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CHALLENGES REGARDING THE RECENT EVOLUTION OF NATIVE LIME TREE SPECIES IN THE MANAGED FORESTS OF CARANSEBEŞ AREA, WESTERN ROMANIA

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Abstract

The total forest area in Romania has been sustainably managed based on ten years plans for more than 50 years. Tilia sp. (lime tree species) area in Romanian forests covered around 214,000 ha in 1966 (1% of the total forest area) but recent data show that the lime - tree species proportion has easily been increasing in the last decades. From the 40 genera and over 350 species of the Tilliaceae family that are spread especially in the tropical and subtropical regions, in Western Romania the lime tree species are represented by three native species of the same Tilia genus: Tilia cordata Mill., Tilia tomentosa Moench. and Tilia platyphyllos Scop. Data from the national forest inventory, data from succesive forest management plans for the period 1968-2016 and recent field research data from Western Romania were analysed. The research studies and official reports from the region present lime-tree species as resistent to abiotic (draught, pollution) and biotic stress (no important parasite or disease of Tilia sp. has been reported in the Western part of Romania). An interesting situation is presented in Caransebes area, in the same region. Recent data analysis shows that in this area, the lime-tree species have maintained or even increased their total area in spite of all silvicultural management measures which were performed in the last decades in accordance with the management plans stipulations and which have favoured the beech, oak or coniferous species against the lime trees. The lime tree ecological demands and also its reproductive systems (both vegetative and sexuate) seem to be a competitive advantage in the present-day climate change local context. The future forest management planning activities should consider adequate measures to use the lime-tree species competitive advantage in order to promote a sustainable forest management in the region. The aesthetic species wood qualities and their numerous uses in wood industry are also very important arguments in this respect.

Key words*: forest management plans, silvicultural management measures, climate change, species competitive advantage.*

INTRODUCTION

The total forest area in Romania has been sustainably managed based on ten years plans for more than 50 years. The first Management Plan for the Forest District Caransebeş was elaborated in the year 1954 and after that in the year 1968, 1978, 1986, 1996, 2006 and 2016 (National Institute for Research and Development for Forestry „Marin Drăcea", 2016). We only analyzed the period 1968-2016 because in the year 1974 the forest district was split up and from then the surface of forest is relative constant at 18500 ha. After the year 2006 the Experimental Basis Caransebeş (EBC) (current name) of National Institute for Research and Development for Forestry „Marin Drăcea" has restituted to the former owners approximate 1000 ha of forest from which 546.7 ha from Forest Unit I (compartment 1-8,11-13A, 30A-34,36,37,43) were *Tilia* genera species were very well represented.

Lime trees are important species covering large areas in the forests administrated by the EBC. Especially *Tilia tomentosa* Moench., silver lime but also *Tilia cordata* Mill., and *Tilia platyphyllos* Scop., lime trees found here a large altitudinal amplitude, from plain and hilly area to the mountain areas, and as a consequence EBC is the right place in the western Romania, where the natural distribution of lime trees can be studied in order to observe the specific requirements and the extension tendency of this species.

In terms of lime trees importance for the forest ecosystems and soil properties, various research found that lime is related to a considerably higher pH, base saturation, base cation and boron pools comparing to spruce, which determined the most acidifying effect on

the mineral top soils (Hagen-Thorn et al., 2004).

Regarding the sdudied area, EBC is situated in the western Romania, on the western part of Poiana Rusca Mountains, western part of Muntele Mic and Tarcu mountains, and also on their prolonges until to Timis river on his right part (National Institute for Research and Development for Forestry „Marin Drăcea", 2016).

The research area considered for the present study is located between the follow geographical coordinates: $44^0$57'-$45^0$17' nordic latitude and $22^0$30'-$22^0$52' estic longitude.

For a good understanding of site conditions for EBC forests, we need to specify that the altitude varies from 200 to 1600 m and the average temperature is 11°C in Timis river lowland area (meteo station Caransebeş), decreasing to the mountain area, to 4°C at meteo station Muntele Mic at the altitudinal limit of forest.

The extremes of averages temperatures variate in a limit of 7°C (a gradient of 0.44°C/100 m of altitude) (National Institute for Research and Development for Forestry „Marin Drăcea", 2016).

Forests of EBC are situated on partly sunny sides with slopes more than 30°C in many cases, or even steepness, with soils on poor rocks, harsh, acidic, dominating as deep being superficial to medium soils (National Institute for Research and Development for Forestry „Marin Drăcea", 2016).

