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SUITABILITY FOR TREE SPECIES AFFORESTATION USING GIS AIDED LANDSCAPE MODEL IN THE REPUBLIC OF MACEDONIA

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Abstract: The area of the Balkan Peninsula has been exploited to a large extent throughout the history. For thousands of years this region has been populated; much of the landscape has been distorted and on certain vulnerable sites not much of the primary vegetation is left. There are information from the famous Turkish traveler Evlija Celebija from couple of centuries ago, that the area along the river Vardar was covered with dense forest. Today this area is the most vulnerable area to desertification. The purpose of this study is to assess the possibility to do a forestation of the non-forested vulnerable areas with the most common autochthonous tree species and to assess the best suitable places for the reforestation on the area of the Republic of Macedonia. The study area is very diverse in sense of the growth conditions for the trees. For this study dozen tree species are chosen from different climatic zones in which they normally thrive. For identifying the natural potential of the site, three main factors were chosen: soil with geology, slope and vegetation zones. These factors were integrated into a GIS landscape model created through multi-criteria decision process. Finally, suitability maps for afforestation of different tree species were created.

Keywords: natural regeneration, forest tree species, sustainable development

INTRODUCTION

A main feature of the Republic of Macedonia is its richness of the dendroflorae (Dzhekov, 1988). The reason for this is the geographical location of the country, the development of the relief, the climate diversity, the changes in parental rock, etc. The territory of Macedonia has been quite exploited in the past couple of centuries which now results in large un-vegetated areas; mainly these are the areas along the river of Vardar. Afforestation measures have taken place after the Second World War, which have alleviated the general condition, but there are still large areas needed to be forested. Hence, the reason for writing this paper and determine the proper tree species used in the process and their allocation both vertically and horizontally. To this end, it was decided to choose from 15 species assembled in three groups, namely, deciduous, coniferous and shrubs. The species used in the afforestation process must be indigenous as this is enforced by the Law on Nature (Official Gazette 67/04) of the Republic of Macedonia. Each of the species represents a number of other species which thrive together in an association. These species have been carefully selected, in order for them to be used for planting throughout the country, in various climate and soil conditions, and also as an example/sample of their ecological group: xero-, meso- and hygrophyte plant species.

According to Filipovski Gj. *et al* (1996), the Republic of Macedonia is divided on 8 climate-vegetation-soil zones. These are:

1. Sub-mediterranean zone (50-500 m.a.s.l.)
2. Continental-submediterranean zone (up to 600 m.a.s.l.) (covers 34,9% of the territory of RM)
3. Warm continental zone (600-900 m.a.s.l.) (27,4%)
4. Cold continental zone (900-1100 m.a.s.l.) (13,3%)
5. Sub-mountainous continental-mountainous zone (1100-1300 m.a.s.l.) (9,7%)
6. Forest-continental-mountainous zone (1300-1650 m.a.s.l.) (10,4%)
7. Sub-alpine mountainous zone (1650-2250 m.a.s.l.) (3,8%)
8. Alpine mountainous zone (above 2250 m.a.s.l.) (0,5%)

