HEIGHT STRUCTURE ANALYSIS OF PURE *JUNIPERUS EXCELSA* M. BIEB. STANDS IN PRESPA NATIONAL PARK IN GREECE

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UDC 502.4

Received: 12 May 2010
Accepted: 29 May 2011

Abstract

The aim of this study was to analyze height structure of pure *Juniperus excelsa* stands in Prespa National Park in Greece. Since many trees in these stands are multi-stemmed, the height structure based on the tallest stem in each tree was chosen as a representative measure of stand structure. During the summer of 2009, a plot of 100 m x 100 m, which was divided in four subplots of 50 m x 50 m, was established in a medium site quality stand, while a plot of 50 m x 50 m was established in a good site quality stand. Moreover, 90 plots of 25 m x 20 m were established in juniper stands and groups having different canopy cover percentage and forms of *J. excelsa* trees in good and medium site quality areas. In all plots the height of the tallest stem of each tree was measured. In most stands, in both sites, the height class of 5 m dominates in height structure. However, in some cases the class of 3 m dominates in medium site qualities and the class of 7 m in good site qualities. The highest trees found in medium and good site qualities were 12 m and 14 m respectively. The density of *J. excelsa* groups and stands ranged from 80 to 580 *J. excelsa* trees per ha. The rather low tree-height of Juniper trees in Prespa National Park as well as the height structure and density of *J. excelsa* stands are the result of anthropogenic disturbances. The results of this study will contribute to the knowledge and protection of this rare ecosystem in Greece.

Key words: disturbances, protected area, site insensitive species, site quality.

Introduction

Juniperus excelsa M. Bieb. is a species of central and southern Balkans which is also found in Anatolia, Crimea, central and southwest Asia and east Africa (Athanasiadis 1986, Boratynski et al. 1992, Christensen 1997). *Juniperus excelsa* is a site insensitive species, which is able to adapt from full light to dense shade and to show growth increase if the growth conditions are ameliorated (Milios et al. 2007, Milios et al. 2009). These traits contribute to the survival of *J. excelsa* in intensely disturbed and severe environments (Milios et al. 2009). In Greece, in most cases, small groups of *J. excelsa* trees are formed or trees appear as scattered individuals in open forests in degraded ecosystems. In very few cases *J. excelsa* is observed in larger units of pure and mixed stands (Milios et al. 2007).

The aim of this study was to analyze the height structure of pure *J. excelsa* stands in Prespa National Park in Greece. Prespa National Park is one of the very few places where the species forms pure stands in extended areas. The results of this study will contribute to the knowledge and protection of this rare ecosystem in Greece.

Study Area

The study was carried out in the western part of Prespa National Park in Greece. Prespa National Park is situated in the northern-western part of Greece close to the Albanian and F.Y.R.O.M. borders. The *J. excelsa* stands and groups (mixed and pure) appear in an area of approximately 2732 ha within altitudinal range from 840 to 1360 m. The substratum consists of limestones and dolomitic limestones and the soils are clay to clay silt (Pavlides 1985). The soils are rather shallow and surface appearances of parent material are observed in many cases (Pavlides 1985). On average the annual precipitation in Nestorio, which is one of the closest meteorological stations, is 817 mm and the mean annual temperature is 10.8°C.

In the pure *J. excelsa* stands species such as *Quercus macedonica, Juniperus oxycedrus*, *Quercus pubescens, Pyrus amygdaliformis, Carpinus orientalis, Acer monspessulanum* and *Juniperus foetidissima* occur. Their density is low and they do not influence the physiognomy of stands.

Research Method

Juniperus excelsa stands appear in two site types. Site type A represents the more or less productive sites (good site qualities) of the area, whereas site type B represents the less productive sites (medium site qualities). For characterizing sites, the soil depth was determined through soil profiles. In site type A the soil depth ranged approximately from 26–30 to 50 cm and in site type B from 5 to 20–25 cm. The vast majority of *J. excelsa* stands is found in site type B.

