PRODUCTION CAPACITY OF DOUGLAS-FIR (*Pseudotsuga menziesii* (M i r b.) – F r a n c o) IN ALBANIA

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Abstract

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Douglas-fir (*Pseudotsuga menziesii* (M i r b.) F r a n c o), an introduced fast-growing and highly productive species, has been grown in plantations in Albania for more than three decades. To clarify its productive range, and to provide forest managers with relevant information for planting, we studied its productivity in a wide range of site conditions, the first such data concerning the development of this species in Albania. A total of 4 plantations in different parts of the country, which had been left to develop naturally with no intentional felling or silvicultural treatment, were selected for this purpose. When planted in the cold subzone of *Castanetum* or in the warm subzone of *Fagetum* in the altitudes between 700 (800) m and 1000 (1200) m above sea level in rich and deep soil (70–80 cm) Douglas-fir grows very fast and is very vigorous. Depending on site quality, mean annual net increments at age 20 varied from 12 to 14.8 m^3ha^{-1}, annual height increment varied from 80 to 120 cm $year^{-1}$ and the total standing volume varied from 300 to 400 m^3ha^{-1}. Douglas fir can be recommended as an alternative tree species for plantation in the selected forest stands in Albania, but further investigation should be carried out to test its long-term growth and adaptation and ecological effects.

Key words: Douglas-fir, Albania, growth, plantation, site conditions

Introduction

The forest resources of Albania comprise an area of about 1 028 060 ha or 35.7% of its territory, while the growing stock of forests is estimated to be about 82.8 million m^3 of standing timber (Anonymous, 2000). With almost two thirds of the county area having a Mediterranean climate, most of this forest resource is composed from shrubs and broadleaf

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species. One way to increase forest productivity and improve species structure is plantation forestry which can be used to establish forest in lands potentially suited for growing timber but currently devoid of forest, or to rehabilitate forest lands rendered unproductive by occupation by shrubs and economically low value tree species. In Albania most plantations established in the last four decades consist mainly of conifers, even though conifer species currently occupy only 17% of total Albanian forest reserves. The principal species employed include natives, such as: European black pine (*Pinus nigra* A r n.) (Dida et al., 2001), Aleppo pine (*Pinus halepensis* M i l l.), Stone pine (*Pinus pinea* L.), Maritime pine (*Pinus pinaster* A i t.) (Karadumi, 1985) as well as exotic, fast-growing high productivity species, such as Monterey pine (*Pinus radiata* D. D o n) and Douglas-fir (*Pseudotsuga menziesii* (M i r b.) F r a n c o).

The high productivity and superior wood quality of Douglas-fir has made it one of the most important timber trees in the world. In its country of origin, United States, the area occupied by Douglas-fir is 14.3 million ha or 7.3% of the country's non-reserved timberland (Hermann, Lavender, 1999). Named after the man who brought it to Britain from America, the species has been successfully introduced in the last 100 years into many regions of the temperate forest zone (Hermann, 1987). Douglas-fir is a fast-growing source of valuable timber throughout Europe (Cristofolini, 1968; Holjavko, 1981; Polman, Militz, 1996; Luis, Monteiro, 1998; Kantor et al., 2001; Court et al., 2001; Malcolm et al., 2001; Dunbar et al., 2002; Feliksik, Wilczynski, 2003). The area occupied by Douglas-fir varies from country to country. The countries with the largest share of Douglas-fir plantation in Europe are France, Germany, the United Kingdom and the Netherlands (Hermann, Lavender, 1999). In the UK, Douglas-fir comprises 2% of the forest area. First seed crops are achieved at age 30-40 years and normal rotation age is 45-60 years, but the production of viable seed is very low (0.03 Mha^{-1}) compared with that of other native conifers (Malcolm et al., 2001). In Ireland, Douglas-fir amounts to a total area of 3300 ha (Dunbar et al., 2002). France has by far the largest area of Douglas-fir (ca 330 000 ha) (Curt et al., 2001), while Finland, Norway, Sweden have less than 100 ha each occupied by Douglas-fir (Hermann, Lavender, 1999). Its successful introduction to Europe is probably the result of a fortunate combination of favorable site conditions and suitable seed sources for the early plantations. Douglas-fir has not only been introduced in Europe, but in the southern hemisphere as well with New Zealand having the largest and the earliest large-scale plantations (Hermann, Lavender, 1999).

