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THE PRODUCTIVITY OF PINE STANDS ON DEGRADED LANDS

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Abstract

The surface of degraded agricultural lands continues to increase under the influence of climatic changes. Pines have been the most frequent forest species used for afforestation in the past (period 1950-1990).
The present paper presents data regarding the current state, biometric and auxologic characteristics of pine stands which emphasize the bioproductive and ecologic potential. The productivity and production were analyzed in the pine stands formed by main species such as European black pine and Scots pine, pure or mixed. The wood production (m^3ha^{-1}) recorded in pine stands is different, being based on the degradation form, phytoclimatic layer and age. As such, the volume of stands with European black pine varies between 258.89 and 512.66 m^3ha^{-1}, while for the stands with Scots pine, the values varies between 206.75 and 418.04 m^3ha^{-1}. For both species, it was obtained an semnificative correlation coefficient (R^2>0.8) between diameter class (D) and unit volume (v). In the forest steppe of hill (S_s), on strongly fragmented landslides, the European black pine has proved better growth than Scots pine. In the hill zone (FD_3), similar growth conditions for both species were obtained.

Key words: *afforestation, degraded lands, bioproductive potential, average radial growth, volume.*

INTRODUCTION

The degraded agricultural lands surface is in continuous growth in the context of climate changes. Thus, in our country, the surface of these lands summing aproximatively 6.3 million hectares from which 2.5 million hectares are strongly degraded (Nistor and Nistor, 2002).
The degraded agricultural lands afforestation represents the principal way of ecological reconstruction and the valorification of these types of lands (Untaru et al., 2013). In this regard, the Strategy and the National Programme of Actions for Desertification Control (2008), and also the new Forest Code (Law 46/2008), they provided for afforestation almost 2 million hectares of degraded agricultural lands at the national level.
Forestry species frequently used in the past (1950-1990 period) at the degraded lands afforestation were the pines, in present being less and less used, in the detriment of some fast-growing species (locust and so on) but also for biodiversity. The pine species utilised at the degraded lands afforestation were, especially, the European black pine, Scots pine, Weymouth pine and also the Western yellow pine and so on.
The effects of the pine forestry cultures realised onn degraded lands consist in improvement/amelioration, stabilization and the valorification of ineffective lands making the object of other uses (Constandache et al., 2010) but also in the mitigation of global warming effects through the highly capacity of atmospheric carbon dioxide storage (CO_2) (Dincă et al., 2015), the stop of lands degradation due to the capacity of fixing and improvement of the soils (Nicolescu et al., 2018), the anthropogenic pressure reduction on the natural forestry ecosystems and the utilisation of those as an alternative for obtaining the fossil fuels (Spîrchez and Lunguleasa, 2016).
Deforestation and exploitation activities have generated a multitude of degraded lands, being subsequently subjected to the phenomena of collapse, landslide and intensification of floods frequency, especially on lands with high slopes (Silvestru-Grigore, 2016).
The pine stands occupy almost 5% from the forests surface from our country being realised both on degraded lands and another types of lands from the outside range (Constandache et al., 2017; Untaru et al., 2008; Enescu and Dănescu, 2015). These kinds of stands have been realised on different types of degraded

lands (eroded, ravenous, rocky, tailings) and in another countries (Bulgaria, Anglia, Austria, Finlanda, Germania, Spania).

In eastern England, in Scots pine stands were elaborated studies regarding on influence of physiological factors which can affect the evapotranspiration and it was analyzed on vertically and horizontally have been developed in wild pine trees and the root system has been analyzed vertical and horizontally the root system in function of the distance between trees and soil properties (Roberts et al., 1976). In Scots pine plantations in the middle boreal region established in Finland, it was estimated that the volume of carbon dioxide and the water vapor flow stored by the Scots pine using the covariance method (Lohila et al., 2007).

Between the years 1993-1994, in Germany, were efectuated measurements in pine stands regarding the gas exchanges at the leafs level, the transpiration as well as the sap flow analysis (Sturm et al., 1997).

In northwestern Spain, in the Scots pine stands, the quantitative characteristic represented by the commercial volume was analyzed, using 14 volume equations (Diequez, 2006).

The abroad specialty literature mentions that the scots pine forests had shown significant differences in regard with the biometric parameters, in comparison with broad-leaved species.

Even though the number of trees was 5.4 times lower, this species reached a base surface larger than 189.6%, a higher volume with 30.8% and a growth of 30.9% of the current volume in comparison with broad-leaved species (Vlad et al., 2019). Furthermore, the dimensions of average trees were also larger in scots pine stands, with an average diameter larger with 128.2% and an average height higher with 40.7% than the locust stands (Lukić et al., 2015). Although that the pine species have made the object of many previous research, at the national level exists a real need of updated informations regarding at the productivity of those species in different vegetation conditions, in the context of climate change. The obtained results emphasized the fact that scots pine is a species that can adapt to extreme site conditions and can be successfully used in afforestation projects for degraded lands (Vlad et al., 2019).

