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## THE ROLE OF FOREST VEGETATION IN THE MITIGATION OF THE ECOLOGICAL IMBALANCES RESULTING FROM CLIMATE CHANGE IN THE PUTNA-VRANCEA RIVER BASIN

Cristinel Constandache<sup>1</sup>, Lucian Dinca<sup>2</sup>, Laurentiu Popovici<sup>1</sup>, Ciprian Tudor<sup>1</sup>

<sup>1</sup>"Marin Dracea" National Institute for Research and Development in Forestry (INCDS), Focsani Station, 7 Republicii Street, e-mail address: cicon66@yahoo.com;

<sup>2</sup>"Marin Dracea" National Institute for Research and Development in Forestry (INCDS), Brasov Station, Closca Street, e-mail. dinka.lucian@gmail.com, Romania

### Abstract

Climatic changes displayed through extremes (thermic or hydric) correlated with uncontrolled anthropic interventions exercised over time on land usages are the main factors that emphasize ecological and hydric disequilibrium from the South, East part of Romania. Specific of our country, the torrential precipitation regime generates rapid floods in mountain and hill areas. Torrential and land degrading processes occur on slopes and on the main hydrographic network as a result of torrential runoffs. Their consequences extend on a larger area than the one on which they occur. This happens especially as a consequence of perturbing the hydrological regime of water courses, generating floods in downstream areas or the coggling of accumulation lakes in periods with rain redundancies.

Forest protection cultures (forest vegetation) installed on degraded or overexploited agricultural lands from the hill and mountain areas represent the most efficient solution for attenuating the negative effects of climatic changes. This happens by steadily re-establishing the hydrological equilibrium, together with creating an ecological equilibrium that has positive effects on the soil and waters.

This paper emphasized the results of investigations realized in 2017 concerning the characteristics of forest protection cultures created on strongly and excessively degraded lands, followed by their hydrological and anti-erosion effects in the context of extreme meteorological phenomenon. As such, the runoff coefficient had values lower than 6.5% (from the total volume of precipitations in 24 hours), while the specific erosion was under 0.24 t/ha/an. The maximum charge of alluvium (erosion) produced by rain is of over 40 mm; their frequency and intensity has increased lately.

**Keywords:** *degraded lands, erosion, forest protections plantations, runoff*

### Introduction

The main ecological disequilibrium from Putna-Vrancea basin are determined by land degradation (erosion, landslides etc.) as well as by afforestation, torrential processes or floods. These events are highlighted in the context of climatic changes based on the area's high predisposition to erosion and landslides (Bogdan et al. 2015).

Torrential processes and land degradation cause major damages to both economic and social objectives: forest roads, human settlements, agricultural and forest lands or cultures, accumulation lakes and many more.

At the same time with diminishing or even cancelling the soil's production capacity, land degradation leads to the derangement of water runoff regime for both surface and subterranean waters, as well as to the changing of the microclimate and the degradation of the landscape. In this situation, a number of soil characteristics must be taken into account: humidity (Dinca et al. 2018), organic carbon stock (Dinca et al. 2015) and land geomorphology (Sparchez et al. 2017). The quantity of eroded material from strongly eroded lands frequently exceeds 50 t/year/ha, while surface runoffs can reach 70% of the precipitation volume (Untaru et al. 2006).

Previous investigations have emphasized the importance of forest protection cultures in improving and capitalizing degraded lands and especially in their hydrologic and anti-erosion protection (Giurgiu 2006, Untaru et al. 2006). Forest ecosystems with a proper structure have an important role in retaining, filtering water and in regulating surface waters, as well as in reducing soil erosion and transporting alluvium. All these aspects have an effect in maintaining water quality and in ensuring a permanent water flux (Chang 2006, Constandache et al. 2018). Investigations realized in 2017 had as main purpose to determine the runoff and erosion from afforested degraded lands, taking into consideration the characteristics of precipitations and protection forest cultures.

### ***Materials and methods***

The investigations were realized in six long-term research plots (runoff parcels) located on afforested degraded lands from Caci-Barsesti experimental perimeter, situated in Putna basin from Vrancea County (Figure 1).

The research areas have different characteristics in regard with forest vegetation (composition, consistency, age, biometric characteristics etc.) or with the land (slope, exposition, degradation shape and intensity).

