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PREDICTIONS ABOUT SESSILE OAK FOREST ECOSYSTEMS FROM BANAT MOUNTAINS IN THE NEXT 80 YEARS

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Abstract

The climate impact on sessile oak ecosystems may be measured by means of the HYPE climatic software. The climatic modelling software is employed to predict future temperatures and precipitations across the studied teritory. After interpreting the data provided by the software, we can predict how forest ecosystems will be influenced by climate change in the future. Different plots across the Banat Mountain range have been studied in order to determine the future existence of oak forest ecosystems. Consequently, two simulations have been designed, leading to two different future climatic scenarios. To begin with, the first scenario there is a moderate increase in green house gases (rcp-4.5) whilst in the second scenario there is an accentuated increase (rcp-8.5). The analysis which resulted from the data processing from within all three sessile oak stands reveals the fact that the Moldova-Noua and Paltinis stands will be the most vulnerable ones and the Bocsa-Romana stand the less vulnerable one. The importance of these results is closely related to how local forest administrators can use such findings in order to apply the best management measures.

***Key words**: climate change, forest ecosystems, sessile oak, Banat Mountains.*

INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC) made climatic projections with increased seasonal temperatures and decreased amounts of summer rainfall in certain regions across the temperate zone (Christensen et al. 2007). There is recent scientific research in Europe in which authors studied effects of climate change on species distribution for beech (*Fagus sylvatica*) and silver fir (*Abies alba*) (Baumbach et al., 2019; Garcia-Duro et al., 2021).

For the next decades changes of temperature and precipitation patterns will reshape forest ecosystems as well as future forest management (Allen et al., 2010; Bonan, 2008; Lindner et al., 2010).

In Romania climate changes affected forest ecosystem of pines (Constandache & Dincă, 2019; Silvestru-Grigore et al., 2018; Vlad et al., 2019) and Norway spuruce (Murariu et al., 2021; Dincă et al., 2019). Beside trees (Dincă et al., 2020; Ducci et al., 2021; Kutnar et al., 2021), there is also a negative impact regarding region landscape (Fedorca et al., 2020), wildlife (Fedorca et al., 2021) or even logging (Cantar et al., 2022).

In this article we used a software "HYPE" wich is a climatic model developed by the Swedish Meteorological and Hydrologic Institute because it has a high resolution for estimating data in areas where no data are available.

The program has good results and easy in use unlike older models (Harper, 2008) wich they were generated errors (Dickinson et al., 1989) or being time consuming (Edwards, 2010).

The present research paper aims to analyze 3 sessile oak forest ecosystems which are representative for the Banat mountains regarding the future climate changes in the next 80 years. (Figure 1).

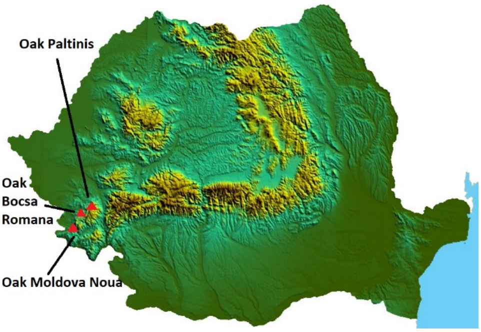

Figure 1. Location of oak plots in Banat Mountains

MATERIALS AND METHODS

The "HYPE" model and its software menus have been used in the current study with the purpose of introducing entrance parameters. Therefore the coordinates of points, the indicator type as well as the wanted climatic scenario have been introduced.
As a result, global warming is estimated to vary between 1 and 3.7°C, by means of the representative concentration pathway (RCP). Subsequently, simulations show that the database (present day 1986-2005) will be exceeded with values between 1.0 (RCP 2.6) and 3.7°C (RCP 8.5) by the end of the 21st century (Quante and Colijn, 2016).
There is a number of three scenarios that the HYPE software offers: there is a low growth in greenhouse gases ("Low - RCP 2.6"), there is a moderate growth ("Moderate - RCP 4.5") or a high growth ("High - RCP 8.5") (Figure 2).