Nevertheless, managing stands towards a future stable desired ecosystem should be validated by long-term studies that should examine the ecosystem's changes through more successive stages (Ganatsas et al., 2011).

Regarding the analysis of the internal structure of the wood, in the pine stands installed in the Buzău Subcarpathians, Silvestru-Grigore found that the species of Scots pine and european black pine have different behaviors on degraded lands. Thus, the european black pine shows a better stability than the Scots pine, rendered by a lower coefficient of variation for heights (Silvestru-Grigore et al., 2016). These two species of pine, are different is terms of radial growth dynamics, Scots pine proving an faster juvenile growth spurt and also high growth range that European black pine (Silvestru-Grigore et al., 2018).

The effectuated researches in the current stage have had as scope the continuity of previous researches in the view of actual state knowledge, the biometrics and auxological characteristics of the stands from different pine species, with different ages (38-70 years), realised in the past on different categories of degraded lands, showing the bioproductive potential of those.

The results have been obtained after the made researches in the period 2015-2020 in the research plots located in the improvement perimeters in degraded lands from the south-east contry zone.

The obtained results are very important having in the view the afforestation necessity of some large surfaces of existing degraded lands at the national level, as well as the necessity of sustainable management of the realised forestry cultures.

MATERIALS AND METHODS

The researches have been made in the 12 experimental plots (SE) on long term, in representative situations of pine stands and of degradation forms. It has been analysed the forestry cultures pure or mixed of Scots pine, European black pine, Weymouth pine. It was analysed and highlighted the current state, biometrics and auxological characteristics, the productive potential of pine stands in different environmental conditions.

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It was made the measurements and observations in forestry cultures from different species of pine, from the improvement perimeters of degraded lands in which exists or were located in the research plots (on long term).

Territorial, the researched were held in the forest steppe zone (Livada Perimeter- Râmnicu Sărat forest district; the hilly oak stands storey (Murgești perimeter- Râmnicu-Sărat forest district; the oak stands storey (Caciu-Bârsești, Experimental Base Vidra); the beech stands storey (Roșoiu-Andreiașu perimeter- Focșani forest district. The research consisted in collecting field data, processing and interpreting of them. The processing of field data was performed in a computer system by using specific statistical programs in silviculture. In order to highlight the structural characteristics of the pine stands, the analysis of the experimental distributions of the main biometric parameters of the trees was performed by means of the theoretical distribution functions (normal, beta) corresponding to the horizontal structure. Another way of analyzing the stand structure was represented by the analysis of the correlations between different qualitative and quantitative characteristics, through general statistical methods. The unit volume expressed in m^3*ha^{-1} was determined using the bifactorial regression equation method provided in "*Dendrometric methods and tables, 2004*" (Giurgiu *et al.,* 2004), using the corresponding regression coefficients for Scots pine, European black pine species and Weymonth pine.

Plotting the curves of the unit volumes were highlighted by using the exponential regression equations of the form $y = ax^b$ (Figures 1 and 2), in which y-represents the unit volume, and x-the diameter.

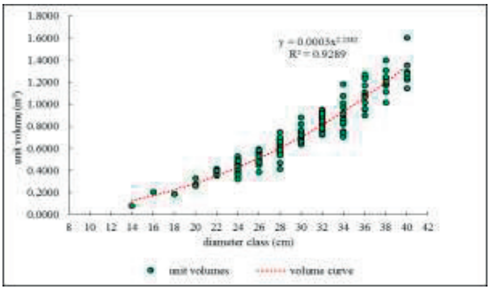

Figure 1. The regression equation of unit volume (European black pine– SE12 Livada)

Unit volumes are evenly distributed by diameter classes, due to the number of trees that are found in approximately equal proportions. The correlation coefficient (R) has a value close to 1 which denotes a very close interdependence relationship between volume and diameter (Figures 1 and 2).

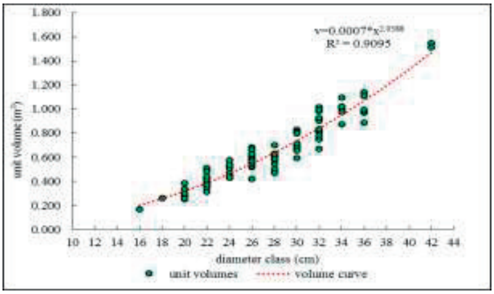

Figure 2. The regression equation of unit volume (Scots pine- SE6 Livada)

RESULTS AND DISCUSSIONS

It was analyzed the Scots pine, European black pine, Weymonth pine stands and were installed on lands affected by different forms and intensities of degradation (Tables 1), in different sites (phytoclimatic layers).

The forestry cultures analyzed are in general pure or mixed cultures between different species of pine as well as pine mixed with deciduous species. On lands with advanced degradation, forestry cultures were made from a smaller number of main species (pines) and secondary species and/or shrubs. On lands with better conditions, a larger number of main and mixed species (pines, oaks, maples, ashes and so on) were used. The number of seedlings planted per hectare generally varied between 6700 and 10000. In the case of mixtures, deciduous species were introduced in intimate mixture, on lands with advanced degradation and in small bouquets (bouquets of 10-50 pine seedlings alternating with bouquets of 10-30 deciduous seedlings), on lands with more favorable conditions or with various microstational conditions.

