - moderate climate (in the western side) with cool winters and fairly warm summers with precipitation all year round.

For the HCVF identification was used „The High Conservation Value Forests Toolkit” (Jennings et al. 2003), based on a methodology that has 4 steps:

- 1. Establish a team with forest engineers, scientists, communities and NGOs at a regional level;

- 2.The identification of the most important critical values from the forest and the place they are located;

- 3. Development the best management measures for the identified HCVFs in order to maintain or enhance the identified value;

- 4. Monitoring the identified HCVF to see if the management measures are properly applied.

The benefits of the HCVF identification consist: in better and more accepted forest planning decisions; management decisions based on a precautionary principle; effective use of local knowledge; better understanding by all stakeholders on the range of forest values and the costs and benefits of protecting them; reduction of the conflict between competing aims of resource use (Vogt et al., 2000; Nusbaum and Simula, 2005; Bartley, 2007; Auld et al., 2008; Fujita, 2010).

3. Results

In the 24 FD from FAC Suceava was identified an area of 18,543.63 ha with HCVF,

representing 8% from the total area with HCVF

(228,636.58 ha) from the national forest fund managed by NFA Romsilva.

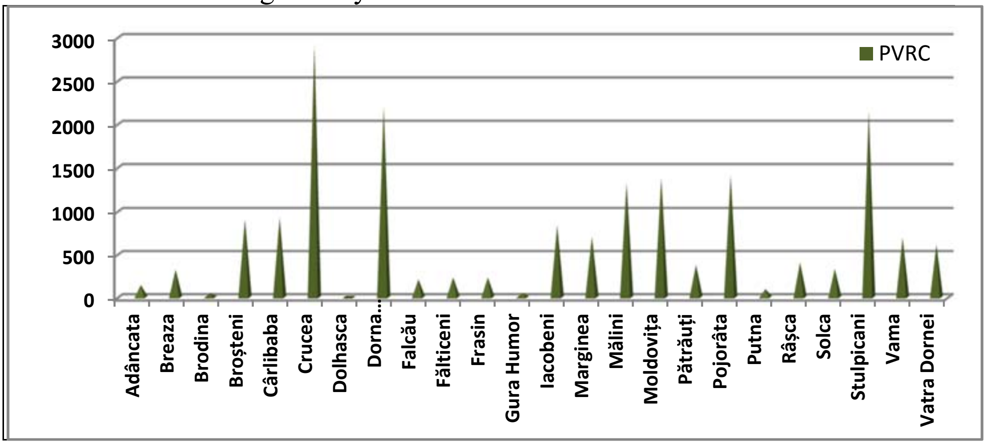


Fig. 1.The 24 FD from FAC Suceava with High Conservation Value Forests

In all the 24 FD assessed, were identified HCVF, three of them with the greatest area, respectively FD Crucea representing 16%, Dorna Cândreni and Stulpicani representing 12% of the total area with HCVF from FAC Suceava (Fig. 1).

It have been identified 8 categories of HCVF (Fig. 2) such as: 31% HCV 1.1. - Forest areas from protected areas; 24% HCV 1.3. - Forest areas with critical seasonal use; 20% HCVF 4.2- Forest areas for erosion control; 12% HCVF 4.1.-Forest areas for watershed protection; 6% HCVF 3 - Forest areas that are in or contain rare, threatened or endangered ecosystems; 5% HCVF 6 - Forest areas critical to local communities' traditional cultural identity; 2% HCVF 4.3 - Forest area with critical impact on agriculture and air quality and 0,22% HCVF 1.2. - Habitats for rare, threatened or endemic plant species.

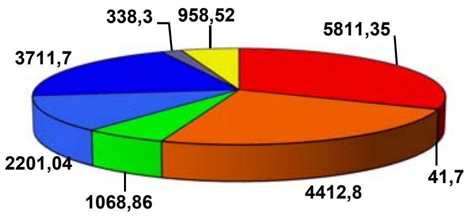
The distribution of HCVF is represented on the Suceava map (Fig. 3) where it can be seen that all the Forest districts have on their area between two and five HCVF. The most categories of HCVF are in FD Crucea, Stulpicani, Broșteni and Marginea (5 categories).

4. Discussion

4.1. HCV 1.1. - Forest areas from protected areas

The protected areas provide important habitat for native species that are under pressure. All of these, together with national, nature parks and nature reserves will give to native species the best chance of survival in the face of threats and of habitat loss (Myers, 2000; Oszlanyi, 2004; Strimbu, 2005).

In FAC Suceava, from the total area with HCVF 1.1., 34% are in FD Dorna Cândreni and 19% in FD Stulpicani, the rest of FD have much smaller forest areas from protected areas (Fig. 4).



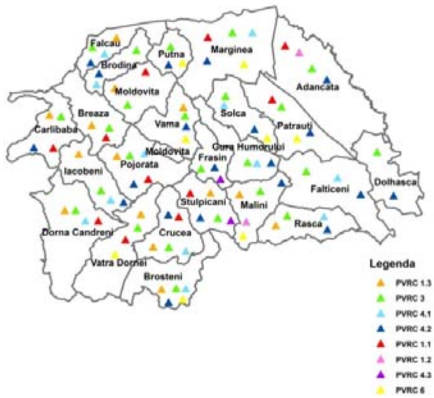


Fig. 2 and 3 The categories of High Conservation value Forests

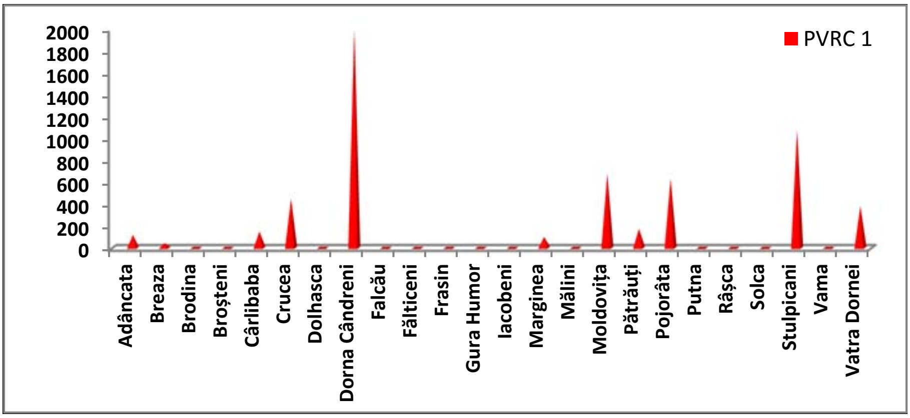


Fig. 4. Forest areas from protected areas

In FD Dorna Cândreni- 61% of forest area from protected areas are represented by national park Călimani. In this region there is a significant concentration of flora and fauna species protected by national law and EU Directives. The percentage of habitats of European interest exceeds 95%. According to the Handbook of habitats there are 13 habitats, including 4 of special importance (Habitats Directive), 18 species of birds, 9 species of mammals, 2 species of reptiles, 5 species of fish (including *Hucho hucho*), 6 species of invertebrates (including *Rosalia alpina*) and 8 species of plants are of community interest;

- 35% are represented by Poiana Stampei Bog, representative for Dorna Basin and hosts most species of oligotrophic peat, here is a compact population of *Sphagnum wulfenianum*, very rare in Romania;

- 4% the protected area Cucureasa.

In FD Stulpicani – HCVF 1.1.are represented 100% by a secular forest – Slătioara and Todirescu meadows. Here is a variety of plant species from different biogeographic regions, the herbaceous species diversity creates a special polychromy. Here, we find species such as*: Pulsatilla patens, Echium russicum, Dictamnus albus, Adonis vernalis, Trolius europaeus*, etc.

4.2. HCVF 1.2. - Habitats for rare, threatened or endemic plant species

One of the most important aspects of biodiversity value is the presence of threatened, endangered or endemic species. Forests that contain populations of threatened, endangered or endemic species are clearly more important for maintaining biodiversity values than those that do not, because these species are more vulnerable to continue habitat loss (Nussbaum, R., M. Simula. 2005; Newton, A.C. 2008).

The presence of the species requires designation of HCV 1.2 only if the concentration of the species is large enough to justify specific management measures.

In FAC Suceava only in two forest districts (Fig. 5) were identified significant concentrations of species like in Adâncata, approximately 16 ha (38% from the total area with HCVF 1.2.) with *Fritillaria meleagris* and in FD Mălini 26 ha (68% from the total area with HCVF 1.2.) with *Taxus baccata.*

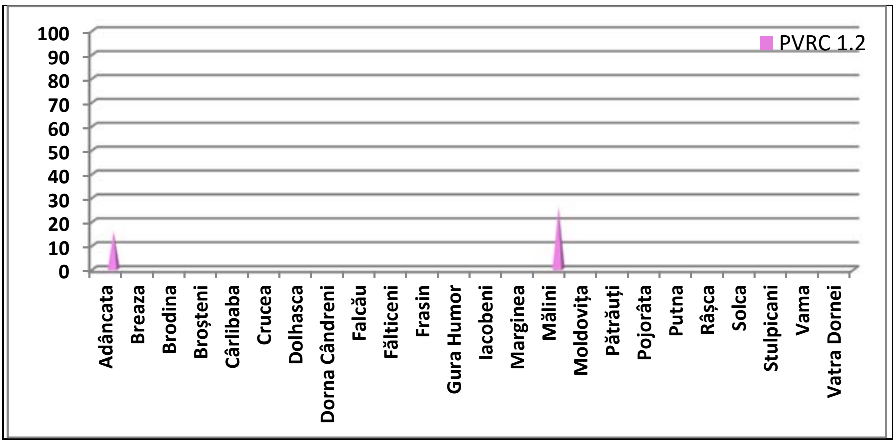


Fig. 5. Habitats for rare, threatened or endemic plant species

4.3. HCV 1.3. - Forest areas with critical seasonal use

This element is designed to ensure the maintenance of important concentrations of species that use the forest only at certain times or at certain phases of their life cycle. It includes critical breeding sites, wintering sites, migration sites, migration routes or corridors.

The species mentioned in the national and international legislation ratified in Romania which, at different stages of their development cycle, depending on the complex forest ecosystemwere identified in fourteen FD (Fig. 6), three of them having important forest surfaces with HCVF 1.3. such as Moldovița (15%), Iacobeni and Pojorâta (both with 14%). Here were identified large concentrations with Capercaillie (*Tetrao urogallus*) and bears (*Ursus arctos*) den. An important thing is that much of the areas with critical seasonal useare included in protected areas and in national and nature parks and have become HCVF 1.1.

4.4. HCVF 3 - Forest areas that are in or contain rare, threatened or endangered ecosystems

This category of HCVF was identified in all of the 24 forest districts (Fig. 7), two of them having the largest surfaces, respectively FD Crucea 21% and FD Marginea 14%.

In both forest districts, the forest habitats of community interest with the largest area are 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Pandion, Alnion incanae, Salicio albe*). These forest habitats are riparian forests of *Alnus incana* of montane and sub-montane rivers occurring on heavy soils (rich in alluvial deposits) periodically inundated by the annual rise of the river level, otherwise well-drained and aerated during low-water (Lazăr et al 2007). The herbaceous layer includes many large species (*Filipendula ulmaria, Cardamine* spp. *Carex* spp., etc) and various vernal geophytes (*Ranunculus ficaria, Anemone nemorosa, Corydalis solida*, etc).This type of 91E0 forest habitats, occur in all the 24 forest districts assessed. Another type of forest habitat of community interest that is very wide spread across the FAC Suceava is 91D0 Bog woodland, respectively coniferous forests on a humid to wet peat substrate, with the water level permanently high.

Even if protected areas cover a sufficient area, unfortunately the protected areas statute does not always mean implementation of adequate measures for the protection of rare forest ecosystems. Some of forestry ecosystems are naturally rare and the aim of this HCV 3 is to provide protection for these type of threatened or endangered ecosystems.

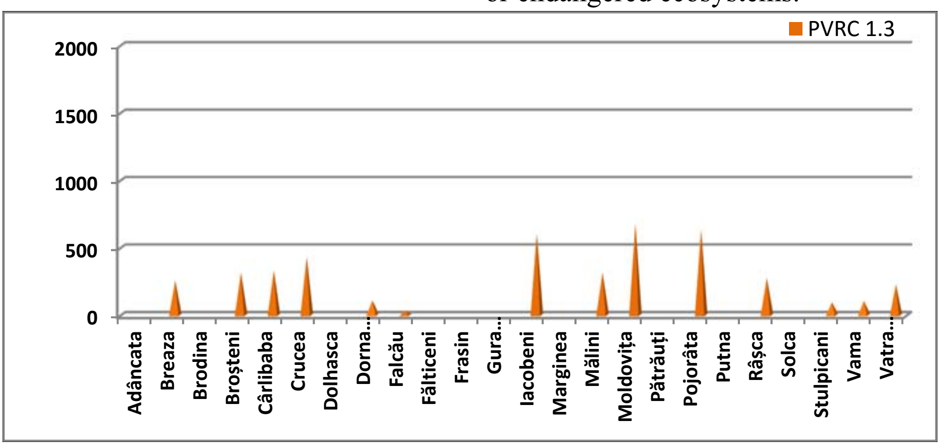


Fig. 6. Forest areas with critical seasonal use

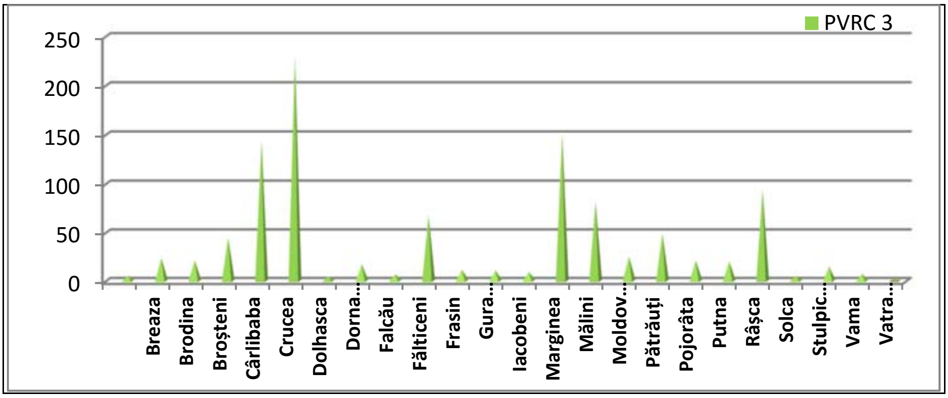


Fig. 7.Forest areas that are in or contain rare, threatened or endangered ecosystems

4.5. HCVF 4.1.- Forest areas for watershed protection

The forests area substantial factor for maintaining the terrain stability and have an important role in preventing flooding, controlling stream flow regulation and water quality. Where the forest covers large areas from the water catchments, it has a critical role in maintaining the quantity and quality of the water.