Although reputed to be a potentially high yielding species, Douglas-fir productivity in its country of origin, as well as in countries where the species has been introduced, is very variable and different factors, including site index, substantially affect its growth (Monserud et al., 1990; Corona et al., 1998; Dunbar et al., 2002; Feliksik, Wilczynski, 2003). In Albania, Douglas-fir has been planted for experimental purposes since 1967. This study investigated the site conditions where Douglas-fir has been planted in the country, and the development and the growth of this species. By surveying 4 Douglas-fir plantations we aimed to evaluate the growth of this species in Albania and explain the variation in performance between sites. This information should help forest managers with relevant information for using this species and give insight into the challenges in growing exotic species out of their native range.

Material and method

Ecological survey

All four plantations of Douglas-fir (*Pseudotsuga menziesii* (M i r b.) F r a n c o) in Albania were investigated: Qafe-Bari (Puka district), Biza (Tirana district), Stravaj (Librazhdi district) and Qafe-Shtama (Kruja district). These areas belong to phyto-climatic zones *Castanetum* (cold subzone) and *Fagetum* (warm subzone) (Nako, 1969). Two year-old seedlings had been used for planting (Anonymous, 2002). They were established from seedlings grown in the local nurseries in order to be adapted to micro-climatic conditions. The seeds were obtained from Italy but they were of USA origin (Oregon and New Mexico, data from FPRI archive). The exact provenance of each batch of seed is unknown, in spite of investigations of management records. The plantations are well distributed in the country, and are situated in a longitude from 41°03' N to 42°07' N and latitude 19°07'E to 20°27'E (Table 1). Average slopes of the areas ranged from 25 to 70 percent (12-35°), and dominant aspects represented include north and northeast (Table 1). Climate is favorable for the growth of most coniferous species (Vangjeli et al., 1997): mean annual rainfall ranges from 1800 to 1900 mm, and annual rainfall regime is uniform (Anonymous, 1975).

T a b l e 1. Description of the study areas (climatic data are based on the multi annual average records from the nearest meteorological station, corrected with respective gradients)

Characteristic	Study area			
	Qafe-Bari	Biza	Qafe-Shtama	Stravaj
Location				
Longitude	42° 07' N	41° 17' N	41° 03' N	41° 32' N
Longitude	20° 10' E	20° 12' E	20° 26' E	19° 29' E
District	Puke	Tirana	Kruje	Librazhd
Site				
Size [ha]	4.0	2.4	1.5	3.0
Elevation [m]	700-760	1180-1260	1160-1220	1110-1180
Aspect	NE	N	NE	N
Slope (degrees)	14	12	35	18
Mean temperatures				
Annual [°C]	9.5	9.3	8.9	9.3
Coolest month [°C]	1.2	1.7	0.9	2.0
Warmest month [°C]	18.6	19.1	17.7	19.5
Rainfall [mm]				
Annual	1964.4	1939.1	1801.9	1911.6
During vegetative period (May-August)	222.9	214.7	217.4	234.0

All the measurements were performed in circular sample plots. The area of each plot was 400 m^2 and at each site several plots were surveyed to cover ca 10% of total plantation area, while all the area of the Qafe-Shtama plantation was surveyed. For each plot, the following variables were assessed: elevation above sea level (with altimeter), slope (with Blume Leiss hipsometer), and aspect of the slope (north-south or east-west components reported in degrees).