Mixed deciduous species and shrubs introduced in mixture with pines from the planting or previous naturally installed, have an important ameliorative role but also in regulating the structure of the stand, contributing at the assurance of the necessary biological diversity. An important role in the improvement/ stabilization of the land and in the evolution of the pine plantations have had the sea buckthorn used in mixture with the pine or in the planning/consolidation of very strongly to excessively eroded lands, in the Roşoiu-Andreiaşu and Caciu-Bârseşti perimeters.

Thus, the pine plantations made in mixture with sea buckthorn or through consolidation technologies of the lands, with the help of sea buckthorn (where sea buckthorn entered in the vegetation), on very heavily eroded lands, have recorded growth increases of pines by 20-30% higher compared to pure pine cultures or made on consolidated lands through other methods (terraces supported by fences), as a result of soil enrichment in nitrogen (Constandache et al., 2016; Dincă et al., 2018).

Depending on the shape and intensity of degradation, at the installation of plantations is where necessary various landscaping/ consoledation works, in order to ensure the minimum vegetation conditions of the seedlings (Constandache et al., 2006; Constandache et al., 2010). The dynamics of biometric parameters (diameter and height) in the stands made on degraded lands, is realised under the influence of the complex of harmful abiotic and biotic factors, in close interdependence with the land conditions on which the forest cultures were made, with the phytoclimatic storey, with forestry works (tending and management) applied, with the effect of harmful abiotic factors, with the species in the stand composition.

Pines have given good results in terms of growth in diameter and height (Table 1) even on land with advanced degradation conditions, having an important role in improving and capitalizing on degraded lands.

Analyzes carried out in pine stands on lands affected by landslides and strong erosion (Murgesti perimeter), located in the hilly oak stands storey (FD_1) showed that pine species have larger diameter growths, achieving at the age of 30 years, basal diameters which varies between 16-17 cm ahead of the other species (ash, manna ash 9 cm), and at older ages at 40 this gap widens: pines 21.1-25.6 cm and ashes 11-13.2 cm (Table 1, Figure 3).

Table 1. The evolution of average diameter in relation with age

Experimental block	*Experimental plot (SE)*	*Species*	*Mean diameter (cm)*							
			Age (years)							
			10	*15*	*20*	*25*	*30*	*35*	*40*	*45*
M	12	Pi.n	5.30	7.75	10.20	13.70	19.50	-	-	19.86
		Pi	-	10.40	13.00	16.20	18.40	19.10	20.20	21.27
		Fr/Mj	-	6.10	7.10	9.50	9.60	9.50	10.70	13.18
		Fr/Mj	-	-	-	-	-	-	-	11.04

Symbols semnifications: M - Murgeşti; Pi - Scots pine; Pi.n - European black pine; Fr - ash; Mj - manna ash

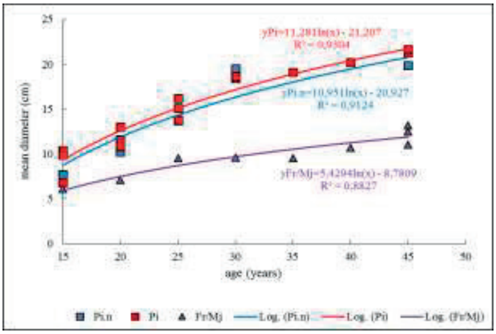

Figure 3. The evolution of average diameter for different species on strongly eroded ± landsliding - FD_1

The decenal average growths in diameter (cm) and height (m) of the species analyzed in the Murgeşti perimeter are as follows:

Species	*Diameter growth (cm)*	*Height growth (m)*
Pi.n	3.80	2.76
Pi	3.91	3.15
Fr/Mj	1.88	1.75

Regarding the recorded biometric characteristics, the largest diameters (between 26 and 30 cm) and heights (between 21 and 23 m) were registered by the Scots pine and the European black pine, at the age of over 60 years, on moderately to heavily eroded lands (Table 2).

The analysis of the differences between the two species (Scots pine and European black pine) showed that, in moderately eroded land conditions, Scots pine achieves, on average, smaller diameters with 0.99 cm (3-5%) and higher heights by 1.26 m (5-6%) compared to European black pine.

The number of trees is lower in the case of Scots pine stands (647-756 exemplars/hectares) with 13.6-21.2% compared to European black pine stands, the cause being the higher vulnerability of Scots pine to the damage provoked by factors abiotics (wind, snow) (Constandache et al., 2017).