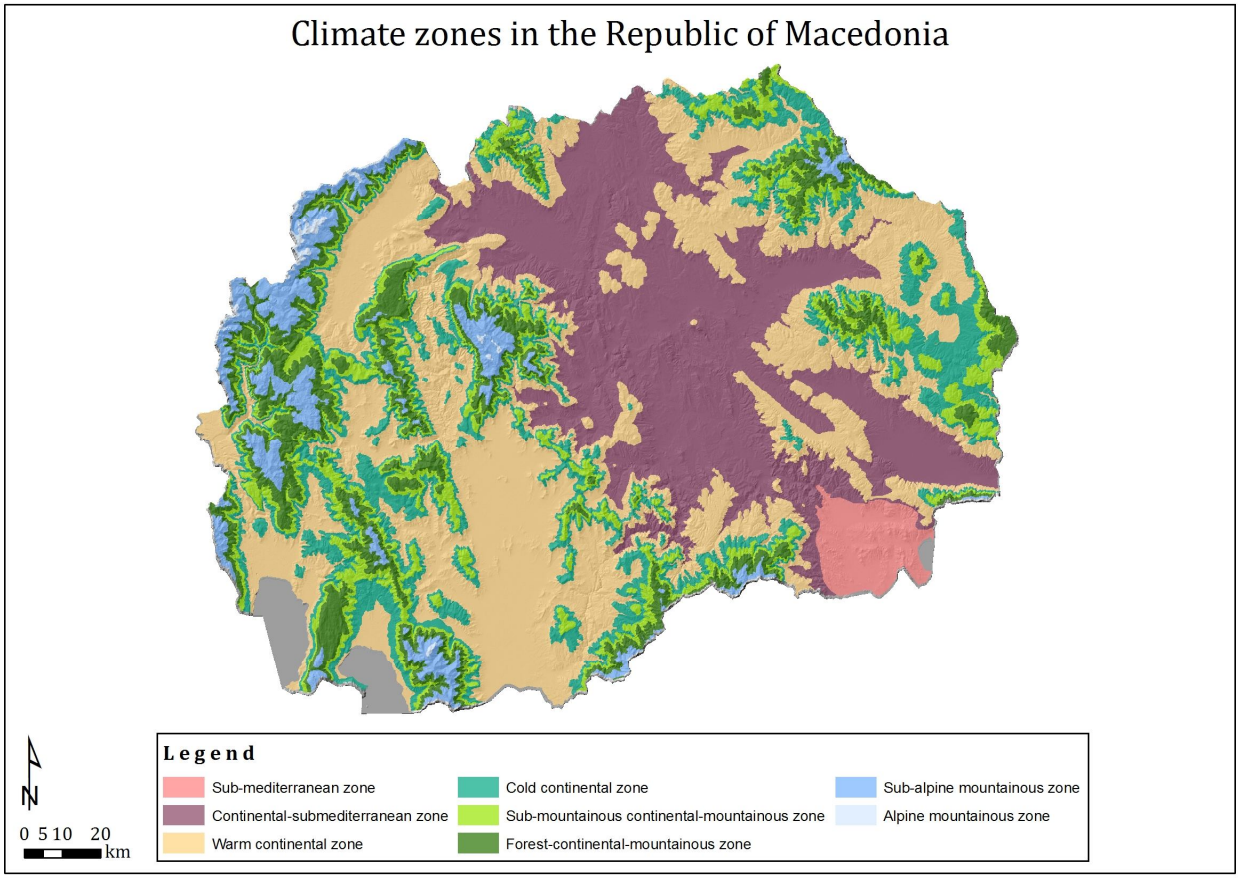


Figure 1. Climate-vegetation map of the Republic of Macedonia.

The characteristics of the vegetation will be presented by describing each of the above zones.

***Coccifero-Carpinetum orientalis* Oberd. 1948 emend. Ht. 1954** - *Sub-mediterranean zone*

This zone is located in the most southern part of the Vardar valley (Gevgelija region). It spreads to the lake Dojran on the east, covers smaller areas and can be found on altitudes varying from 40-500 meters above sea level. The climate in this zone can mostly be described as Mediterranean, because it can be felt throughout the region. The Aegean Sea is 60-90km away; the zone is protected from the continental climate by the surrounding mountains. The mean annual temperature is 14,2°C. The vegetation in this zone actually is the northern widespread of the vegetation which is located in Greece. The difference between this zone and the "greek phrygana" is the abundance of deciduous trees and shrubs. Coniferous hard-leaved woody species are present, primarily the oak *Quercus coccifera* and *Phillyrea media*, and from the deciduous the Downy oak (*Quercus pubescens*) and the Oriental Hornbeam (*Carpinus orientalis*).

Querco-Carpinetum orientalis macedonicum **Rudski 1939 apud. Ht. 1946** - *Continental-submediterranean zone (up to 600 m.a.s.l.)*

This zone occupies larger areas in the country, mainly the central and northern parts of it. The valleys along the river Vardar are mostly notable in this zone. The relief is elevated up to 600 meters, but can go as low as 100 meters (Tikvesh, Veles, etc.), meaning the difference in altitude is 500 meters. The geological composition is heterogeneous. This zone is typical transitional zone in which the Mediterranean and east-continental influences are apparent and combined. At the same time, the influences vary with location. The Mediterranean climate is mostly prominent in the southern part, and then weakening in each direction, especially towards the north. The influence of the continental climate is more perceptive towards the mountainous regions. The mean annual temperature is 12,7^{o}C, while the mean annual precipitation is 507mm. This zone is characterized by being termophyle and xerophyle association with a specific physiognomy and ecology. Dominant species are: *Quercus pubescens*, *Fraxinus ornus* (Flowering Ash), *Carpinus orientalis*, *Acer monspessulanum* (Montpellier maple), etc.

Quercetum frainetto-cerris macedonicum **Oberd. 1948 emend. Ht. 1959** - *Warm continental zone*

The climate properties in this zone are unfavourable for the endemic species; the drought eliminates the mesophil component, while the cold winter eliminates the termophyle one. The human factor also plays a part in this regard. *(600-900 m.a.s.l.)*
The main role in this association belongs to the Hungarian oak (*Quercus frainetto*) and the Turkish oak (*Quercus cerris*). The Hungarian oak is more dominant. This, at times can be false, but that is only due to the logging of the Hungarian oak. Some parts of these forests are subjected to regressive succession, hence a large part of the forests are being transformed from high stand forests to coppice forests. Erosion follows the destruction of the forests. Due to the riffle soil layer, the conditions for afforestation of the same species are minimal. After the destruction of the association in some parts of the study area, the black pine (*Pinus nigra*) has inhabited the land as secondary habitat. Other associations or individual species can populate some area if it has been subjected to regressive succession.

Orno-quercetum petraeae **Em 1968 -** *Cold continental zone*

Starting from this association and upwards, there are no valley terrains, but only mountainous ones. This association usually spreads at altitudes of 900-1100 m.a.s.l., actually the lower part (base) of the mountains. The sessile oak (*Quercus petraea*) is the dominant species in this association, and they are the last oak species (in terms of vertical expansibility). This region is also characterized by having large agricultural areas, grazing lands and meadows). This also means that the forests in this area are being destroyed on account of farmlands. Other species accompanying the sessile oak are the beech (*Fagus sylvatica* ssp. *moesiaca*), the hop hornbeam, the chestnut (*Castanea sativa*), other oaks (*Q. frainetto, Q. pubescens*), etc. However, there are many other species of trees and shrubs which can be found in this association. The geologic background is silicate or carbonate.