A soil pit (1x1x1 m) was opened on each sample plot. Soil horizons were described using a standard protocol (as per Mason, 1992). Samples (ca 500 g) were collected in each soil horizon in order to make complementary physical and chemical soil analyses in the laboratory. Each soil sample was analyzed for pH, organic carbon, soil levels of phosphorus (P), potassium (K), and particle size distribution. Soil analysis was performed at the soil laboratory of Agriculture University of Tirana.

Dendrometrical survey

The method consisted in measuring all trees with diameter larger than 6 cm on a circular plot (400 m^2). For each tree in the circular plot, diameter at breast height (1.30 m) was measured to an accuracy of 1 cm and recorded in 2-cm diameter classes. Height and branchiness were measured, and the volume and the number of trees per unit of area (ha) calculated. The height was measured with a Blume-Leiss dendrometer, and the age at breast height (1.30 m) was determined using an increment borer. Five trees per plot were felled for stem analysis. Felling was done ~ 0.10 m above the ground and the exact height of the first disc was recorded. Stem analysis involved the analysis of a complete tree stem and entails counting and measuring the annual growth rings on a series of cross-sections taken at different heights, to determine past rates of growth and changes in stem form. Time Series Analysis (TSAP) software (Frank Rinn, Engineering and Distribution, Heidelberg, Germany) which allows measurement, database handling and analyzing of tree-ring time was used for stem analysis. For each diameter class (at intervals of 2 cm) the height of 3 trees was measured and then the average height was calculated. Since volume tables for Douglas-fir in Albania are not available, in calculating the volume we used the volume tables generated for Silver fir (*Abies alba* M i l l.) stands in Albania (Habili, 1983; Habili et al., 1985). We considered, using a volume model for Silver fir growing in similar ecological conditions in Albania, better than using a volume model for Douglas-fir growing in another country and other ecological conditions.

Investigation of former practices and vegetation

In this study, we collected and compared information from different sources: direct evidence from forest managers, evidence from the archive of Forest and Pasture Research Institute, composition of ground vegetation, edaphic features, and chemical analyses of soils. While these indicators alone did not constitute absolute evidence of former land use, we considered that the information was reliable when at least two indicators were in agreement, for example when silvicultural records and vegetation composition indicated that the plot was formerly covered with a beech acidic forest.

Results

Environmental characteristics of sampling sites

The Douglas-fir trees considered in the study were planted between 1967 and 1970 in the altitudes between 750 m and 1250 m above sea level respectively (Marku, 1988). Altitudinal distribution of Douglas-fir plantations in Albania increases from north to south, reflecting the effect of climate on the growth of the species. The principal limiting factors are temperature in the north and moisture in the south (Mitrushi, 1955).

The Qafe-Bari plantation represents the northern extreme of Douglas-fir plantations in Albania and has the lowest altitude (760 m). The area has been previously occupied by black pine forests, but after a strong wind, most of the trees had fallen down and the area was planted with Douglas-fir (Anonymous, 2002). The area planted with Douglas-fir in Qafe-Shtama was the smallest amongst those considered (Table 1). Biza plantation grows at an altitude of 1240 m and together with Qafe-Shtama are located in central Albania while Stravaj site represents the southeastern extremity of Douglas-fir plantations in Albania.

During the winter, snow is a common phenomenon in all sites and may accumulate to a height of 1m and last for relatively long time (December-February) (Anonymous, 1975).

The soil nutrient status and the depth of soils can be major edaphic constraint for forest productivity in spite of favourable climatic conditions. Soils at all the sites have originated from metamorphosed sedimentary and magmatic material (Veshi, Spaho, 1971). The bed-rock varied from magmatic in Qafe-Bari, to serpentine in Stravaj and Biza where bare rocks were sometimes exposed, to limestone in Qafe-Shtama. Soil belongs to the group of brown forest soils (Zdruli, Lushaj, 2001) with dark brown surface horizons, but becoming lighter-colored beneath. Depth of soils ranged from shallow on steep slopes and ridgetops to deep in deposits and colluvial materials. They are deep (70-80 cm), while horizon A_0 varied between 1-6 cm of thickness (Table 2).