In each site, there are dense and sparse *J. excelsa* stands and groups. In the dense formations the canopy cover percentage (canopy cover area x 100/ total area of *J. excelsa* formations) ranges from 60 to 80% while in the sparse ones the canopy cover percentage ranges from 30 to 40%. Regardless of the density of the stands and groups, the *J. excelsa* trees appear as scattered individuals or in small aggregations.

Another characteristic that differentiates the Juniper formations regardless of their density is the height where the living foliage (branches having living needles) appears. In almost all areas of site type B the living foliage of trees appears at ground level. All the trees are multi-stemmed, which results in the formation of an impenetrable hemispherical or spherical crown. This type of tree form characterizes, by far, the most *J. excelsa* stands and groups. On the other hand, in all areas of site type A and in a very small proportion of areas in site type B in a significant number of trees the living foliage appears at a height of 50–60 cm above the ground.

Therefore, as a result six structural types were recognized: 1) dense (DAH) and 2) sparse (SAH) groups or stands in site type A where in a significant number of trees the living foliage appears at a height of 50–60 cm above the ground, 3) dense (DBH) and 4) sparse (SBH) groups or stands in site type B where in a significant number of trees the living foliage appears at a height of 50–60 cm above the ground, 5) dense (DBG) and 6) sparse (SBG) groups or stands in site type B where the living foliage of trees appears at ground level.

During the summer of 2009, in each structural type 15 plots of 500 m^2 (20 m x 25 m) were established with the use of the stratified random sampling method. Moreover, in order to have a representative view of *J. excelsa* stand height structure in extended areas, a plot of 100 m x 100 m, (EB) which was divided in four subplots of 50 m x 50 m, (EB1, EB2, EB3 and EB4) was established in a site type B area, whereas a plot of 50 m x 50 m (EA) was established in a site type A area, since in all cases the pure *J. excelsa* formations in site type A appear in areas lower than 0.7 ha.

In each plot the height of the tallest stem of each tree having height over 1.3 m was measured as a representative measure of stand structure, since most of the trees in site type B are multi-stemmed and the presentation of all heights or of diameters in figures could have created a confusion.

Results

In almost all structural types and in the EB plot (100 m x 100 m) the height class of 5 m dominates (Fig. 1, Fig. 2). In the SBG structural type the height class of 3 m dominates. In the good site qualities in the EA plot (50 m x 50 m) the greater number of trees fall in the height class of 7 m. The highest tree found in medium and good site qualities was 12 m (DBH, DBG) and 14 m (DAH), respectively (Table 1).

The highest mean density of *J. excelsa* trees was found in DBG structural type, while the absolute highest density was found in DAH structural type. The SBG structural type exhibits the lowest mean and the absolute lowest density of *J. excelsa* trees (Table 1).

In the EB plot the height structure appears to be more or less stable concerning the three plots (EB1, EB1 + EB2 and EB) shown in the Figure 2, starting from the plot of 50 m x 50 m (EB1) and moving on to larger plots (e.g. 50 m x 100 m, 100 m x 100 m).

Discussion

The density of *J. excelsa* trees in Prespa National Park is lower than the density of junipers in the mixed stands of the central part of Nestos Valley situated in the north-east of Greece as well as the corresponding density in *J. excelsa* stands of Isparta – Sutculer in Turkey (Milios et al. 2007, Carus 2004). The maximum height of the juniper trees in Prespa National Park is higher than that of Nestos Valley, and more or less the same as the height of the highest trees in Isparta – Sutculer in Turkey and is lower than that of *J. excelsa* stands in Balouchistan (Milios et al. 2007, Carus 2004, Ahmed et. al. 1990). Moreover it is lower than the maximum tree height in *J. excelsa* formations in the valley of Hayl Juwary in Oman (Fisher and Gardner 1995).

