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THE GROWTH OF BOSNIAN PINE (*Pinus heldreichii* Christ) IN HERZEGOVINA

USPIJEVANJE MUNIKE (*Pinus heldreichii* Christ) U HERCEGOVINI

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Stands of Bosnian pine on the mountain Čvrsnica in Herzegovina are pure natural stands with distinctive protective, social, pioneering and productive functions. Bosnian pine is an endemic tree species and a relict from the Tertiary period, preserved in the Balkans and in the southern part of the Apennine peninsula from the glaciation period. It grows naturally over a small, broken, and limited area, to which very few artificial additions have been made. Past research on these stands has mostly been concerned with their floral and geographical aspects, the study of soil, and the survey of plant communities featuring the Bosnian pine, while research on structural and taxative elements in the stands of Bosnian pine has been almost negligible. The current production capacity, forest soil potential, age and increment were assessed on the basis of recorded management elements and descriptions in the existing stands of Bosnian pine. The processes of natural regeneration in these stands should be adapted to the actual conditions in the stands, as well as to the condition of the soil, natural regeneration and rotation period. Bosnian pine on Čvrsnica in Herzegovina grows on a terrain characterised by harsh conditions and the poor productive capacity of the soil. In such conditions, it plays a multiple role: not only is it a pioneering species, but it also protects the soil, creates suitable conditions for the arrival of other tree species, and gives an attractive appearance to the landscape. Productive capabilities on Mount Čvrsnica are lower than those in other parts where this tree occurs, but are still satisfactory in the light of the given conditions.

Key words: *Pinus heldreichii* Christ, tertiary relict, endemic species, biological properties, site class, young growth, tree growth and increment, stand growth and increment, production.

INTRODUCTION
UVOD

Bosnian pine is a Tertiary relict preserved in the Balkan Peninsula during the glaciation period. This endemic tree species of a limited, broken and small natural distribution occurs in central and western parts of the Balkan Peninsula, and in the southern part of the Apennine peninsula. Forest stands of Bosnian pine occur fragmentarily in high mountains of Herzegovina, Montenegro, Kosovo, Macedonia, Albania, Bulgaria and Greece, while in southern Italy the species appears in separate groups. This leads to the conclusion that Bosnian pine is distributed over a sub-Mediterranean region, where its forest associations occur mostly at high altitudes (between 1,000 and 1,900, and sometimes over 2,200 m above sea level), and cover steep, arid slopes on a lime substrate. In this way, they often form the upper border of forest vegetation. The growth rate of Bosnian pine in stands is very slow. It occurs predominantly on limestone and dolomite, and less frequently in the zone where lime and dolomite substrates meet with serpentine or acid silicate substrates. In the former case, it covers extreme sites characterised by narrow ridges, steep slopes, prominent cliffs and ground slides, and sometimes it even occurs in flatter calcareous areas. On such shallow, stony soils of a mostly humus type, stands of Bosnian pine represent a permanent stage of vegetation. As it is not threatened by other forest tree species, it is practically the only species to be used in reforesting such arid, water-less areas. The stands often have inconsistent, broken and open canopies. More comprehensive complexes are only found in relatively more favourable site conditions (Stefanović 1977). In spite of their very limited distribution range, Bosnian pine forests are very important for many reasons: for example, they represent a rarity in the forest vegetation, and have a very important role in preventing erosion. The excellent technical properties of Bosnian pinewood make these forests economically valuable, too. Bosnian pine is also known to be a distinctly pioneering tree species. For this reason, it plays a very important role in the dynamics of vegetation, particularly in progressive succession (Fukarek 1966). As a tree species, it contributes significantly to the rich dendroflora of Herzegovina. There have been a number of papers and studies about the Bosnian pine, but most have treated it only partially. Therefore, in order to study this tree in full detail, future research should adopt a more comprehensive approach.

The goal of this research is to provide further insights into some productive characteristics of pure Bosnian pine stands in Herzegovina. The following steps have been taken: Bosnian pine stands in Herzegovina have been located, their ecological conditions studied, the biological properties of Bosnian pine examined, the development and increment of the tree and stands studied, and Bosnian pine productive capacity assessed in given ecological conditions. The study of some taxative elements, believed to be good indicators of the productive capacity of Bosnian pine forests, has been carried out. The research was carried out on the mountain of

Čvrsnica, where one of the largest complexes of pure stands of Bosnian pine in Herzegovina occurs.

RESEARCH SO FAR
DOSADAŠNJA ISTRAŽIVANJA

In the middle of the 19th century, Theodor Heldreich, a Greek botanist, found a new species of pine while studying the flora on the mountain Olympus in Greece. The new species seemed to him to resemble the species *Pinus maritima* Ait., and so he sent a twig under this name to Edmond Boisser, a botanist in Geneva. The twig remained in a herbarium until it came into the hands of a Swiss botanist Herman Christ, who was at that time preparing a monograph on European pines. On the basis of this twig, H. Christ described a new, previously unknown pine species, which he called *Pinus heldreichii* Christ 1863.