Forest areas for watershed protection were identified in twelve forest districts from FAC Suceava, the most of them being for river protection. In FD Crucea with the largest area (44% HCVF 4.1.) (Fig. 8) the forest areas are for Bistrița river protection.

In some of forest districts, the HCVF 4.1.are for protection of the mineral water springs such as in FD Broșteni and Dorna Candreni.

4.6. HCVF 4.2- Forest areas for erosion control

When the risks of severe erosion, landslides and avalanches are extremely high and the consequences, in terms of loss of productive land, damage to ecosystems, property or loss of human life, are potentially catastrophic, it can be considered that the ecosystem service provided by the forest is critical, and it should be designated HCVF 4.2.

This category of HCVF was identified in 20 forest districts (Fig. 9), 23% of the total area with HCVF 4.2 are in FD Crucea and 17% are in FD Stulpicani.

In all these forest districts, the HCVF 4.2. is a risk of serious erosion, because there is a slope with more than 35 degrees and the terrain instability might include damage to ecosystems.

4.7. HCVF 4.3 - Forest area with critical impact on agriculture and air quality

Where forest areas are close to agricultural lands, their impact can sometimes be crucial for maintaining the resources or economic production. The forests impact will vary according to the climate and topography, spatial configuration of the agricultural land and the forest, as well as the crops types.

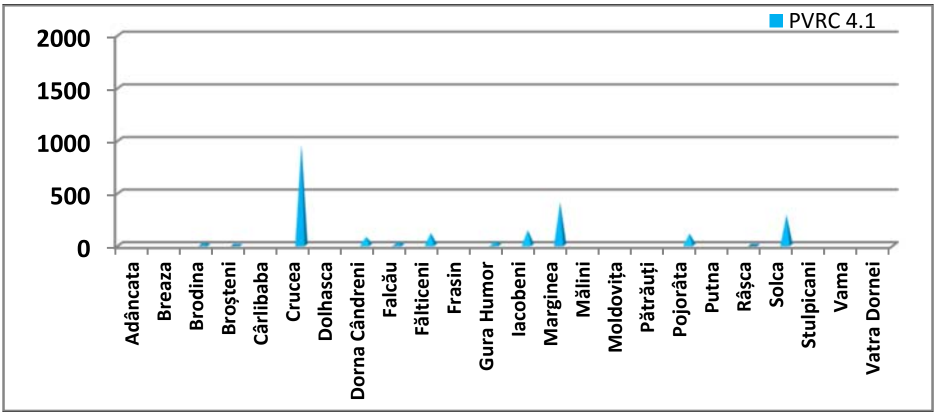


Fig. 8. Forest areas for watershed protection

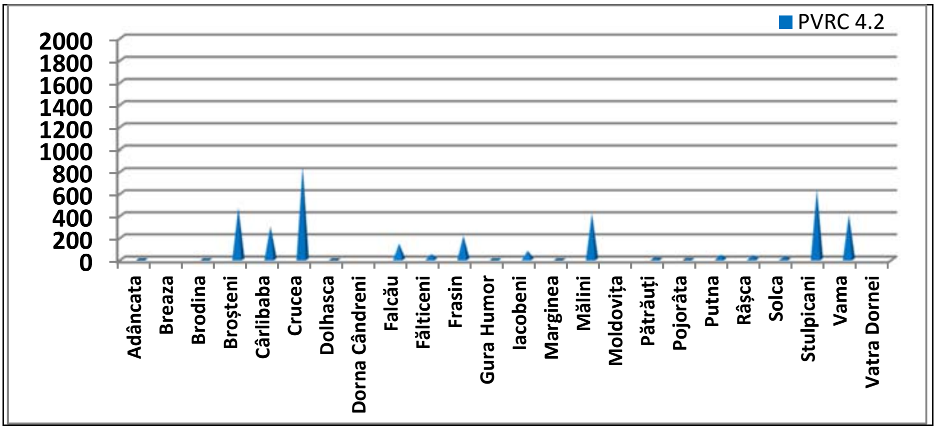


Fig.9. Forest areas for erosion control

The crucial importance of the HCVF 4.3.and ameliorative influence includes stabilization of environment, the development of optimum regime for isolation of vehicles, accumulation of toxic substances, noise insulation.

In FAC Suceava, there were identified small areas with HCVF 4.3 (Fig. 10) only in two forest districts, both of them being against air pollution. In FD Stulpicani 333 ha in FMU V Tarnița and 5.3 ha in FD Frasin around the tailing deposits from FMU IV Belțag.

4.8. HCVF 6 - Forest areas critical to local communities' traditional cultural identity

This type of forests includes sacred or religious sites, specific areas that have been historical sites, specific areas with remnants from the past linked to the identity of the group, frequent used of forest products/materials for artistic, traditional, and social status purposes, names for landscape features, stories about the forest, historical associations, etc.

51% of the HCVF 6 from FAC Suceava are in FD Mălini (Fig. 11), representing forests of religious sites, respectively forests around the Slatina monastery. In the rest of 7 forest districts there were identified forests from cultural sites (Ion Creangă) and forest around the monasteries, such as Sucevița, Moldovița and Putna.

The difference between having some significance to cultural identity and being critical will often be a difficult line to draw, therefore it will simply be possible to decide this in consultation with the communities in question.

Various types of information will be required to determine whether a forest is critical to the traditional cultural identity of local communities. This would normally include: Indicators of potential cultural significance, stories about the forest, historical associations and how long the community has been associated with a particular forest. This is very important, because a change to a forest can potentially cause an irreversible change to traditional local culture or a particular forest provides a cultural value that is unique or irreplaceable of a forest.

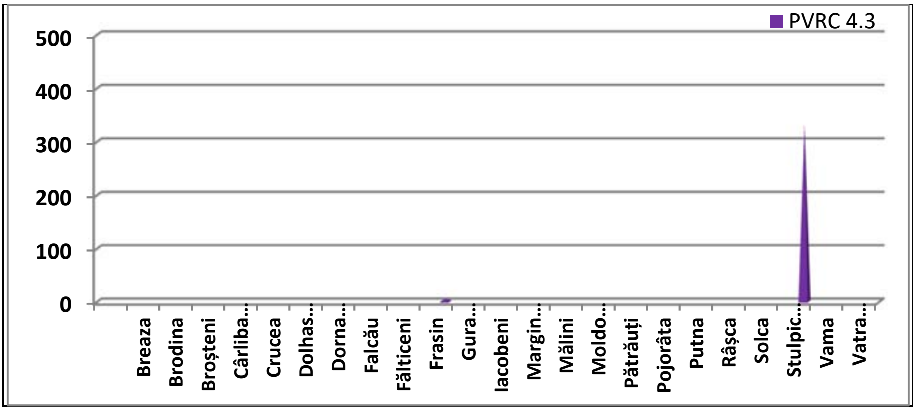


Fig.10. Forest area with critical impact on agriculture and air quality

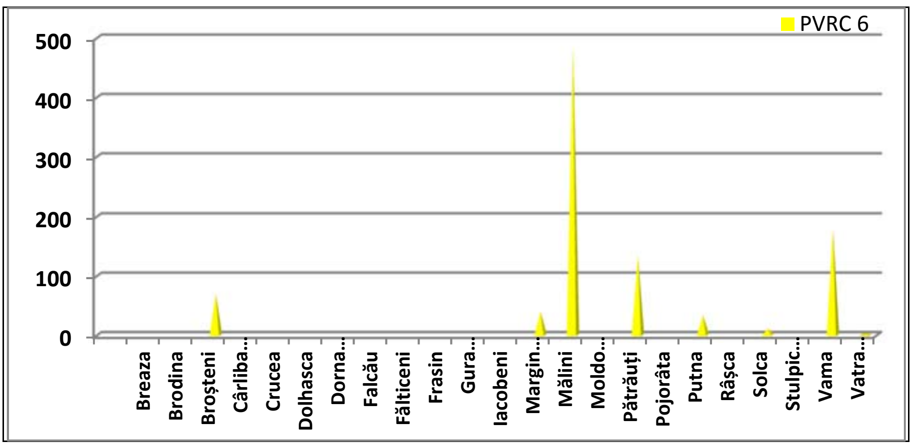


Fig. 11. Forest areas critical to local communities' traditional cultural identity

5. Conclusion

FSC requires that forest managers should identify HCVs within their forest districts (FDs), respectively management units (FMUs), to manage these to maintain or enhance the values identified, and to monitor conservation impacts. Appropriate HCV management within natural forests can range from complete protection to extractive uses such as selective logging or harvesting of natural products (Stewart, 2010).

It requires public consultations and a precautionary approach to manage HCV areas.

The HCV concept has been adopted beyond its original context of forest certification.

The HCV approach may also become a significant driver for land-use planning and for plantation design (McCormick et al. 2009).

By providing a common language for industry, conservationists, communities and financiers, this approach needs to be much better understood by managers, practitioners and auditors.

Conservation scientists need to engage with the implementation of the HCV requirements and to adopt this concept for non-forest ecosystems such as grasslands and wetlands.

By identifying and managing the HCVF there are demonstrated conservation benefits of the HCV approach by existing direct and circumstantial evidence.

Acknowledgments

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Evaluation of normality in the determination of spatio-temporal autocorrelation of monthly precipitation in the central-west region of Venezuela

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Abstract: Venezuelan monthly precipitation data is geocoded, discontinuous in space and time. Missing data, summarized records, installation and removal of stations is common. Second order properties were evaluated (spatio-temporal autocorrelation), but data is not normally distributed, then a Box-Cox transformation was applied because it is known that non normal distributions tend to hide spatio-temporal autocorrelation. Intensity of spatio-temporal autocorrelation was estimated using Moran's I and its cluster variant LISA. Both with their spatio-temporal version. Cluster analysis allowed to characterize precipitation stations using k-means with five groups of monthly precipitation (low, low-medium, medium, medium-high and high). Results show an increase of the amount of clusters mapped and better representation of precipitation.

Keywords: spatial temporal autocorrelation, Box-Cox transformation, non-normality, Moran´s I, LISA, monthly data precipitation.

1. Introduction

Managing spatio-temporal data is a common task when dealing with climate variables, in some cases it is possible to obtain many observations at different times from numerous spatial locations. This type of data corresponds statistically with a structure of Pooled time series cross-section (time series with spatial cross section) (Gujarati and Potter, 2010), which is the structure shown in figure 1. This type of structure requires highly volumetric data for its processing (Androva and Boland, 2011). In order to perform the modelling, it is frequent that one of the two components (spatial, temporal, or both components) is discarded (Cressie and Winkle, 2011).

But, modern statistics is introducing the concept that *"Stochastic data does not originate from a random and independent process"* (Cocchi and Bruno, 2010). This idea is also present in Tobler´s First Law of Geography (1970), which establishes that *"Everything is related to everything else, but near things are more related than distant things"*.

From the univariate perspective, this refers to the fact that a variable can be correlated with itself, but in another position in space.

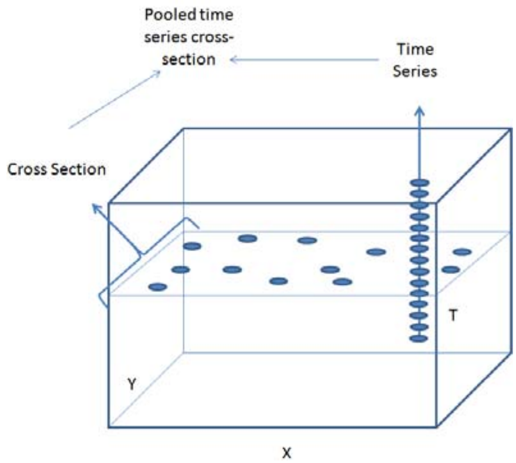

Figure 1. Structure of Pooled time series cross-section.

This will be called Spatial Autocorrelation. However, if we consider a spatio-temporal phenomenon, there may be Spatial Temporal Autocorrelation instead of Spatial Autocorrelation (Stojanova, 2012). Anselin (1988) defines three possible types of correlations: Spatial (contemporaneous correlation), Temporal (time-wise correlation) and Spatial Temporal Autocorrelation (space-time correlation).

Spatial Autocorrelation and Spatial Temporal Autocorrelation are designated as Second Order Properties (Lloyd, 2010), and may be presented as three types: Positive Autocorrelation (similar values cluster together in a map), Negative Autocorrelation (dissimilar values cluster together in a map) and Absence of Autocorrelation (Independence) (Figure 2). An important element to consider is the type of neighborhood (spatial and spatio temporal) of the variables. Celemin (2009), Lloyd (2010) and Toral (2001) define many types of contiguity, such as “Queen”; “Bishop” and “Rook” (Figure 3).

The use of indexes corresponds with Lattice techniques (spatial analysis of discrete data), and may be categorized into two kinds of index, as follows.

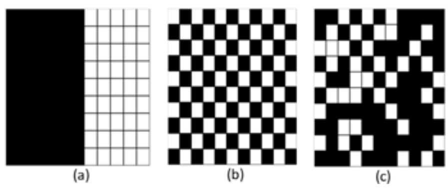

Figure 2. Positive Autocorrelation . b) Negative Autocorrelation. c) Absence of Autocorrelation (Independence).

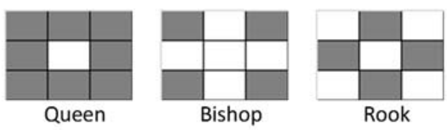

Figure 3. Three types of neighborhood.

Global Measures: Moran´s I which is a variation of Pearson´s Linear Correlation Coefficient (Moran, 1950) is described by several authors (Bosque, 1992; Cressie, 1993; Lloyd, 2010; Olaya, 2011; Toral, 2001).

$$I = \frac{N}{S_0}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{w_{ij}(x_i-\mu)(x_j-\mu)}{\sum_{i=1}^{N}(x_i-\mu)^2};$$

$$E(I) = \frac{-1}{N-1}$$

Where μ is the mean of the variable x, w_{ij} is the weigthed ponderation matrix, $E(I)$ is the expected value in the absence of Autocorrelation (Independence) and N is the number of observations.

