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 **02/05/2018 – 31/12/2018** period

I. INTRODUCTION – THE SCIENTIFIC CONTEXT

Globally, the decline of trees closely followed by their death is currently one of the most important research topics in the field of forest ecology (Allen et al., 2010). The direct and indirect effects of rising temperatures, accompanied by changes in the intensity and frequency of precipitations (i.e., droughts) (IPCC, 2014), are considered to be the main determinants of these widespread tree decline and mortality events (Hereş et al., 2012; Cailleret et al., 2017; Hereş et al., 2018) that have affected all types of forest biomes all over the world: savannas, conifer and deciduous forests from Mediterranean and temperate continental areas, tropical forests, etc. (Allen et al., 2010). At present, the exact ecological implications of forest decline and mortality remain unknown at local / regional (decreased productivity of forest ecosystems, changes in the distribution of different tree species, alteration of succession processes, changes of the floristic composition, etc.), and global levels (the capacity to retain atmospheric carbon, climate control, etc.) (Anderegg et al., 2013). Given all these aspects and the fact that it is desirable to prevent and reduce the associated risks, it is very important to study the causes that underlie tree decline and mortality and how forest ecosystems respond to such severe disturbances (i.e., climate change) in order to understand how the processes of natural succession, that ensure the presence and permanence of forests, will take place in the future. In this respect, variables such as the current situation of forests (i.e., native species vs. non-native species), their structure (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.

The vast temperate forests of Europe have suffered an intense anthropogenic impact since ancient times, a pressure that continues today to meet the needs of society (firewood and construction, berries, agriculture, etc.). As a result, the areas

occupied by forests in the past have decreased considerably over time, reaching in some cases only small fragments, an aspect that has significantly affected their ecological structure, functions, and services (Anderegg et al., 2013). In the last ≈ 150 years, in order to recover forested areas, numerous plantations have been established all over Europe. As a result, many of the forests we currently have in Europe are plantations (mainly monocultures) whose main purpose is to satisfy the needs of the society. Thus, given that conifer species such as *Pinus sylvestris* L. (Scots pine) are easy to establish and manage and show a rapid growth with a large volume of wood, such non-native species have been favored to the detriment of native species such as deciduous species (*Quercus* sp., *Fagus* sp.) that are characterized by a slow growth. Conifers, therefore, currently occupy areas in Europe that extend far beyond their natural limits of distribution, both in latitude and altitude (i.e., altitudes too low for their ecological optimum such as pasture areas or hills) (Spiecker, 2003), which makes many of these conifer species to suffer significant processes of decline and mortality given the current conditions determined by climate change (IPCC, 2014).

In Romania, whose climate is predominantly temperate continental, processes of tree decline and mortality have also begun to be more frequent in recent decades, conifer species such as *Pinus sylvestris* L. (Scots pine) and *Pinus nigra* Arn. (black pine) being among the most affected ones, at least in some areas (i.e., Brașov; Photo 1, A.-M. Hereş, personal observations; Petriţan et al., *in prep*.). Although the underlying factors of these processes remain largely unknown, it is becoming increasingly clear that the droughts (more frequent and severe) associated with climate change play a key role on how trees react, thus shaping the future of the forests (Levanič et al., 2013). If the severity and frequency of droughts increase in the future, according to climate change scenarios targeting Romania (i.e., an increase in average temperature by ≈ 2-3 ° C and a decrease in precipitation by ≈ 10% by 2100; IPCC, 2014), then the risk of increasing tree decline and mortality increases, which will impact on the short, medium, and long term the functioning and productivity of forests (Anderegg et al., 2013).

Photo 1: Scots pine affected by decline and mortality in the vicinity of the city of Brașov (*photo: Ana-Maria Hereș*)

In the Braşov area, there have been important processes of decline and mortality in recent years, affecting especially non-native species of planted conifers (Photo 1, e.g. outside the natural limits of distribution), all these processes taking place in periods immediately following consecutive years when temperatures and droughts were more intense than normal: 2000, 2001, 2002, 2003, 2007, 2009, 2010, 2011 or 2012 (http://www.meteoromania.ro/anm/?lang=ro_ro). On the contrary, native deciduous species do not appear to be affected by such decline and mortality events.

II. OBJECTIVES

The NATIvE project proposes the study, using dendrochronological methods (i.e., tree-rings) and field inventories (i.e., natural succession processes), of historical growth rates of planted non-native tree species (Scots pine and black pine) and of naturally present native tree species (*Quercus petraea* (Matt.) Liebl., sessile oak; and *Fagus sylvatica* L., European beech), as well as the study of the secondary succession of forests (i.e., regeneration), in forested areas from the Braşov region, affected by mortality among conifers.