At that same time, a well-known collector Franjo Maly found a large number of related pine species on the mountain Orjen (the border of Austrian Dalmatia and Turkish Bosnia of the time), and took ample material to Vienna. He gave the collected material to the botanist Antoine Franjo, who was also preparing a monograph on European pines. After studying this rich material, F. Antoine concluded that it was a specific pine, so he made a comprehensive and detailed description illustrated with a number of original photographs, and called the species *Pinus leucodermis* Antoine 1864 & Fukarek 1979. After some time, the botanist Christ 1867 realised that the "new" species *Pinus leucodermis* Antoine was in fact the species from the mountain Olympus, and suggested that it might be its "young form". He changed its name into *Pinus laricio* var. *leucodermis* (Ant.). This should be pointed out, because by doing so, Christ himself renounced his earlier described "species", which he, on the basis of some morphological similarities with the black pine, added to the varieties of the species *P. laricio* Poiret Fukarek 1979. After that, whenever new sites of white-bark pine were found, they were named *Pinus leucodermis* Antoine by most botanists. *Pinus heldreichii* Christ was considered a special species, or its name was attributed as a synonym to the species *P. leucodermis* Antoine. A detailed description of the species *P. leucodermis* Ant. appears in the first edition of a classic handbook on conifers by Beissner in 1891, but a separate description of the species *P. heldreichii* Christ also appears in a footnote. Among the first to point out the identity of *P. heldreichii* and *P. leucodermis* was the botanist Boissier in 1884, later joined by the botanists Adamović 1905 & Halacsi 1904, whose authority at the time was unquestionable. This belief was held until recently, when a connection between these two pine species was re-established, but depicted in a new manner. Particular merit goes to the botanist Hayek 1926, who, observing the rules of botanical nomenclature, used the name *P. heldreichii* Christ as the correct one. Since then, white-bark pine has been referred to as *P. heldreichii* Christ in most dendrological-botanical discussions. Had it been possible to unquestionably establish the identity between the species discovered by Heldreich and described by Christ, and the species discovered by

Maly and described by Antoine, there would have been no problems in their nomenclature. The name *P. heldreichii* Christ, as the older, would have been the only correct one. However, such complete identity between white-bark pine from the mountain Olympus and that from the mountain Orjent was again questioned by the botanist Markgraf 1931. Gaussen 1960 gave a new interpretation of white-bark pine as two independent species. As we see, there have been different opinions on the problems of variability and taxonomic affiliation of white-bark pine. The whole problem was well presented by Fukarek 1979. He suggested that Bosnian pine was the basic species, and that white-bark pine of hybrid character came into being by crossing *P. leucodermis* x *P. nigra*. With regard to the fact that white-bark pine is similar or identical to Bosnian pine, and that hybrids with black pine occur where their distribution areas overlap, the belief of Fukarek 1979 should be adopted, provided, as he himself says, that its validity is confirmed by further research. This tree species displays individual and group variability, which is manifested by its morphological and phenological characteristics, growth and the anatomical structure of needles (Stilinović & Tucović 1972, Tucović & Stilinović 1975, 1977, Popnikola 1975, 1978). Known varieties of Bosnian pine are: var. *leucodermis* (Ant.) Markgraf, var. *longiseminis* Papaioannou (1975b), var. *pančići* Fukarek (1951), var. *typica* Markgraf (1931) and spontaneous hybrids between *P. nigra* x *P. leucodermis* (Fukarek & Vidović 1965) occurring on the mountain Prenj, in the Rujište locality in Herzegovina. From the above, it follows that Bosnian pine has two taxons: var. *heldreichii* Christ (Syn. var. *typica* Markgr.) and var. *leucodermis* (Ant.) Markgr.

The majority of research on the Bosnian pine so far has dealt with plant-geographical research, the study of soil in its forests, the survey of plant communities in which it occurs, and similar studies. Little, or hardly any, attention at all has been paid to the structural and productive characteristics of Bosnian pine forests.