Table 2. Biometric characteristics of stands on different bioclimatic storeys - it should be larger and clearer

SE Number	*Degradation form*	*Current composition*	*Age (years)*	*Consistency*	*Dmed (cm)*	*Hmed (m)*	*Number trees on species per hectares*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Livada - Râmnicu Sărat Perimeter (internal forest steppe)							
6	E2	80 Pi	64	0.7-0.8 / 0.69	26.00	19.70	691
		4 Pin			30.00	19.00	28
		5 Mj			7.70	7.60	461
		5 Ul			8.90	7.80	362
		5 St			15.10	10.50	105
		1 Pa			16.00	10.19	54
		Total			**16.50**	**13.00**	**1700**
8	E1	83 Pis	59	0.8/ 0.79	26.90	18.00	630
		11 Pi			32.00	19.90	78
		6 Pa			10.30	10.70	292
		Total			**22.10**	**17.00**	**1000**
9	E1	92 Pin	59	0.7/ 0.93	25.80	17.10	930
		3 Mj			7.30	7.10	338
		2 Sc			8.00	6.60	169
		3 Pa			22.67	17.80	42
		Total			**19.00**	**13.40**	**1479**
10	E1	86 Pi	61	0.8/ 0.98	24.70	18.50	796
		12 Pa			9.10	12.80	747
		1 Cs			8.40	6.50	67
		1Pin			30.00	16.65	9
		Total			**16.87**	**17.78**	**1619**
12	E1	98 Pin	63	0.8/ 0.76	27.90	19.20	767
		1 Fr			6.40	6.30	180
		1 St			16.86	14.24	29
		Total			**23.50**	**16.60**	**976**
Murgeşti - Ramnicu Sărat perimeter (hilly storey of oak stands with common oak)							
12	A1	52 Pi	43	0.8	21.27	16.74	850
		34 Mj			11.04	11.98	560
		14 Fr			13.18	14.65	220
		Total			16.66	14.82	1630
17	E2 / A1	100 Pin	44	0.9	18.31	14.85	1545
18	E1 / A1	100 Pi	44	0.5-0.6	22.72	16.90	693
Caciu- Bârseşti Perimeter (Sessile Oak storey)							
5	E3	49 Pin	38	0.6-0.7	13.69	12.62	1027
		47 Pi			14.56	13.57	982
		4 An			12.00	10.65	91
		Total			**14.02**	**12.98**	**2100**
8	E3	82 Pi	37	0.7-0.8	11.16	12.14	2165
		18 Pin			9.17	9.36	392
		Total			**10.80**	**11.70**	**2557**
Roşoiu-Andreiaşu Perimeter (European beech stands storey)							
9	E3	96 Pi.n	50	0.7	26.11	18.78	744
		4 Ar.t, Ci			13.33	9.19	133
		Total					**877**
10	E3	95 Pi	50	0,6-0,7	27.33	19.53	400
		5 Ar.t			13.96	9.62	71
		100					**471**

Symbols semnification: SE - experimental plot; Dmed - average diameter (centimeters); Hmed - average height (meters); Pi - Scots pine; Pi.n - European black pine; Pi.s - Weymonth pine; St - common oak; Pa.c - Norway maple; Fr - ash; Mj - manna ash; An - alder; Cs - chestnut; Ul - elm; Ci - European sweet cherry; Ar.t - Tartarian maple

On very strongly eroded soils (e3), in cultures with an age of approx. 40 years old, the average diameter is 12-14.6 cm, and the average height is between 11-13.6 m). The two species have been introduced into the intimate mixture, and the Scots pine recorded higher growths than the European black pine, both in diameter and height. The average number of trees/hectares is approx. of 2000 exemplars/hectares.

Pine stands recorded different auxological characteristics (growths, volumes) in relation with species, age, environmenal conditions and production class. Thus, in Romania, according to the relative production tables (Giurgiu and Drăghiciu, 2004), the total production (m^3ha^{-1}) is between 57-1175 m^3ha^{-1} in the case of the Scots pine and between 59-951 m^3ha^{-1}, in the case of European black pine, values that are estimated according to age and production class (I-V). In the case of the both species, the production cycles are different (cycle of 100 years - Pi; cycle of 90 years-Pi.n) and the total productivity is calculated for the pine species that are part of their natural range, at full consistency (c = 1.0).

According to Cotos and Duduman, 2017, in the case of European black pine, the technical cutting age (years) adopted for the target assortment "5-34", "> 5" cm is 55 years, for production class III, depending on the evolution of average growths. In production class V, the technical cutting age was increased by 20 years for reaching the assortments with target diameters "5-24", "5-34" and "> 5", due to lower increases in seasonal conditions characterized by inferior productivity and on soils with small edaphic volume, sometimes superficial, skeletal. The age of maximum technical cutting adopted for European black pine is 90 years, for all production classes, but for assortments with different target diameters in size.

In order to estimate the total volume per hectare (m^3ha^{-1}) (Figures 4, 5 and 6), the volume of healthy trees was taken into account, and the values obtained depend on the characteristics of the stand (stand density, age, species in the composition) and of environmental conditions.