Precipitations (and other meteorological parameters) were recorded with an automatic Em50 Decagon pluviograph. Runoffs (both solid and liquid) were determined through measurements of water and alluvium volumes that have run down runoff parcels in basins situated at the parcel's basis. The alluvium was extracted by filtering water samples taken from basins, being dried at 105<sup>o</sup> C and then weighted. The quantity resulted from a sample was correlated with the water volume from the basin and with the parcel's surface. As such, the quantity (or volume) of eroded soil after a rain with certain characteristics has resulted from surfaces with different types of forest vegetation. The characteristics of forest protection cultures were determined in 11 permanent research plots (Figure 1) situated in different degraded land conditions and were obtained through different management and afforestation technologies. The stand's data were permanently monitored through periodic measurements (at five years) concerning the main biometric (diameters, heights etc.) and quality (health) parameters Pine stands have ages between 38 and 40 years old, so that they are capable of offering valuable scientific information concerning the type of cultures and silvicultural operations necessary for an efficient management of stands from degraded lands, particularly to ensure ecological and functional efficiency under the conditions of harmful factors.

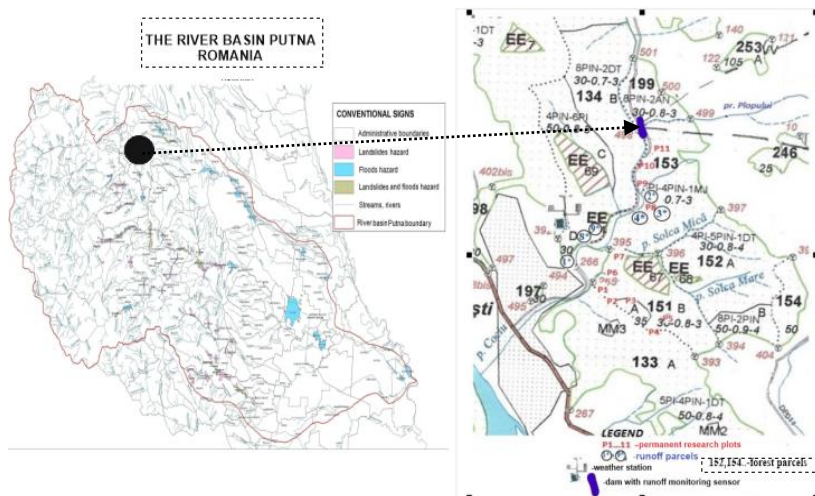


Figure 1. Location of the permanent research plots in Caciú-Barsesti perimeter

## Results and conclusions

### *The characteristics of forest protection cultures*

Forest vegetation (forest protection plantations) represent the most efficient solution for stopping land (and slope) degradation, for improving degraded lands as well as for re-establishing the ecologic and hydric equilibrium of lands affected by different degradation processes (Clinciu 2008).

The realized investigations have emphasized the characteristics of forest protection cultures that have a hydrologic and anti-erosion protection role, installed on lands affected by complex degradation processes from Caciú-Barsesti torrential hydrographic basin. The structural diversity (composition, consistency, sample number) as well as the forest culture's health state are important elements for their functional efficiency (hydrologic, anti-erosion etc.).

Forest cultures with the age between 38 and 40 years old, realized on strongly eroded and gullied lands have the following characteristics:

- the main species from their current composition are Scots Pine and Black Pine (intimate or grouped mixture), representing 80 – 100%. The difference consists of broad-leaved species (manna, black alder) originating from natural regeneration; white sea buckthorn has initially represented approximately 50% of the composition and had an important role in stabilising the slopes (Constandache et al. 2016, Silvestru-Grigore et al. 2018).

- the number of trees per hectare varies between 1766 and 3924 samples; the comparison analysis between the real number of trees and the number of trees from the tables emphasizes the fact that in certain situations there is a higher number of trees than the theoretical one. This aspect signals the need of an urgent silvicultural intervention (thinning), (Nistor & Constandache 2013); on certain areas (small gaps with a surface of 20-50 m<sup>2</sup>), the stand consistency is more reduced (0.5-0.6), even though the land is covered by white sea buckthorn (Figure 3); the cause of this

reduced consistency is explained by extreme micro-stational conditions that did not allow the maintenance of pines or by damages caused by snow in better land conditions;

-the average consistency is of 0.7-0.8, and can sometimes reach even 0.9-1.0 (full). In this last case, a tendency of structure homogeneity is evident, a fact that can have consequences in the stands evolution, either positive (increasing the cenotypic biodiversity's degree) or negative (reducing stand consistency and increasing their vulnerability towards harmful biotic and abiotic factors).