NATURAL DISTRIBUTION
PRIRODNA RASPROSTRANJENOST

Bosnian pine usually forms pure stands, but sometimes it is mixed with other conifers (Macedonian pine, black pine, fir) and deciduous trees (beech) in Mediterranean and sub-Mediterranean mountains of the Balkan Peninsula and south Italy. Beautiful small stands are found in the Bosnian mountains of Hranisava, Bjelašnica and Visočica, and in Herzegovina on the northern slopes of Čvrsnica, Čabulje, Prenj, Velež and Orijen-Štirovnik. In Montenegro and Kosovo, it occurs on Bijela Gora, Lovćen, Durmitor, Sinjajevina, Bjelasica, Maganik, Kamenik, Komovi, Koritnik, Žlijeb and on the slopes of the Prokletije range. In Macedonia, it is found on Galičica, Korab, Rudoka and a range of Šar-Planina. In Bulgaria, it occurs on Pirin and Slavjanka (Ali-Batuša). In Albania, it has the widest distribution from the north to the south of the country. In Greece, it occurs in the north, in Epirus, Macedonia and Tesalia on the mountains of Gramos, Tymphi, Pinda, Vermion, Olympus, and lower Olympus (Kato-Olympus). In south Italy, it is found in

Calabria and Brasilicata. On Bjelašnica near Hranisava, south-west of Sarajevo, at a distance of about 24 km as the crow flies and about 43° 44' 30" latitude and 18° 08' longitude east of Greenwich, there is the northernmost site of this pine on the Balkan Peninsula. Longo studied the occurrence of Bosnian pine (Markgraf 1931) in Italy; in 1905 he found the pine on Montes Fina near Lauria in Brasilicata and on Monte Pollino, and in 1906 on the line from Orso Marso all the way to Monte Mantea in Calabria. This is the southernmost point of its geographical distribution in Italy, located at an eastern latitude of about 39° 42' and a longitude of 15° 55'. According to Hoffman, Bosnian pine is present in the Apennines of Campagnia east of Naples. Its northernmost site in Italy is located at a latitude of 40° 43' to 40° 44', and a longitude of 2° 43' east of Monte Mario. In 1921, Stojanov announced the occurrence of Bosnian pine on South Orvil (Ali-Batuš) in Bulgaria in the eastern part of the Balkan Peninsula. A year later, Stefanov found it slightly more northward, on the northern-east slopes of the highest peak of Orvil (Pirin) at 41° 46' to 41° 50' latitude on Muller's map. In 1957, Papaioannou found the southernmost site of Bosnian pine distribution in Greece, at 41° 20' 30" latitude and 0° 06' 20" longitude east of Athens. Earlier, the distribution borders of Bosnian pine extended from the north to the south and from the east to the west. A disjunct distribution of Bosnian pine within the above-mentioned borders was established in more detail by numerous local studies. In the vertical distribution, it usually takes up a belt 1,000 – 1,900 m above sea level, but also occurs at lower altitudes (720 m) in Greece, and higher ones (2,500 m) on Olympus, also in Greece.

ARTIFICIAL DISTRIBUTION
UMJETNA RASPROSTRANJENOST

In order to extend the area of Bosnian pine distribution artificially, a careful study of its ecology, adaptive capacity to new sites, resistance, and other factors should be made. As Bosnian pine is a very important sub-Mediterranean tree species, it would be useful to present data on how this tree behaves outside its natural area, that is, in specific sites where it has been grown for shorter or longer periods in the form of larger or smaller forest cultures. The bio-ecology of Bosnian pine has been dealt with in detail by a number of scientists (Blečić 1959, Janković 1960, 1967, Blečić-Tatić 1960, Fukarek 1966). Bosnian pine is adapted to a short vegetation period, a dry and mountainous summer climate, and harsh winter conditions in high mountains. Knowledge gained by practical and scientific research so far has prompted foresters to use this species to reforest xerothermal sites, and sometimes even mesophyllic ones. About four to six decades ago the first smaller Bosnian pine cultures were established, which speaks of the interest at that time to introduce this tree species into areas outside its natural distribution range. These and similar undertakings enable us to follow the success of introducing the Bosnian pine into more or less unfavourable specific sites in the Balkan Peninsula. In the sites where Bosnian pine was artificially raised, a significantly slower growth rate of this spe-

cies was noted compared to that of black pine, which confirms the assumption that this species is characterised by slow growth at its young stage. Individual variability in artificial populations confirms the observations of other authors about the individual and group variability of this tree species in its natural populations. The presence of extreme changes in Bosnian pine cultures (dwarf growth, viviparity, and others) requires more detailed, comprehensive and experimental research on this species in its natural and artificial populations. The existence of 10 to 20 per cent better phenotypes in Bosnian pine populations analysed so far justifies their selection (mostly through multiple selection procedure) for further growth in lower sites. Therefore, it is reasonable to expect that this tree species will achieve much better results in the sites outside its natural distribution. This fact is very important for forestry, especially with regard to afforesting inhabited areas. Ample fructification of Bosnian pine in its lowest natural sites points to prospective benefits from raising vegetative and generative seed plantations in warmer sites outside its natural distribution range. In order to do so, detailed bio-ecological, genetic and other experimental research should be carried out. Bosnian pine is ideal for afforesting bare, stony, calcareous, water-less and karstic mountain regions in which black pine does not occur and where only Bosnian pine can form beautiful, well-developed trees. Bosnian pine is a tree species with the fewest requirements in Europe. Its wide ecological range enables it to grow at high altitudes in a belt of dwarf pine, where it reaches the border of forest vegetation. For this reason, Bosnian pine should be used to afforest high, bare mountainous regions in which other commonly used afforesting species are out of the question.