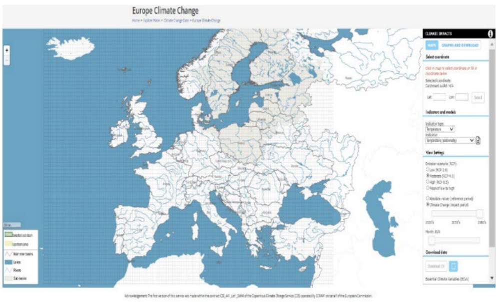

Figure 2. "HYPE" program menu

Following the choice of the scenarios, a convenient timeframe needed to be established (in our case 2100) and then we had to download the file from the "Download data" submenu.
Microsoft Excel was used to transform the obtained data into table form in order to represent monthly values. There are three sessile oak stands situated in the Banat Mountains that have been used to extract the data.
The HYPE Software belongs to a family of regional climatic models. The name REMO 2009 is related to a regional atmospheric model (REgional MOdel) which was originally developed by the Max Planck Institute for Meteorology (MPI-M) in Hamburg.
The reason for which the REMO 2009 model was chosen is because it is the most recent hydrostatic version (Jacob & Podzun, 1997; Jacob, 2001). To obtain average monthly values for the studied period (1971-2100) Microsoft Excel was used to process data.

RESULTS AND DISCUSSIONS

The results provided by the HYPE modelling program have been introduced in Microsoft Excel. The data processing shows both the mean annual precipitations and the mean annual temperatures for each stand up to the year 2100. Each scenario is represented in a graphical form: i.e. an average growth of greenhouse gasses (rcp-4.5) and a high growth of greenhouse gases (rcp-8.5). Also, there is a set of values for precipitations and for temperatures corresponding to each installed stand.
A problem that we have also faced in the analysis of the stands in the Transylvanian area (Crisan et al., 2021a; Crisan et al., 2021b) as well as in the area of the Moldavian plateau (Crisan et al., 2022) will be the productivity of the stands within the conditions of changing climatic factors.
In order to better explain the effects that these changes in climate data values have on the species and implicitly the forest ecosystems, we will refer to the ecological data sheets of the species taken from the Dendrology textbook (Şofletea and Curtum, 2008) (Table 1).
Thus, the sessile oak is not very particular about the summer heat, preferring a transitional climate from the Atlantic to the continental. It is a mesothermal, mesophytic species and its

ecological optimum in terms of precipitation is between 600-800 (850) mm/year. Sessile oak are located in the ecological optimum at the age of 100 years reach a productivity of 6 m³/year/ha (Stănescu et al., 1997 in Șofletea & Curtu, 2008).

Table 1. Ecologic card (Stănescu et al., 1997) *Quercus petraea* (Matt.) Liebl.

Ecologic factors	Values or states of ecologic factors													
	Variation of the species' biologic potential based on ecologic factors													
Average annual temperature (°C)	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11
								l	s	s	o	o	o	s
Average annual precipitations (mm)	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500		
		s	o	o	o	s	l	l						

where "l" represents the limit, "s" the suboptimum and "o" the optimum

The data from Table 1 represents the time period in which the annual average level of temperature and precipitation is representative for oak species. According to the future climatic scenarios there will be periods of time when the annual averages will exceed the species existence interval.

The first sessile oak stand under study in the area of the Banat Mountains is the one from Bocșa Română Forest District from Caras Severin County. It can thus be seen in Figure 3 the arrangement of the trees inside the sample surface.

Even if the basic species in this area is the sessile oak that forms the floor of the dominant and codominant trees, the existence of a sub-floor of vegetation corresponding to the trees and shrubs of several species can be observed as well. In this case, the hornbeam has a fairly consistent presence of approximately 34% (Figure 4) and this can give us an indication of how the composition of this forest ecosystem could evolve in increasingly limiting climatic conditions for the existence of the main species, namely the sessile oak.

Also, this composition represents a challenge for the management of this stand, as it is necessary to maintain a balance between the optimal development of the dominant trees, valuable from the forestry and economic point of view, and the gradual extraction of the less valuable trees, avoiding the sudden reduction of the stand's consistency.

For the sessile oak area installed at Bocșa Română Forest District, the annual average temperature shows an increasing trend in the case of both climate scenarios (Figure 5).