Local Measures: are variations of global measures and they characterize Spatial Autocorrelation and Spatial Temporal Autocorrelation, such as the LISA test (Local Indicators of Spatial Association). In this case, each one of the observations can be assigned in one of 5 types of clusters: Positive Autocorrelation (H/H, High values surrounded by High values and L/L, Low values surrounded by Low values); Negative Autocorrelation (H/L, High values surrounded by Low values and L/H, Low values surrounded by High values); and Absence of Autocorrelation (A/A) (Anselin, 1995):

$$I_i = \frac{x_i-\mu}{S_i^2}\sum_{j=1, j\neq i}^{n} w_{i,j}(x_j-\mu);$$

$$S_i^2 = \frac{\sum_{j=1,j\neq i}^{n} w_{i,j}(x_j-\mu)^2}{n-1} - \mu$$

Because the observations have different spatial and temporal locations, a variant of Moran's I and LISA indicator, the Spatio Temporal Moran´s I (ESRI, 2013) was developed. Lattice techniques assume that the data have normal distribution $X \sim N(\mu, \sigma^2)$, if the data is non normal it can introduce bias in the statistical analysis (Bivand et al, 2008). Bianco (2013), Vilar, (2006) and Velilla (1991) suggest a transformation in the case of non-normal data. Among the many families of transformations, one that is most used is the Box-Cox transformation:

$$Z(\lambda) = \begin{cases} \frac{X^\lambda - 1}{\lambda} \text{si } \lambda \neq 0 \\ Log(X) \text{si } \lambda = 0 \end{cases}$$

The value of λ must be estimated, for that purpose, Log-Likehood Methods are used.

Venezuela is a Tropical country with maritime and continental extension. It is a country with different climates due to the Intertropical Convergence Zone and the orographic control. These conditions generate a seasonal rainfall that can be 10 times higher in one location as compared to another. Rainfall is unimodal at the center and east of the country and is bimodal at the north west of the country (with peaks in May – June and in September – November). In this study we focus towards the evaluation of the Spatial Temporal Autocorrelation of the monthly precipitation data that was obtained after a Box-Cox transformation.

2. Materials and methods

The information was obtained from 961 climatic stations of the monthly precipitation data from official institutions (Figure 4), with non-normal data. Rainfall has the characteristic of having only positive data and usually the probability density function is decreasing and monotone (Bidegain y Díaz, 2011; Moran, 1969). In order to avoid bias in the characterization of the Spatial Temporal Autocorrelation, a Box-Cox transformation was performed.

In order to characterize the second order properties (Spatial Temporal Autocorrelation), the following hypothesis was tested with the transformed data:

- H_0: Monthly precipitation does not have linear null Spatial Temporal Autocorrelation (Absence of Autocorrelation/Independence).
- H_1: Monthly precipitation has Spatial Temporal Autocorrelation that is different from linear null (it is different from Absence of Autocorrelation/Independence).

If the null hypothesis is rejected, then the Spatial Temporal Autocorrelation must be characterized as either positive or negative: if the estimated I>expected $E(I)$, then the Spatial Temporal Autocorrelation is positive; if the estimated I< expected $E(I)$, then the Spatial Temporal Autocorrelation is negative. The test for Moran´s I and the LISA test for Cluster categorization were performed with the following spatial temporal characteristics: Significance level of 5%, Standard Space-Time Window, Inverse distance relationship between the objects and absence of Threshold Distance, Temporal window of 24 months (Cryerand Chan, 2008 ; Gilgen, 2006 and Pruscha, 2013).

As mentioned above, with the LISA test, 5 types of cluster are obtained: H/H, L/L, H/L, L/H and A/A. Monthly precipitation is highly seasonal, and all the stations have a combination of the 5 types of clusters. Since Stations of high precipitation will have more clusters of the type H/H, Stations of low precipitation will have more clusters of the type L/L and Stations located at transition sites will have more clusters of the type A/A, an analysis of cluster dominance using the K-means test was performed.

The optimal number of categories was estimated using the “Elbow” method suggested by Matthew (2011) and developed by Ketchen and Shook (1996). Using the K-means test, each station, was characterized as High, Medium-High, Medium, Medium-Low and Low precipitation.

3. Results

The estimated value of λ to perform the Box-Cox transformation was 0.34. We found an improvement of the normal distribution with a skewness coefficient that approaches normality. Zero values create a distortion because they determine the physical barrier of the variable (Figure 5).

Moran´s I requires normality but not in a strict sense, it is affected mainly by high skewness or by an excess of outlier values.

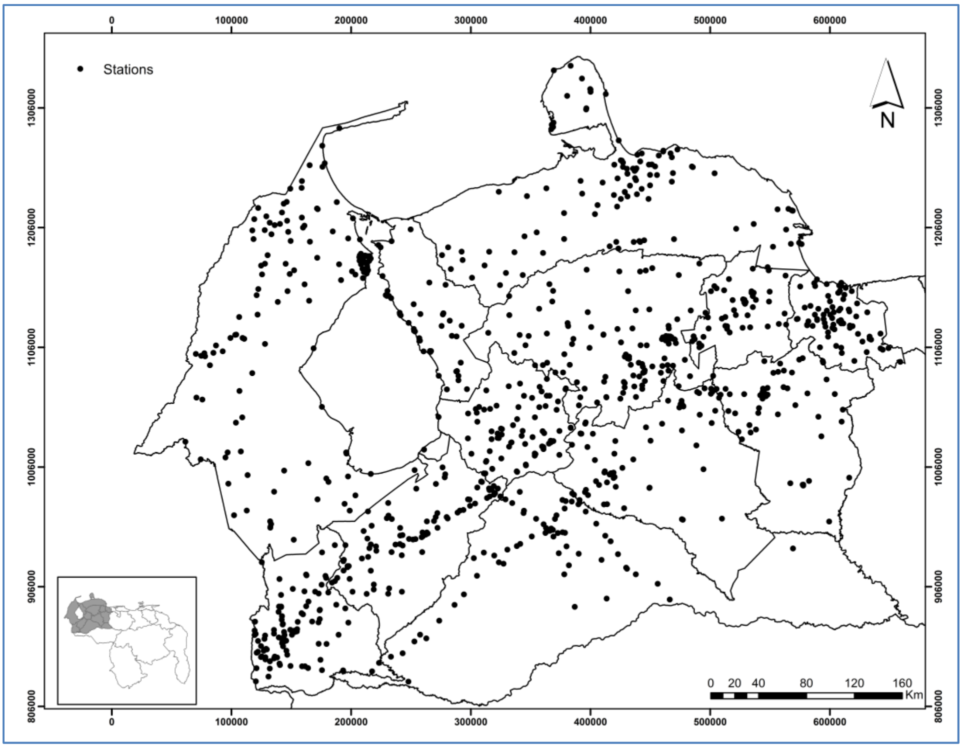

Figure 4. Stations selected.

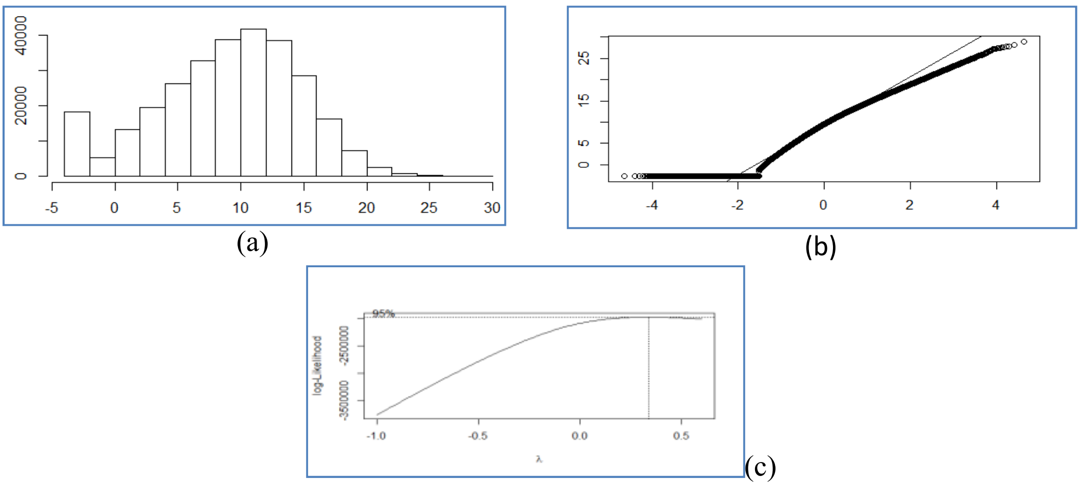

Figure 5. (a) Histogram of monthly precipitation, (b) Q–Q plot of monthly precipitation; (c) Log-Likehood for the estimation of λ in the Box-Cox transformation.

Zhang et al. (2008) reported that the number of clusters almost duplicates when the transformation is performed. In our case, we obtained a skewness of 1.63 for the data without transformation and a skewness of -0.30 with the Box-Cox transformation.

The results in Table 1 indicate that the null hypothesis is rejected and characterize the process as positive linear Spatial Temporal Autocorrelation. Because the transformation decreases the risk of bias, these results are closer to reality than those presented by Andrades and Lopez (2015) due to the fact that the Moran I requires that the distribution of the data be as symmetrical as possible. The magnitude of the Moran´s I statistic, is not comparable to the one previously obtained by Andrades and López (2015), in which the nature of the distribution is entirely different and the results are biased.

The vast majority of clusters obtained are typified as AA followed by LL and HH, characteristic of positive Spatial Temporal Autocorrelation. Less frequently we obtained, the negative Spatial Temporal Autocorrelation (HL and LH).

Table 1. Spatial Temporal Moran´s I of transformed monthly precipitation.

Parameter	Value
Moran´s I	0,196942
Expected I	-0,000003
Variance	0,000001
Z-Score	478,41
p-value	0

The dominance of the AA, HH and LL is expected since the Spatial Temporal Autocorrelation is positive. The dominance of AA indicates that the Moran's I is an index with low sensitivity to spatio-temporal changes (see Table 2). When comparing these results with the ones obtained by Andrades and Lopez (2015), we found that in the present work there is an increase in the number of clusters HH and LL. This may indicate that the transformation controlled the negative effect of skewness and revealed the occurrence of a greater number of clusters that had not been previously detected, increasing the number of clusters by 3.2%.

A method for choosing the appropriate cluster number is to compare the Sum of Squared Error (SSE) for a range of cluster solutions. SSE is defined as the sum of the squared distance between each member of a cluster and its cluster centroid, SSE can be seen as a global measure of error. As the number of groups increases, the SSE should decrease because pools are by definition, smaller.

Table 2. Number of clusters with Box-Cox transformation of monthly precipitation

Cluster	Frequency	Frequency excluding AA (%)
HH	12.8	41.3
LL	1.5	39.8
HL	1	11
LH	2.5	7.9
AA	71.2	--

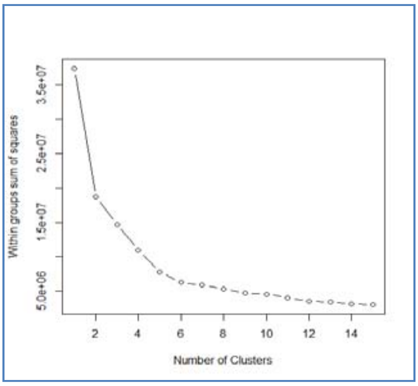

Figure 6. Variation of SSE with the Cluster number.

The appropriate number of clusters could be defined as the turning point where the slope is stabilized, this produces an "elbow" appearance, when plotted (Matthew, 2011).

For this case (see Figure 6) the appropriate number of clusters is 5 because this is the point of inflection of the curve. With the transformed data, 65 stations were categorized as Low precipitation (7%), 289 stations as Middle-Low precipitation (30%), 143 as Medium precipitation (15%), 357 as Medium-High precipitation (37%) and 107 stations as High precipitation (11%).

4. Discussion

Compared with the results of Andrades and Lopez (2015), in this work we obtained 17 less stations in the Low category, 10 more stations in the Medium-Low category, 17 more stations in the Medium category, 20 stations less in the Medium-High category and 11 more stations in the High category.

This difference is probably due to the use in this work of the Box-Cox transformation that controlled the asymmetric distribution of precipitation that otherwise distorted the allocation of clusters that were subject to transition phenomena and therefore underestimated their distribution into categories (see Figure 7).

Using the Box-Cox transformation ensures a more accurate representation of reality. The main problem with autocorrelation is that a model may look better than it actually is. Autocorrelation generates several consequences: 1) Estimators are linear and unbiased, but they are not the best, they are inefficient 2) the most serious consequence of the autocorrelation is that the $\hat{\boldsymbol{\beta}}_2$ estimator, has no minimum variance and therefore it is not efficient, and 3) the correlation coefficient R^2 is increased.

All of these problems result in hypothesis tests that become invalid (Gujarati and Potter, 2010; Bhattarai, 2010; Ramanathan, 2013). Therefore, the modeling techniques must take these conditions into account.

5. Conclusion

With the use of the Box-Cox transformation we found a more realistic and adequate characterization of the Spatial Temporal Autocorrelation, obtaining a greater number of clusters with the LISA Test, in comparison with the results of Andrades and López (2015). The present results prove the hypothesis of the existence of Spatial Temporal Autocorrelation within the monthly rainfall data. It is important to point out that there are alternative autocorrelation indexes, such as the Kelejian-Robinson index, that do not need normality nor linearity and therefore they do not require transformations.

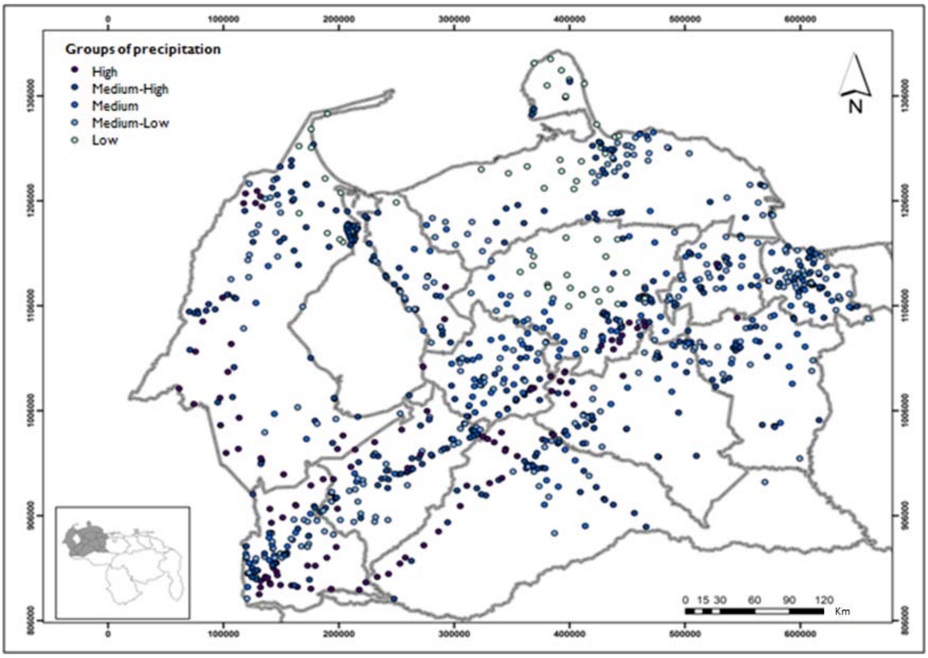

Figure 7. Categories of precipitation stations assigned by the cluster analysis of the K-means.

