RST – Scientific report regarding the implementation of the "*NATIvE* – Potential climate chaNge mediated recovery of AuTochthonous broadleaf species to the detrIment of allochthonous planted conifErs" project (code: **PN-III-P1-1.1-PD-2016-0583**; Financing Contract for Project Execution **NO. 41 / 2018**) within the **01/01/2019 – 31/12/2019** period

I. INTRODUCTION – THE SCIENTIFIC CONTEXT

Climate change is nowadays not only a projection of the future, but a reality and in this new context all life forms are already facing higher temperatures and more frequent, intense, and severe droughts (IPCC 2013). Forests, estimated to cover about 30% of the Earth's surface, are already globally showing worrying levels of decline and mortality as a result of these extreme climatic events (Allen et al., 2010, 2015; Hartmann et al. 2018). This is of major importance because forests provide ecosystem services at local, regional, and global levels (Pan et al. 2011; Bonan 2016), playing a crucial role in mitigating climate change.

Given this complex climate context and its impacts on forest ecosystems, we need to understand these processes to ensure the future of our forests and the ecosystem services they provide (i.e., climate change mitigation, timber production, social services, etc.). Specifically, it is very important to understand the underlying causes of tree decline and mortality and how forest ecosystems respond to severe disturbances (i.e., climate change) in order to understand how natural succession processes, that ensure the presence and permanence of forests, will take place in the future. forests. In this regard, variables such as the current situation of forests (i.e., native species vs. non-native ones), their structure (i.e., plantations vs. natural forests), or the genetic predisposition of different tree species, are key factors that should be considered for a better understanding of the future of our forests.

According to the last National Forest Inventory (IFN, 2018), Romania has approximately 7 million ha of forest. Romania's climate is temperate-continental and climate models estimate that in Eastern Europe temperatures will rise by up to 2-3 Celsius degrees, while rainfall is likely to fall by up to 10% by the end of the XXI century, droughts representing therefore a real threat in these regions (Collins et al. 2013). In this context, tree decline and mortality events have been already registered in Romania (Barbu and Popa 2001; Curiel Yuste et al. 2019). Specifically, conifer species such as *Pinus sylvestris* L. (Scots pine) and *Pinus nigra* Arn. (Black pine) seem to be

among the most affected, at least in some regions such as Brasov (Photo 1, A.-M. Hereş; Curiel Yuste et al. 2019), while deciduous species such as *Fagus sylvatica* L. (European beech) and *Quercus petraea* Matt. Liebl. (sessile oak) do not seem to suffer much in this regard. In 2012, important Scots pine and Black pine mortality events were recorded in the Brasov region, events that followed the severe drought recorded in 2011 (Ionita et al. 2016) and the high temperatures recorded in 2012 (Marcu and Borz 2013). Both Scots pine and Black pine areas have been planted in the past outside the distribution area of the two affected species. These plantations have established on degraded areas replacing native deciduous species.

Photo 1 – Scots pine affected by decline and mortality in the vecinity of the city of Braşov (*photo: Ana-Maria Hereş*)

II. THE OBJECTIVES OF THE NATIvE PROJECT

Within the NATIvE project, it is proposed to study, using dendrochronological methods (i.e., annual tree-rings) and field inventories, both the historical growth of planted non-native tree species (Scots pine and Black pine) and native tree species naturally present (European beech and sessile oak), as well as the secondary succession of mixed forests (i.e., regeneration) and competition located in the Braşov region, all affected by mortality events among conifer species (i.e., Scots pine and Black pine).

The specific objectives of the NATIvE project are therefore: *i*). to analyze the historical growth of the planted non-native conifer species (Scots pine and Black pine)

in comparison with that of the naturally present native deciduous trees (sessile oak and European beech); *ii*). to study the different strategies used by non-native planted species (Scots pine and Black pine) and by the naturally present ones (sessile oak and European beech) to cope with droughts, and the ability of these tree species to recover after they have been facing severe droughts; and *iii*). to evaluate the regeneration success of the planted non-native conifer species (Scots pine and Black pine) compared to that of the naturally present native deciduous trees (sessile oak and European beech).

The objectives of the II stage (01/01/2019 – 31/12/2019):

Activity 2.1: The measurements of the tree-rings will be continued. For this, specific dendrochronological methods and software will be used. This activity started in the I stage.

Activity 2.2: After evaluating the field seedlings inventory made in the I stage, a second one will be conducted, is necessary.

Activity 2.3: Carrying out statistical analyses and writing manuscripts in order to disseminate (international conference) the preliminary results of the NATIvE project and publish them in specialized journals. This activity will continue in stage III.

III. RESULTS OF THE NATIvE PROJECT

Activity 2.1: The measurements of the tree-rings will be continued. For this, specific dendrochronological methods and software will be used. This activity started in the I stage.

The study sites selected to implement the NATIvE project are the following: Codlea, Teliu, Lempeș, and Răcădău (Table 1). All 4 study sites show processes of decline and mortality among conifer species that have been planted in the past (i.e., Scots pine and Black pine). These study sites are all mixed forests of planted conifers with native deciduous species (i.e., sessile oak and European beech).