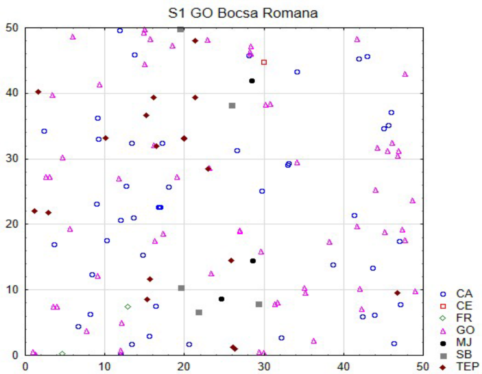

Figure 3. Tree positions for Bocsa Romana plot

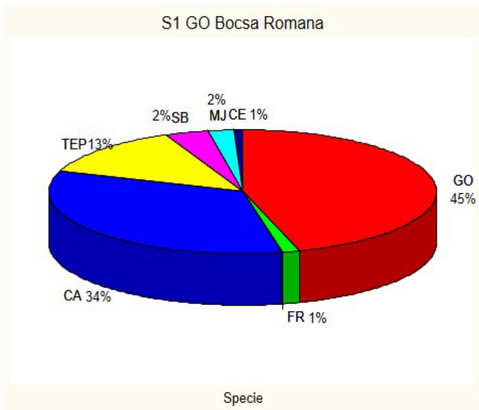

Figure 4. Forest composition for plot Bocsa Romana

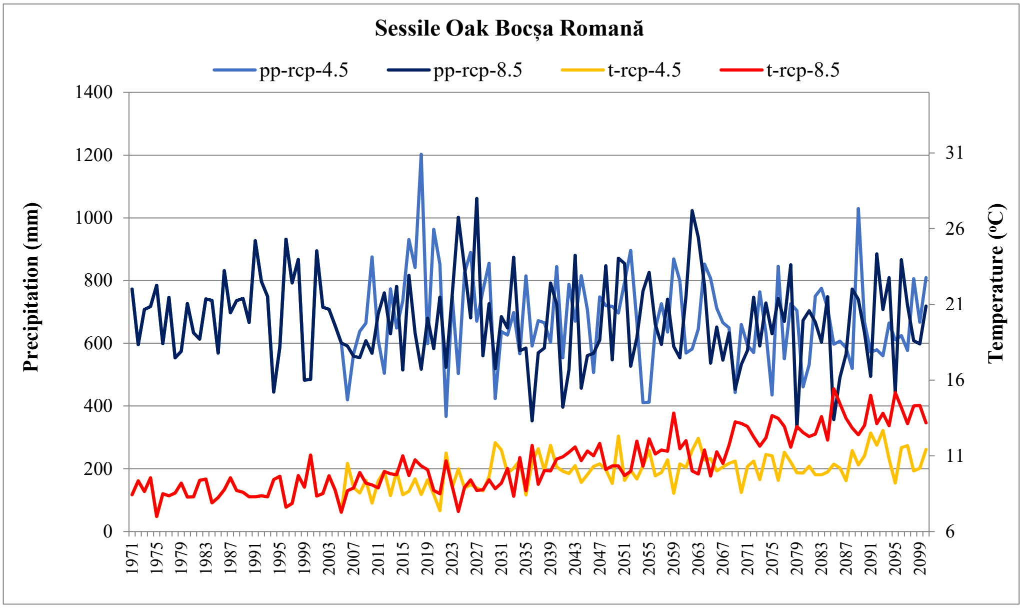

Figure 5. Climatic scenarios for the sessile oak plot from Bocsa Romana

For this location, in terms of annual mean precipitations in both rcp 4.5 and rcp 8.5 scenarios there does not appear to be any major problems in the future time frame, with most values falling between the extremes of the species range, for both climate scenarios. These stands will be less impacted in the next 80 years.

In the case of the annual average temperature in the first climate scenario rcp-4.5 there will be years in which stands will suffer from the increase in annual average temperatures.

In the case of the rcp-8.5 scenario in which greenhouse gases increase significantly from the year 2068, problems begin to appear, the average values of temperatures exceeding the endurance limit of the species and this will not change before the end of the analyzed time interval, namely the year 2100 .

The second experimental area was installed within the Păltiniș Forest District, forest unit V-111 C and represents the second area studied where the sessile oak is found as the main species in the Banat mountains. The layout of the trees can be seen in Figure 6.

It can be observed within this surface the small proportion of secondary species of the South European flowering ash and the European hornbeam (Figure 7).

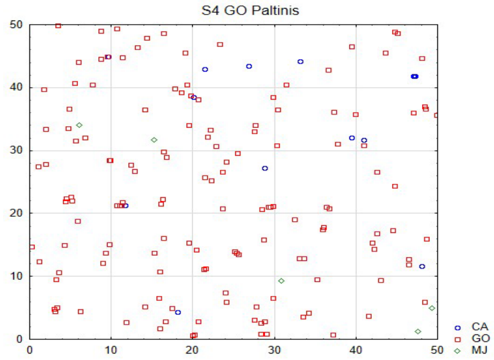

Figure 6. Tree positions for Paltinis plot

The sessile oak tree located in the area of Păltiniș Forest District seems to encounter higher temperatures and precipitation values with a negative effect on the growth and development of the trees than the one in Bocșa Română Forest District.