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Afforestation in Romania: Realities and Perspectives

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Abstract: Romania's forest cover is at this time below, but quite close to the European average. Despite that, recent forestry activities tend to be more oriented towards forest exploitation and not to increase the national forested area. The general public perception is that afforestation activities are limited only to NGO's projects and media actions and numerous reports and statements made by some of these organizations are rather sensational and confusing. This paper tries to cast more light on this controversial issue, presenting accurate data and considering the whole context of afforestation - from the history of afforestation activities in Romania to the recent statements and reports submitted by the government agencies involved in these particular issues. The necessity and opportunity of afforestation is also substantiated from the perspective of reintroduction into production of marginal and degraded land. An analysis of the situation of funding through the National Rural Development Programme (2007-2013) measures is performed and possible future directions regarding afforestation programmes are discussed.

Keywords: afforestation, degraded lands, forest regeneration, funding measures.

1. Introduction

Indisputable, the forest represents a vital global resource. Being a renewable resource it is continuously harvested for quite a considerably amount of time. It is unthinkable to imagine a world without forest because of the many implications of it in our everyday lives. Forest does not embody only a sum of trees, but a complex natural system highly interconnected with a lot of different environmental elements.

Today, we all know the whole benefit package that comes along with the existence of forest in our life. Forest can deliver a wide range of ecological services regarding biodiversity, soil protection, water quality, habitat providing, along with social and recreational services. The new environmental realities recognize the significant role of forests in mitigating climate change, as natural carbon sinks and as a source of renewable wood that can be used as fuel or raw material for different products. Considering these particular aspects, it is easy to understand why forest cover represents such an important indicator in many recent statistics and reports.

The distribution of forest resources is uneven, both at the level of states and continents. Today, the global forest cover is approximately 4 billion hectares, which means that almost one third of the terrestrial area is forested (FAO, 2010). But nearly 8000 years ago, the forest cover was double, according to World Resources Institute data. The development of agriculture and the construction of the modern human society lead to massively loss of forest cover. This phenomenon was concentrated excessively in the last two centuries and the recent trends are uncomforting (Palaghianu, 2009).

The global forest cover has been drastically decreasing annually by nearly 7 million hectares in the last two decades (see table 1). Today we are facing a rapid pace of deforestation and this tendency is likely to get worse considering the increasing trend of wood or wood products consumption (Palaghianu, 2007).

However, in recent years there is a growing interest for wood resources management and remarkable progress became visible considering the afforestation efforts. It's worth mentioning the positive example of Europe which extended its forested area with nearly 1 million hectares per year in the last two decades.

The importance of afforestation in balancing the forest resources is now generally accepted and every regional or national forest strategy includes an afforestation programme (Mather, 1993). The European Union is actively involved in the management of forest resources using the Common Agricultural Policy (CAP) and since 1992 EU is also engaged in afforestation initiatives (Council Regulation 2080/92). Beginning with the year 2000, the forestry sector was incorporated into the Rural Development Plan, according to the Council Regulation 1257/1999.

The UE aims to extend the forested areas and the funding mechanisms support two categories of forest initiatives: afforestation and other forestry measures.

2. A review of afforestation activities in Romania

Romania has consistent forest resources: about 6.5 million hectares and the forest cover is estimated at 27% of the country's total area (INS, 2013). However, Romania's forest cover is still below the European Union average which is currently estimated at 42% (EC, 2013).

It is known that Romanian forest cover was superior far back in the past and several well-known studies indicate that fact (Giurescu, 1975; Doniță et al., 1992).

Table 1. Forest cover of the world (according to FAO data, 2010)

Year	**1990**	**2000**	**2005**	**2010**
	million hectares			
Africa	749	709	691	674
Asia	576	570	584	593
Europe	989	998	1.001	1.005
North and Central America	708	705	705	705
Oceania	199	198	197	191
South America	946	904	882	864
Global	4.168	4.085	4.061	4.033

During the last two centuries, when the forest loss at global level was at the highest level, Romania lost nearly 2 million hectares of forest, but in the last century the forest cover remained almost unchanged, varying around 6.5 million hectares (see fig. 1).

Taking into account the historical and current loss of the forests, afforestation and reforestation represented a key element in the effort of preserving the forest resources. And such efforts were made from early time in Romania.

We could start with the first document of Grigore Ureche, the chronicler who mentioned the early ”*afforestation*” actions guided by Stephen the Great, voivode of Moldavia, after the battle of the Cosmin Forest (1497). More consistent information regarding not only the basic forest management but also afforestation was specified in the forest regulations from Transylvania (1775 and later in 1781). These first guidelines and procedures were quickly followed by similar forest protocols in Bukovina (1786), Moldavia and Wallachia (1792).

However, the earliest afforestation actions should be considered the mobile sand fixation and afforestation that were executed in Oltenia province in 1852 (Giurescu, 1975). Soon after that, in 1864 the first three forest nurseries were established, each of it having an area of 50 hectares (in Brăila, Iaşi and Ismail counties).

The promulgation of the first Forest Code in 1881 brought some consistent improvements in the forestry sector, and later, in 1889 a new national service was founded, a service that joined afforestation and torrents control.

This action demonstrates the early understanding of the role of afforestation in controlling torrents, landslides and erosion.

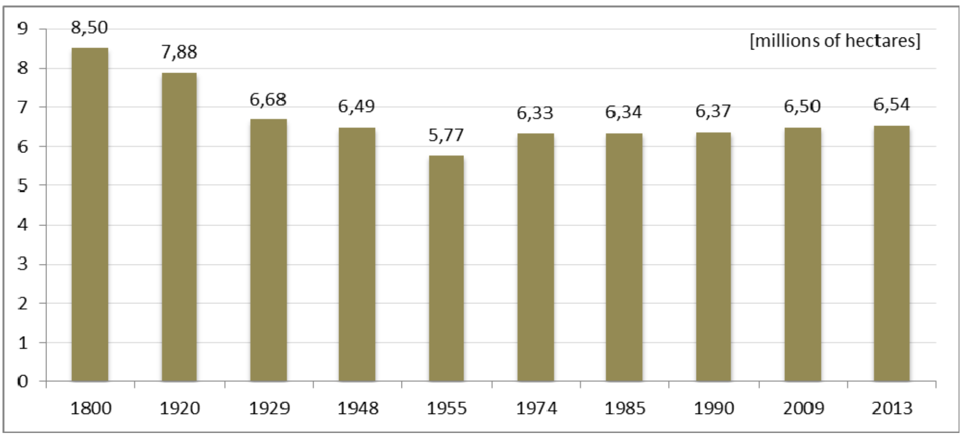

Figure 1. Changes of the forest cover in Romania during the last two centuries (unit: millions of hectares)

Specific tasks were undertaken in the effort of preventing and controlling the erosion of watershed in the following years and later at the beginning of the 20th century.

For instance, in a rather difficult period, between 1930 and 1947, 97.000 hectares of degraded land were afforested (Crăciunescu et al, 2014).

After the World War II, the Romanian forests were nationalized and the state took over the forest resource management. The WWII reparations paid to Soviet Union and the intense activity of the SOVROM, Soviet-Romanian enterprises, created to manage the debt recovery, have left deep scars in Romanian forests. In the 50's the forest condition was severely altered - more than 700 thousand hectares were deforested. Furthermore, an additional 600 thousand hectares were considered degraded lands. As a result, a massive afforestation national plan was developed for reforestation of 1 million hectares. This notable objective was finally achieved in 1963, after more than a decade of impressive afforestation efforts. The annual average of reforested land was around 70 thousand hectares, with a maximum of 98 400 hectares in 1953.

In the communist period, the forestry management was quite well balanced and manifested a particular interest in afforestation. In order to direct and control the field specialists there were edited Technical Guidelines in 1948, 1953, 1966, 1969, 1977 and 1987. The standards for seed quality assessment were updated in 1963, 1973, 1983 and the afforestation infrastructure was developed by creating numerous seed orchards, seed stands, seed processing facilities and large forest nurseries in order to boost the seedlings production.

3. Present state of afforestation in Romania and future trends

Today, the Romanian forest covers 6.5 million hectares (INS, 2013) but after 1990 the state was no longer the sole landowner and manager. Still, the state represents, with nearly 50% of the forest, the most important landowner and the legal state-owned entity, RNP - National Forestry Administration, represents the largest administrator of Romanian forest.

After 1990 the forestry sector suffered remarkable changes. The planning and control of the state were not so strict due to the change of the regime. Unfortunately, new obstacles appeared, considering the forest fragmentation and restitution. The infrastructure needed for afforestation was also damaged because forest nurseries and seed orchards were returned to former owners, who have neglected or destroyed it.

The new forestry paradigm was better focused on natural regeneration and the afforestation effort was abruptly reduced. Moreover, illegal logging and forest fragmentation have contributed to the negative general public perception on forestry.

Unfortunately common people consider many of the significant silvicultural activities to be unfamiliar and incomprehensible, because of an improper dissemination. Furthermore, quite few public statements clarify the available data and information, which are generally ignored by the public (Palaghianu & Nichiforel, 2016).

Although significant changes in forest cover were not found (Dutcă & Abrudan, 2010; MECC, 2010; INS, 2013), it is quite obvious that Romanian forests have suffered at least structural alterations in the past two decades.

This observation is emphasised by numerous media campaigns – some of them extremely persuasive and partially controversial. Greenpeace, WWF Romania or the local initiative "*Plantăm fapte bune în România*" were heavily involved in such environmental campaigns that pointed out to the recent loss of forests. It's worth mentioning the Russian Greenpeace report on Romanian forest (Greenpeace, 2012), which stated that 3 hectares of forest per hour are "*disappearing*". Numerous media entities have cited this report and its results and many associated this loss of forest with illegal logging, which in fact was not accurate. The public perception was easily altered by media pressure and by misunderstanding the difference between authorised clear-cutting needed in forest regeneration and illegal logging. In association with the increased wood logging and undersized afforestation plans (see figure 2) the general perception on Romanian forestry seems that it is more oriented to logging, whatever these actions are legit or not.

However, what is the reality, beyond the media slogans or persuaded perceptions? Although, the TBFRA-2000 report (TBFRA, 2000) presented a positive average annual change of forest of 14.7 thousand hectares between 1955 and 1990, this was not a constant trend. After 1990 the rhythm of afforestation was clearly diminished. The reports on the first decade after 1990 (Georgescu & Daia, 2002), indicated an annual average of nearly 10 thousand hectares of afforestation between 1992 and 2001 and a comparable value for the natural regenerated areas. This trend regarding afforestation was maintained at the almost same level for the next period (2005-2013), as shown in figure 2, considering only the afforestation completed by RNP.

After 1990, the state was not the only forest administrator and different funding mechanisms emerged. Despite all the property and administration changes, RNP still represents the most active and visible entity involved in the afforestation effort. RNP has several different mechanisms of funding afforestation: its own budget, the Fund for the improvement of the lands with forest destination, the Fund for forest conservation and regeneration, as well as funds from the state budget. The output of all funding instruments leads to the previously mentioned annual average of nearly 10 thousand hectares afforested.

In the past two decades there were additional funding mechanisms that have been available or used for afforestation programs: the SAPARD (Special Accession Program for Agriculture and Rural Development) Program – measure 3.5 (for the period 2000-2006), the Environmental Fund and Environment Fund Administration afforestation programs and, finally, the European Union funding instruments that have been implemented by the

National Program for Rural Development (PNDR) measures (in 2007-2013 and 2014-2020 programs).

The SAPARD Program (2000-2006) was implemented by PNADR (National Plan for Agriculture and Rural Development) and the measure 3.5 was specifically designed for forestry.

The 3.5 measure included more than 7 million euros (7.445 mil. euros) funding support for afforestation (a target of 15,000 hectares) and nearly 4 million euros (3.722 mil. euros) for forest nurseries. At the end of the program, 3 afforestation projects and one nursery project were funded and a disappointing 1.3% funding absorption rate was reached (MADR, 2011).

Unfortunately, the Environmental Fund (founded by government emergency ordinance no.196/2005) and Environment Fund Administration were not able to produce more significant results. Due to excessive bureaucracy and numerous changes in the funding guides, one single afforestation project (designed for an area of 40.5 hectares) was funded in the first 7 years from the creation of this funding mechanism (RCA, 2013).

The latest updated reports show an improvement in the past years: 2,836 hectares of afforestation were funded till 2014 (RCA 2014).

Considering the partial failure of the previous funding mechanisms, the European Union funding instruments were considered more adequate and better balanced. The National Program for Rural Development (PNDR) for 2007-2013, granted 1.2 billion euros for forestry measures of the total 7.5 billion euros.

The 221 Measure – *The first afforestation of agricultural land* was designed for promoting afforestation projects, with a total budget of 229 million euros.

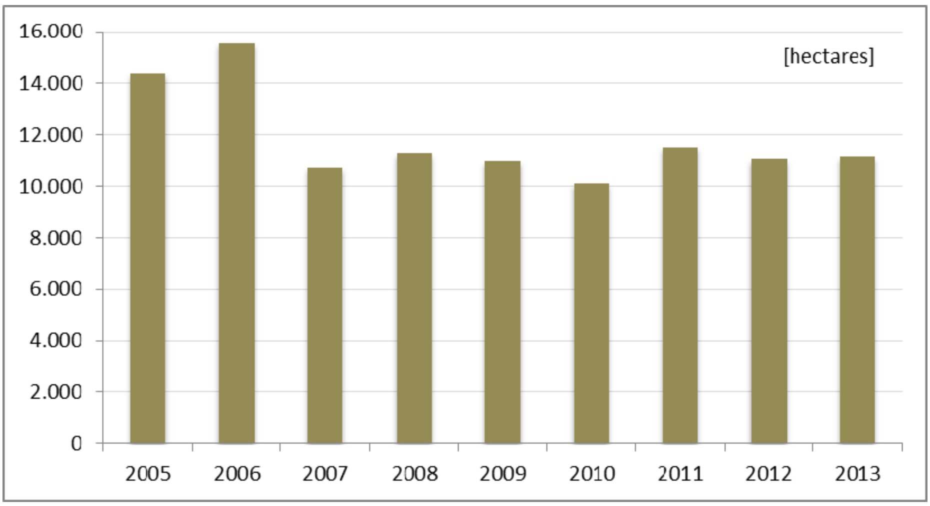

Fig. 2 Afforestation completed by the National Forestry Administration RNP (2005-2013) (unit: hectares)

The outcomes at the end of the term consisted in 29 projects, funded with a total of 185 thousand euros, resulting in a shocking absorption rate of 0.08%.