Table 1: Study sites and coniferous and deciduous species selected for the implementation of the NATIvE project

Study site	Geographic coordinates	Species	No. of trees
Codlea	45°42'35.22"N	Scots pine	30
	25°25'54.93"E	sessile oak	30
Teliu	45°42'1.66"N	Scots pine	30
	25°51'36.30"E	European beech	30
Lempeș	45°43'31.57"N	Black pine	30
	25°38'52.11"E	sessile oak	30
Răcădău	45°37'50.77"N	Black pine	30
	25°35'43.07"E	European beech	30

In 2018, wood cores were extracted in order to estimate the historical growth of the planted non-native tree species (Sild pine and Black pine) and of the native deciduous tree species (sessile oak and European beech). Specifically, two wood cores were extracted from each selected tree (photo 2) using Pressler increment borers with an inner diameter of ≈ 5 mm. The sampling of the wood cores was carried out according to standard dendrochronological procedures: at a height of 1.3 m (from the ground level) and perpendicular to the slope to avoid possible reaction wood. The selected trees (both conifers and deciduous): were adult and dominant, had similar diameters (DBH, diameter at breast height), had as similar as possible microclimatic conditions, showed no clear competition with neighbouring trees, had a crown without severe defoliation (i.e., <10 - 20%; this visually evaluated criterion is accepted as a good indicator of the health of a tree and was always done by the same person to ensure consistency of data), and showed no evident signs of pathogens (i.e., insects, fungi).

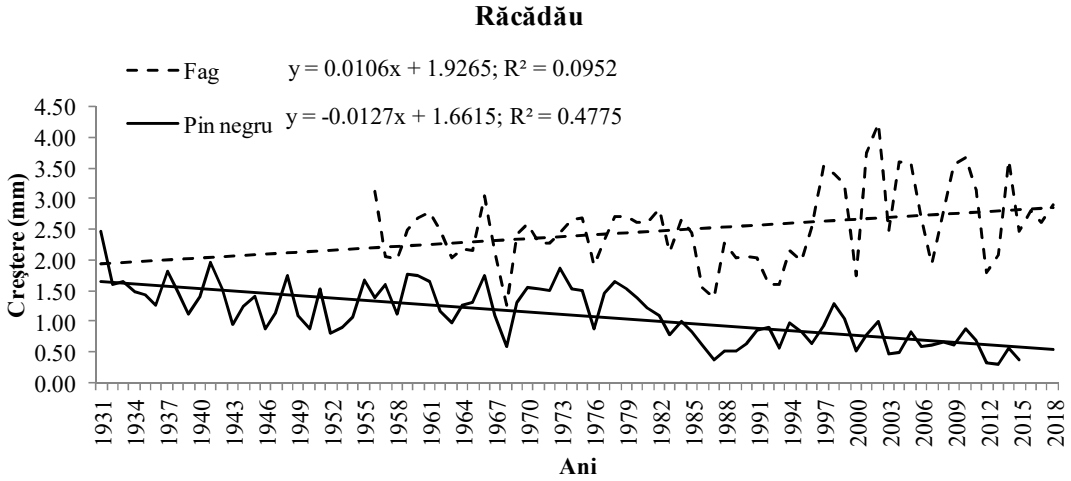
Photo 2 – Wood cores extractions from sessile oak (Lempeş) (*photo: Jorge Curiel Yuste*)

In 2019, all the wood cores extracted in 2018 were measured and the corresponding annual tree-ring widths were obtained. These measurements were performed separately on each tree, study site, and species. All measurements were performed using specific dendrochronological software: CooRecorder (Cybis Elektronik & Data, Saltsjöbaden, Sweden). The accuracy of the cross-dating process was subsequently verified using COFECHA (Holmes 1983), all resulting chronologies being accurate according to dendrochronological standards. These measurements were further used in statistical analyses being correct. In order to perform statistical analyses, the values of the two wood cores extracted and measured per each tree were averaged, a standard procedure performed to take into account the intra-annual variability of growths.

For the tree-rings measurements, Ştefan Petrea, a master student ("Silvicultură multifuncţională", Universitatea Transilvania Braşov, UniTBv), has given support. He will the use data from the NATIvE project in order to write his dissertation thesis that will be supervised by dr. Ana-Maria Hereş (UniTBv) and dr. Ion Catalin Petritan (UniTBv).

Preliminary results obtained so far from performing statistical analyses, indicate that deciduous trees (i.e., sessile oak and European beech) are doing better in terms of growth (positive trend) than the planted non-native conifers (i.e., Scots pine and Black pine), which seem to have difficulties to maintain their growth rates (negative trend) (Figure 1).

Figure 1 – Black pine and European beech (Răcădău) growth. The line trends are given together with the equation and the R^2 values.



Activity 2.2: After evaluating the field seedlings inventory made in the I stage, a second one will be conducted, is necessary.