Texture varied from gravelly sands to clays. Surface soils were moderately acid with pH varying from 5.4 to 6.0. Their organic matter content varied from moderate to high while total nitrogen content varies considerably among the horizons but not between the sites (Table 2).

Based on soil chemical analysis, soils from the sampled stands can be considered rich in humus and nitrogen. Among all sites, that of the Qafe-Shtama plantation was the richest compared to the other sampling locations As depicted in the table, pH values show that uptake complex are not saturated in bases (sour) (Table 2). Soils in all sites had a high available water-holding capacity (WSC) because of the presence of loamy deposits as well as having a fine-texture.

Dendrometric characteristics of stands

The planted Douglas-fir differed slightly in survival among sites. Stand density varied from 2750 to 2950 stems ha^{-1}, from an initial planting density 3300 stems ha^{-1}. Biza plantation had the highest stand density, while Qafe-Shtama had the lowest number of trees per hectare (Table 5). Trees of all stands were in very good vigor and vegetative state, and did not show any visible symptoms of biotic damage or fungus attacks. The self-thinning was satisfactory at all sites.

One of the important factors that may determine the future of a stand, is its current structure; i.e. the distribution of trees in diameter classes. Fig. 1 shows the distribution on diameter classes for Qafe-Shtama where all the individual trees were inventoried.

Calculation of X^2 (observed) with the data from Qafe-Shtama stand show that $X^2 = 6.27$, while for the level of significance $P < 0.05$ and 6 degree of freedom, X^2 (expected) = 12.59. This means that the stands tree diameter distribution has a normal distribution. The same held true for the three other stands considered in the study (data not shown).

Table 2. Soil chemical analysis in the sampling sites (data represent the average of 4 soils pits for each site)

Site	Horizon	Depth [cm]	pH	Humus [%]	N [%]	P [mg/100 g soil]	Porosity
Stravaj	A	0–13	5.6	6.83	0.448	14.65	53.7
	AB	13–26	5.6	4.38	0.290	10.07	50.3
	B	27–50	5.4	1.96	–	6.41	47.8
	BC	51–71	6.0	0.89	–	2.93	55.2
Biza	A_0	0–1	5.4	6.83	0.490	19.23	54.89
	A	1–21	5.4	6.03	0.420	16.48	52.60
	AB	21–41	5.6	4.10	–	10.98	50.23
	B	41–60	6.4	0.62	–	3.48	47.62
	BC	60–75	6.0	0.76	–	2.56	42.35
Qafe-Bari	A_0	0–6	5.6	6.83	0.490	16.48	55.78
	A	6–34	6.0	6.76	0.350	5.49	52.31
	AB	34–46	5.4	1.48	–	1.26	49.52
	B	46–57	6.0	1.34	–	1.46	45.63
	BC	57–79	6.0	1.24	–	1.28	47.65
Qafe-Shtama	A_0	0–4	5.5	6.64	0.470	16.48	60.53
	A	4–30	5.8	6.06	0.320	5.49	58.74
	AB	30–40	5.8	2.18	–	1.26	55.14
	B	40–53	6.1	1.40	–	1.46	46.21
	BC	53–65	6.0	0.87	–	1.28	40.45