Another initiative was the Measure 122 - *Improving the economic value of forests*, which encompasses various activities from the forestry field, including the creation of nurseries. From the total of 135 million euros, only 1 million euros was used in funding projects and consequently the absorption rate was 0.8%.

The new PNDR 2014-2020, granted only 300 million euros from the total 8 billion euros (excluding the 10 billion euros for direct payments) for forestry measures. The Measure 8.1 for afforestation has a budget of 105 million euros and doubles the standard costs for the afforestation activities, in order to boost the absorption rate of funds for this particular field.

4. Conclusion

It is quite obvious that investments in afforestation do not seem very attractive due to the considerable time gap between investments and benefits, in this particular field.

However, considering the important role of forests in the environmental and social paradigm as well in the mitigation of climate change, the state should play a more significant role. In the absence of private investors, the state should be more active and should encourage afforestation by different funding mechanisms or attractive tax incentives.

The UE funding scheme is ineffective without an adequate support from the state. We can mention the Mediterranean states (Spain, Italy or Portugal) which have greatly benefited from the UE funds (Zanchi et al, 2007). Their outcomes regarding afforestation were as solid as their afforestation policies (Palaghianu & Clinovschi, 2007).

In Romania, the official statements recognize the importance of afforestation and one important objective of the National Afforestation Programme (2004) and the Forest Code (2008) was the afforestation of 2 million hectares of degraded lands. Moreover, the Law no. 100 /2010 regarding the afforestation of degraded lands was a new reinforcement of that ambitious objective, but the new versions of the National Afforestation Programme from 2010 and 2013 altered successively the target from 2 million hectares to 422 thousand hectares, respectively to 229 thousand hectares.

Although, the latest results of Romania in the field of afforestation seem inconclusive, different opportunities will soon arise along with the development of the new PNDR 2014-2020.

The latest Measure 8.1 for afforestation appears to be limited in budget, but it brings new mechanisms of payment and the promise of reducing the bureaucracy. This might be a fresh restart for the old Romanian afforestation engine.

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Evaluation of ecoprotective function intensity in stands with coniferous growing outside their natural vegetation area. Case study in the Forest District Adâncata, P.U. VII Zvoriștea

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Abstract. The replacement of natural stands by artificial stands leds over time to important changes in the forest ecosystems characteristics. In the 1965-1970 period only, on 37,000 ha such cultures were installed by substitution works. The aim of this paper is to study the evolution of the degree of ecoprotective function intensity (Cf index) of stands part of the Production Unit VII Zvoriștea, Forest District Adâncata before and spruce and Scots pine stands were installed. For this purpose the Cf index was computed for the years: 1965, 1975, 1985 and 2005. The index takes into account diversity, stability and forest continuity. The results allow the evaluation of the intensity of the function, as follow: 100-150 – very weak, 160-250 – weak, 260-350 – medium, 360-450 – good and 450-550 – very good. The intensity of the function was: very weak - 1965-18%; 1975- 16%; 1985-30%; 2005-31%; weak - 1965- 85%; 1975- 19%; 1985- 31%; 2005- 7%; medium - 1965- 0%; 1975- 65%; 1985-39%; 2005- 62%.

Keywords: ecoprotective functions, intensity of the function, artificial stands, natural vegetation area

1. Introduction

Over time forest ecosystems have undergone significant changes evidenced by the replacement of natural stands by artificial stands and the extinction of some species outside of their natural area of vegetation. In Romania during the 1960-1986 period, in order to obtain wood for pulp and paper production in a short time, fast growing species stands were installed outside their natural vegetation area. In the 1965-1970 period only, such cultures were installed on 37,000 ha by substitution works (Marcu and Ionescu, 1970; Barbu, 2004). At national level it is estimated that 300,000 ha of these stand types were created. The main used species were spruce and Scots pine. The decline of industry led to the abandonment of these stands in relation to the purposes for which they were originally created. One of the important features of the spruce is the shallow rooting (Șofletea and Curtu, 2007). This feature makes spruce stands vulnerable to windthrows (Popa, 2002). To quantify the structure-function relation two indexes were developed GEF index (Cenușă, 2000) and Cf index (a global index that quantify the ecoprotective function intensity) (Cenușă and Barbu, 2004).

The aim of this paper is to study the evolution of the degree of ecoprotective function intensity for stands where resinous species outside their natural vegetation area were installed beginning with the 70's.

2. Materials and methods

The study was carried out in Production unit VII Zvoriștea, Forest District Adâncata (fig. 1). Forest district Adâncata is representative for resinous artificial stands installed between 1965 and 1975. The site is situated in Suceava Plateau. The mean altitude is 400 meters a.s.l. and the vegetation is dominated by beech and oak stands. Annual precipitation ranges between 600 and 800 mm and the mean annual temperature is 8°C.

The research methodology (Cenușă and Barbu, 2004) implies the *Cf* index calculus. The *Cf* index takes into account: diversity index *Cd,* stability index *Cst* and forest continuity index *Cc* (fig. 2 and equation 1). Diversity index Cd is computed as function of the diversity of species (*Cd1*), diversity of forest types (*Cd2*) and diversity of age structure (*Cd3*).

$$Cf = \frac{2Cd + 3\,Cst + Cc}{6} \qquad (1)$$

Cf index has been computed for the years before (1965) and after (1975, 1985, 2005) spruce and Scots pine stands were installed. The results obtained allow us to assess the intensity of the function, as follow: 100-150 – very weak, 160-250 – weak, 260-350 – medium, 360-450 – good and 450-550 – very good.

3. Results

In the analyzed stands diversity index (*Cd*) ranges between 100 and 350. In 1965 this coefficient varies between 150- 250 (fig. 3a) for the entire study area, while in 1975 the dominant value of *Cd* is between 0 and 150 (fig. 3b), which indicates the presence of coniferous species installed in previous years outside their areas of vegetation. With the increase in the area occupied by resinous stands, the area where the values of the Cd index is in the range of 0-100 increased remarkably (fig. 3c).

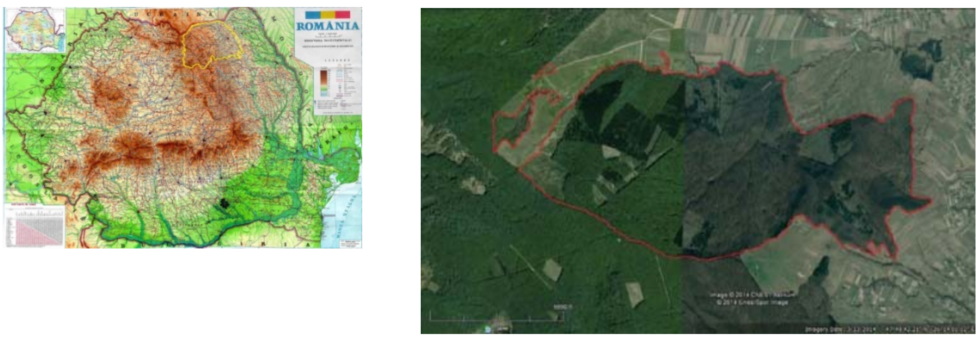

Figure 1. Study area

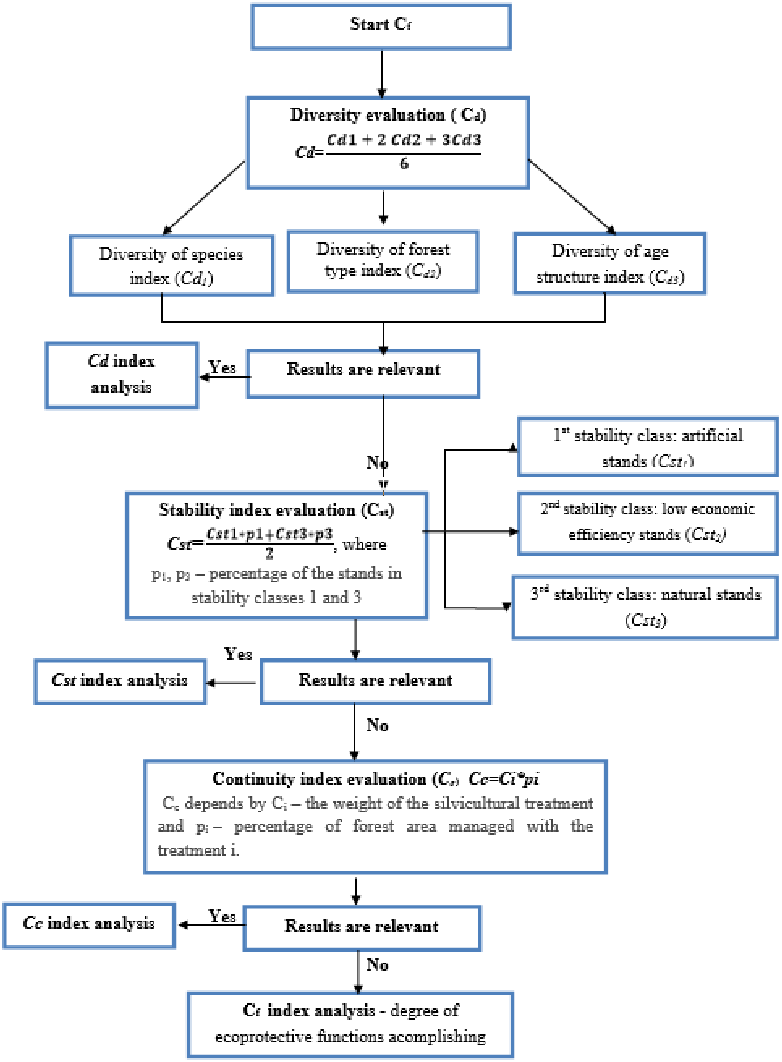

Figure 2. Cf index calculus

In 1965 the stability index (*Cst*) has values between 100 and 250 (fig. 4a), pointing out that forest stands that constituted Zvoriștea Cailor area were more stable compared to the years 1975-1985 (fig. 4b and 4c), when the stability coefficient values were between 50-100. In 2005 we can see a notable increase in the area where the stability index values are in the range of 150-200 (fig. 4d).

The continuity index (*Cc*) depends on the weight of the silvicultural treatment and percentage of forest area managed with each treatment. The values of this index varies between 100 and 450 (fig. 5).

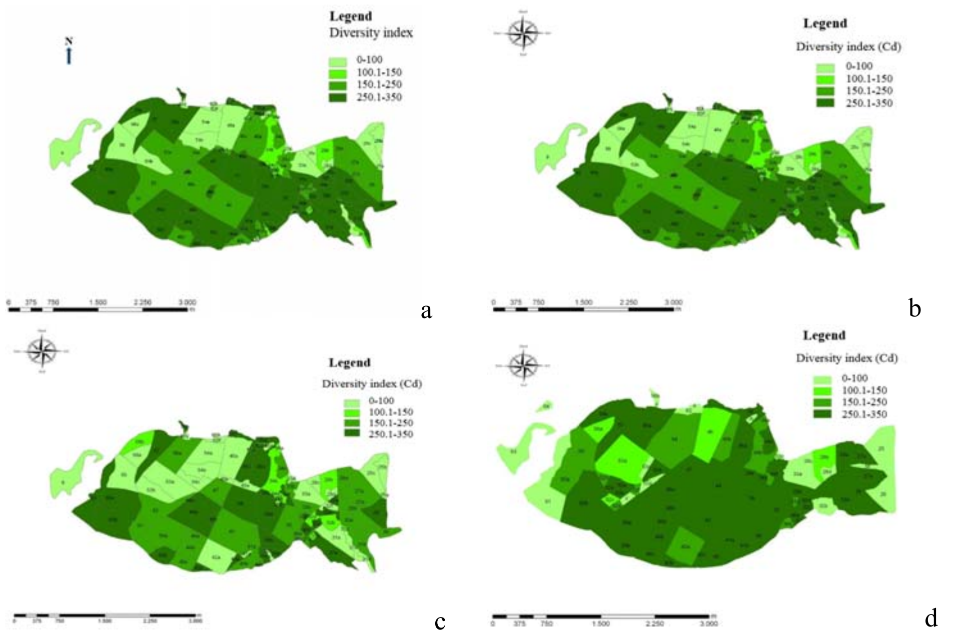

Figure 3. Diversity index (Cd) values in Zvoriștea Cailor stands, PU Zvoriștea, FD Adâncata in: 1965 (a), 1975 (b), 1985 (c) and 2005 (d).

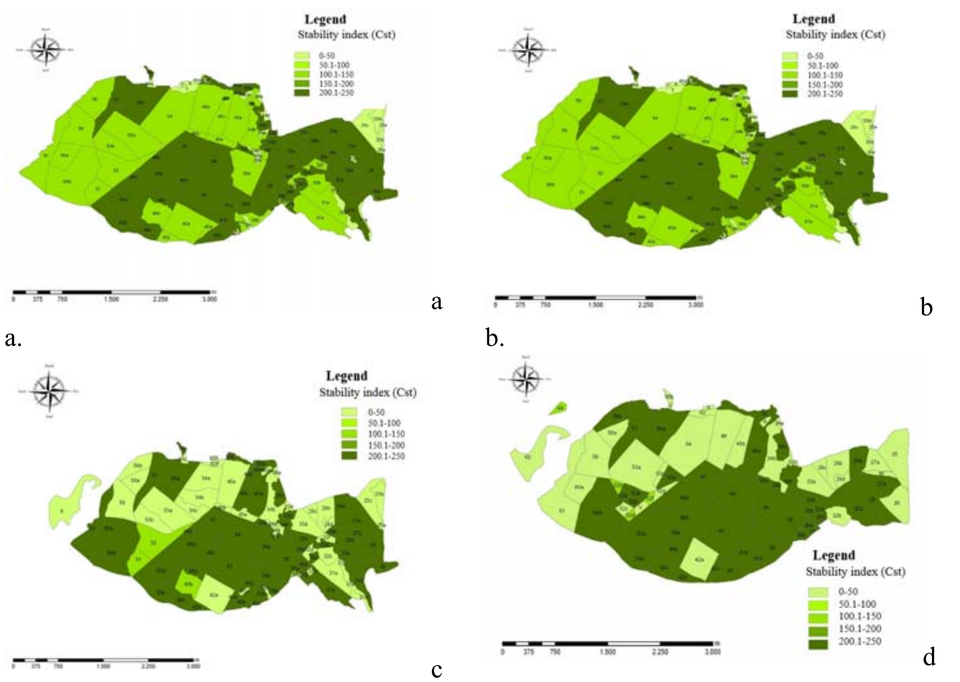

Figure 4. Stability index (Cst) values in Zvoriștea Cailor stands, PU Zvoriștea, FD Adâncata in: 1965 (a), 1975 (b), 1985 (c) and 2005 (d).