Festuco heterophyllae - Fagetum **(Fagetum submontanum) Em 1965 -** *Sub-mountainous continental-mountainous zone*

This is an association which inhabits the areas where the sub-mountain continental mountainous climate is apparent. It spreads at altitudes of 1100 to 1300 m.a.s.l. The geological substrate comprises compact silicate and carbonate rocks. This association has some similarities with the next one upwards, but also differs off it. The beech *region* starts from these altitudes and upwards. This region is widely spread, hence its occupation of large areas. The climate conditions in this region are sub humid, without periods of drought, favourable for occurrence of beech and beech-fir forests. These forests are climate-zonal, mesophil and are divided in two belts: lower sub-mountainous and upper mountainous. The beech in this region is believed to be *Fagus sylvatica* L., but these species differs from that in Central Europe for instance. Micevski (1993), discusses that the beech is *Fagus sylvatica*

L., and that the taxon *moesiaca* (*Fagus moesiaca* K. Maly) can be found on some habitats, but only as a form. Other tree and shrub species that can be found in this association are: *Carpinus betulus* (European Hornbeam), *Corylus avellana* (common Hazel), *Quercus petraea*, *Prunus avium* (Wild cherry), *Festuca heterophylla* (Variousleaf fescue), *Euonymus latifolia* (Broad Leaved Spindle), and many others. In broader areas, and on flatter lands, this association is destroyed and replaced by grazing lands, meadows. All communities in this association are mesophil and neutral, but some areas are extremely acid as well (Malesh). It can be noted that, in this association, two communities of pine forests are apparent (*Orno-Pinion* Em and *Fago-Pinetum nigrae* Ht. et Em).

Calamintho grandiflorae-Fagetum* Em 1965 *(Fagetum montanum) - *Forest-continental-mountainous zone*

This is the area of the zonal-climate vegetation where beech forests thrive most and can be found at altitudes ranging from 1300 to 1650 meters above sea level. The relief is mountainous and the substrate mainly comprises compact silicate and carbonate rocks. The climate conditions in these large areas are characterized by not having a drought, the extreme temperatures are mild, while occurrences of fog are often. The dominant tree species is the beech (*Fagus sylvatica* ssp. *moesiaca*) and by its dominance it prevents other species to thrive. Hence, the European silver fir or Bulgarian fir (Micevski K., 2005) (*Abies alba /A. borisii-regis*) is struggling to advance more. Shrub species are also not well developed and the ground story consist only species which are shade-tolerant. Other deciduous tree species that can be found in this zone are the Norway maple (*Acer platanoides*) and the Wych elm (*Ulmus scabra*), among others. It must be noted though, that due to destruction of the beech-fir forests, the Scots pine (*Pinus sylvestris*) forms a community on secondary habitats (*Fago-Pinetum silvestris* /Ht et Em 1963/ Em 1981), especially on north and cold expositions (aspects). This zone of pure beech forests are mesophil, neutral to weak acid.

Sub-alpine mountainous zone

This zone encompasses the forest associations of the sub-alpine beech, the fir, the Norway spruce (*Picea abies*), the Macedonian pine (*Pinus peuce*) and the mugo (mountain) pine. This zone spreads in relatively wide mountain belt, ranging from 1650 to 2250 meters above sea level. The geological composition in this zone mainly comprises silicate and carbonate rocks. The climate in this zone is typical mountainous climate. The temperatures drop during all the seasons, especially during the summer and the spring. The summers tend to get shorter, colder and more humid, while the winters are longer, pretty cold and snowy. The vegetation period is rather short in this zone. The mean annual temperature in this zone is 4^{o}C, but this is not deemed as an accurate number due to the reason that the meteorological station is located only 100 meters above the lowest boundary of this belt (1650 m). Interpolation results in mean temperature of 3,5^{o}C. The mean annual precipitation is 1001mm. The increase in altitude results in reduction of the precipitation. This is the highest, last vegetation belt where the species have to fight for survival in the unfavourable conditions. Several climate-zonal associations are apparent in this zone; such are the communities of the sub-alpine beech, the fir, the spruce and the Macedonian pine. The Scots pine and rarely the black pine can be found as secondary habitats in some conditions. However, the forests in this zone have been cut down in many areas because high quality pastures were the result out of it.

Alpine mountainous zone

This zone represents the areas above 2250 meters occupying the territory of the Republic of Macedonia. This is the area where climate-zonal high-mountainous grass communities are apparent. The geological substrate is composed of silicate and carbonate compact rocks. The climate in this area is characteristically mountainous- alpic, and is more explicit in regard to the previous zone. Most notable differences are the average and extreme temperatures, as is their distribution throughout the year. This is the only zone where the mean annual temperature is below 0, -0,4^{o}C specifically. The

annual precipitation is 791mm and is 25% less than the previous zone. The grass vegetation belongs to two orders of species: *Onobrycheto-Seslerietallia* Ht (on carbonates and dolomite) and *Seslerietallia comosao* Simon (on silicate surface).