BOSNIAN PINE IN HERZEGOVINA
MUNIKA U HERCEGOVINI

GENERAL
OPĆENITO

Bosnian pine is distributed in the form of pure natural stands over high mountain ranges in Herzegovina. However, it often forms mixed stands with black and dwarf pine, and may also individually occur in mixed stands of beech and fir. The wide ecological amplitude of this tree species enables it to occur in a number of forest types, that is, to form a special alliance of *Pinion heldreichii* forests (Horvat 1946). This alliance represents a wide complex of phytocoenoses, of which Herzegovinian phytocoenoses is one of the basic groups. Several types of Bosnian pine forests from the group of Herzegovinian phytocoenoses growing naturally on the above mentioned mountains have been studied so far. Herzegovinian forests of Bosnian pine (*Pinetum heldreichii hercegovinicum* Horv. 1963) most commonly occur in the form of fragmented stands, where either individual trees or groups of trees are found within several phytocoenoses in high-mountainous swards or in associations of sub-Alpine beech and dwarf-pine pine forests. According to Fukarek

(1966), Bosnian pine forms the following phytocoenoses in this natural part of its distribution area:

a) *Amphoricarpo-Pinetum heldreichii* Fukarek 1966 inhabits narrow, exposed and extremely steep dolomite crests between 1,300 and 1,800 m above sea level. It is characterised by a number of endemic species, among which *Amphoricarpus neumameri*, *Thesium auricilatum* and *Hieracium villosum*, typical of xerophyllic and rocky phytocoenoses, are prominent.
b) *Senetio-Pinetum heldreichii* Fukarek 1966 occupies relatively more favourable sites. This association is also characterised by some endemic species, such as *Senetio vissianianus* and *Sesleria coerulans*.
c) *Pinetum-nigre-heldreichii* Fukarek 1966 covers border regions of black pine and Bosnian pine, where the natural hybridisation of these two species takes place. This is reflected in the morphological characteristics of both species in the phytocoenoses of black pine and Bosnian pine.
d) *Mugo-Pinetum-heldreichii* Fukarek 1966 inhabits higher altitudes of the sub-Alpine border area with dwarf pine, where a sub-Alpine form of Bosnian pine is represented in the phytocoenoses of dwarf and Bosnian pine.

In terms of geographical position, Bosnian pine in Herzegovina is naturally distributed between 43° 23' 00" northern latitude, or between 17° and 19° longitude east of Greenwich. Above a 4-square-kilometre-large glacial lake of Blidinje at an altitude of 1.183 m, there are pure natural stands of Bosnian pine extending in a north-east - south-west direction on the mountain of Čvrsnica, whose highest peak Pločno is situated 2,226 m above sea level. In this part of the natural range of Bosnian pine distribution, which is located at the edges of forests with neglected and abandoned mountain pastures and swards, this species expands by natural regeneration. There, young stands of Bosnian pine display a clear tendency to expand further into the areas previously covered by pastures. The basic reason for this phenomenon lies in the diminution of the number of cattle in the area, the movement of the local people into the foothills of Čvrsnica, and a general abandonment of nomadic-style cattle-breeding in Herzegovina.

SITES
NALAZIŠTA

More important complexes of pure Bosnian pine stands in Herzegovina are found on the mountains of Prenj (863 ha), Čvrsnica and Čabulja (472 ha), Velež and Nevesinje Crna Gora (105 ha), and Orjen-Štirovnik (76 ha). The stands of Bosnian pine in the westernmost and northernmost border of its natural distribution on Mountain Čvrsnica are excluded from forest management. This area of 340 ha within the management unit of Čvrsnica belongs to the karst commune of Posušje. Some pure stands of Bosnian pine in Herzegovina are located in the region of "Central Neretva", as well as in that of "Upper Neretva".

An important feature of these forests is a high percentage (over 50%) of the parent substrate (limestone), which significantly lessens the productive capacity of this tree species and these forests. According to the data from the forest-management basis, the total area under Bosnian pine in Bosnia and Herzegovina is 5,865 ha, which is only about 0.5% of the total surface area under high forests. Of this, 1,528 ha are taken by pure stands of Bosnian pine. Pure stands are those in which Bosnian pine is represented by 90 or more per cent in terms of wood volume. A more significant artificial distribution of forest cultures of Bosnian pine has not been recorded over larger areas in Herzegovina, except the sporadic planting of several dozen individual seedlings.