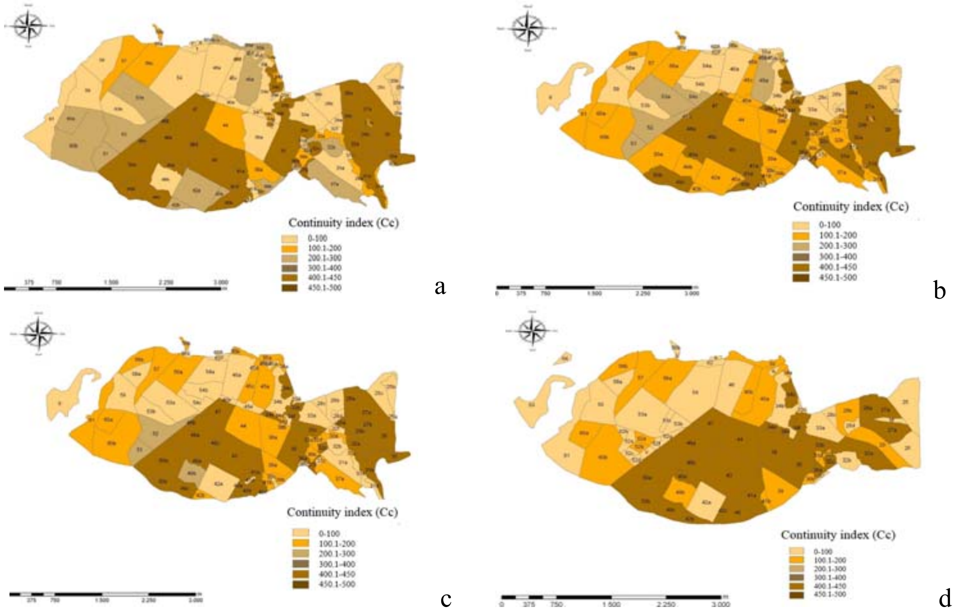

Figure 5. Continuity index (Cc) values in Zvoriștea Cailor stands, PU Zvoriștea, FD Adâncata in: 1965 (a), 1975 (b), 1985 (c) and 2005 (d).

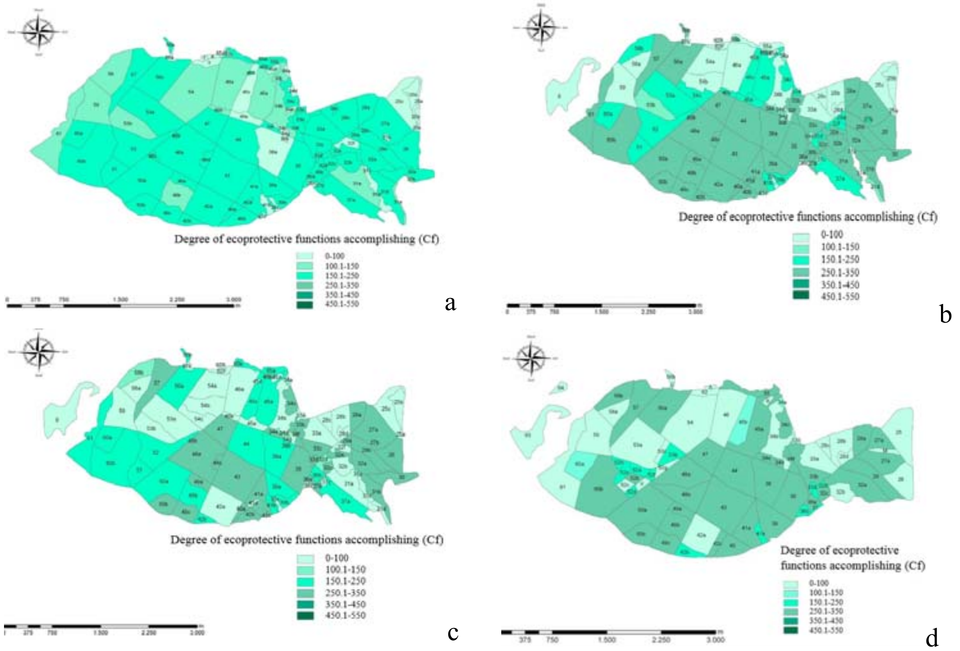

Figure 6. Cf index (degree of ecoprotective functions accomplishing) values in Zvoriștea Cailor stands, PU Zvoriștea, FD Adâncata in: 1965 (a), 1975 (b), 1985 (c) and 2005 (d).

The lowest values are registered in pure spruce stands where the clear cutting treatment was applied. The intensities of the ecoprotective function accomplishing computed with equation 1 and related to the surface were:

- very weak: 1965 - 18%; 1975 - 16%; 1985 - 30%; 2005 - 31%;
- weak: 1965 - 85%; 1975- 19%; 1985 - 31%; 2005 - 7% and
- medium: 1965 - 0%; 1975 - 65%; 1985 - 39%; 2005 - 62% (fig. 6).

4. Conclusions

The Cf index was initially developed for mountain forests but it can be used successfully in other forest types.

Before resinous being installed (year 1965) the intensity of ecoprotective function accomplishing was very weak on 18% of the study area and increases at 31% in 2005.

The maximum value for the *Cf* was 350 which indicates that the highest intensity of function was medium, with the most extent in 2005 (62% of the study area). Computed for different periods, this method allows a good evaluation of the forest management quality.

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Analysis of wild boar population dynamics in Suceava County for the period 2004-2016

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Abstract: This paper tries to capture the wild boar population dynamics in Suceava County, correlated with the change of the climatic factors and of the agricultural areas for the period 2004-2016. The current legislation has changed the wild boar hunting period, so that the male of this species may be harvested throughout the year. This regulation occurs as a consequence of the increasing population density and implicitly, of the damage caused by this species to the crops. In the last decade, we can notice a growing tendency of the monthly average temperatures for the dormant vegetation period, but also a decrease in the amount of precipitations. According to the available data, the number of wild boars in Suceava County has increased by over 50% in the past 12 years. It may be noticed an increasing tendency in the number of individuals (of population density) related to the increasing average temperatures and the decreasing precipitation, but without a statistical correlation. On the other hand, there is a significant correlation between the density of the wild boar population from the plateau area and the area under crop. There is also a higher increase in population density in the plateau area compared with that in the mountainous area.

Keywords: *Sus scrofa*, dynamics, population.

1. Introduction

The wild boar (*Sus scrofa*) is a species of major importance in the Romanian and European fauna, being spread all over the European continent. In Romania, it is by far the most adaptable species of game, being met from the Delta and the Danube Valley to the alpine zone, at altitudes of over 2000 m (Șelaru, 1995).

Since the 1980s, the wild boar populations have increased remarkably and almost simultaneously all over Europe and implicitly Romania has recorded significant increases. Therefore, in some European countries, the wild boar is collected throughout the year, as it is considered a vermin species. This population's growth has economical and ecological consequences on a large scale.

In Romania, throughout the years, there have been some laws which provided for certain hunting periods of this species.

- Law 103/1996 – provided for the wild boar hunting male and female, between 1 August and 15 February;
- Law 407/2007 – took the previous legal previsions regarding the hunting period;
- Law 149/2015 brought regulations on the hunting period; According to its provisions, the male boar can be hunt all year and the female, from 1 June to 31 January.

The regulations occur as a consequence of the increasing population density, and because of the damage caused to the farming areas.

Fig. 1. Area of study in Europe

As a result of the impact of this species on the agriculture, as well as the need to develop the game management practices, we were interested in the environmental factors, responsible for this development.

In the light of the above, the purpose of the study presented in this paper was to determine whether the variation mode of the temperatures and of the multiannual monthly average precipitation for the dormant period and the change in the areas in crop and the type of crop, can influence the boar population density, for the studied period 2004-2016. This work objective is the determination of the variation mode in time of the boar population in the mountain area and the plateau area of Suceava County, with the change of climatic factors (temperature, precipitation), as well as with the change of the areas and types of lands under crop.

2. Materials and Methods

The study was carried out in Suceava county, including all the 71 hunting areas in the county, with a total area of 718536 ha productive for hunting. In order to achieve our goals, the area where the measurements were performed, was divided into two distinct zones, depending on the climate storeys and on the main use of the land (forest or agricultural).

The study area was divided as it follows:

- The mountain area, located in the western half of the county, which includes 43 hunting territories with a total area of 527390 ha for productive hunting;

Fig. 2. The two areas of study in Suceava county

- The plateau area, located in the eastern part of the county, which includes 28 hunting territories with a total area of 191146 ha for productive hunting.

This division aimed at the altitude, vegetation and relief differences, which trigger climate consequence in terms of shelter and food. These factors influence the wild boar spatial distribution and population density (Comșia, 1961).

The data on the numbers of boars for the period 2004-2016 used in this paper was taken from Suceava Forest Guard, the meteorological data used was taken from the weather stations Rarău and Fălticeni, while that on agricultural land was taken from the national Institute of Statistics (INS) data base. The data processing was done in the Microsoft EXCEL, XLSTAT – determining the variation mode of the climatic factors in the study for the dormant period in the studied period of time 2004-2016. It was also determined the variation manner of the farming lands for the plateau area, aiming at the variation of the boar population density in relation to the mentioned factors.

3. Results. Discussions.

It was used the data on the wild boar populations from the 71 hunting territories, to determine the dynamics of the population density for the 12 year studied period, on two distinct areas (mountain and plateau) (fig.3). It is observed a continuous increase in the population density over the entire studied period.

For the mountain area, there is an increase in density from 3.8 boars/1000 ha in 2004 to 5.2 boars/1000 ha in 2016. For the plateau area, it can be observed a higher increase from 1.9 boars/1000ha at the beginning of the period studied, to 4,6 boars/1000 ha in 2016.

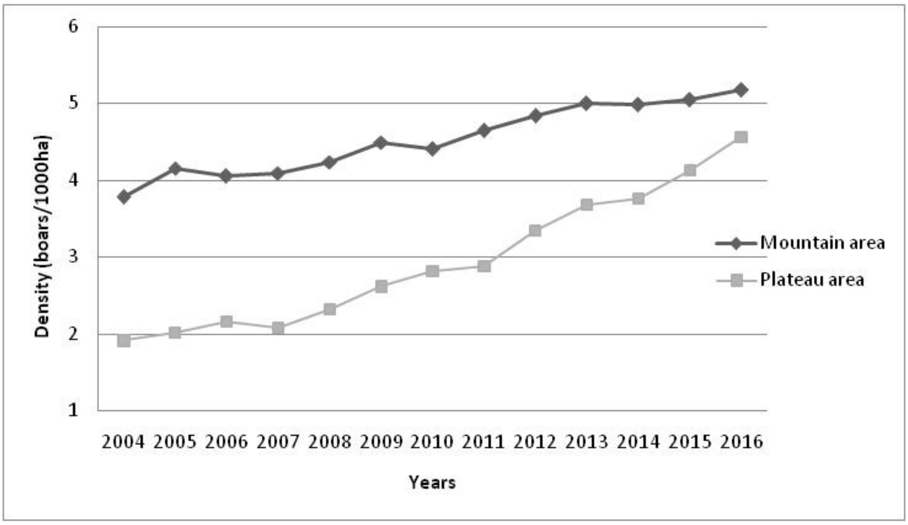

Fig.3. Analysis of Wild Boar Population Dynamics in period 2004-2014 for mountain area and plateau area

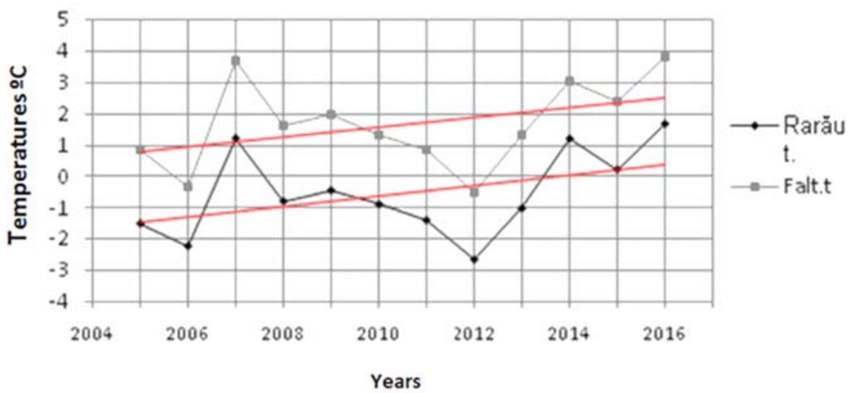

Fig.4. Variation of recurrent monthly average temperatures for dormant season for mountain and hill areas

For the dormant period, it was determined the variation mode of the multiannual average temperatures. One can notice an increasing tendency of them (fig. 4).

In figure 5 it is presented the density variation of the wild boar populations compared with the average
temperatures of the dormant period showing a rising tendency. From a statistical viewpoint, the analysis shows that there was not a strong correlation, considering the correlation coefficient R, which has a value of 0.401 for the mountain area, and 0.458 for the plateau area, with a given number of 12 freedom degree.

The increase of temperature from October to March leads to more available food, it reduces juvenile death, but also it determines this species reproduction at younger age.

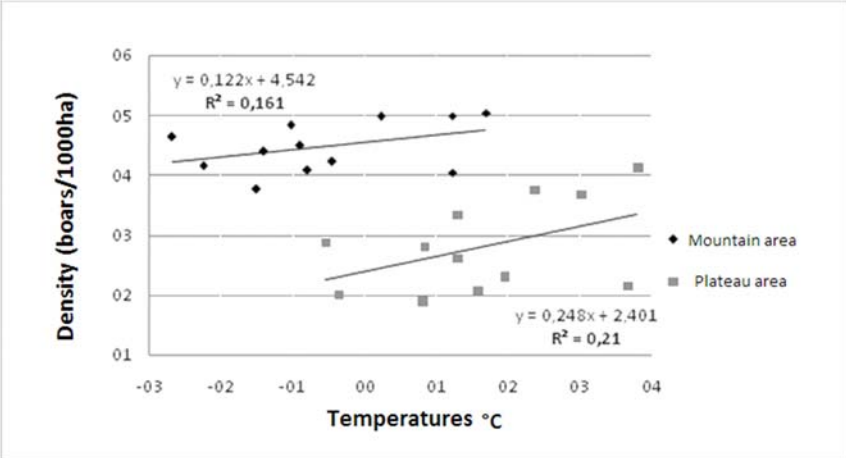

Fig.5. Variation mode of wild boar population density compared to average temperature from October to March

Moreover, the wolves attack the wild boars less, as the snow layer is less thick and the boars are more vigorous. The dynamics of the wild boar populations was also analysed in relation to the variation of the multiannual monthly average. For both studied areas, the precipitation has a decreasing tendency in time (fig.6.).