All trees from which wood cores have been extracted in 2018 have been revisited in 2019 to make the inventory of seedlings (regeneration) and the inventory of adult, possible competitor trees (Photo 3).

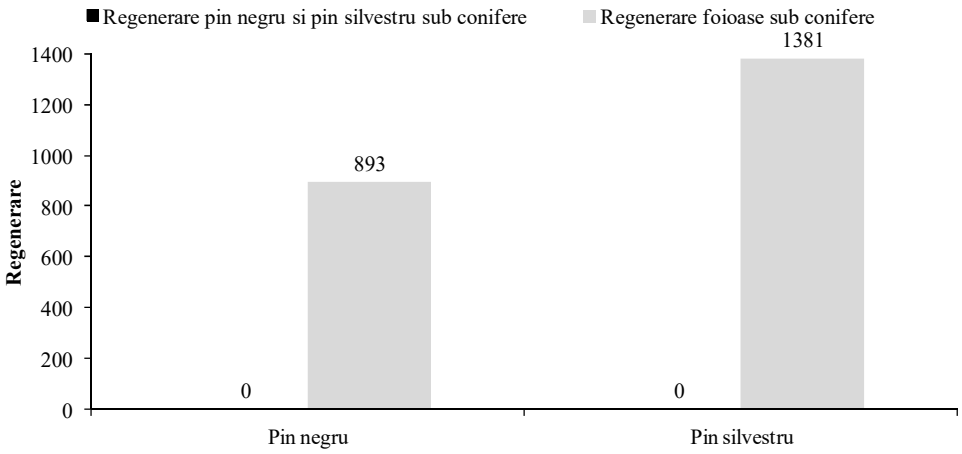
Photo 3 – Inventory around a sessile oak tree (Codlea) (*photo:Ana-Maria Hereş*)

The seedlings and competition inventories within a circle of 5 m diameter around each tree from which wood cores were extracted (i.e., hereinafter referred to as reference trees). These inventories were carried out in parallel by three people in order to minimize possible errors, the obtained data being contrasted between them for

validation. Specifically, all seedlings (diameter <10 cm), regardless of species, were counted to estimate regeneration. At the same time, all trees with a diameter > 10 cm were also counted in order to estimate possible competition.

Until now, only the data related to the regeneration of the seedlings under conifers (Scots pine and Black pine) could be analyzed. The analysis of the regeneration of seedlings under deciduous trees and the competition will be performed in the next period. Preliminary results indicate that Scots pine and Black pine have difficulties to regenerate, while deciduous trees regenerate very well under conifers (Figure 2).

Figure 2 – Scots pine, Black pine, and deciduous species regeneration below reference trees (all pine trees from which wood cores were extracted)



Activity 2.3: Carrying out statistical analyses and writing manuscripts in order to disseminate (international conference) the preliminary results of the NATIvE project and publish them in specialized journals. This activity will continue in stage III.

During 2019, a first article, in which the soil part of the study sites was treated, was published. Specifically, this ISI article highlights the fact that tree mortality results in increased soil respiration (i.e., significant CO_2 emissions), which causes forests to become carbon sources and decrease their ability to absorb carbon. These results are of particular importance given that CO_2 emissions contribute to exacerbating climate change (Curiel Yuste et al. 2019).

At the same time, during 2019 we worked on a second article regarding the mortality of conifers (Scots pine and Black pine). The results of this manuscript show that severe droughts, such as the one recorded in 2011, lead to the decline and mortality of the two non-native pine species. The fact that these species were planted outside their natural

distribution range seems to play an important role in this regard. In addition, Scots pine and Black pine appear to have problems with regeneration, which puts into balance their future presence in these forests. This article is in a very advanced stage and will be sent for publication within the next period (Hereş et al. *in prep*).

Regarding the dissemination of the results of the NATIvE project, the project director participated in 2019 to a conference that took place in Austria (Vienna; EGU General Assembly 2019). During this conference, the project director presented preliminary results of the NATIvE project in a poster (Title: "*How does drought-related mortality affect conifer species? The role of historical management practices on the current response of trees to climate*").

The management of the NATIvE project:

In 2019, it was only necessary to purchase a high-capacity external hard drive. This hard disk is needed to save all NATIvE project data, especially wood core images that have been obtained by scanning the wood cores at a very high resolution (1200 dpi). This high resolution was needed in order to correctly analyse the wood cores, so they occupy a lot memory. The materials purchased in 2018 were used for the field and laboratory.

IV. CONCLUSIONS

The activities (2.1, 2.2, and 2.3) proposed for the II stage of the NATIvE project were successfully carried out during 2019, according to the working plan. The analysis of the data from a statistical point of view will be completed within the next period and the results will be disseminated: an international conference (possibly in March 2020 in Lund-Sweden, where the project director sent an abstract and is waiting for a response in this sense), a master's thesis (Ştefan Petrea, previously mentioned), and the publication of articles in specialized ISI journals.

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Braşov, 25.11.2019 **Dr. Ana-Maria Hereş**