CLIMATE
KLIMA

The climate of a country depends to a great extent on its geographical position, the distance from the sea and orographic conditions. The area of natural distribution of the Bosnian pine falls within the sub-Mediterranean region, where this species mostly occupies the highest positions (between 1,000 and 1,900 m). The river valleys of the Neretva, with its tributaries the Drežnjanka, the Doljanka, the Rama and others, open this region to a warmer and more humid climate than that of the continental parts. Above this belt, the influence of a mountainous climate is felt as high as 1,500 m above sea level. The regions of a sub-Alpine belt with spruce and dwarf pine forests above this altitude have a typical harsh climate, which is characterised by very long winters and abundant snowfall. The features of the climate with a pronounced mountainous influence are reflected in sudden transitions from one season to another. Winters are usually long and rich with precipitation, especially snow, and summers are short and cool. There are early autumn and late spring frosts. Bosnian pine is naturally distributed on the border of the Mediterranean and continental climate, where air currents differ both in their strength and duration. It can, therefore, be concluded that the climatic conditions in the area of natural Bosnian pine distribution in Herzegovina are very heterogeneous, and that a continental-mountainous climate and a sub-Mediterranean climate of a cooler belt can be distinguished. As there are no meteorological stations in the stands of Bosnian pine, the data from the four closest stations were taken: Mostar, Konjic, Posušje and Tomislavgrad. A ten-year average from the period 1981 – 1990 was taken for the meteorological station of Mostar, and ten-year averages for the periods 1971 – 1980 were taken for those of Konjic, Posušje and Tomislavgrad.

AIR TEMPERATURE
TEMPERATURA ZRAKA

The mean annual air temperatures are between 9.1°C and 14.4°C However, if mean annual air temperatures are calculated with a thermal gradient for the belt at altitudes between 1,000 and 1,900 m, (in which adult natural Bosnian pine stands

grow), the mean annual air temperature is between -0.9°C and 5.4°C. From this, it can be concluded that natural stands of Bosnian pine in Herzegovina appear at annual air temperatures averaging between -0.9°C and 5.4°C. The lowest mean monthly temperature of -0.9°C occurs in January, while the highest of 24.6°C occurs in July. The mean monthly maximums and minimums are as follows: the mean monthly maximum in the warmest month (M) is between 23.7°C and 31.7°C, the mean monthly minimum in the coldest month (m) is between -3.3°C and 1.9°C, and the temperature deviation (M-m) is from 29.8°C to 26.4°C. The absolute annual temperature minimum varies greatly and ranges from -18.8°C to -8.8°C. The absolute annual temperature maximum differs less dramatically and ranges from 35.0°C to 41.2°C. Bosnian pine is greatly affected by the number of icy days with temperatures below -10°C. If several such days occur in a row, this tree species will die. These data allow us to conclude that Bosnian pine is a very plastic pine species as regards air temperature.

PRECIPITATION
OBORINE

According to data, the mean annual precipitation quantity in the stands of natural Bosnian pine distribution in Herzegovina is between 1,279 mm and 1,553 mm. The lowest mean monthly precipitation of 10 mm was recorded in August, while the highest of 352 mm was recorded in November. The most important factor for the growth of Bosnian pine is the pattern of precipitation over seasons. According to the available data, the seasonal arrangement of precipitation is unfavourable, which has a damaging effect on the development of the species, particularly in the summer period (July - August). The least rainfall, between 46 mm and 49 mm, occurs in the summer season, which is 15.3 mm, or 16.3 mm on average per month. According to the data for the meteorological station which has the highest annual precipitation quantity (1,553mm), spring accounts for 23.5%, summer for 8.9%, autumn for 38.1% and winter for 29.5% of the total precipitation quantity. The whole growing season receives only 36.7% of rainfall. With temperatures over 5°C, or 10°C, the season lasts 305 or 205 days a year. The data for the meteorological station which has the smallest precipitation quantity a year (1,279mm) show that precipitation is distributed as follows: 29.4% occurs in the spring, 11.4% in the summer, 28.6% in the autumn, and 30.6% in the winter. The vegetation period, lasting for 324, or 223 days in a year, and having average temperatures of 5°C or 10°C, receives slightly more rainfall (40.3%). The number of rainy days ranges between 107 and 122. The number of snowy days, which is between 12 and 29, is much more important. The height of snow on the ground ranges from 2 cm to 110 cm. Heavy, wet snow is especially harmful for the tops of Bosnian pines. It can be concluded from the above that natural stands of Bosnian pine grow well in those areas where an abundant quantity of humidity from air and precipitation is available.