Analysing the density variation of the wild boar populations in relation to the average precipitations in the dormant period (fig. 7.), it cannot be noticed a significant correlation, from a statistical viewpoint. There is only a tendency in boar density increase, as the average precipitation decrease.

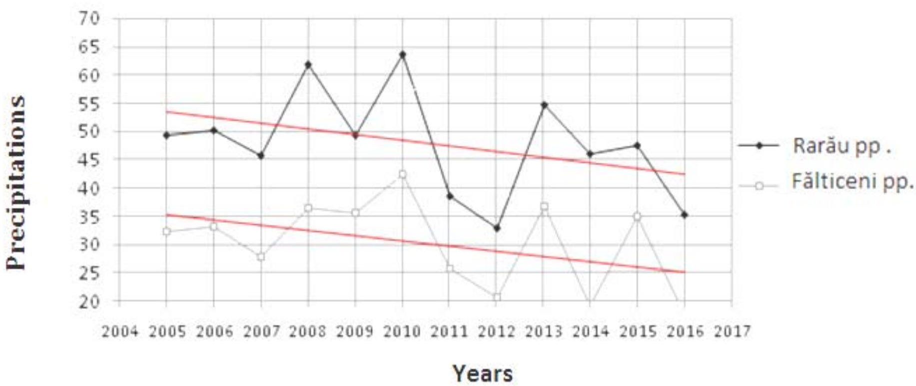

Fig. 6. Variation of recurrent monthly average precipitations in dormant season in mountain and plateau areas

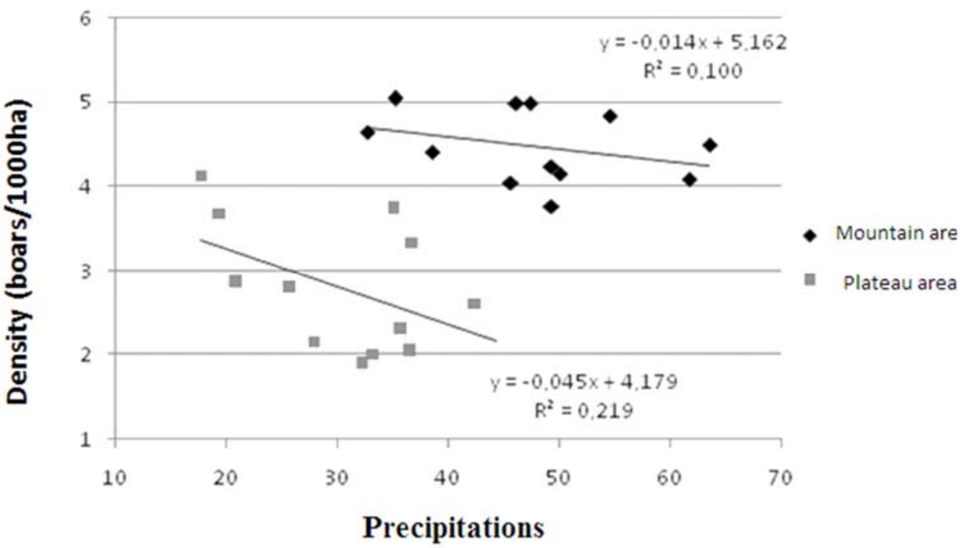

Fig.7. Variation mode of wild boar population density compared to average precipitations in October - March

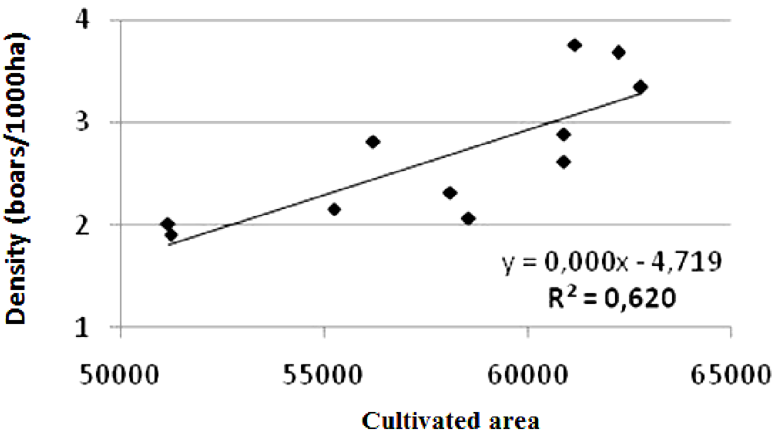

Fig.8. Variation mode of wild boar population density in the hill area reported to cultivated area.

For the plateau area there was also considered the data on the main crops, as a food source and shelter for the wild boar in this area, as well as the development of its plots in the period 2004-2016. The cultures taken into account were those of corn, grain and feed corn. Their areas were taken from the National Institute of Statistics database. It may be noticed a significant correlation between the wild boar population density in the plateau area and the cultivated area (fig.8), considering that correlation coefficient R is 0,787. This means that with the development of the cultures mentioned previously, there are provided better conditions for food and shelter for wild boars. This fact leads to a higher growth in density of this population in the plateau area, compared with the mountain area (table 1). The farm land extension as a surface, has led to a greater development of the wild boar populations in contrast to that in the mountainous area.

Table 1. Density increase for mountain area and plateau area

Area	Density (boars/1000 ha)		Increase (boars/1000 ha)
	Year 2004	Year 2016	
Mountain	**3,8**	**5,2**	**1,4**
Plateau	**1,4**	**4,5**	**2,6**

4. Conclusions

We may notice a tendency for the wild boar population density to increase, along with the increase of the monthly average temperatures, for the period October to March.

Moreover, the wild boar populations have a higher growth, due to the decrease of the average precipitations for same period, in the studied period.

The milder climatic conditions, the easier access to food and better shelter facilities due to the large crop areas contribute to a greater increase of the wild boar populations in the plateau area, in contrast to the mountain area.

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Considerations regarding the angular acceleration influence on the vehicles movement in curves

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Abstract: This paper aims to elucidate the effects of angular acceleration on vehicles movement in curves, especially on transition curves. It is explained the nature of such effects, indicating the difficulties to be overcome. Finally, we proceed to quantify the influence of angular acceleration in crossing a transition curve.

Keywords: angular acceleration, transition curves

1. Introduction

It is known that on vehicles movement in curves, the angular acceleration is limited, in terms of comfort, to values of 0.05 rad / s^2 (Bereziuc, 1981). This article aims to elucidate the nature of this discomfort and how much the angular acceleration influence vehicle movement on a transition curve.

2. Material and methods

The discomfort caused by the angular acceleration seems to be the force that angular acceleration would generate. According to the mechanics second law, any acceleration applied to a mass generates a force. The problem is that the angular acceleration [rad / s^2] x vehicle mass [kg] does not give Newtons. So, it would not be a force as defined in mechanics. Then, from where the discomfort comes?
We observe that on crossing with constant speed – v a circular curve with radius - R, the angular speed is constant: v = ωxR, while on crossing a clothoid, due to its variable radius, the angular speed is also variable, and thus generates angular acceleration. Modifying the curvature radius generates a "run" of the circle to the inner - ΔR (tangent displacement) (see Fig. 1), actually a decrease of the radius from infinity (∞) to the finite value of the radius (R). Radius variation relative to time apparently measure angular speed variation, and therefore, indirectly, angular acceleration.

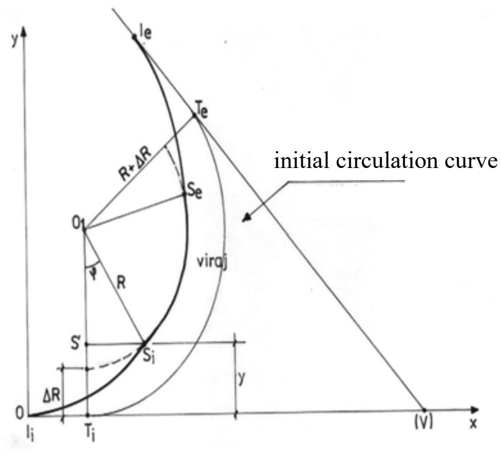

Fig. 1 Radius decreasing from infinity to a finite value by "running" inwards

Angular speed changes with radius decreasing. We believe that a force (acceleration) that would capture the radius length variation could replace angular acceleration.

This acceleration (we will call yet pseudo angular acceleration) has the advantage that is measured in m / s^2 and not rad / s^2. Replacing we spoke about refers to effects, strictly speaking.

It is known that $\Delta R \cong \frac{L^2}{24R}$,
where:
R is the corner radius;
L is the clothoid length;

Radius variation relative to time will generate an average speed v_1;

$$v_1=\frac{\Delta R}{t}=\frac{L^2V}{24RL}=\frac{LV}{24R}$$

Due to the clothoid shape, v_1 is an average value of the speed with which the radius is varying, from 0 in alignment to $2v_1$ at the end, when entering the corner.

The value in module of this acceleration could be just the angular acceleration we sought, which we have tried to avoid, because is not expressed in m/s^2.

Thus, at the end of a clothoid traveling along with a speed v = 40 km / hour, the corner radius being R = 200 m, we would have a pseudo angular acceleration

$$a_\omega^* = \frac{Lv}{24Rt} = \frac{v^2}{24R} = \frac{(40:3,6)^2}{24x200} = 0,03\frac{m}{s^2},$$

which multiplied by the vehicle mass of approximately 20 t would generate a horizontal force of about 60 kgf.

3. Results

We managed to discern the nature of discomfort caused by the angular acceleration and we expressed the effect of this acceleration by a force that can be quantified.

4. Discussion

A series of approximations and assumptions have been made to be able to express the discomfort given by the angular acceleration through a force. This force is not very high, about 300 times less than the vehicle weight, and approximately 20 times smaller than the maximum centrifugal force, according to the example shown.

5. Conclusion

The discomfort caused by the angular acceleration in transition curves is real. This discomfort is not exaggerated compared to vehicle weight, respectively maximum centrifugal force.

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Spatio-temporal association among monthly precipitation and relief in the central-west region of Venezuela

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Abstract: Venezuela is a tropical country where precipitation is affected both by global and regional conditions, such as the Intertropical Convergence Zone and relief. The aim of this research is to analyse the spatio-temporal relationship between monthly precipitation (time series spatially geocoded data) and relief at the central-west region of Venezuela. Two approaches were applied. First, we established the fit of the linear equation by Ordinary Least Squares (OLS). Second, was the implementation of modified Moran`s I (bivariate Moran`s I) between variables. Results show that there is a homoscedastic process and violation to spatial independence in disturbances. We performed a characterization of positive spatial autocorrelation of disturbances in most of the cases. Bivariate Moran`s I showed positive dominance of spatial correlation during the low precipitation months of February through June. This analysis reveals that the orographic effect is especially strong during the first semester of the year. Nevertheless, these results are conditioned by the asymmetric distribution of precipitation. It is possible that the results could be completely different after the transformation of the variable.

Keywords: Spatial dependence, linear OLS model, Moran´s I, bivariate Moran´s I, monthly data precipitation, model assumptions.

1. Introduction

Use and management of spatio-temporal data are common tasks when dealing with climatic variables, it is possible to obtain many observations at different times from numerous spatial locations. This type of data corresponds statistically with a structure of Pooled time series cross-section (time series with spatial cross section) Gujarati and Potter (2010), this structure is shown in figure 1. This type of structure uses a big amount of data (Androva and Boland, 2011). In order to perform the modelling, it is frequent that one of the two components (spatial or temporal, also both components) is discarded (Cressie and Winkle, 2011).

However, modern statistics is introducing the concept that the *"Stochastic data does not originate from a random and independent process"* (Cocchi and Bruno, 2010).

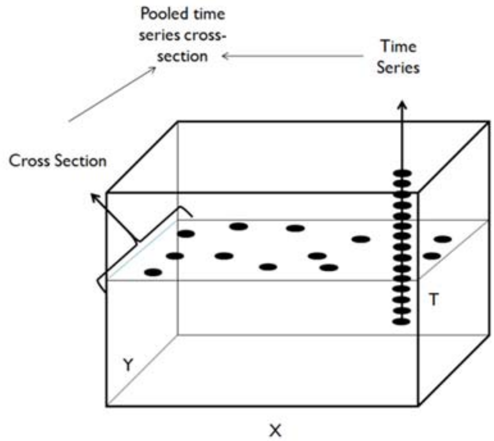


Figure 1. Structure of Pooled time series cross-section. Variables X, Y for space and T for time measurements.

This idea is also present in Tobler´s First Law of Geography (1970), which establishes that "*Everything is related to everything else, but near things are more related than distant things*", this law can be seen from various points of view: a statistical problem (Spatial Autocorrelation, SA) means concentration or dispersion of values in a mapped variable (Vilalta, 2005), and a theoretical problem (Spatial Dependency, SD), means that the dependent variable of a spatial unit is a partial function of the same variable in the neighbouring units (Flint, et al., 2000) (Figure 2). Another important concept is the Spatial Heterogeneity, defined as variation in the relationship among variables in space (LeSage,1999). A formal statistical definition is that the residuals are not constant in a regression (heteroscedasticity) or in the coefficients of a model (Anselin, 2001).

Spatial Heterogeneity is due to a real and substantive variation that evidences validity of the geographical context in the definition of a variable (O'Loughlin and Anselin, 1996).

There are many causes for the Spatial Heterogeneity: 1) There is a statistical problem and as a consequence, there is heteroscedasticity in a regression model; 2) There is substantive spatial variation in a variable.

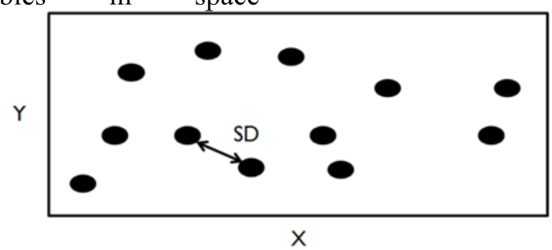


Figure 2. Spatial Dependency (SD)for different spatial units.

Spatial Heterogeneity should be studied for various reasons:

1) The structure under spatial instability may because by the geography (group wise),

2) Due to Spatial structure, there is a tendency to produce heterogeneity together with Spatial Autocorrelation and

3) In a transversal slice regression model, both effects Spatial Autocorrelation and Spatial Heterogeneity, can be mistakenly interpreted.

From a statistical point of view, if Spatial Autocorrelation is not considered, the coefficients of the regression are inefficient to show the amount of relationship among variables and if Spatial Heterogeneity is not considered, statistical significance tests can be refused because the standard errors are inflated. As a consequence, Toblerś First Law (1970) can be interpreted from a univariate point of view, in which case there is Spatial Autocorrelation and Spatio Temporal Autocorrelation (STA) and a bivariate point of view, in which case there is Spatial Correlation so that a variable in one place can be correlated with a variable in another place (SC).