The biometric characteristics of the analysed stands can be summarized as follows:

-the average diameter ( $D_m$ ) ranges between 11.57 cm and 14.93 cm for the Scots Pine and between 9.17 cm and 13.69 cm for the Black Pine;

-the average height ( $h_m$ ) is situated between 12.07 m and 13.59 m for the Scots Pine and between 8.97 m and 12.62 m for the Black Pine;

-higher diameters and heights were observed for the Scots Pine in comparison with the Black Pine, with approximately 15.66% for the diameter and 20.59% for the height.

The realized investigations lead to the conclusion the Scots Pine realizes both a growth increment as well as a quality one in mixture stands of Scots and Black pines and especially in mixture with white sea buckthorn (Constandache et. al 2016).



**Figure 2.** Runoff parcel (2)

**Figure 3.** Scots Pine and Sea buckthorn from the "vegetally armed" terraces

The analysis of height distribution (Figure 4) and of the number of trees on diameter classes (Figure 5) is in a direct relationship with the number of species from the stand's composition as well as with the effect of harmful abiotic factors (snow). As such, in the case in which only the original species were present and the influence of abiotic factors is insignificant, the distribution of trees on diameter categories respects the theoretical distributions frequently used in silviculture (normal theoretical distribution and Beta distribution).

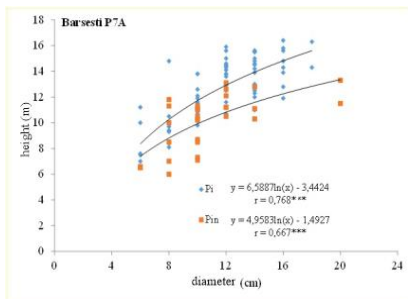


Figure 4. Height distribution of diameter classes

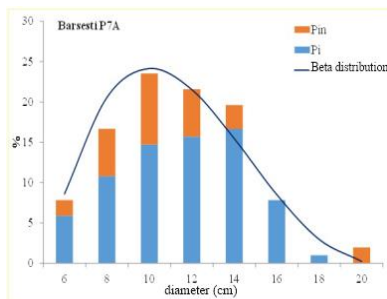


Figure 5. Tree number distribution on diameter classes

The bilayer (multilayer) stand tendency is evident in the case in which more species are present from natural sources, correlated with a significant influence of abiotic factors. This is a consequence of the apparition of a new vegetation layer formed of endemic species from the forest subarea in which forest protection cultures were installed.

The analysed structural markers (height distribution, number of trees, diameters, spacing etc.) show that these stands have the tendency to evolve towards diversified structures (Vlad & Constandache 2014). The same tendency is emphasized by biodiversity markers (Gini, Camino). A high diversity designates the stand's functionality and stability, parameters that determine the efficiency of analysed stands in fulfilling protection functions (Constandache et al. 2013).

#### *The functional efficiency of forest protection cultures*

The investigation's results demonstrate that the forest vegetation installed on degraded lands has an essential role in reducing runoff and erosion, having a direct impact in protecting water and soil resources (Constandache et al. 2010; Constandache et al. 2015, Costin 2006). Forest protection cultures have a direct impact on steadily re-establishing hydrologic equilibrium, together with creating an ecologic equilibrium in the created areas, with an effect on ensuring water quality (Constandache et al. 2018).

Investigations realized in 2017 in Caci-Barsesti perimeter – Vrancea, in experimental parcels installed on stands from degraded lands with purpose of studying runoff and erosion have emphasized the hydrologic and anti-erosion effect of forest vegetation in the context of an increase in torrential precipitation (both as frequency and as intensity).

As such, it was observed that the frequency and intensity of precipitations that cause runoffs has increased during the last period of time. As such, from a total of 24 rains that have accumulated 396.3 mm, recorded in May-October 2017, 15 rains (62% of the total number) that have registered 382.3 mm (96% of the total quantity of precipitations) have caused runoffs (Figure 6).

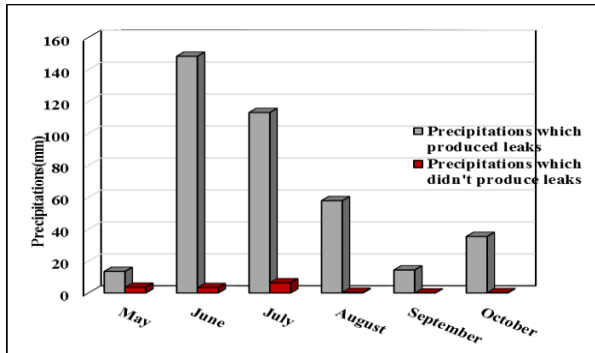


Figure 6. Runoff variations

During June and July, the quantities of precipitations were considerable, namely 136.8 mm and 119.4 mm, while May and September were the most poor months in precipitations (14.4 mm in September).