The prediction of the program for both climate scenarios (rcp-8.5 and rcp 4.5) in the case of precipitations shows us that the sessile oak stands in this area will be slightly impacted with only 6 predicted exceedances of the lower thresholds in the next 80 years in the case of the rcp 4.5 and rcp scenarios 8.5 (Figure 8).

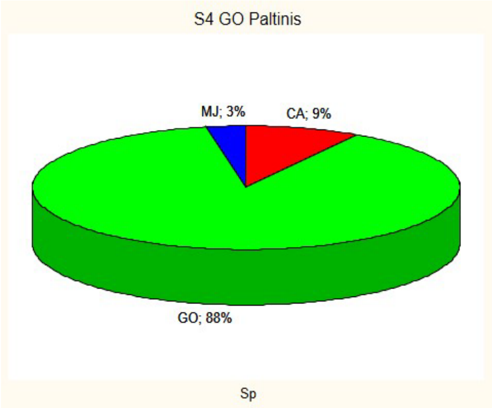

Figure 7. Forest composition for plot Paltinis

From the point of view of the evolution of the average annual temperatures, there will be very serious problems for the trees that grow in this area. Thus, in the case of both climate scenarios, there are more than 70 years in which these trees will be subjected to temperature stress. This situation is all the more worrying since towards the end of the time interval the average annual temperatures will exceed by 6°C or even 7°C the limit value of the existence of the species (as the stands are very strongly impacted).

The experimental area 7 was installed within the Moldova Nouă Forest District, IV-7B united forest and represents the last sessile oak area within the Banat Mountains. The layout of the trees can be seen in Figure 9.

Even if the basic species in this area is the sessile oak that forms the floor of the dominant and codominant trees, the existence of a sub-floor of vegetation corresponding to the trees and shrubs of several species can be observed. In this case, the sorbus is present in a proportion of 12%, field maple 10%, hornbeam 7% and ash 2% (Figure 10). This can give us an indication of how the composition of this forest ecosystem could evolve in increasingly limiting climatic conditions for the existence of the main species, namely the sessile oak.

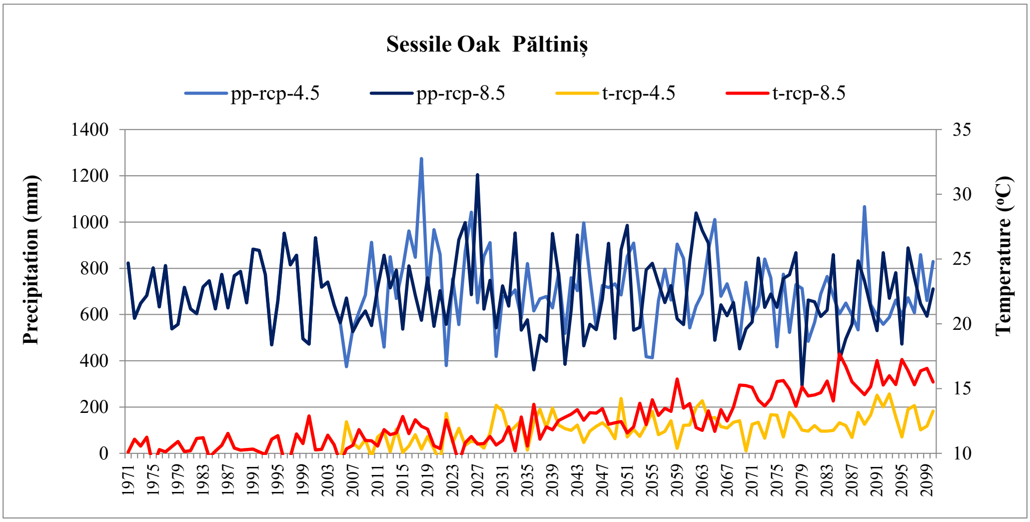

Figure 8. Climatic scenarios for the sessile oak plot Paltinis

The surface located within the Moldova Nouă Forest District is the last surface analyzed in the Banat Mountains area, being made up of almost 70% of sessile oak (Figure 10).

It can be seen that the arboretum will have problems not so much because of the lack of precipitation as because of the increase in average temperatures throughout the half of the 21st century (Figure 11).

Thus, the sessile oak from Moldova Nouă Forest District will be very strongly impacted unlike (Bocșa Română forest plot) the first stand analyzed (the one from Bocșa Română) and like the stand from OS Păltiniș, having 75 and 74 values that will exceed the heat tolerance threshold of the species.

In the case of both climate scenarios, rcp-4.5 and rcp-8.5, from the point of view of average annual precipitations, the sessile stands will be slightly affected, so in this area there will be no problems in the water supply from precipitations even if the darkest scenarios of climate change are met.