Spatial Autocorrelation, Spatial Dependency and Spatial correlation are designated as Second Order Properties (Lloyd, 2010), and may be presented as three types, Positive, when similar values cluster together in a map, Negative, is when dissimilar values cluster together in a map and Absence of Spatial Dependence (Independence) (Figure 3).

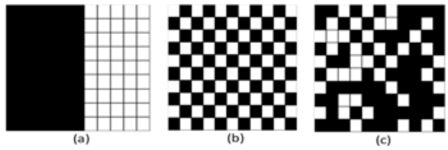


Figure 3. Positive Autocorrelation . b) Negative Autocorrelation. c) Absence of Autocorrelation (Independence).

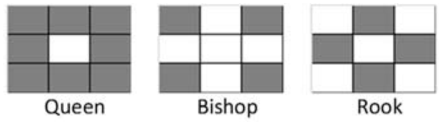


Figure 4. Three types of neighbourhood.

An important element to consider is the type of neighbourhood of the variables. Celemin (2009), Lloyd (2010) and Toral (2001) define many types of contiguity, such as “Queen”, “Bishop” and “Rook” (Figure 4).

There are three possible scenarios of Spatial Correlation. First, there could be two variables in a time slice; second there could be two variables, one with Spatio Temporal grouped data, and another variable which is time invariant and third there could between variables of grouped Spatial Temporal data (Panel spatio temporal data) (Anselin, 1988).

This introduces a set of relevant questions: How can two variables in a slice be correlated? How can two variables be correlated if one is in a slice and the other has grouped Spatial Temporal data? Gujarati and Potter (2010), Sridharan et al. (2011) and Anselin (2005), proposed the application of a linear regression using Ordinary Least Squares (OLS) and performing the diagnostics of the assumptions of the model, such as Multicollinearity among regressive variables, Heteroscedasticity of residuals, Autocorrelation of residuals and no normality of residuals.

In order to evaluate Autocorrelation of residuals, it is common to use of indexes to evaluate the presence or absence of spatial autocorrelation in the residuals. Moran´s I which is a variation of Pearson´s Linear Correlation Coefficient (Moran, 1950) is described by several authors (Bosque, 1992; Cressie, 1993; Lloyd, 2010; Olaya, 2011; Toral, 2001)

$$I = \frac{N}{S_0}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{w_{ij}(x_i-\mu)(x_j-\mu)}{\sum_{i=1}^{N}(x_i-\mu)^2};\ E(I)=\frac{-1}{N-1}$$

Where $\boldsymbol{\mu}$ is the mean of the variable $\boldsymbol{x}$, $\boldsymbol{w_{ij}}$ is the weigthed ponderation matrix, $\boldsymbol{E(I)}$ is the expected value in the absence of Autocorrelation (Independence) and $\boldsymbol{N}$ is the number of observations.

It is possible to use an index that spatially correlates two variables, like the Bivariate Moran's I (Zhu et al, 2007; Stojanova, 2012).

$$I_{y1y2} = \frac{N\sum_i[(\sum_j w_{ij}(y_{1i}-\bar{y}_1))(\sum_j w_{ij}(y_{2i}-\bar{y}_2))]}{\sum_i(\sum_j w_{ij})^2\sqrt{\sum_i(y_{1i}-\bar{y}_1)^2}\sqrt{\sum_i(y_{2i}-\bar{y}_2)^2}}$$

Where $\boldsymbol{N}$ is the number of observations, $\boldsymbol{w_{ij}}$ is the is the spatial weighting matrix indicating the spatial relationship between objects **i**and **j**, $\bar{\mathbf{y}}_1$ and$\bar{\mathbf{y}}_2$are the means of the variables $\mathbf{y_1}$and$\mathbf{y_2}$. The range of I values is (-1,1), negative values indicate negative Spatial Correlation, positive values indicate positive Spatial Correlation and values close to 0 indicate absence of Spatial Correlation.

Bivariate and Univariate Moran's I must be taken with caution, for the following reasons: 1) When there is no statistical significance, it does not mean that there is no autocorrelation, it is possible that there is a nonlinear relationship; 2) The degree of significance depends on the extension of the area under study and 3) The measure does not consider Spatial Heterogeneity.

Venezuela is a Tropical country with a maritime and continental extension, a country with different climates due to the Intertropical Convergence Zone and the orographic control. These conditions generate a seasonal rainfall that can be 10 times higher in one location as compared to another. Rainfall is unimodal at the centre and east of the country and bimodal at the north west of the country (with peaks in May –June and in September – November). The orographic control generates inversion of trade winds (1500-2500 msnm): almost 0% of humidity in atmosphere, restricting clouds and precipitations. A thorough description of the orographic control is presented by Goldbrunner (1984), indicating that due to the general circulation of the atmosphere over the Venezuelan territory, it is possible to distinguish two periods commonly called "summer" (dry) and "winter" (rainy). During the period of December through April it is observed that most of northern Venezuela is under the influence of the northeast trade winds 20. with its anticyclonic fields which depend on the height of the relief. The divergence of the resulting flow causes subsidence of air masses, causing strong temperature inversions depending on the altitude, called "trade wind inversion."

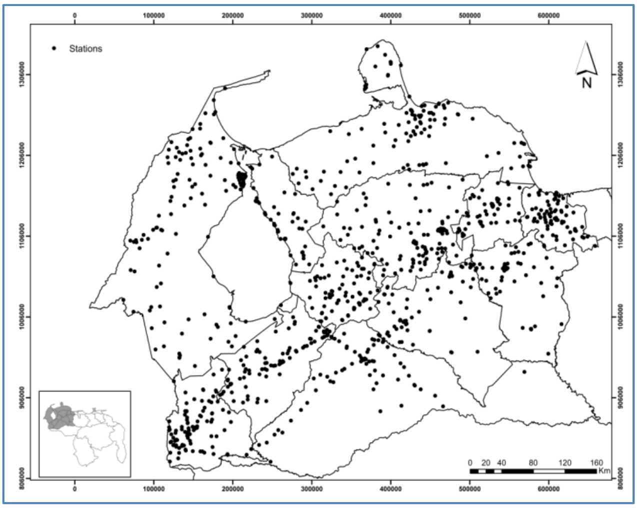


Figure 5. Monthly precipitation stations selected.

Above an altitude which ranges from 1500 to 2500 meters the atmosphere is almost devoid of humidity, limiting the development of clouds caused by the phenomenon of convection, which means they cannot originate rainfall. Therefore, the following hypothesis is proposed: Monthly precipitation has linear Spatial Correlation with altitude.

2. Materials and methods

We used data from 961 climatic stations of monthly precipitation from official institutions, (Figure 5), corresponding to Non-normally distributed data. Additionally, rainfall has the characteristic of having only positive values and usually the probability density function is decreasing and monotone (Bidegain y Díaz, 2011; Moran, 1969).

A general scheme of the methodology applied is shown in Figure 6. In this research we are addressing Spatial Correlation between a spatial variable (altitude in meters) and a variable of pooled spatial temporal data (monthly precipitation in millimetres). Since Spatial Correlation between precipitation and altitude for a particular year is expected to be similar to previous and subsequent years, and in order to avoid redundancy of the data (a station that has n number of records at constant altitude), 12 year samples were selected with 5 years of interval from 1950 to 2005. For each year selected, every month was analysed. A total of 144 analyses were carried out.

A linear Ordinary Least Squares (OLS) model was fitted for the Monthly precipitation data (independent variable) and the altitude (dependent variable). For each OLS fitted, Pearson's adjusted correlation coefficient was calculated, followed by a diagnosis of the quality of the model using the hypothesis tests (5% level of significance for all the tests). The Jarque-Bera (Jarque and Bera, 1980) Normality test is as follows:

Ho: Normal distribution of residuals.

H1: Non Normal distribution of residuals.

Spatial Autocorrelation of residuals was measured with Moran's I (Moran, 1950; Anselin, 1988), the following hypothesis was tested (Moran's I was used with a relationship of the inverse of the distance without distance threshold):

Ho: OLS regression residuals for monthly precipitation during month $\boldsymbol{m}$ and altitude have null Spatial Autocorrelation.

H1: OLS regression residuals for monthly precipitation during month $\boldsymbol{m}$ and altitude have non null Spatial Autocorrelation. If the null hypothesis is rejected, then the Spatial Autocorrelation must be characterized as either positive or negative.

If the estimated $\boldsymbol{I}$ >expected $\boldsymbol{E}(\boldsymbol{I})$, then the Spatial Autocorrelation is positive.

If the estimated $\boldsymbol{I}$ <expected $\boldsymbol{E}(\boldsymbol{I})$, then the Spatial Autocorrelation is negative.

Heteroscedasticity was tested with the Koenker test (Lamoureux and Lastrapes, 2012; Hafner and Herwartz, 2002; Engle, 2002):

Ho: Homoscedasticity of the residuals and H1: Heteroscedasticity of the residuals

Subsequently, Bivariated Moran's I Zhu et al. (2007) among altitude and precipitation, was evaluated.

Ho: Monthly precipitation during month $\boldsymbol{m}$ and altitude have null linear Spatial Correlation.

H1: Monthly precipitation during month $\boldsymbol{m}$ and altitude have non null linear Spatial Correlation.

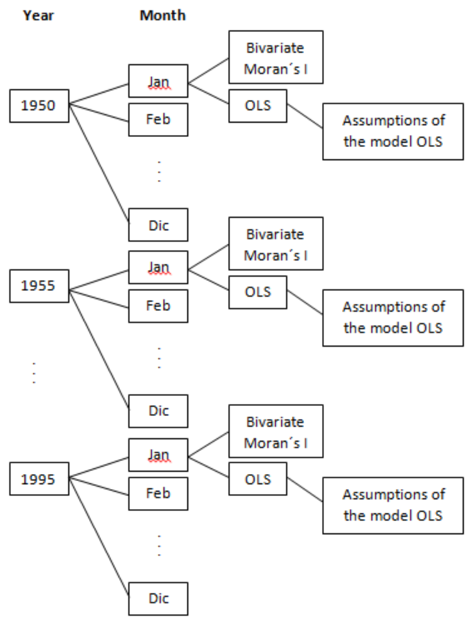


Figure 6. General methodology.

If the null hypothesis is rejected, then the Spatial Correlation must be characterized as either positive or negative:

If the estimated $\boldsymbol{I}$ >expected $\boldsymbol{E}(\boldsymbol{I})$, then the Spatial Correlation is positive.

If the estimated $\boldsymbol{I}$ <expected $\boldsymbol{E}(\boldsymbol{I})$, then the Spatial Correlation is negative.

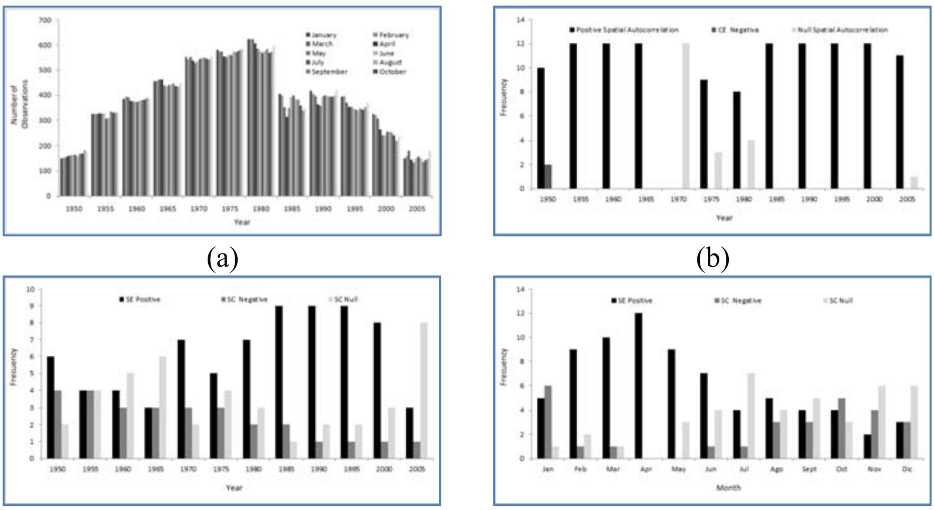
3. Results and Discussion

A low correlation (less than 10%) was found between the variables, this indicates that under the OLS model, the results show no apparent linear correlation. The Jarque-Bera test rejects the null hypothesis in 99% of the cases, this test discards the normal distribution of residuals indicating that the OLS model is incorrectly specified. The significance of the Jarque-Bera test is affected by sample size, which is not the case in this research (59590 records were analysed which represents 20% of the data), with the observations ranging between 623 (1980) and 135 (2005).

The yearly frequency of the residuals of Spatial Autocorrelation according to Moran's I, shows that positive spatial autocorrelation dominates in all the years, except in 1970. The monthly frequency of Spatial Autocorrelation of the residuals according to Moran's I, shows that positive spatial autocorrelation dominates in all the months, with a higher frequency in the months from April to November. According to the Bivariate Moran's I, positive Spatial Correlation dominates and the frequency is proportional to the number of observations and the monthly frequency of Spatial Correlation shows that the relief has more control over precipitation in the months of low rainfall and less influence in the months of high rainfall (Figure 7).

4. Conclusions

The results show violations to the OLS model. These are violations to the assumptions of normality of the residuals and independence of disturbances. Precipitation represents a dynamic process in time and space, and despite the transversal analysis of the data, Spatial Correlation is still found. This justifies the analysis of the Spatial Correlation, especially in the low precipitation months, in which the influence of the relief is greater.



(a) (b) (c) (d)

Figure 7. (a) Number of observations analysed by cross section; (b) Frequency of occurrence of Spatial Autocorrelation types per year, according to the results obtained by Moran's I of the residuals; (c) Yearly frequency of Spatial Correlation according to Bivariate Moran's I; (d) Monthly frequency of Spatial Correlation according to Bivariate Moran's I.

These results are conditioned by the non-normal distribution of rainfall, therefore, it is possible that if a transformation is used, the results may be completely different.

A Spatial Correlation between a cross-sectional space variable and a pooled spatial temporal variable which is maximized in the months of February to June, was tested.

One problem that must be taken into consideration is univariate and bivariate Moran's I tends to underestimate the spatial heterogeneity when the working area is large, as in this case. However, the Koenker test suggests that the stochastic process between rainfall and altitude, is homoscedastic, a result that must be studied in detail.

Furthermore, the spatial relationship between the two variables may be underestimated and the Spatial Heterogeneity may be "masked".

Therefore, the evaluation of the spatial relationship between the two variables with suitable processing should be considered, including a confirmatory analysis (setting a spatial model with its own diagnosis).

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