Regarding lime trees distribution and the type of soils in the research area (Caraş-Severin County, were the EBC is located), the repartition of forest soil types from this county is similar with the distribution in the entire country (the first place is occupied in both cases by dystric cambisol, while the participation percentages of luvisol and preluvisol are similar).

However, they are different regarding the presence of eutric cambisol (much higher in this County comparing n with the country average level).

This fact is caused by the massive presence in this County of inferior premontane-mountain areas, occupied by beech stands, areas specific to this type of soil (Dincă et al., 2017).

MATERIALS AND METHODS

In order to achieve the research objectives presented above, there were performed the following *a bibliographic research and documentation*, data from succesive forest management plans for the period 1968-2016 and data from national forest inventory; observations in the field on a determined itinerary to identify the the presence/absence of lime species on different previously established check areas; analysis of lime trees distribution and recent field research data from Western Romania were analysed.

The research area consists of 17733 ha of natural forest from which 655 ha are lime forest located in the Western part of Romania, Caraş-Severin County, Caransebeş area.

RESULTS AND DISCUSSIONS

The lime tree species had a steady representation over the last 50 years in the Forestry Unit (F.U.) I, II, III of the EBC. The percentage of participation in the total research area (all 7 F.U. of the EBC) is 4% (Table 1), but in the F.U. I percentage is 17%, in F.U. II is 10% and in F.U. III the percentage of lime is 6% (National Institute for Research and Development for Forestry „Marin Drăcea", 2016).

Table 1. The structure of lime forests in research area Caransebeş (EBC) 1968-2016

Year	1968	1978	1986	1996	2006	2016
Lime in the forest stand species composition %	4	4	4	4	4	4
Site class	II, 6	II, 3	II, 3	II, 4	II, 8	II, 9
Crown density	0.91	0.83	0.83	0.83	0.82	0.8
Age years	43	60	60	67	73	78
Current annual increment m^3/year/ha	4.0	8.4	8.4	7.6	6.7	5.5
Volume 1000 x m^3	271	200	195	214	218	215
Average volume m^3/ha	254	297	297	318	319	329

Starting with the year 1974 many forest stands called compartments (Co.) were undergoing definitive cuts as management options. Concidering „The national programe for resinous wood in this compartments were

planted resinous wood to raise the value of the forest. For planting the following species were used: Douglas fir, *Pinus* spp., Norway spruce, European silver fir and European larch. As a result of analyses of Forest Management Plans and after that the field work revealed that nowadays the native species (lime, beech, sessile oak, hornbeam) have returned in their natural range of the research area.

Because the lime-tree species have a good capacity to sprout and suckering and being a faster growing species they reconquered their initial territory.

As can be seen from Table 2 after the Management Plans from the year 1978 the surface covered by *Tilia* sp. decreases because of the definitive clear cuts, but after the year 1986 the surface grows steadily.

In the same table we can see that the origin of lime tree species is 81% from shoot and only 19% from seed.

After the bibliographic analysis some observations in the field were performed considering the most interesting cases (13 compartments in Table 3).

Table 2. Lime tree evolution in Caransebeș region between 1968-2016

Lime	Surface				Productivity				Proportion			Origin		Vitality	
	Total ha	%	Group I ha	%	Sup %	Med %	Inf %	Med	50	50-80	80	Seed %	Shoot %	Good %	Weak %
1968	803.0	4	192.5	20	100	0	0	100	74	21	5	6	94	100	0
1978	638.8	4	11.7	-	66	33	1	86	79	18	3	8	92	99	1
1986	657.4	4	55.0	9	58	41	1	83	74	24	2	10	90	97	3
1996	671.4	4	86.3	13	61	39		83	75	21	4	12	88	99	1
2006	683.2	4	97.4	14	21	77	2	83	75	22	3	7	93	96	4
2016	655.3 (729.2)*	4	187.34	29	14	86		80	79	20	1	19	81	97	3

*After the year 2006 the Experimental Basis Caransebes (actual name) give to former owners approximate 1000 ha of forest from wich 546.7 ha from Forest Unit I (compartments 1-8,11-13A, 30A-34,36,37,43) were *Tilia* species were very well represented.