In the overall area of the species distribution the height structure of *J.*

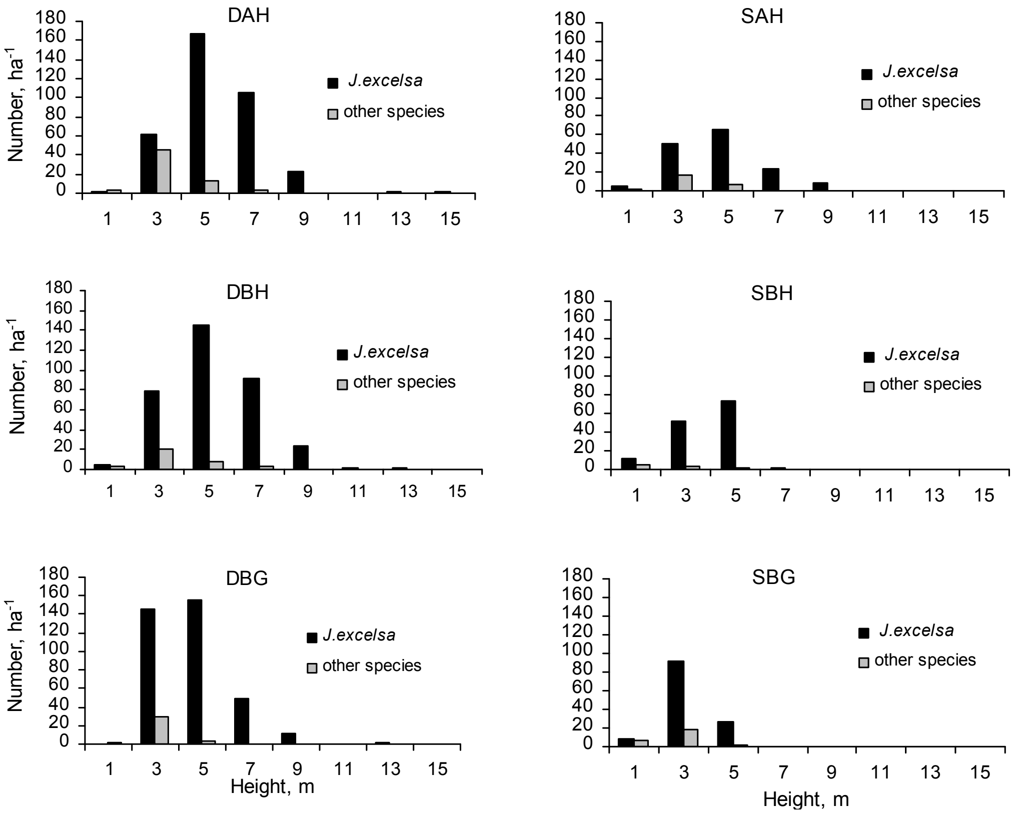

Fig. 1. Distribution of heights in the six structural types.

excelsa formations varies. The height classes that dominate in the *J. excelsa* stands found in four site types in the central part of Nestos Valley, range from 4 to 8 m (Milios et al. 2007). Moreover, the lower height classes (2–8 m) show the highest density of trees in the height structure of *J. excelsa* stands in Balouchistan, however, it has been remarked that height classes ranging from 6 to 9 m dominate in the *J. excelsa* formations in the valley of Hayl Juwary in Oman. (Ahmed et. al. 1990, Fisher and Gardner 1995).

As it can be concluded from the height structure of all structural types, the pure *J. excelsa* stands in the study area are uneven aged. The height and age structure as well as the density of *J. excelsa* stands in Prespa National Park have been strongly affected by anthropogenic disturbances. In 1917 and during the World War II in some locations of site type B all the *J. excelsa* trees were cut by the army (Pavlides 1985). Moreover, even today illegal cuttings have been observed (personal observation).