The aim of this study is to develop a model for allocation of suitable locations for planting purposes of 15 shrub and tree species.
In accordance with the national legislation, the species used during the afforestation/reforestation processes, must be of indigenous origin. In order for us to take into account the diversity in species occupying the territory of the Republic of Macedonia, we've decided to produce suitability maps for 15 species which are in several ways leaders in their respective communities/associations. These species are:

Shrub species	**Deciduous trees**	**Coniferous trees**
Rubus ulmifolius	*Ostrya carpinifolia*	*Pinus nigra*
Juniperus oxycedrus	*Quercus petraea*	*Pinus sylvestris*
Corylus avellana	*Betula pendula*	*Pinus peuce*
Taxus baccata	*Fagus sylvatica* ssp. *moesiaca*	*Abies alba*
Salix alba	*Populus alba*	*Picea abies*

This was made possible through realizing several objectives:

1. Procuring an climate-vegetation map
2. Soil data categorization
3. DEM

STUDY AREA AND DATASET DESCRIPTION

The Republic of Macedonia is located in the central part of the Balkan Peninsula. It is a landlocked country with a total area of 25,713 km^2 and approximately 80% of the entire territory is represented by hilly and mountainous regions. About 2% of the land area is covered by water, comprising 35 large and small rivers, three natural lakes (Ohrid Lake, Prespa Lake, Dojran Lake), and over 100 artificial reservoirs.

Figure 2: Location of the study area.

The dataset used for this research comprised the following:
DEM - An 80 meter resolution digital elevation model, from which slope was derived. Hillshade was also derived to provide better visual representation of the terrain as a background layer.
Climate-Vegetation-Aspect map - This map represents the climate-vegetation zones in the Republic of Macedonia, by taking in regard the aspect as well.
Soil map - soil map of the country was used in the calculations for suitable locations for the species in question.

METHODOLOGY

The whole of the territory of the Republic of Macedonia was taken into consideration during the conduct of this research. This was carried out for a reason to get a general idea about the distribution of species throughout the country. The input data used was the *soil* data, the *climate-vegetation* data and the *slope* data. These, were subsequently divided into several categories as presented in the tables below. For each of the categories a value was defined. This value represents the possibility of a species to thrive on such a terrain. It was decided to provide the same grade/value for the soil and slope categories for a simple reason that each of the species would thrive better on richer soil (cambisoil in relation to lithosoil, although some of the species are not to be found on silicate/carbon rocks in Macedonia) and would vegetate better on flat terrain rather than one that is steeper. The Altitude, (m) rows, represent the climate-vegetation data but shown in meters above sea level. For instance *Quercus petraea* thrives best at altitudes of 900-1100 meters. It can also be found on lower or higher altitudes (i.e. climate zones), but the value decreases accordingly. The quantification process can be seen in the following tables.

		Shrub species				
		Rubus ulmifolius	*Juniperus oxycedrus*	*Corylus avellana*	*Taxus baccata*	*Salix alba*
Soil	Lithsosoil/Regosoil/Syrosem	1	1	1	1	1
	Colluvial soil/Calcomelanosoil	2	2	2	2	2
	Cinamonic/Ranker/Vertisoil	3	3	3	3	3
	Rendzinic soil/Alluvial/	4	4	4	4	4
	Cambisoils/Cernzoem	5	5	5	5	5
Altitude (m)	to 600	8	8	8	6	10
	from 600 to 900	10	10	10	8	8
	from 900 to 1100	8	8	10	10	6
	from 1100 to 1300	6	6	8	8	4
	from 1300 to 1650	2	4	6	4	0
	over 1650	0	2	0	2	0
Slope (%)	to 10	5	5	5	5	5
	from 10 to 20	5	5	4	5	4
	from 20 to 30	4	4	3	4	2
	from 30 to 40	4	4	2	3	0
	from 40 to 50	2	1	0	1	0
	over 50	1	1	0	1	0

		Deciduous species				
		Ostrya carpinifolia	*Quercus petraea*	*Betula pendula*	*Fagus sylvatica ssp. moesiaca*	*Populus alba*
Soil	Lithsosoil/Regosoil/Syrosem	1	1	1	1	1
	Colluvial soil/Calcomelanosoil	2	2	2	2	2
	Cinamonic/Ranker/Vertisoil	3	3	3	3	3
	Rendzinic soil/Alluvial/	4	4	4	4	4
	Cambisoils/Cernzoem	5	5	5	5	5
Altitude (m)	to 600	8	4	6	2	10
	from 600 to 900	10	8	8	4	6
	from 900 to 1100	8	10	10	6	4
	from 1100 to 1300	4	8	8	10	2
	from 1300 to 1650	2	4	6	4	0
	over 1650	0	0	0	2	0
Slope (%)	to 10	5	5	5	5	5
	from 10 to 20	5	4	5	4	4
	from 20 to 30	5	3	3	3	2
	from 30 to 40	4	2	3	2	0
	from 40 to 50	3	1	1	1	0
	over 50	2	0	0	0	0