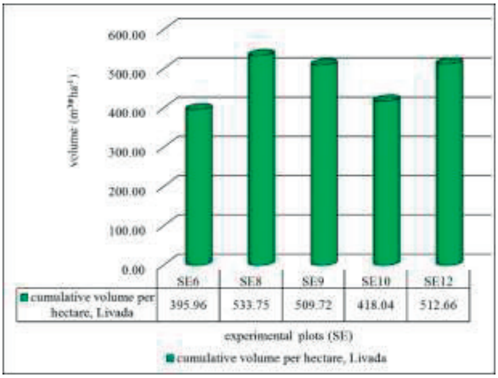

Figure 4. Graphic distribution of cumulative unit volumes (m^3ha^{-1}) recorded in the case of pine stands in the Livada perimeter

On moderately to heavily eroded lands, at the ages of 65-69, a maximum volume of 533.75 m^3ha^{-1} was obtained for the Weymonth pine. In the case of Scots pine, a volume was recorded in the range of 395.96-418.04 m^3ha^{-1}, and for European black pine, it was obtained values of the volume between 509.72-512.66 m^3ha^{-1}, higher compared to Scots pine.

The distribution of volumes on diameter classes shows that the Scots pine reaches a maximum volume (Figure 5) at the diameter class 26 (65.93 m^3ha^{-1}), and the European black pine registers a maximum volume at the diameter class 28 (95.74 m^3ha^{-1}).

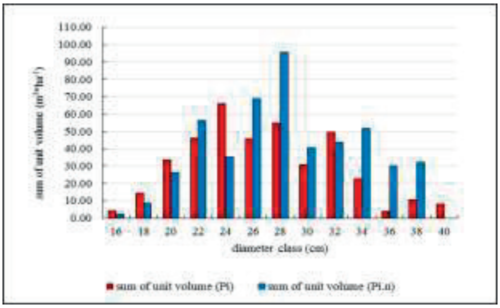

Figure 5. Comparative productivity situation (m^3ha^{-1}) for the both pine species in experimental plots SE9 and SE10, Livada - it should be larger and clearer

On slippery/landsliding and heavily eroded lands, the pine stands (Figure 7) with the age of 48-49 years, recorded volumes generally between 206.75-369.96 m^3ha^{-1} (Figure 6).

On very heavily eroded lands, the pine stands with the age of 55 years old, in SE9 (74% European black pine and 8% Scots pine) it was obtained a higher volume (258.89 m^3ha^{-1}) compared with SE10 (83% Scots pine - 224.47 m^3ha^{-1}), although the proportion of pines in the composition is almost equal in the two plots (Table 3, Figure 5).

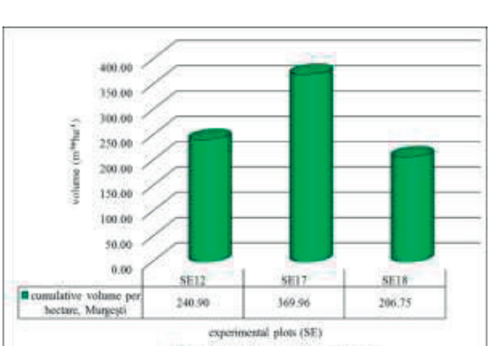

Figure 6. Graphic distribution of cumulative unit volumes (m^3ha^{-1}) recorded in the case of pine stands from Murgeşti perimeter

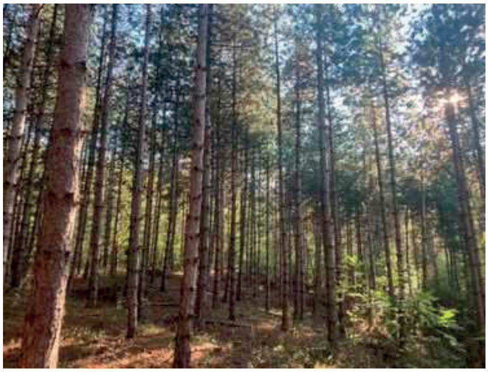

Figure 7. Pure stand of European black pine in SE17 Murgeşti (landslide)

In stands with the age smaller (38-42 years) a higher volume was achieved in the case of plot SE 5 (223.43 m^3ha^{-1}), where the two pine species are in almost equal proportions (Pi - 47%, Pi.n - 49%), compared to the volume obtained in the case of SE 8 (157.54 m^3ha^{-1}), where the Scots pine has a higher proportion (74% - Pi, and 26% - Pi.n - Table 3).