Another disturbance, which influenced the growth rates and the heights of trees was the cutting of the Juniper branches by the local residents in the

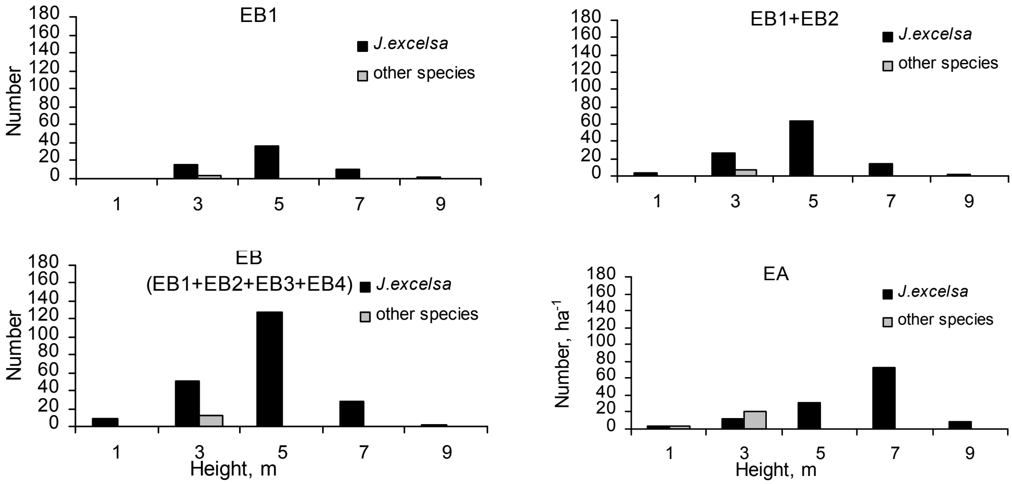

Fig. 2. Distribution of heights in EB1, EB1 + EB2, EB and EA plots.
(in the EB1, EB1 + EB2 and EB plots, Number is the actual number of trees in each plot while in the EA plot the number of trees per hectare is given)

Table 1. Structural characteristics of pure *J. excelsa* stands and groups.

Structural types	Density of *Juniperus excelsa*, ha^{-1}		Density of all species, ha^{-1}	
	X ± SD	Range	X ± SD	Range
DAH	360 ± 67	300–580	424 ± 53	360–580
SAH	155 ± 19	120–180	180 ± 25	120–220
DBH	347 ± 51	260–420	380 ± 57	280–480
SBH	136 ± 26	100–200	147 ± 36	100–220
DBG	361 ± 46	300–460	396 ± 51	300–480
SBG	127 ± 28	80–180	151 ± 32	100–200
	Height of *Juniperus excelsa* trees, m		**Height of other species trees, m**	
	X ± SD	**max**	**X ± SD**	**max**
DAH	5.07 ± 1.762	14	3.03 ± 1.142	7
SAH	4.21 ± 1.746	9	2.92 ± 0.946	5
DBH	4.76 ± 1.750	12	3.07 ± 1.258	6
SBH	3.54 ± 1.000	6	2.40 ± 1.228	5
DBG	4.06 ± 1.542	12	2.67 ± 0.799	5
SBG	2.93 ± 0.827	5	2.79 ± 0.588	4

X ± SD = Mean ± Standard Deviation

past. The locals used these branches to make traps for the fish in Prespa Lakes (Catsadorakis 1995). Grazing is another disturbance factor in the area. Even though grazed *J. excelsa* seedlings or sapling were not found, trampling of regeneration might have affected the density of stands.

In the future, more research is needed regarding the regeneration and dynamics of the *J. excelsa* stands in Prespa National Park in order to be properly protected and managed.

Conclusions

The *J. excelsa* stands in Prespa National Park in Greece are differentiated by their density and the height where the living foliage of trees (branches having living needles) appears. In most stands, in both sites, the height class of 5 m dominates in height structure. However, in some cases the class of 3 m dominates in medium site qualities and the class of 7 m in good site qualities. The highest trees found in medium and good site qualities were 12 m and 14 m respectively. The height and age structure as well as the density of *J. excelsa* stands in Prespa National Park have been strongly affected by anthropogenic disturbances.

Acknowledgments

The first author is financially supported by the Bodossaki Foundation.

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