		Coniferous species				
		Pinus nigra	*Pinus sylvestris*	*Pinus peuce*	*Abies alba*	*Picea abies*
Soil	Lithsosoil/Regosoil/Syrosem	1	1	1	1	1
	Colluvial soil/Calcomelanosoil	2	2	2	2	2
	Cinamonic/Ranker/Vertisoil	3	3	3	3	3
	Rendzinic soil/Alluvial/	4	4	4	4	4
	Cambisoils/Cernzoem	5	5	5	5	5
Altitude (m)	to 600	2	0	0	0	0
	from 600 to 900	6	4	0	4	0
	from 900 to 1100	10	6	4	6	0
	from 1100 to 1300	10	8	8	10	4
	from 1300 to 1650	4	10	10	4	10
	over 1650	0	2	2	2	6
Slope (%)	to 10	5	5	5	5	5
	from 10 to 20	5	5	5	5	5
	from 20 to 30	5	5	5	5	5
	from 30 to 40	4	4	4	3	4
	from 40 to 50	2	2	2	2	2
	over 50	2	2	2	1	2

Tables 1, 2 and 3: Quantification of the slope, altitude and soil data for each of the species used.

During the production of the maps, normally, there were areas where the respective species cannot be found in natural circumstances. Such areas (altitudes, zones) were given a value of zero (0). Hence, the needs for a Boolean map (a map consisting of areas with a value of zero (0) and one (1), where the zero represents an area not suitable, and one represents the opposite). The final equation is:

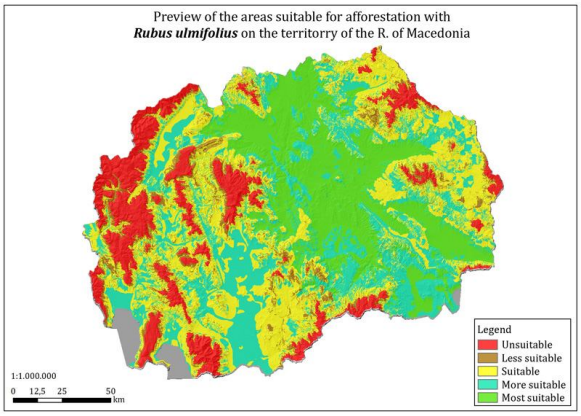
*([soil value] + [climate value] + [slope value]) * [Boolean map of the species in question]*

This equation resulted in a stretched suitability map with values from 0 to 20. Each of the maps was reclassified into five (5) classes.

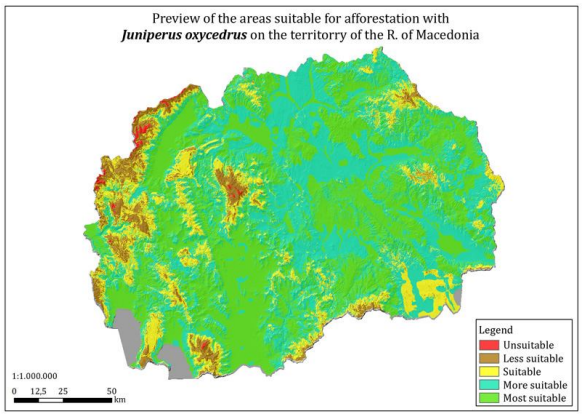
0 - 3	4 - 8	9 - 12	13 - 16	17 - 20
Unsuitable	Less suitable	Suitable	More suitable	Most suitable

RESULTS AND DISCUSSION

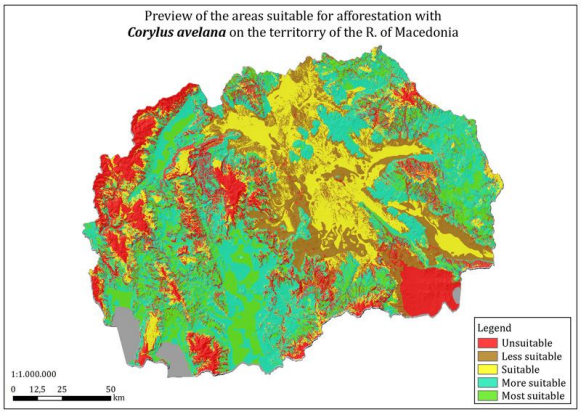
The results of this research are suitability maps which present the suitable locations where each of the fifteen species involved can be planted throughout the territory of the Republic of Macedonia.
Brief description for each of the species will be presented below, accompanied by a suitability map for the species in question.



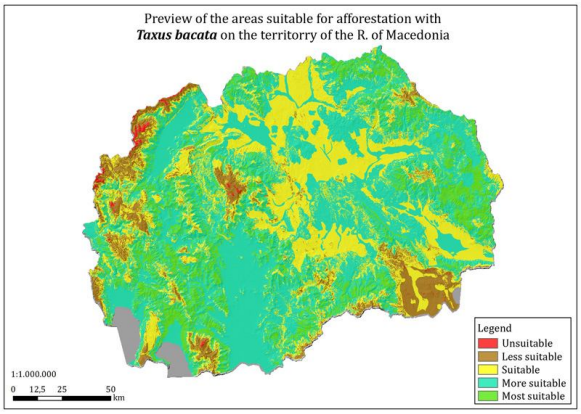
The distribution of the suitable locations for the *Rubus ulmifolius* (wild blackberry) has resulted with very high accuracy. Field surveys have aided to this assertion. Since the *Rubus ulmifolius* thrives mostly on areas with altitudes up to 900 m.a.s.l., the *suitable* locations on the map along the river Vardar, as well as the lower terrains of the country are the ones where the wild blackberry is mostly populated. The higher altitudes are not suitable for afforestation with the *Rubus ulmifolius*.