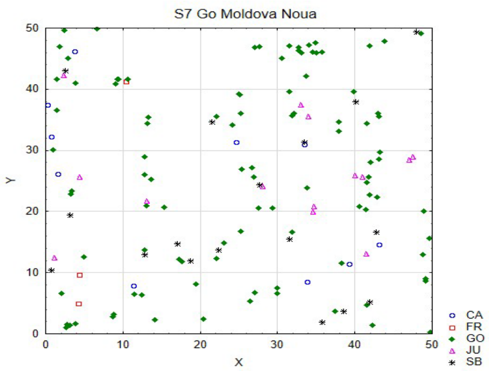

Figure 9. Tree positions for Moldova Noua plot

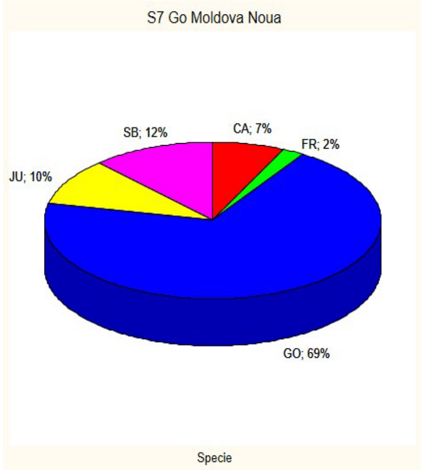

Figure 10. Forest composition for plot Moldova Noua

In the case of the rcp-4.5 climate scenario, the impact of average annual temperatures will be medium and very strong in the case of sessile oak stands. In the case of the rcp-8.5 climate scenario, the impact of average annual temperatures will be strong and very strong in the case of the sessile oak.

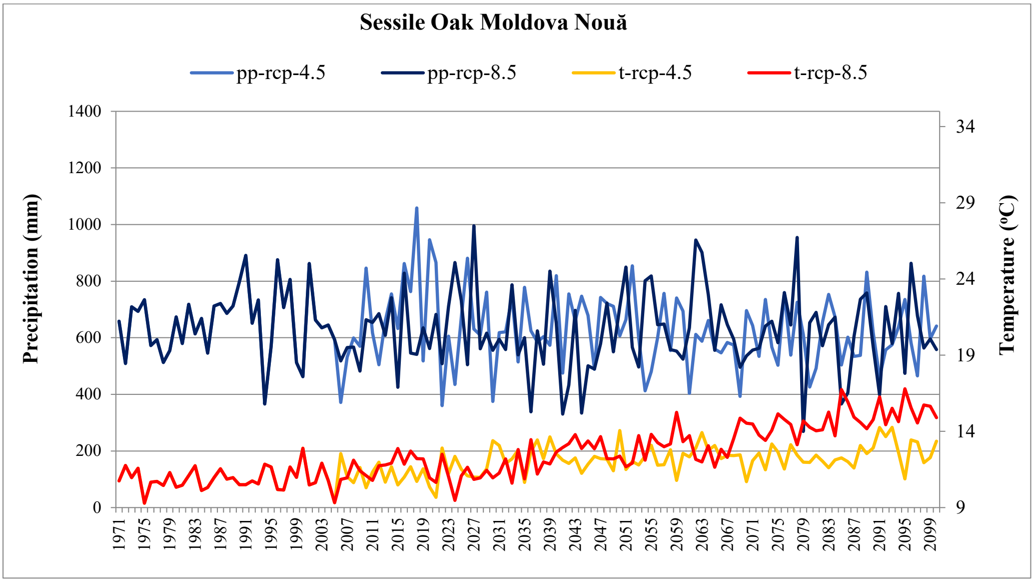

Figure 11. Climatic scenarios for the sessile oak plot from Moldova Noua

CONCLUSIONS

The research study analyzed three oak forest ecosystems from the Banat mountains in future climatic scenarios characterized by the increasing effects of greenhouse gas concentrations. Over the next 80 years, the climatic scenarios have been analyzed in the context of moderate and significant changes. Depending on the changes that can be anticipated regarding changes in temperature and precipitation regimes on ecological indicators, periodic evaluations and studies are needed to determine their spatio-temporal variability. At the same time, by capitalizing on and improving a database, forecasts of the impact of destabilizing climate factors on forest ecosystems can be issued.

Moreover, forestry must take into account the future changes in the ecological conditions of the species so that, through the accumulation of silvotechnical works, decision-makers can intervene promptly and efficiently.

At the same time, a rethinking of both regeneration solutions and the choice of species for afforestation can significantly contribute to the creation of stands much more resistant to future climate changes.

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