Table 3. Volumes and average growths ($m^3year^{-1}ha^{-1}$) in pine stands located on degraded lands

SE Number	*Degradation form*	*Pine species and their proportion in composition*	*Age (years)*	*Volume ($m^3 * ha^{-1}$)*	*Average growth ($m^3 * an^{-1} * ha^{-1}$)*
1	*2*	*3*	*4*	*5*	*6*
Livada - Râmnicu Sărat Perimeter (internal forest steppe)					
6	E2	80 Pi	69	395.957	5.657
8	E1	83 Pis	64	533.750	8.340
9	E1	92 Pin	64	509.718	7.964
10	E1	86 Pi	66	418.060	6.334
12	E1	98 Pin	68	512.662	7.539
Murgeşti - Ramnicu Sărat perimeter (hilly storey of oak stands with common oak)					
12	A1	52 Pi	48	240.900	4.818
17	E2 / A1	100 Pin	49	369.964	7.399
18	E1 / A1	100 Pi	49	206.749	4.135
Caciu- Bârseşti Perimeter (Sessile Oak storey)					
5	E3	47 Pi	38	118.220	3.110
		49 Pin		105.210	2.770
8	E3	74 Pi	42	98.106	2.336
		26 Pin		59.434	1.415
Roşoiu-Andreiaşu Perimeter (European beech stands storey)					
9	E3	74 Pi.n	55	234.560	4.260
		8 Pi		24.330	0.440
10	E3	83 Pi	55	224.471	4.081

Legend: Al - landslide; E1-E3 - moderately eroded lands (1), strongly (2), very strongly (3)

The analyzes show that the wood production (m^3ha^{-1}) recorded in the pine stands on degraded land is different in relation with the shape and intensity of degradation, phytoclimatic storey, age of stands, proportion of pines in the composition of the stand (Figure 8).

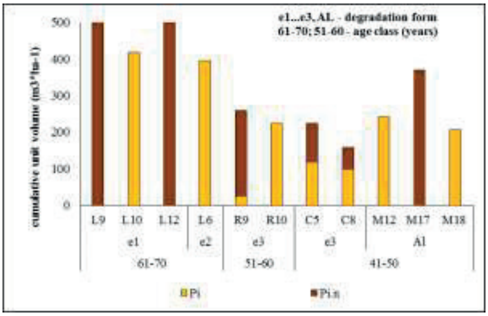

Figure 8. The volume (m^3ha^{-1}) of wood in pine stands situated on degradated lands (L - Livada perimeter; R - Roşoiu perimeter; C - Caciu perimeter; M - Murgeşti perimeter; 5, 6, 8, 9, 10, 12, 17, 18 - number of SE)

Thus, on the moderately eroded lands (E1), the productivity it's bigger at the old age. Between two pine species, on the ladns with similar environmental conditions, the recorded productivity by the European black pine is bigger than for Scots pine, having an behaviour better on lands from internal forest steppe. The differrence it's determined by the biometric characteristics (diameter, height), and also by the number of exemplars per hectare. In the similar mode, the annual average growth ($m^3year^{-1}ha^{-1}$) varies in ration with same factors (degradation intensity, age and so on) being between 4.08 and 6.33 $m^3year^{-1}ha^{-1}$ at Scots pine and between 4.26 şi 7.96 $m^3year^{-1}ha^{-1}$, at European black pine (Table 3).

The pine stands from degraded lands suffered damages (ruptures, drying) caused by harmful abiotic factors (wind, snow, drought, and so on) in all areas/vegetation storeys. The Scots pine, in pure stands on lands with lower degradation intensity, was more severely affected in contrast to European black pine and pine stands mixed with deciduous species.

As a result of damages caused by harmful factors (wind, snow) especially on moderately eroded lands, the proportion of pines in the composition has decreased from 50-100% to 36-49%. The analyzes performed show an increase in the proportion of European black pine in relation to Scots pine, the latter being more strongly affected. With age, the number of species in the composition of trees has increased from 1-4 species at planting to 3-6 species today, some of which are subsequently installed by natural regeneration (Figure 2).

As they get older, the number of species in the stand's composition has grown from 1-4 species at planting at 3-6 species in present, some of them previous installed through natural regeneration (Figure 9).

Figure 9. The apparition on the natural regeneration of manna ash and maple, at the shelter of mature stands of pine (SE6 Livada)

Under the massif of pine stands have been installed the local hardwood species such as maple, ash and especially manna ash, since the age of 25-30 years, with the thinning of the stands caused by damages. Pine stands (mixed with deciduous trees) have a structure formed by two storeys, consisting of a dominant pine storey and a second storey composed from deciduous storey.

The intimate mixture with the pines (at planting) but also the younger age of these species (further installed by natural regeneration), makes them achieve lower growths, being dominated by pines.

From the analysis of afforestation compositions in permanent research plots results that in most situations of degraded lands, at the afforestation were used comparative pine species with other species (Traci, 1975; Untaru, 1976).

Pine stands installed on degraded lands are not natural types of forest specific and they were viewed as transition stands whose purpose was to improve the vegetation conditions and to prepare the ground for the gradual installation of the forestry species specific to the natural type of forest. One's they get older, the assortment of species naturally installed in pine stands on degraded lands, marks the succession trend towards deciduous compositions favorable to the zonal vegetation, with structural diversity and higher ecological stability.

CONCLUSIONS

Among the existing pine species, European black pine, Scots pine and sometimes Weymonth pine have been used in afforestation of degraded lands, in pure cultures or mixtures (between pine or deciduous species).

Pines have given good results even on lands with advanced degradation conditions, having an important role in the improvement and capitalization of degraded lands.