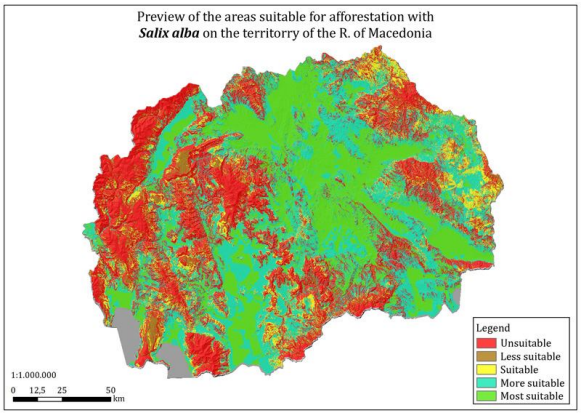
The *Juniperus oxycedrus* (prickly juniper) map is accurate and according to its ecology it is *most suitable* to areas with altitudes ranging from 700-900 m.a.s.l. This juniper in Macedonia has *common distribution*, so big amount of terrains which are not populated by other tree species and are mostly influenced with warmer to temperate climate can be occupied by *Juniperus oxycedrus* (most likely because of its *wide ecological amplitude and its pioneer characteristics*).



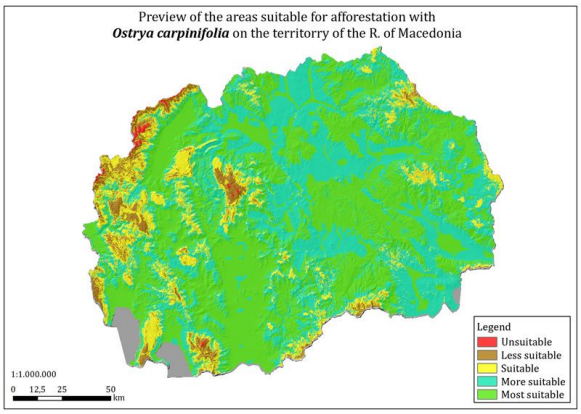
The map shows the *most suitable areas* for planting with *Corylus avelana* (common hazel) which are at medium altitude (800-1000 m.a.s.l.), but here are also included faulty suitable areas which are situated in some parts of the Vardar valley which is influenced by the sub-mediterranean climate. The common hazel is a *mesophyte*, so this map has *questionable medium to low* accuracy for future population of the *Corylus avelana*.



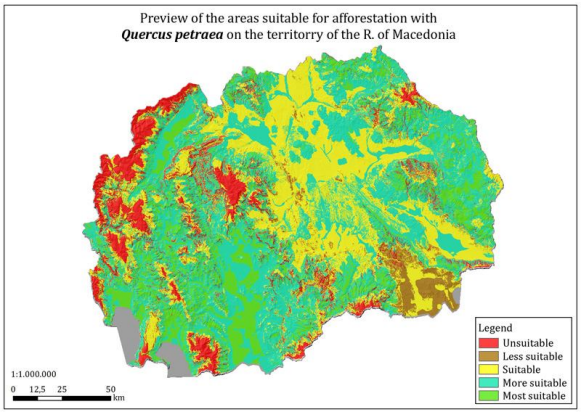
Common yew (*Taxus baccata*) has *common range* in Macedonia, particularly *under the canopy* of dense forests (because of its shade tolerance). *Taxus baccata* thrives on moist climates, but also has ecological capability to thrive on different soils and air conditions. The distribution of the common yew in the nature is now much reduced, but as a shade tolerant shrub with ecological engagement, this map has *medium to high accuracy*.



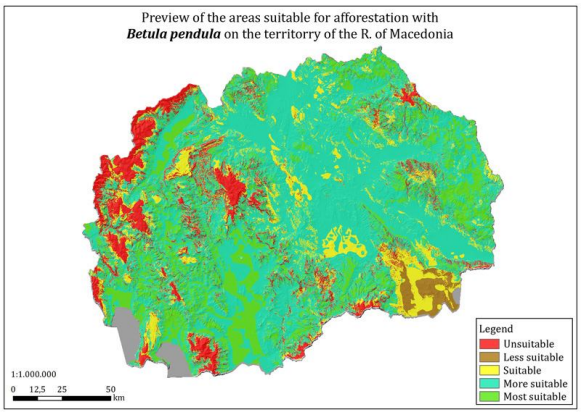
This distribution map of the white willow (*Salix alba*) is *highly accurate*. *Salix alba* is a representative of the common riverside dendrofloral elements of the ravines and valleys and often river hills in Macedonia. This tree species can be found and planted almost at every *floodplain at low to medium high altitude*.