Therefore, the objectives of the NATIvE project are: *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 native ones (sessile oak and European beech) to cope with droughts, and the ability of these tree species to recover after facing severe drought events; 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 stage I of the NATIvE project (02/05/2018 – 31/12/2018):

Activity 1.1: Selection of sites and tree species (non-native conifers and native deciduous trees), sampling (extraction of wood cores), as well conducting a first inventory of seedlings to estimate the regeneration of these tree species.

Activity 1.2: Measurements of annual tree-rings using specific dendrochronological methods and programs, activity that will be continued during stage II.

III. RESULTS

The identification and selection of forests to be studied within the NATIvE project; the selection and marking of planted non-native conifers and naturally occurring deciduous species; wood cores extractions:

For the selection of the study sites and tree species, the experience of the professors from the Faculty of Silviculture and Forest Engineering (Transylvania University of Brașov), who know very well the forests in the region of Brașov, was taken into account. In a first phase, considering the objectives of the NATIvE project, field visits were carried out to evaluate possible study sites and tree species. Accordingly, the study sites selected for the NATIvE project are the following: Codlea, Teliu, Lempeș, and Răcădău (Table 1). All four study sites show processes of decline and mortality among conifer species that have been planted in the past (Scots pine and black pine) and are mixed forests with native deciduous species (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

At the moment, all the trees (Table 1) that will be used within the NATIvE project have been identified and marked. At the same time, all these trees were georeferenced individually using a Garmin GPS in order to be later easily found to make seedlings inventories, this latter data being then analysed to estimate the regeneration of the studied species (Scots pine, Black pine, sessile oak and European beech). Two 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 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 extraction from sessile oak (Lempeş) (*photo: Jorge Curiel Yuste*)

Wood cores processing and measurements of annual tree-rings:

The sampled in the field wood cores were subsequently processed in the laboratory: dried, glued on permanent wooden supports, and progressively cleaned using abrasive sandpaper (granules of 60, 120, 500 and 1200) until the limits of the annual tree-rings became visible. Subsequently, all cores were scanned (A3 graphics scanner, Epson Expression 11000XL) at a resolution of 1200 dpi. The obtained images (.jpg and .tiff) are analyzed in order to measure the annual tree-rings using the CooRecorder and CDendro software (Cybis Dendrochronology) (Photo 3). Tree-rings measurements are currently in process and will continue during stage II because the amount of cores taken is large and the process of measuring the tree-rings is extremely elaborate.

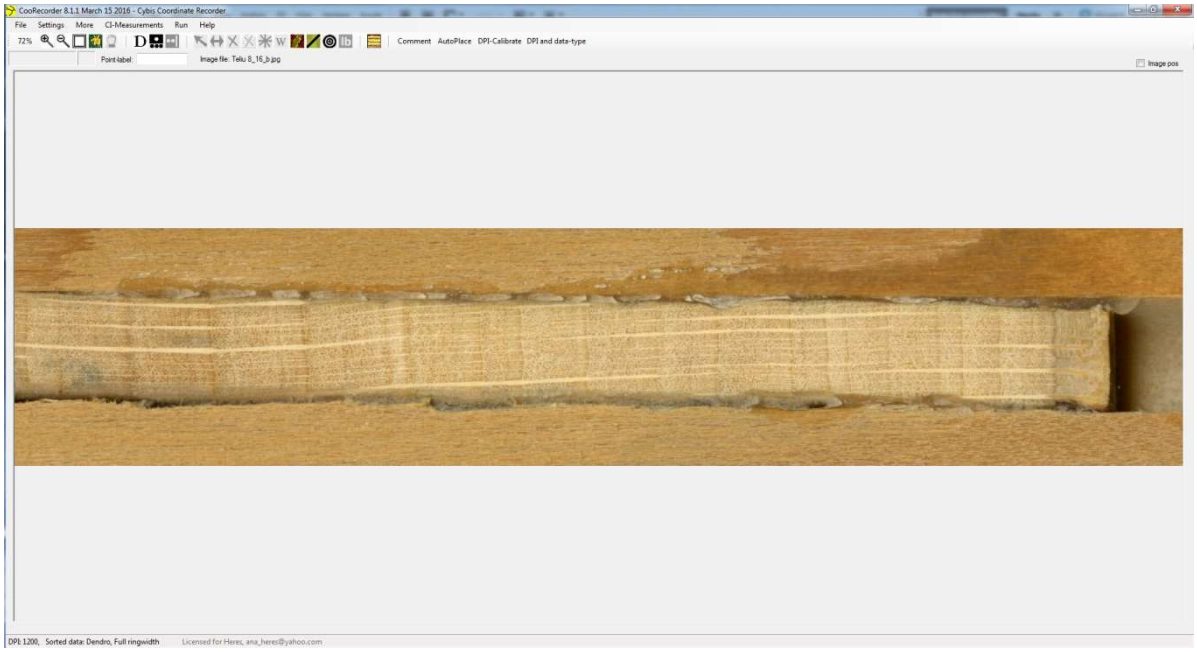

Photo 3: Analyses of wood cores using the CooRecorder software (European beech - Teliu) (*photo: Ana-Maria Hereş*)