The dynamics of biometric parameters (diameter and height) in pine stands realised on degraded lands, is made under the influence of the complex of harmful abiotic and biotic factors, in close interdependence with the land conditions on which forestry cultures were made, with phytoclimatic storey, with forestry works (tending and management) applied, with the effect of harmful abiotic factors, with the species from the composition of the stand.

The volume of wood accumulated of the pine stand on degraded lands, between 157.54 and 533.75 m^3ha^{-1}, is different in relation with the shape and intensity of degradation, phyto-climatic storey, age of the stands, proportion of pines in the composition of the stand, being larger on moderately eroded lands with older ages.

Between the analyzed pine species, the Weymonth pine achieved the largest volume, followed by the European black pine and then the Scots pine, on lands with similar environmental conditions. The differentiation is determined by the biometric characteristics (diameter, height) as well as by the number of exemplars per hectare.

The average annual growths vary in relation with the the same factors, being between 4.08 and 6.33 $m^3year^{-1}ha^{-1}$, at the Scots pine, between 4.26 and 7.96 $m^3year^{-1}ha^{-1}$, for the European black pine, and the Weymonth pine achieves 8.34 $m^3year^{-1}ha^{-1}$, achieving the maximum growth on moderately eroded lands, in the internal forest-steppe.

The stands from pine species on degraded lands have suffered damages (ruptures, drying) caused by harmful abiotic factors (wind, snow, drought, etc.), of which the Scots pine is the most vulnerable.

Under the massif of pine stands, since the age of 25-30 years, with the thinning of stands caused by damages, native deciduous species such as maple, ash, manna ash, and so on, have naturally installed. The intimate mixture with the pines (at planting) but also the younger age of these species (later installed by natural regeneration), makes them achieve lower growths, being dominated by pines.

Favoring the natural installation of deciduous species under the shelter of thinned pine stands, highlights the importance of pines in the ecological reconstruction works of degraded lands.

Considering the significant plots of degraded lands existing at national level, as well as the need for those improvement and sustainable use, the use of pines for ecological reconstruction through afforestation of these lands contributes, in addition to generating essential ecosystem services in zones exposed to degradation (soil protection and water) and to achieve additional incomes from the capitalization of the wood or non-wood products resulted.

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REFERENCES

Constandache, C., Nistor, S., Ivan, V. (2006). Afforestation of the degraded lands unsuitable for agriculture in the southeast of the country (in Romanian). *Analele ICAS,* 49, 187-204;

Constandache, C., Blujdea V., Nistor S. (2010). Achievements and perspectives on the improvement by afforestation of degraded lands in Romania. *Land Degradation and Desertification: Assessment, Mitigation and Remediation*, 547-560, Springer Publishig House.

Constandache, C., Nistor S., Ivan, V., Munteanu, F., Păcurar, V.D. (2010). Eficienţa funcţională a culturilor forestiere de protecţie şi a lucrărilor de ameliorare a terenurilor degradate. *Revista pădurilor,* 1, 26-31;

Constandache, C., Nistor, S., Untaru E. (2012). Cercetări privind comportarea unor specii de arbori şi arbuşti utilizate în compoziţia perdelelor forestiere de protecţie din sud-estul României. *Revista de Silvicultură şi Cinegetică*, 30, 35-47;

Constandache, C., A. Peticila, L. Dinca and D. Vasile. (2016). The usage of Sea Buckthorn (*Hippophae rhamnoides* L.) for improving Romania's degraded lands, *AgroLife Scientific Journal* 5(2): 50-58.

Constandache, C., Dincă, L., Tudose, N.C. (2017). *The vulnerability to climate changes of pine forest cultures from outside their natural range,* Book of proceedings AgroSym 2017, pag 2605-2611, Bosnia.

Cotos, A., Duduman, G. (2017). Technical cutting age for the principal forestry species from Romania, Forestry Bucovina, 17(2), 115-129.

Constandache, C., Dinca, L., Tudose, N.C., Panaitescu, C. (2018). Protecting surface water resources through silvicultural methods. *SIMI 2018, Proceedings Book, section pollution assessment & management systems*, 276-284.

Constandache, C., Dincă, L., Tudor, C., Oneț, C (2019). The ecological reconstruction of forest ecosystems affected by landslides, *Natural Resources and Sustainable Development,* 9, 144-159.

Diegues-Aranda, V., Castedo-Dorado, F., Alvarez-Gonzales, J.G., Rojo, A (2006). Compatible taper function for Scots pine plantations in northwestern Spain. *NRC Research Press Web*, 36, 1190-1205.

Dincă, L., Dincă, M., Vasile, D., Spârchez, G., Holonec, L. (2015). Calculating Organic Carbon Stock from Forest Soils, *Notulae Botanicae Horti Agrobotanici* Cluj-Napoca, 43(2), 568-575.

Dincă, L., Holonec, L., Socaciu, C., Dinulică, F., Constandache, C., Blaga, T., Peticilă, A (2018). *Hipphophae Salicifolia* D. Don - a miraculous species less known in Europe, *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 46(2), 474-483.