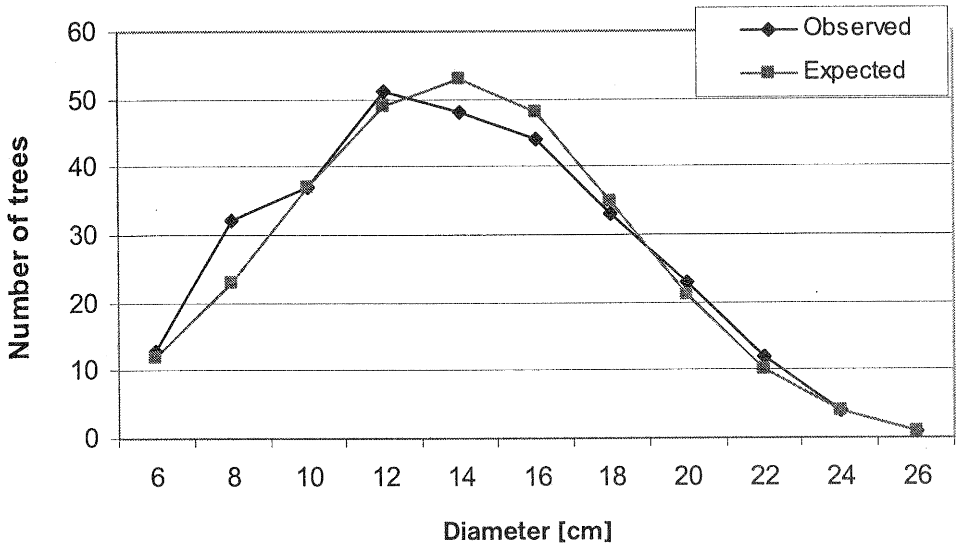

Fig. 1. Stand structure curves based on tree diameter for Qafe-Shtama plantation.

The results of stem analysis to ascertain the total height and the annual height increment, performed by TSAP software are given in Tables 3-5. From direct measurement of the felled trees, the results indicate that annual height increment at age 20 varied from 60-100 cm. However, in Qafe-Bari we recorded trees on the 20th of July that at age 17 have had an annual height increment of 125 cm (Table 4). Stem analysis showed that height and radial growth increment reached their maximum at about age of 20 while increases in volume continued.

The average height of study trees differed between the areas. Trees of Qafe-Shtama plantation were the shortest at all ages, differing significantly from other plantations at age 10 and 15 ($P < 0.05$). As with total height, average stem diameter differed among sites. Trees grew somewhat better in diameter in Qafe-Bari and Stravaj than in Qafe-Shtama or Biza. Ten years after being planted, Douglas-fir averaged almost two times taller in Stravaj than in other sites and nearly three times as large in stem diameter at Qafe-Bari than at the other sites.

The data of crown width and height aboveground of the longest limb, measured to characterize visibly evident differences among sites in tree crown and vigor, confirmed that the average crown radius differed slightly between sites, and the averages ranked in nearly the same order as for stem diameter. This is also related to the fact that differences in stand density were very small.

The first 10 years of their life, the growth of Douglas-fir is not very fast, but it accelerated after this age. Individual trees from all the plantations had a mean height increment ranging from 0.4 in Qafe-Bari to 0.94 m year^{-1} in Biza, and increase in basal diameter ranging from 0.9 cm year^{-1} in Qafe-Bari to 1.66 cm year^{-1} in Biza (Table 3).

T a b l e 3. Stem analysis of the average felled trees in every plantation (data represent the average of 5 trees for each site and age class)

Site	Age of the tree [year]	Diameter at breast height [cm]	Height [m]	Volume [m³]	Basal Diameter [cm]
Qafe-Shtama	5	0.00	0.80	0.000046	0.96
	10	1.36	2.90	0.000711	2.96
	15	7.71	6.00	0.015107	8.77
	20	13.26	10.40	0.061484	15.82
	25	16.38	12.50	0.119257	20.73
Biza	5	0.00	1.30	0.000033	0.66
	10	2.12	4.00	0.001174	3.25
	15	7.13	8.70	0.015819	7.63
	20	12.40	10.90	0.067843	14.85
Qafe-Bari	5	0.00	1.90	0.000386	1.55
	10	5.75	7.80	0.009067	7.72
	15	12.07	9.70	0.057658	16.04
	18	14.56	10.80	0.098460	19.03
Stravaj	5	0.00	1.70	0.000225	1.52
	10	1.14	4.80	0.000860	3.45
	15	4.85	9.30	0.008961	7.46
	20	10.07	12.60	0.043667	12.47
	24	13.98	14.90	0.099500	17.16