WINDS
VJETROVI

The region in Herzegovina where Bosnian pine grows naturally is rather windy. Strong winds mostly occur outside the growing season. These include northerly, north-westerly, north-easterly and south-westerly winds. Northerly winds blow mostly in winter and spring, while southerly ones occur in summer and autumn. The region is dominated by a north-easterly wind (buran), typical for the karst area in general. Dominant and important winds of a northerly direction blow with an incidence of 43%, while winds of a southerly direction blow with an incidence intensity of 20%. The studied area is characterised by the fact that the total number of windless days in a year is 25%, and the total number of windy days is 75%. The impact of the buran is of decisive importance for the growth of forests in this region. This impact is mainly reflected in its detrimental mechanical action involving the drying of the atmosphere and the soil.

SOIL
TLO

The diversity of soil types is closely connected with the kind of geological substrate. The sites in which the complexes of pure natural stands of Bosnian pine occur are geologically built of younger lime and dolomite rocks of the Cretaceous period and in higher regions of lime and dolomite rocks with distinct karst landforms of the Triassic and Jurassic period. The soil complexes on limestone and dolomite are most frequently represented on the parent substrate of these rocks. Black soil (humus) occurs most frequently on steep slopes, brown calcareous soil on milder slopes and inclinations, while illimerised soil is found at the foothills and in funnel-shaped holes. The most represented soils are as follows: a class of immature soils (A)-C, profile-type lithosol (rock material), a class of humus-accumulative soils A-C, profile-type calco-melanosol (calcareous-dolomite humus and rendzina), a class of cambic soils A-(B)-C, profile-type calco-cambisol (brown soil on limestone and dolomite), and a class of eluvial-illuvial soils A-E-B-C, profile-type luvisol (illimerised soil). The soils in the chosen experimental plots are developed on two basic geological substrates - limestone and dolomite - and have different typological properties. Apart from the differences resulting from the role of the parent substrate in the soil formation, the soils developed on the limestone have more typological characteristics due to a more pronounced karst phenomenon. An evolutionary soil series has been recorded on limestone, ranging from shallow black soil, to medium-deep brown soil, to deep illimirised soil. With the last, the geological substrate is deep and outside a physiologically active profile (funnel-shaped-holes). Rendzina, with its series of shallow, less skeletal soils in the profile and no stone blocks on the soil surface, (a particular characteristic of a karst region), has developed on the dolomite substrate.

SOIL TYPE CHARACTERISATION
KARAKTERIZACIJA TIPOVA TALA

Rendzinas on dolomite are found in Plot 3 (Orlov Kuk) and are represented by the profile Orlov Kuk 3. These are predominantly shallow soils. By their mechanical structure, they are sandy clays, that is, skeletal sandy clayey loams. In these soils the skeletal part is calcareous. The quantity of free carbon is over 50%, and the soil reaction is alkaline. The surface horizon has a very high humus content, and the transitional horizon still contains enough humus. The participation of nitrogen in the soils is almost analogous with the humus content, and the C:N ratio is favourable. In terms of physiologically active nutrients, these soils have a poor to medium supply of K_2O, and a poor supply of physiologically active P_2O_5. Therefore, the nutritive values of these soils on dolomite (rendzina) are lower than those of black soils (humus) on limestone. Humus on limestone occurs in Plot 2 (Kraljeva Kleka) and is represented by the profile Kraljeva Kleka 2. These are shallow and distinctly skeletal soils. On the profile of the soil, a 5cm - thick subhorizon A is clearly visible, made up of pine needles in various degrees of decomposition. The soil profile is airy and porous due to high amounts of the skeletal factor. However, the soil residue is porous and well drained due to a stable crumbly-granular structure, although by its structure it is clay. The soil reaction is neutral. Apart from this, black soils on limestone contain a high percentage of free carbons due to large amounts of tiny skeletal particles. The mentioned soils are well supplied with K_20, but poorly supplied with P_2O_5, They have a medium to high humus factor. Brown soils on limestone are found in Plot 1 (Šestiver) and are represented by the profile Šestiver 1. The surface horizons of these soils are similar to the shallow soils in the respective plots described above, but with less humus, apart from the specially excluded subhorizon A_0A_1 in the profile Šestiver 2. The deeper horizons of the mentioned soils are light clays with a well-defined granular-crumbly structure. The soil reaction is slightly acidic, there are no free carbons, and the C:N ratio is favourable, as is the case with most such soils. Like rendzinas and humus, these soils are also well supplied with physiologically active potassium, and poorly supplied with phosphorus.

BIOLOGICAL PROPERTIES
BIOLOŠKA SVOJSTVA

Bosnian pine is a monoecius, anemophilous, heliophytic, calcific tree species. However, it can also develop on the silicate substrate in secondary sites in areas where the calcareous and silicate parent substrates meet. It blossoms in May and June, depending on the altitude, propagates with seeds, and commonly inhabits the steep, stony and rocky terrain of the sub-Alpine belt, where it has no competition. It forms pure or mixed stands with other coniferous and deciduous trees. In terms of general distribution, Bosnian pine is an endemic species of the central and western part of the Balkan Peninsula and the southern part of the Apennine peninsula.