The rain with the highest intensity was recorded during the period 06 - 07.08.2017, being of 0.15 mm/min for a period of 180 minutes, with a quantum of 26.2 mm (Figure 7).

The aggressivity pluvial index (that showcases how damaging is the action of precipitations) had a maximum value of 0.61 (on a scale from 0 to 1) in June (the maximum quantity of precipitations in 24 hours related to the total quantity from that month).

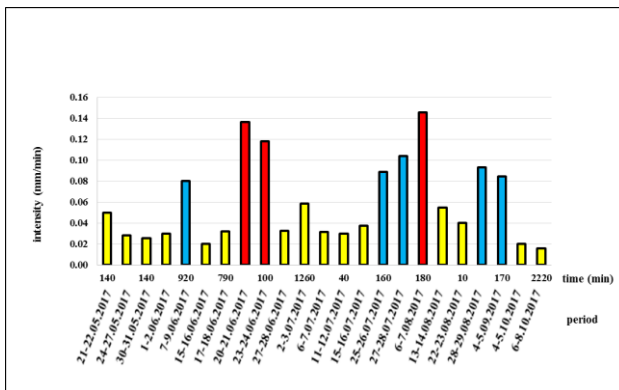


Figure 7. Intensity distribution based on rainfall duration during different periods of time

The runoff coefficient from forest protection cultures had values lower than 6.5% (from the total volume of precipitation in 24 hours) (Figure 8), while the specific erosion was under 0.24 t/ha/year (Figure 9) even in conditions such as torrential rains or when the soil was saturated with water from precipitations recorded in a previous period of time (of up to 15 days).

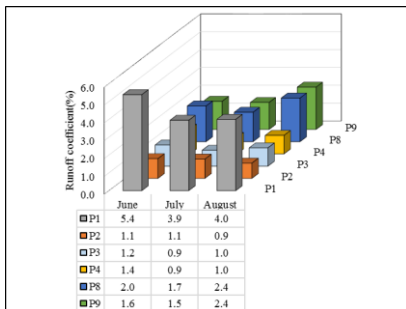


Figure 8. Distribution of runoff coefficient on months

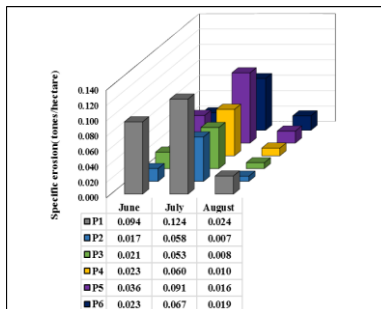


Figure 9. Specific erosion on parcels

The maximum alluvium charge (erosion) was produced at rains exceeding 40 mm (5.5 g/l), with an average pf 3.95 g/l on strongly eroded land and with a low degree of vegetation coverage. The efficiency of forest cultures on strongly eroded lands increases as they advance in age (over 40 years) and is higher in pine cultures mixed with White Sea buckthorn.

Climatic changes from the last period of time, with increased rains that have a torrential character were confirmed by the persistent waves of catastrophic floods from the last years. They lead to an amplification of soil erosion, torrential runoffs and an increase of catastrophic floods, which require prevention measures and works.

## Conclusions

Forest protection cultures represent the most efficient solution for stopping land degradation, for improving already degraded lands and for re-establishing the ecologic and hydrologic equilibrium of lands affected by different degradation processes. Forest ecosystems that have a proper structure and health state play an important role in retaining and filtering water, in regulating runoff, reducing soil erosion and in transporting alluvium, in the conditions of increased meteorological conditions.

Under the direct effect of forest protection cultures, the successive rehabilitation of the hydrological equilibrium occurs, at the same time with the creation of an ecologic equilibrium in the created areas, with effects in ensuring water quality. The runoff coefficient from forest protection cultures has recorded values lower than 6.5% (from the total precipitation volume in 24 hours), while the specific erosion was under 0.24 t/ha/year, even under torrential conditions or on soils saturated with water from precipitations recorded in a previous period of time. On the other hand, on degraded lands, surface runoffs can reach 70% of the precipitation volume, while the specific erosion exceeds 50 t/year/ha. The hydrologic and anti-erosion efficiency of forest cultures created on degraded lands increases as they advance in age and is higher in stands with a mixed structure.

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