The management of the project:

In order to implement the NATIvE project, different Pressler increment borers (600 mm, inner diameter of ≈ 5 mm), with two and three starts, were bought. These increment borers were used in the field to extract wood cores from conifers (Scots pine and Black pine) and deciduous (sessile oak and European beech) trees. At the same time and in accordance with the established working plan, travel expenses for field campaigns were also made.

IV. CONCLUSIONS

The activities (1.1 and 1.2) proposed for the I stage of the NATIvE project were successfully carried out during 2018. Within the next period the measurements of the annual tree-rings will be completed and the data will be analyzed. At the same time, a first evaluation of conifer (Scots pine and Black pine) and deciduous (sessile oak and European beech) tree seedlings was performed. This evaluation will be continued and estimated numerically in the next spring-summer period in order to properly evaluate the permanence and stability of the seedlings once the snow has melted.

V. BIBLIOGRAPHY

Allen, C.D., Macalady, A.K., Chenchouni, H., Bachelet, D., McDowell, N., Vennetier, M., Kitzberger, T., Rigling, A., Breshears, D.D., Hogg, E.H., Gonzalez, P., Fensham, R., Zhang, Z., Castro, J., Demidova, N., Lim, J.H., Allard, G., Running, S.W., Semerci, A., Cobb, N., 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. For. Ecol. Manage. 259, 660–684.

Anderegg, W.R.L., Kane, J.M., Anderegg, L.D.L., 2013. Consequences of widespread tree mortality triggered by drought and temperature stress. Nat. Clim. Change 3, 30–36.

Cailleret, M., Jansen, S., Robert, E.M.R., Desoto, L., Aakala, T., Antos, J.A., Beikircher, B., Bigler, C., Bugmann, H., Caccianiga, M., Čada, V., Camarero, J.J., Cherubini, P., Cochard, H., Coyea, M.R., Čufar, K., Das, A.J., Davi, H., Delzon, S., Dorman, M., Gea-Izquierdo, G., Gillner, S., Haavik, L.J., Hartmann, H., Hereş, A.M., Hultine, K.R., Janda, P., Kane, J.M., Kharuk, V.I., Kitzberger, T., Klein, T., Kramer, K., Lens, F., Levanic, T., López Rodríguez, J.C., Lloret, F., Lobo-Do-Vale, R., Lombardi, F., López Rodríguez, R., Mäkinen, H., Mayr, S., Mészáros, I., Metsaranta, J.M., Minunno, F., Oberhuber, W., Papadopoulos, A., Peltoniemi, M., Petritan, A.M., Rohner, B., Sanguesa-Barreda, G., Sarris, D., Smith, J.M., Stan, A.B., Sterck, F., Stojanovic, D.B., Suarez, M.L., Svoboda, M., Tognetti, R., Torres-Ruiz, J.M., Trotsiuk, V., Villalba, R., Vodde, F., Westwood, A.R., Wyckoff, P.H., Zafirov, N., Martínez-Vilalta, J., 2017. A synthesis of radial growth patterns preceding tree mortality. Glob. Change Biol. 23, 1675–1690.

Hereş, A.M., Martínez-Vilalta, J., Claramunt López, B., 2012. Growth patterns in relation to drought-induced mortality at two Scots pine (Pinus sylvestris L.) sites in NE Iberian Peninsula. Trees Struct. Funct. 26, 621–630.

Hereş, A.M., Kaye, M.W., Granda, E., Benavides, R., Lázaro-Nogal, A., Rubio-Casal A.E., Valladares, F., Curie Yuste, J., 2018. Tree vigour influences secondary growth but not responsiveness to climatic variability in Holm Oak. Dendrochronologia 49, 68-76.

IPCC, 2014. Climate change 2014: impacts, adaptation, and vulnerability. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the

Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 1132 pp.

Levanič, T., Popa, I., Poljanšek, S., Nechita, C., 2013. A 323-year long reconstruction of drought for SW Romania based on black pine (*Pinus nigra*) tree-ring widths. Int. J. Biometeorol. 57: 703 – 714.

Spiecker, H., 2003, Silvicultural management in maintaining biodiversity and resistance of forests in Europe – temperate zone. J. Environ. Manag. 67: 55 – 65.

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