REPRODUCTION
POMLAĐIVANJE

Bosnian pine reproduces naturally only with seeds. Artificial methods of reproduction, apart from sowing seeds, are not known. Several attempts at vegetative propagation have not been successful, although this method of propagating this species would be very important in general, as it would greatly ease the selection of individuals with higher yields, a faster increment, larger dimensions, and other factors. Vegetative propagation in Herzegovina and other areas has not yet been put into practice. Bosnian pine growing in stands begins bearing seed after the age of 40, and that growing in isolated spots much earlier. Crop years occur every 2 to 3 years.

ADAPTABILITY
ADAPTIVNOST

An extremely important property of every tree is its ability to adapt to various living and growing conditions. Bosnian pine in Herzegovina occurs naturally in isolated areas as a Tertiary relict and as an endemic tree species. So far, it has not been introduced into cultures on a large scale. In the ecological conditions reigning in the sub-Mediterranean region and the region of high mountains, Bosnian pine has found its place on steep stony or rocky terrain of the sub-Alpine belt, where it has no competition. It has adapted well to the soils developed both on limestone and dolomite (primary sites), and to a drier climate (with less air humidity and precipitation). Bosnian pine also occurs on a serpentine and silicate substrate, where the climate is slightly more favourable (secondary sites), and at meeting points of limestone and dolomite substrates. In relation to temperature, Bosnian pine has wide amplitude, because it tolerates both winter lows and summer highs. It has very modest requirements in terms of soil and soil humidity. It succeeds naturally on sun-exposed sites, where the soil is usually immature, the parent rock comes to surface, and the growing period is marked by arid conditions. The primary site of Bosnian pine is in the sub-Alpine region, most commonly on a carbonate substrate. Due to its modest humidity requirements, this pine is capable of forming stable stands despite adverse conditions. As a distinctly calcific species, it can also grow in sites with a silicate substrate, in a meeting zone with calcareous or dolomite parent substrate, provided that there is no competition from other, faster-growing tree species, since Bosnian pine grows very slowly, especially at the early age. Such conditions usually occur when the primary forest vegetation growing at lower altitudes or on sun-exposed slopes is suppressed by a fire or clearcutting. Bosnian pine appears there as a pioneering tree species. Its forests are then in the secondary site and represent the first stage of progressive succession. They are more productive, but their survival depends on adequate management procedures, which should be adapted to the bio-ecology of this tree species. In its primary site, Bosnian pine grows well and regenerates naturally. In all stands in Herzegovina, there is natural young growth whose quality is conditioned by the space and light in the parent

stand, and by the size of the mountain clearings immediately adjacent to the parent stands of Bosnian pine.

WORKING METHODS
METODA RADA

To study the growth and productive capacity of Bosnian pine forests in Herzegovina, a control method was used for assessing increment and production. A method of tree analysis was used for monitoring tree growth and production. The control method requires a longer measuring period if reliable results are needed.

The volume and volume increment of Bosnian pine stands is expressed in m^3 of the total timber mass (with small branches). Böhmerle's tables for black pine were used to calculate the volume (Grunder - Schwappach 1952). Böhmerle's tables show the timber mass in so-called large timber (over 7 cm at the thinner end) including branch material. By using this percentage, the timber mass of large trees was converted into the so-called total timber mass and then equalised. The results were then compared with the volume tables for total timber mass according to Drinić & Prolić 1979. The data from these tables provide mean values of site quality classes for Bosnian pine in Herzegovina. These tables proved to be very reliable.

In order to evaluate the possible extent of cutting in experimental plots, trial tree marking was conducted. The trees were marked according to the silvicultural principles of productive continuity. The trees were classified using the silvicultural-technical criteria of classifying common and black pine (Matić 1971). To ensure successful natural regeneration in Bosnian pine stands, a system of shelterwood cutting in very small groups and with a long regeneration period is recommended. This recommendation is realistic and justified in view of the fact that the site conditions of Bosnian pine are very poor. This tree is a distinctly heliophytic species whose stands have typical multi-layered, and even step-like canopies.

To determine the degree of canopy cover, the length of the line covered by the tree crowns above the taxative limits in experimental plot diagonals was measured. The relation between the length of the covered lines and the total length of diagonals in an experimental plot represents the degree of canopy cover in a corresponding experimental plot.

The number of seedlings (young trees below the taxative limit) was studied in randomly arranged experimental circles with a diameter of 17.84 m (area 250 m^2). The number of young trees was classified according to tree species, and within the species according to growth classes.

CHOICE OF EXPERIMENTAL PLOTS
IZBOR POKUSNIH PLOHA

Since Bosnian pine is distributed naturally on the mountains of Herzegovina, the initial decision was to focus on the mountains of Prenj, Čabulja and Čvrsnica.

