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STRUCTURE OF OLD-GROWTH *PINUS HELDREICHII* FORESTS IN PIRIN MOUNTAINS

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Abstract

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Bosnian pine (*Pinus heldreichii* Christ) is a tertiary relict and Balkan sub-endemic species. Its communities are of high conservational value because they are extremely rich in rare and endemic plant and mushroom species. In Bulgaria, *Pinus heldreichii* forests are found only in the Pirin and Slavyanka Montains. Despite the necessity of better knowledge of the species and the forests, many questions are still poorly studied.

The goal of this study is to explore the structure and natural dynamics of old-growth *Pinus heldreichii* forests in Pirin. Four regions were selected in which four sample plots were set. Within them basic characteristics of each tree were measured. Tree ages, growth dynamics and the influence of external abiotic factors were studied. The results were compared with the results from a previous study of younger forests in Pirin. The explored old-growth forests are characterized by much smaller number of trees per 1 ha compared to younger forests. In most of the plots, there are evidences of at least several fires. Regeneration is isolated mostly on dead wood with high class of decomposition. Dominant trees are more than 250 years old. Our data might be valuable in other ecological studies, that need to have better understanding of forest structure and history and might serve as a basis for definition of criteria for old-growth *Pinus heldreichii* forest.

Key words: old-growth forests, *Pinus heldreichii*, structure, Pirin Mts.
Abbreviations: DBH – diameter at breast height; CWD – coarse woody debris; PIHE – *Pinus heldreichii* Christ; PIPE – *Pinus peuce* Griseb.; PIMU – *Pinus mugo* Turra; PCAB – *Picea abies* Karst.; ABAL –*Abies alba* Mill; SOAU – *Sorbus aucuparia* L.

Introduction

Pinus heldreichii Christ (syn. *P. leucodermis* Antoine) is sub-endemic species occurring in isolated subalpine locations in the Balkan Peninsula and Southern Italy. Some of the most preserved forests dominated by *Pinus heldreichii* are located in Pirin Mts. Despite the high conservational value of *Pinus heldreichii* ecosystems their dynamics are not well known yet. Most studies were focused on studying the possibilities to use the species for climate proxies (Todaro et al., 2007; Panayotov et al., 2010; Seim et al., 2012; Lyubenova et al., 2005) or actually producing climate reconstructions (Trouet et al., 2012). These studies confirm that often forests are composed of trees with ages of more than 500 years and up to 1000 yrs and thus can be classified as some of the few examples of really old-growth forests in Europe. Yet, data on structural parameters is not published. This hinders the chances to use the *Pinus heldreichii* forests as examples, which are crucially needed in modern conservational and forestry practices.

Our aim is to study the structure and natural dynamics of old-growth *Pinus heldreichii* forests in Pirin Mts.

Material and Methods

The study area is situated in Dzhindzhiritsa Reserve in the Pirin Mts. in southwestern Bulgaria (Figure 1). Most of the highest zone of the Pirin Mts, including our study

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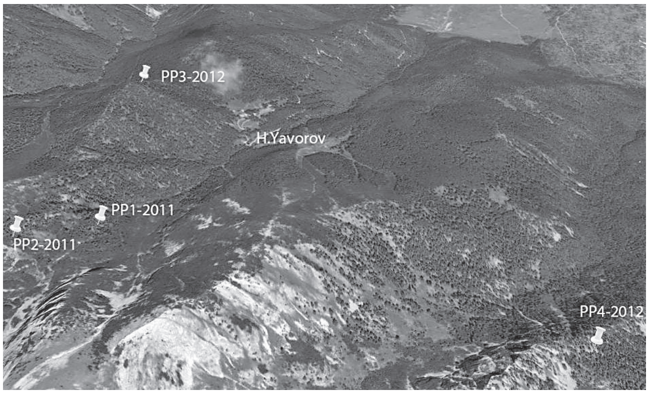

Fig. 1. Position of study site

Table 1

Characteristics of the sample plots

Plot name	Altitude	Exposure	Inclination	Coordinates	
				Latitude	Longitude
PP1	1970	E	40°–50°	41°48′59″	23°22′20″
PP2	2110	E-SE	45°	41°48′53″	23°22′8″
PP3	2020	NE	40°–45°	41°49′29″	23°22′22″
PP4	2014	E-SE	35°	41°48′36″	23°23′40″

area, is currently protected in Pirin National park. The slopes are steep (30–50°) and hardly accessible. This is the reason why anthropogenic influence is limited and our study sites have retained a natural structure.

Based on interpretation of high-resolution satellite images from 2010, we selected 4 regions in which we set 4 sample plots at different altitudes and exposures (Table 1). The plots were with dimensions of 50x50 m (2 plots) to 25x50 m (2 plots). The sizes were set because of constrains in local terrain (i.e. rock bands).