Table 3. Species Evolution in selected compartments (Co.) of the research area Caransebeș between 1968-2016

Year	1968	1978	1986	1996	2006	2016
F.U./Co.						
I/13B	4Li3Se2Be1Ho	4Li3Se2Be1Ho	6Do2Se1Be1Sy	5Do2Se1Be1Sy1Ho	2Li2Do1Se2Be1Sy2Ho	2Li1Do1Se2Be1Sy1Ho
I/14A	3Li3Be3Ho1Hw	4Li3Be2Ho1Se	7Do1Pi1Be1Sy	7Do1Pi1Be1Sy	2Li5Do1Be2Ho	2Li5Do2Be1Ho
I/15A	1Li7Be1Se1Ho	7Do3Pi	6Do3Pi1Be	1Li4Do1Pi2Be2Ho	2Li3Be3Ho1Hw1Dr	2Li3Be3Ho1Hw1Dr
I/16	2Li5Be2Ho1Se	10Do	8Do1Be1Ho	7Do2Be1Ho	3Li1Do4Be2Ho1	2Li6Be2Hw
I/28A	3Li3Be3Ho1Se	7Do3Sy	4Do2Sy2Be2Ho	1Li3Do2Sy2Be2Ca	2Li4Be3Ho1Dr	2Li4Be3Ho1Dr
I/29	3Li4Be2Ho1Se	3Do3No2Si2Hw	3Do2No1Si3Be 1Se	1Li3Do2No1Si1Be1 Ho1Se	2Li3Be3Ho1Se1Dr	2Li3Be3Ho1Se1Dr
I/30B	3Li3Ho2Be1Se	3Do6Si1Sy	3Do5Si1Sy1Hw	2Li2Do4Si1Sy1Hw	3Li2Do2Si1Sy2Hw	3Li2Do2Si1Sy2Hw
II/59A	5Ho4Be1Tu	7Ho2Be1Tu	7Do1Pi	1Li2Do2Pi1Be1Ho3 Hw	1Li2Do2Pi1Be1Ho3Hw	1Li4Do3Ho2Hw
II/60A	6Ho2Be2Tu	10Pi	9Pi1Hw	2Li4Pi1Be2Ho1Hw	1Li4Pi2Be1Ho2Hw	1Li4Pi1Be2Ho2Hw
IV/10A	6Se2Be2Tu	6Se1Be3Tu	7Pi1Do1La1No	4Pi1Do1La2No2Be	1Li3Pi2No1La1Be1Ho1 Se	1Li2Pi1No1La1Be1Ho2 Se1Hw
IV/11A	10Be	10Be	2La2No1Pi2Se1 Sy3Hw	1Li2La2No2Pi1Se1 Sy1Be	1Li1La1No1Pi1Se1Sy4 Be	1Li1La1No1Pi1Se2Ho1 Tu2Be
IV/11C	10Be	10Be	10Be	8No1Pi1Sy	1Li5No1Pi1Sy1Be1Ho	1Li4No1Pi1Be2Se
IV/11F	10Be	10Be	10Be	1Li1Be2No2Pi2Se1 Sy1La	1Li2Be2No2Pi1Se1Sy1 La	1Li2Be1No1Pi2Se1La2 Ho

Li=Lime, Se=Sessile oak, Be=Beech, Ho=Hornbeam, Do=Douglas fir, Sy=Sycamore, Hw=Different hard wood, Pi-Pinus sylvestris, Dr=Different resinous, No=Norway spruce, Si=Silver fir, Tu=Turkey oak, La=Larch

From the selected cases we can see that we have two situations: one in the F.U. I in the Co. 13B, 14A, 15A, 16, 28A, 29, 30B where before 1968 *Tilia* sp. was present and the other one in F.U. II Co. 59, 60 and F.U. IV Co. 10A, 11A, 11C, 11F where this species was not present before. The both situations area analysed as follows.

In the Co. 13B where the species composition in the year 1968 was 4Li3Se2Be1Ho in the year 1978 were made clear cuts and big wood volumes were harvested: No 10 m^3, Be 900 m^3, Se 2070 m^3, Hw 540 m^3, Li 3410 m^3. One year after that afforestation with 60%Do40%Sy was performed. After that in the next two Forest Management Plans (F.M.P.) *Tilia* sp. is no