T a b l e 4. Height increment for the period 1995-1998 of representative trees

Tree/site	Age [year]	Diameter [m]	Height [m]	Periodic height growth in [cm/year]			
				1995	1996	1997	1998
Qafe-Bari	20	11.8	13.8	82	84	110	80
Qafe-Bari	20	11.2	13.5	102	96	94	90
Biza	20	10.95	12.2	98	58	83	60
Biza	20	12	13.9	100	90	83	74
Stravaj	18	12.5	10.8	114	112	100	98
Stravaj	18	8	6.75	105	85	88	94

T a b l e 5. Dendrometric variables of Douglas-fir in different sites

No.	Site	Age [year]	D.b.h [cm]	Height [m]	Stand density [trees/ha]	Volume [m³/ha]	Mean annual net increment [m³/year/ha]
1	Qafe-Bari	28	16	14.1	2875	415	14.82
2	Biza	20	12	13.8	2950	284	14.20
3	Qafe-Shtama	25	15	12.7	2749	303	12.12
4	Stravaj	20	13	10.8	2883	210	11.70

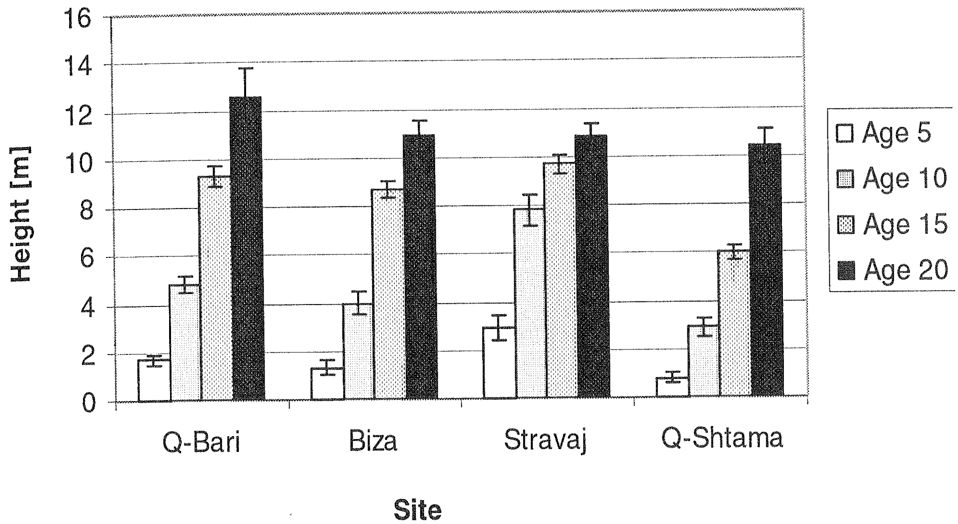

Fig. 2. Variation among sites based on tree height (a single vertical bar represents the average height of five trees in plot in every age class).

Comparing the increment and the yield among different sites (Fig. 2) during the first 10 years, individuals grown in Stravaj have the greatest increase in height and volume, and differed significantly from other sites. These differences are less marked by age 20 and by later age, individuals from Qafe-Bari had the greatest height and volume.

The volume of stemwood did not differ substantially between the sites but slightly less growth in height and diameter and a few less stems resulted in a sizable difference in volume (Table 5).

Former practices and vegetation

Stands considered in the study were pure and even-aged and were located on state properties. It is commonly assumed that the influence of genetic and silvicultural effects on forest height growth remain small when working in monospecific, even-aged and closed plantings (Wang, 1998). Since for all plantations, genetical background and silvicultural treatment would have probably been similar, so the influence of these factors was excluded.