The position of each tree in local coordinate system, diameter at breast height (DBH), height and crown dimensions was measured in each plot. The tree ring cores were extracted using the increment borer to estimate tree ages, study growth dynamics and the influence of external abiotic factors. A total of 100 samples were collected, mounted on wooden boards, air-dried and sanded. Then the cores were scanned at resolution of 1200 dpi and analyzed with the software program CooRecorder. Obtained tree-ring width series were cross-dated, thus insuring the knowing of the exact year in which a tree ring was formed. This procedure was done with the use of visual clues (Stokes and Smiley, 1968) and statistical comparisons with the computer program CDendro. In addition, rings with specific anatomic featured based on visual analysis were marked. Such changes are related to impact of environmental changes, such as natural disturbances or silvicultural purposes (Eisenhart and Veblen, 2000).

Results

The studied old growth forests are characterized generally by smaller number of trees per ha (252 to 544) than younger forests (up to 1777; Stoyanov, 2011). The mean DBH varies between 38 and 59 cm, while the maximum DBH varies between 81 and 133 cm (Table 2). There are more than 5 trees with diameter above 80 cm (up to 28 trees) in all plots. The percentage of trees with DBH > 50 cm varies between 15 and 48% (Figures 2, 3, 4 and 5).

A general characteristic is the very high percentage of

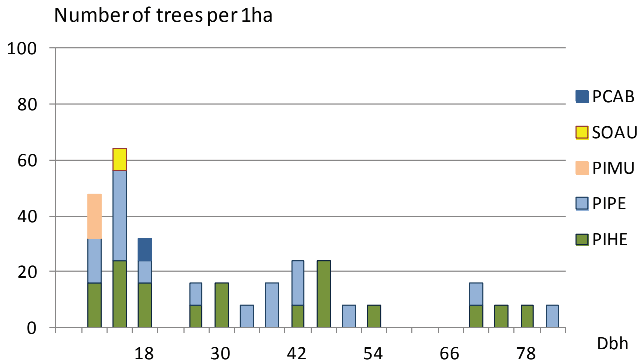

Fig. 2. Diameter distributions in sample plot PP1

Table 2

Structural data for studied forests

Plot name	Max Dbh	Mean Dbh	STD of Dbh	Number trees per 1 ha				Dead Wood – CWD		
				Dbh > 6 cm	Dbh > 10 cm	Dbh > 50 cm	Dbh > 80 cm	Number trees per 1 ha	D > 20 cm	D > 50 cm
PP1	81	38	0.75	328	280	48	8	64	64	40
PP2	133	59	1.84	252	248	120	28	84	84	52
PP3	98	39	1.39	544	424	96	24	168	136	40
PP4	100	40	1.47	260	208	44	16	124	112	52