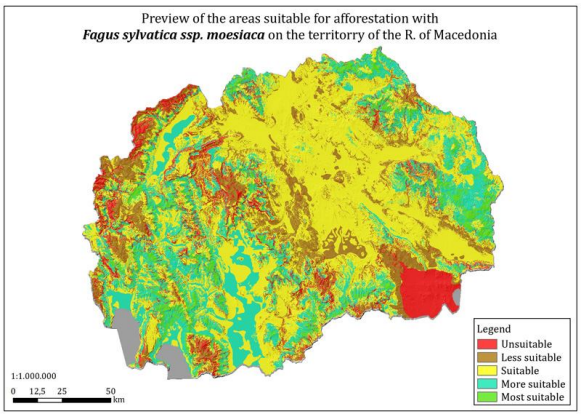
The European hop-hornbeam (*Ostrya carpinifolia*) can be found on various areas- various altitudes, rocks and soils, climate, particularly on south exposure sites. Therefore, the map has *high accuracy*. Likewise, *Ostrya carpinifolia* is also one of the most used species for afforestation and reforestation in Macedonia.



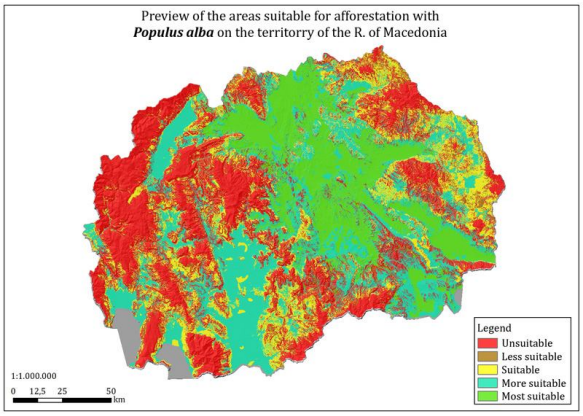
Considering that the Sessile oak (*Quercus petraea*) cannot populate areas which are on carbonate rocks/soils, the model for this species results in *satisfactory accuracy*. Additionally, this oak being a mesophyte, cannot be planted on the dryer and lower parts of the Vardar valley.



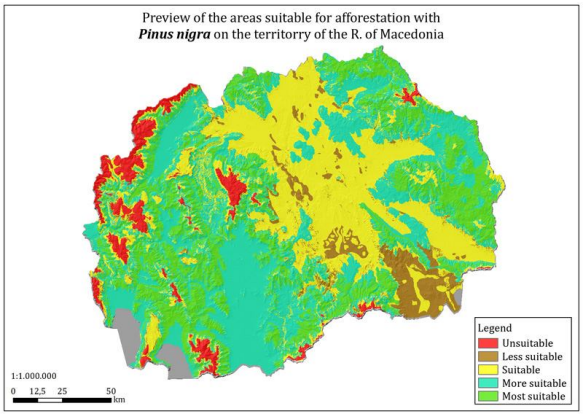
The European silver birch (*Betula pendula*) is a *mesophyte* pioneer. Likewise, the birch has an *ecological boundary*- hot and dry breeze during the summer. This map shows *high accuracy* for the mountainous region and river banks, where the humidity in the air and the soil is high. On the other hand, for the parts of the country with dryer and warmer climate, the map is *low accurate*.



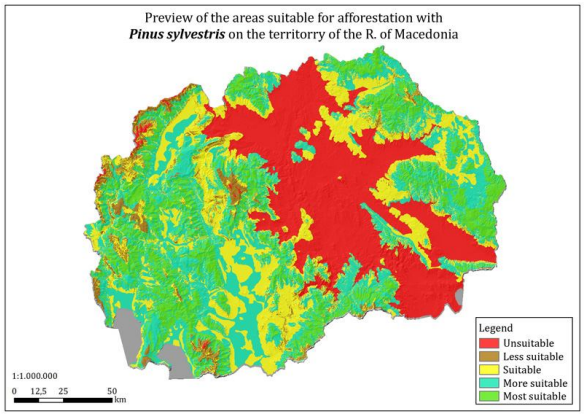
The beech (*Fagus sylvatica* ssp. *moesiaca*) is a *mesophyte*. This map shows suitable areas of the Vardar valley which *cannot be planted* with this tree species (although, as a *local ecologically conditioned phenomenon*, there are several beech particles in the low altitude areas). The beech populates high altitude areas (800-900 and up to 2000 m.a.s.l.), with high air and soil humidity in the mountainous and subalpine region. In conclusion, this map shows high accuracy for the "*most suitable*" areas, whereas the areas designated as "*suitable*" are not completely accurate (i.e. dryer parts of the Vardar valley).



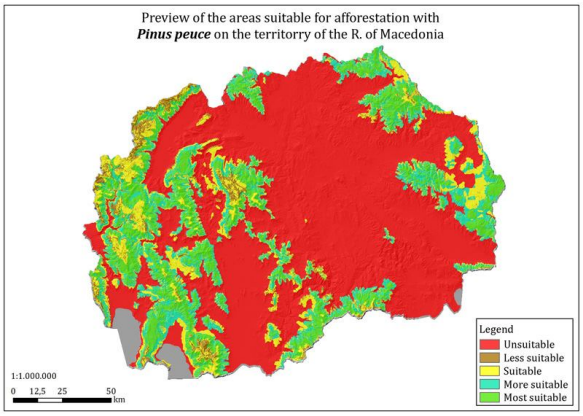
This distribution map of the white poplar (*Populus alba*) is *highly accurate*. *Populus alba* is a representative of the common riverside dendrofloral elements of the ravines and valleys in Macedonia. This tree species can be found and planted almost at every *floodplain at low to medium altitude*.