Rangelands occupied most of the land before reforestation and reliable information indicated that there are no significant differences in forestry practices and vegetation between sites and so these differences can be excluded. Ground vegetation was poor and homogeneous because of the acidic soils, and disturbance. Because of this, it is difficult to relate the ground vegetation in these young Douglas-fir plantations to that of mature forest ecosystems with native species.

Discussion

Considered a fast-growing and highly productive species, Douglas-fir (*Pseudotsuga menziesii* (M i r b.) F r a n c o) has been cultivated for experimental purposes in Albania since 1967. It seems that in Albania, Douglas-fir reached more or less the same growth rates as in its country of origin (Hermann, Lavender, 1990).

Stand density in all sites was very high, comparable with natural stands of costal Douglas-fir (Hermann, Lavender, 1990) and almost twice as high as many planted or managed stands (Cafferata, 1986; King et al., 2002; Curtis, Marshall, 2002). This high number of trees per hectare could be attributed to the high initial planting density and the high survival rate.

Annual height increment was relatively slow during the first 10 years but then began to accelerate. This is in agreement with findings for Coastal Douglas-fir, which attains the largest height increments between 20 and 30 years of age, but retains the ability to maintain a fairly rapid rate of height growth for a long period (Curtis et al., 1974). Competition from fast growing shrubs could have been responsible for the slower growth of planted Douglas-fir in the first years, as reported from Stein (1999). The periodic height growth at all sites was comparable with those reported by Omule, Krumlik (1987) for Douglas-fir of the same age growing in west coast of Vancouver.

The variation between sites in terms of wood production (in cubic volume) was low. Considering the fact that the range in productivity between the best and the poorest sites elsewhere can be more than 250 percent (Hermann, Lavender, 1990), the low variation found in this study further suggests also site conditions have been similar. Franklin, Waring (1980) reported mean annual net increments (MAI) of 7 m^3ha^{-1} on poor sites, and more than 28 m^3ha^{-1} on the best sites, under rotations between 50 and 80 years. Depending on site quality, Bruce (1969) reported MAI at age 50 ranged from 4 m^3ha^{-1} to 14 m^3ha^{-1} in Pacific Northwest, while in Clemons and Skykomish, Douglas-fir achieved a MAI from 6.3 m^3ha^{-1} to 15.7 m^3ha^{-1} at age 40 years (King et al., 2002). In Ireland, the typical sites on which the Douglas-fir stands grew better were the brown soils and in the annual yield of these stands ranged from 8 to 22 m^3ha^{-1}, with a mean value of 15.3 m^3ha^{-1} (Dunbar et al., 2002). In France, Douglas-fir is reputed among forest managers to be adapted to acidic sites and have a high mean annual net increment up to 21 m^3ha^{-1} for the premium yield class (De Champs, 1997). Under French climatic and ecological conditions, as indicated by growth volume simulations, given a planting density of 1100 stems per ha, a final mean diameter at breast height of 50 cm, and a final cutting at a dominant height of 40 m, i.e. at 61 years of age on these sites, the estimated total stemwood production would be 1100 m^3 ha^{-1}. This will correspond with mean annual wood volume increment of 17.9 m^3 ha^{-1} per year (AFOCEL, 1997). In the region of Liguria (Italy), 22 year old trees had reached a mean annual net increment of 11.7 m^3ha^{-1} (Cristofolini, 1968). This may be due to favourable environmental conditions, of climate especially. Similar results were observed central Europe, where as an introduced tree species, Douglas-fir is considered as having a high production potential in pure or mixed forest (Kantor et al., 2001). Planted in Kaukaz, in the altitude of 150 m above sea level, Douglas-fir reached a mean diameter of 43.6 cm, and a mean height 30 m by age 40, thus resulting in a gross volume yield of 1038 m^3ha^{-1} (Holjavko, 1981).