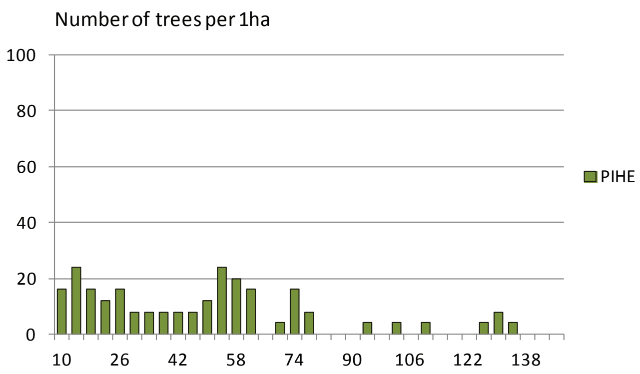

Fig. 3. Diameter distributions in sample plot PP2

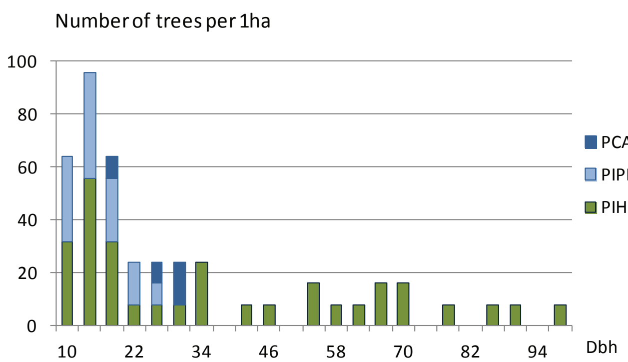

Fig. 4. Diameter distributions in sample plot PP3

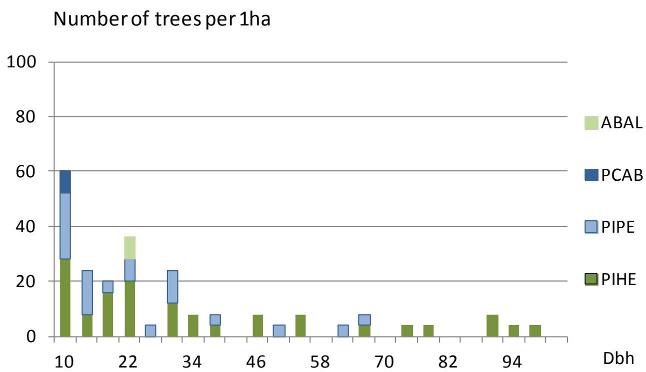

Fig. 5. Diameter distributions in sample plot PP4

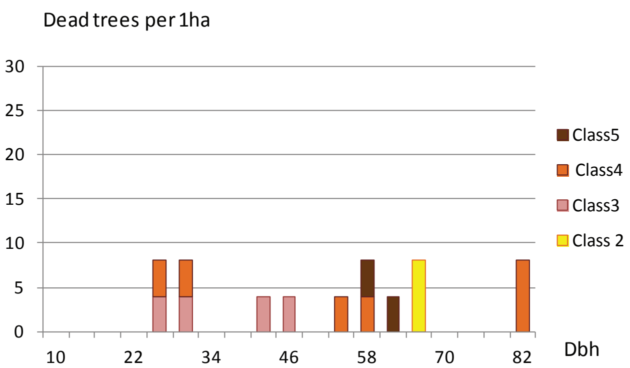

Fig. 6. Diameter and decomposition class distribution of coarse woody debris (CWD) in sample plot PP1

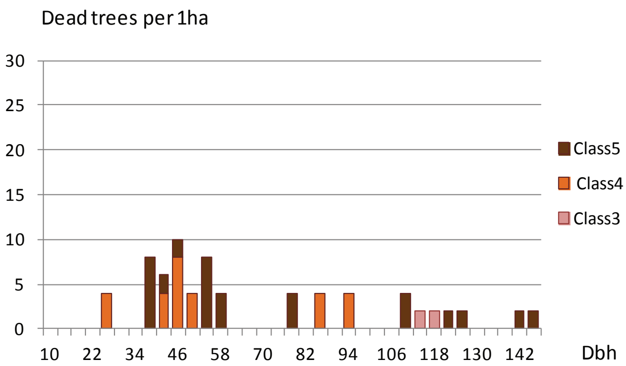

Fig. 7. Diameter and decomposition class distribution of coarse woody debris (CWD) in sample plot PP2

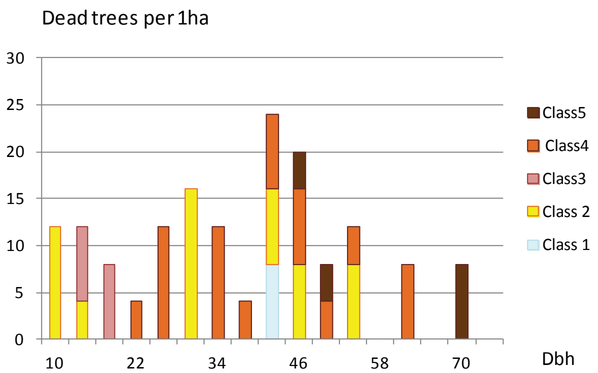

Fig. 8. Diameter and decomposition class distribution of coarse woody debris (CWD) in sample plot PP3

coarse woody debris (CWD). Most of it is logs, some of which are completely dead laying trees with DBH > 130 cm. The dead wood is in various stages of decomposition. Class 1 (freshly dead trees with standing bark) is not present (Figures 6, 7, 8 and 9). Classes 4 and 5 are most common (soft decayed wood, which allows easy penetration by hard subject). Diameter distributions generally resemble reverse J-Shaped, but in plots with lower number of young trees (e.g. plot PP2) cannot be strictly classified.

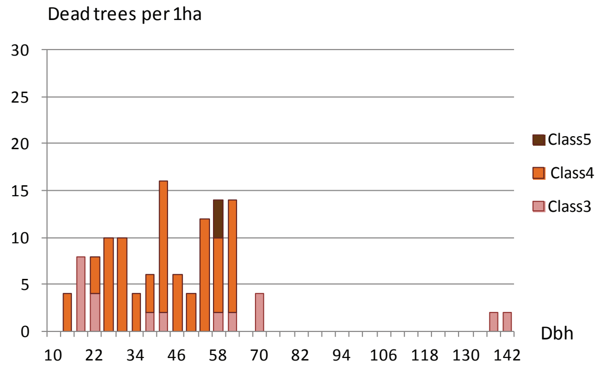

Fig. 9. Diameter and decomposition class distribution of coarse woody debris (CWD) in sample plot PP4

Age of dominant trees is more than 250 years. Single trees reach ages of over 500 years. Regeneration is isolated mostly on dead wood in high classes of decomposition. In most of the plots, there are clear signs of at least several fires, which suggests, that mostly fires drive the natural dynamics of Pinus heldreichii forests.

Conclusions

We studied old-growth *Pinus heldreichii* Christ forests in Pirin Mts. They are characterized by very high proportion of trees with DBH > 80 cm and high percentage of dead wood. Dead wood is often present as logs with very high diameters (DBH > 130 cm). Regeneration is found mostly on dead wood in high classes of decomposition. Age of trees is above 250 yrs., with dominants above 500 yrs. Our data contributes to other ecological studies that need to have better understanding of forest structure and history and might serve as a basis for definition of criteria for old-growth *Pinus heldreichii* forest.

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