Enescu, C.M., Dănescu, A. (2015). Black locust (*Robinia pseudoacacia* L.) - an invasive neophyte in the conventional land reclamation flora in Romania. *Bulletin of the Transilvania University of Braşov Series II: Forestry • Wood Industry • Agricultural Food Engineering,* 6 (55) No. 2, 23-30.

Ganatsas, P., T. Tsitsoni, M. Tsakaldimi and T. Zagas. (2011). Reforestation of degraded Kermes oak shrublands with planted pines: effects on vegetation cover, speciesdiversity and community structure. *New Forests,* 43:1-11.

Giurgiu, V., Drăghiciu, D., Decei, I. (2004). *Methods and dendrometric tables*. Bucharest, RO: Ceres Publishing House.

Giurgiu, V., Drăghiciu, D. (2004). *Mathematical-auxological models and production tables for stands*. Bucharest, Romania, Ceres Publishing House.

IPCC, 2013, https://www.ipcc.ch/report/ar5/wg1/

Lohila, A., Laurila, T., Aro, L., Aurela, M., Tuovinen, J.P., Laine, J., Kolari, P., Miukkinenm K (2007). Carbon dioxide exchange above a 30 year-old Scots pine plantation established on organic soil cropland. *Boreal environment research*, 12, 141-157.

Lukić, S., D. Pantić, S. B. Simić, D. Borota, B. Tubić, M. Djukićand, D. Djunisijević-Bojović (2015). Effects of black locust and black pine on extremely degraded sites 60 years after afforestation - a case study of the Grdelica Gorge (southeastern Serbia). *Forest* 9: 235-243.

Nicolescu, V.N., Hernea, C., Bakti, B., Keser, Z., Antal, B., Rédei, K. (2018). Black locust (Robinia pseudoacacia L.) as a multi-purpose tree species in Hungary and Romania: a review, *Journal of Forestry Research*, 29 (6), 1449-1463.

Nistor, D., Nistor D. (2002). Land Degradation by Erosion and Its Control in Romania. *12th ISCO Conference, Beijing*, 621-626.

Onet, A., Dincă, L.C., Grenni, P., Laslo, V., Teusdea, A.C., Vasile, D.L., Enescu, R.E., Crisan, V.R. (2019). Biological indicators for evaluating soil quality improvement in a soil degraded by erosion processes. *Journal of Soils and Sediments*, 19(5), 2393-2404.

Roberts, J (1976). A study of root distribution and growth in a *Pinus sylvestris* L. (Scots pine) plantation in east Anglia. *Plant and soil*, 44, 607-621.

Silvestru-Grigore, C.V., Spârchez, G., Dinulică, F (2016). The health condition of pine stands installed on degraded lands in Buzau Subcarpathians. *Forest magazine*, 131(3/4), 7-18.

Silvestru-Grigore, C.V., Dinulică, F., Spârchez, G., Hălălişan, A.F., Dincă, L., Enescu, R., Crișan, V. (2018). The radial growth behaviour of pines (*Pinus sylvestris* L. and *Pinus nigra* Arn.) on Romanian degraded lands. *Forests*, *9*(4), 213.

Spîrchez, Gh. C., Lunguleasa, A. (2016). Wood biomass, an important source of renewable energy, *AGIR Bulletin,* 1, 40-42.

Sturm, N., Köstner, B., Hartung, W., Tenhunen, J.D. (1997). Environmental and endogenous controls on leaf- and stand-level water conductance in a Scots pine plantation. *Ann.Sci.For*, 55, 237-253.

Traci, C (1975). The effects of the 1973 drought on the conifer plantations on eroded sites in the Cheia-Macin area in the forest-steppe of N. Dobruja. *Revista Padurilor - Industria Lemnului, Celuloza si Hirtie, Silvicultura si Exploatarea Padurilor*, 90(1), 25-30.

Untaru, E (1976). Reforestation a means of reclaiming degraded soils in the Vrancea area [Romania]. *Bulletin of the Academy of Agricultural and Forestry Sciences (Romania),* 4, 43-52.

Untaru, E., Constandache, C., Rosu, C. (2008). The Effects of Forest Plantations Installed on Eroded and Sliding Lands, Related to their Evolution in the Time, *SILVOLOGIE*, VI, 137-168, Bucharest, RO: Academia Româna Publishing House.

Untaru, E., Constandache, C., Nistor, S. (2012 and 2013) The current state and projections for the future regarding the ecological reconstruction through afforestation of the degraded lands in Romania (I and II). *Forest Magazine*, 6/2012, 28-34; 1/2013, 16-26.

Vlad, R., Constandache, C., Dincă, L., Tudose, N.C., Sidor, C.G., Popovici, L., Ispravnic, A. (2019). Influence of climatic, site and stand characteristics on some structural parameters of scots pine (*Pinus sylvestris*) forests situated on degraded lands from east Romania, *Range Mgmt. & Agroforestry* 40(1), 40-48.