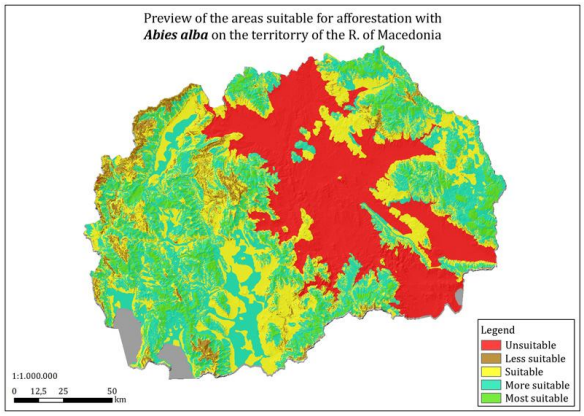
The black pine (*Pinus nigra*) is one of the most widely used tree species for afforestation and reforestation in Macedonia. Its wide ecological amplitude makes this conifer to be at the top of the list, but recent fieldwork shows that the black pine should not to be planted at lower altitudes (500 and above m.a.s.l.). Trees planted at lower altitudes, particularly at xeric areas are under its ecological boundaries. So, this map has *medium accuracy*.



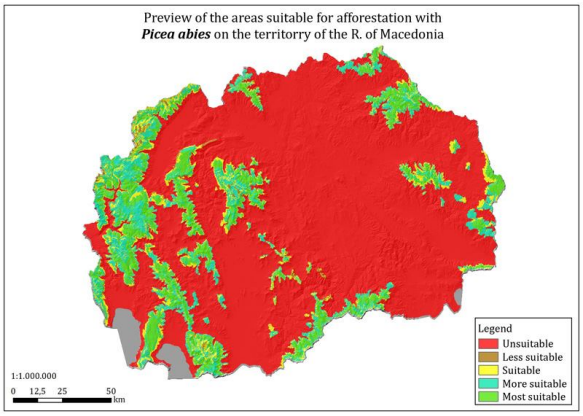
The Scots pine (*Pinus sylvestris*) map shows areas which cannot be populated by this mesophyte. *Pinus sylvestris* in Macedonia *cannot be found on carbonate rocks/soils*, and therefore some of the areas designated as "*suitable*" are not accurate, while the areas designated as "*more and most suitable*" are *highly accurate*.



The Macedonian pine (*Pinus peuce*) can be found mostly, in its compact population, in the National Park Pelister (founded because of this pine), but at some other higher altitudes and where the humidity in the air and soil is high, too. So, this pioneer pine species may be planted in areas shown on the map, excluding the dryer zones. Therefore, the map has *high to medium accuracy*.



Abies alba (*A. borisii-regis*) or the European silver fir is a mesophyte, found in humid climate. This map is *highly accurate*, excluding some small areas with lower altitude and dryer climate.



The map for the Norway spruce (*Picea abies*) is *questionably highly to medium accurate*. Unfortunately, the *Picea abies* has *ecological boundaries on the air humidity* (and soil humidity, too), so Macedonia is the southern border of its European distribution (can be found particularly and only at the locality of Adzhina Reka, National Park Mavrovo). Therefore, it is debatable if this tree can be planted at some other higher altitudes.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the application of this model shows good results in the research resulted in satisfactory results for most of the species, but not for others. Hence, the need and justification that if further developed it can be proved as quite robust and applicable at any level and with high percentage of accuracy. The evaluation of the results can still be debated, and various experts will have a say regarding their respective field of expertise. However, this Decision Support System, with further improvement, i.e. providing more detailed information, will cover the gaps which can be seen here in some of the suitability maps for the species. The lack of "proved" mathematical formula is also the issue in this DSS; a formula was created which would grow more complex and accurate as further input is provided.

This way of producing suitability maps for afforestation purposes has not been carried out in the past in our country. The method needs a lot more input data in order for it to be deemed as absolutely reliable (or close to that). Such input would require implementing detailed species characteristics, detailed climate-vegetation data, habitat specifications, slope and aspect data, various constraint data (agricultural land, urban areas, industrial areas, and protected areas), etc. However, this research shows that this is a very good approach for creating such maps, which results in maps that provide satisfactory accuracy. That was the case in our research, where some of the suitability maps resulted in very good spatial distribution and accuracy, while other maps for some of the species deemed areas as suitable when in fact they aren't such.

The tree species used in this paper has justified their choice, in terms of offering various possibilities for afforestation throughout the country. Finally, the approach used in this research resulted in the creation of a model which was carried out as such for the first time in our country, and with its development will prove to be robust enough to be used during the afforestation of any localities. In the end it can be concluded that the quality of the model is dependent on the quality of the input. Therefore, more research should be done in improving the theoretical background of the modeling process and the input parameters.

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