Douglas-fir achieves very high dendrometrical parameters and yield. The above-estimated indicators are much higher than those achieved by native conifer or broadleaf species in Albania grown in the same or better conditions. Compared with stands of premium class of yield of European black pine (*Pinus nigra* A r n.) which at age 25 year reach a height of 9.9 m, diameter at breast height (dbh) 10.6 cm and mean annual net increment (MAI) 7.3 $m^3ha^{-1}yr^{-1}$ (Habili et al., 1985), and with stands of premium class of yield European beech (*Fagus sylvatica* L.), which at age 25 year reach a height of 10.4 m, dbh 8.3 cm and MAI 6.8 $m^3ha^{-1}yr^{-1}$ (Habili et al., 1985), the same indicators for Douglas-fir of the same age and grown in the same conditions are 1.5-2 fold higher (Table 3-5). These indicators are almost equal with those of premium class of productivity of *Abies alba* M i l l. (Habili, 1983; Habili, 1985; Habili et al., 1985). To our knowledge, there are no reports that any other native or introduced species in Albania reaching a height increment of 125 cm/year.

Conclusions and recommendations

The history of Douglas-fir in Albania is less than 35 years, thus it might be too early to reach final conclusions about its adaptability in these conditions. This study has revealed the soil parent material and climatic conditions that affect the productivity of Douglas-fir stands to date. Results confirm the suitability of Douglas-fir to most of the sites existing in acidic and wet climatic mid-elevation regions in Albania, however, and are in agreement with those found in other countries with similar conditions. Our results give some good indications but should not be used as a common tool for predicting further development of this species in Albania, since the study is only based on abiotic variables and dendrometric measurements. Nevertheless, it confirms the major role played by some environmental variables, such as elevation and physiographic features.

Comparing the current situation in Albania with the results from other countries where *Pseudotsuga menziesii* (M i r b.) F r a n c o has been cultivated, and with the results in the origin country (USA), we suggest that pure Douglas-fir forest can be created in phytoclimatic zones of *Castanetum* (cold subzone) and *Fagetum* (warm subzone) in altitudes between 700 m and 1200 m above sea level.

Research is needed to monitor the long-term adaptation of Douglas-fir in Albania and, as the data become available, the model of the relationship between the site factors and the yield class should be developed.

Translated by the authors

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Zeneli G., Marku V.: **Produční kapacita Douglasky tisolisté** (*Pseudotsuga menziesii* (M i r b.) F r a n c o) **v Albánii.**

Douglaska tisolistá (*Pseudotsuga menziesii* (M i r b.) F r a n c o), rychle rostoucí introdukovaný vysokoproduktivní druh, byla pěstována ve výsadbě v Albánii po dobu více než třiceti let. Za účelem získání informací o její výtěžnosti a postupu pěstování jsme jako první studovali její úrodnost v široké škále podmínek a stanovišť v Albánii. Byly vybrány celkem 4 výsadby ponechané přirozenému vývoji bez záměrné těžby či lesnického ošetření. Ve studené kultuře *Castanetum* a v teplé kultuře *Fagetum* v nadmořských výškách mezi 700 (800) m a 1000 (1200) m rostla Douglaska tisolistá v bohaté hluboké půdě (70–80 cm) velice rychle. Podle kvality stanoviště byly čisté roční přírůstky ve věku 20 let mezi 12 to 14.8 m^3ha^{-1}, roční přírůstek výšky se pohyboval mezi 80 až 120 cm rok^{-1} a celkový objem mezi 300 to 400 m^3ha^{-1}. Douglaska tisolistá může být doporučena jako alternativní stromový druh pro výsadbu ve vybraných lesních porostech v Albánii. Dále by mělo být provedeno testování jejího dlouhodobého růstu, adaptace a ekologických vlivů.