longer mentioned, but in the F.M.P 2006 lime trees appear again with 20% from stand composition, situation maintained in 2016.
The situation is almost the same in Co. 14A where in 1979 after clear cuts a large wood volume was extracted: Be 850 m^3, Se 780 m^3, Hw 410 m^3, Li 1310 m^3 and in 1980 they planted 70%Do20%Sy10%Pi and after that only in the FMP 2006, the lime tree species appear with 20% in the stand composition and the situation has been maintained until 2016.
In the Co 15A a clear cut was performed in 1975 and this stand was planted in 1976 with70%Do30%Pi. After 20 years in F.M.P. 1996 lime species cover 10% and starting 2006 until 2016 was extended to 20%.
In the compartment 16 clear cuts were made earlier in 1975 and in 1976 the afforestation was made with 100%Do. After 30 years, in 2006 lime tree species appear with 30% but after a thinning in 2016 lime percentage in stand composition is 20.
In 28A Co. I, in the year 1974, the forest was clear cut and in the next year was with 70%Do30%Sy planted. After 20 years, in 1996, the lime species show up with 10% which grows in 2006 grows at 20%.
In Co. 29 with a total surface of 57.5 ha, the biggest compartment in the research area, is definitive cuts were performed followed in 1975 by plantations with: 40%No30%Do30%Si. Records show in the F.M.P. 1996 that *Tilia* sp. has 10% and grows at 20% in 2006, situation unchanged in 2016.
In Co. 30B definitive cuts were performed in 1974 and the afforestation was made in 1975 with 60%Si30%Do10%Sy. As a result, in the year 1996 *Tilia* sp. covered 20% and from 2006, until 2016, 30%.
There were situations where before performing clear cuttings *Tilia* sp. was not present but appeared after the afforestation.
In Co. 59A from F.U. II a definitive cut was performed in 1982 and next year in 1983 afforestion was made with 70%Do30%Pi. In the next F.M.P in 1986 *Tilia* sp. was present with 10% and it remained similar from 1996, 2006, 2016.
Also, in Co. 60A, where clear cuts were made in the year 1974 and in 1975 afforestation with 100%Pi was performed. Again in the year 1996, lime tree appear with 20% but after the thinning only 10% remained.
In the compartment 10A from F.U. IV, in the year 1984 clear cuts was done and the wood harvested volumes were in m^3: Be 190 m^3, Se 1920 m^3, Hb 10 m^3. The afforestation was made with 70%PI20%La10%Do. In the F.M.P. 2006 lime trees have had 10% in the forest stand composition and in 2016 is similar situation.
From Co. 11A in the year 1983 were harvested 5720 m^3 of beech and the afforestation was performed with 20%La20%No10%Pi40%Sy. After 10 years, in 1996 *Tilia* sp. appeared with 10% and it remains similar till nowadays.
In Compartment 11C afforestation was done in the year 1986 with 80%No10%Pi10%Sy but in the F.M.P from 2006 until 2017 lime has been present with 10%.
Compartment 11F from F.U. IV was totally clear cut in 1986 and the harvested volumes were: Be 3940 m^3, Se 480 m^3, Hw 90 m^3, Sw 50 m^3. Afforestation was made with 80%Pi20%No but since 10 year later, in 1996, lime has been present covering 10% of the forest stand.
Noumerous similar situations were observed in different forest areas from Western Romania by the authors.

CONCLUSIONS

As we can see from Table 3 in the F.U. I in compartment 13B, 14A, 15A, 16, 28A, 29, 30B after the definitive cuts and afforesting with different resinous species (Douglas fir, Scottish pine, Norway spruce, silver fir, larch and with sycamore). The autochthonous trees (Lime Sessile oak, Beech, Hornbeam) have reclaimed their territory very fast (10-30 years for the lime). This can happen because lime-tree species have a good capacity to sprout and suckering and being a faster growing species they reconquered their initial territory.
According to Spârchez et al. (2011), the anthropic causes that led to the degradation of the stands are: applying the cuts in simple groves, the consequence being the reduction of the biodiversity and the extension of common hornbeam, lime tree and other mixture species to the detriment of common oak species, which leads to as called „derived stand".

Situation is different in the compartment 59A, 60A from F.U. II and Co. 10A, 11A, 11C, 11F from F.U. IV, where lime was not present before. Otherwise in the Forest Unit IV *Tilia* sp. appear starting up from 1996 in co. 10A, 11A, 11F, 57C, 64, 75. In 2006 lime covered 50 ha and in 2016 it raised to 61 ha approximate 2% from the total surface of F.U. IV.

The average age of one compartment where lime is present is usually between 25-80 years, and as a conclusion after the cutting of the initial forest stand, the lime use to find an opportunity to spread in the opened space after the cuttings on large areas.

The present study supports the opinion of various researchers which consider that some species, including lime but also oak, as well as pioneering birch and aspen, seem to regenerate in a discrete and irregular manner. It was hypothesised that their regeneration depends on ephemeral opportune circumstances occurring at the initial phase of gap filling, such as presence of layering fresh logs, sprouting stumps and roots, spots of exposed mineral material, as well as inaccessibility to browsers (Bobiec, 2007).

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