However, the initial decision had to be abandoned owing to a multitude of mines left over from the war, or due to the inaccessibility of some areas. This made the choice of experimental plots more difficult, and so they were set up in the following localities of Bosnian pine on the northern slopes of Čvrsnica which gravitate towards Blidinje Lake:

1. Šestiver (Čvrsnica), compartment 23a - experimental plot No.1.
2. Kraljeve Kleke (Čvrsnica), compartment 22 - experimental plot No. 2.
3. Orlov Kuk (Čvrsnica), compartment 18a - experimental plot No. 3.

Experimental plots were set up in the area of the Management Unit Čvrsnica (one part). All plots were rectangular and 1 ha in size, placed over sloping terrain, with a longer side parallel to isohypsometric line. All experimental plots in the field were marked with a red horizontal line on the border trees at a breast height of 1.30 m. One experimental plot was placed in a stand of black pine on the mountain of Čvrsnica, the aim being to compare the results for Bosnian pine with those for black pine (*Pinus nigra* var. *ilirica* Vidaković). The basic characteristics of the studied stands are shown in Table 1. acteristics of the studied stands are shown in Table 1.

Table 1. The location and size of studied stands
Tablica 1. Položaj i veličina pokusnih ploha

Compartment *Odjel*	Size *Površina* (ha)	Size of exp. plot *Površina pok. plohe* (ha)	Altitude *Nadm. visina* (m)	Exposition *Izloženost*	Inclination *Nagib* (°)
23a	91.0	1.0	1,460-1,500	N-NW	35°
22b	24.0	1.0	1,360-1,400	NW	40°
18a	30.0	1.0	1,270-1,300	N	20°
26a	39.0	1.0	1,280-1,310	W-NW	25°

TREE MENSURATION
IZMJERA STABALA

The trees in every experimental plot were measured at breast height (1.30 m above the ground) with a calliper of 1cm accuracy and a taxation limit of 5 cm, which means that all the trees in the plots with a breast diameter of 5 or more cm were measured. In order to measure the diameter increment, samples (increment cores) were taken in each of the experimental plots with a Pressler increment borer. Increment cores were always taken from the right side of a measured breast diameter. The length of the core (annual ring width) has been measured for the last 10 years to an accuracy of 0.5 mm. The double value of the core length represents the current periodic (ten-year) diameter increment. The heights of several trees were also measured in order to construct a height curve for each experimental plot. The height of trees was measured with the Blume-Leiss hypsometer with an

accuracy of 0.5 m. A sample of the tree best representing the mean stand tree in terms of diameter and height was taken for each of the plots for tree analysis.

DATA ANALYSIS
OBRADA PODATAKA

TIMBER MASS CALCULATION
IZRAČUN VOLUMENA

Timber mass was calculated in the following manner: curves were constructed using the measured tree heights in order to obtain the mean heights for certain tree diameters. With the obtained mean heights, and the use of tables for the black pine (Bohmerle 1893), a tariff was constructed for each experimental plot. The tariffs were equalised with a line. The timber mass in experimental plots was obtained by multiplying the tariffs with the number of trees. For easier presentation and tabling, the calculation based on diameter degrees of 5 cm with a taxative limit of 5 cm was shown. Indicators on the number of trees, basal area and timber mass for all experimental plots are shown in Tables 2 and 3.

CALCULATING INCREMENT AND PRODUCTION
IZRAČUN PRIRASTA I PRODUKCIJE

Increment and production for the stands in experimental plots were calculated using the control method on the basis of two measurements conducted in all existing experimental plots over 15 years. The results of increment and production in experimental plots are shown in Table 4.

Table 4. Increment and production per hectare
Tablica 4. Prirast i proizvodnja po hektaru

No of plot *Broj plohe*	Age from - to *Dob od - do*	Increment *Prirast* (m^3)			Prinova (m^3)			Production *Proizvodnja* (m^3)		
		Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*
1	43 - 58	84.46	-	84.46	1.86	-	1.86	86.31	-	86.31
2	47 - 62	31.36	2.78	34.14	0.95	0.07	1.02	32.31	2.85	35.16
3	23 - 38	41.93	2.65	44.58	0.25	0.05	0.30	42.18	2.70	44.88

TREE ANALYSIS
ANALIZA STABALA

According to the accepted practice, the trees in the experimental plots were analysed in the manner presented in the book "Growth and increment of forest

Table 2. Number of trees and basal area per hectare
Tablica 2.Broj stabala i temeljnica po hektaru

No. of plot *Broj pok. plohe*	Name of area *Naziv predjela*		Age *Dob* (Year-*Godina*)	Number of trees *Broj stabala*			Basal area *Temeljnica* (m^2)			Mean tree for principal stand *Srednje stablo za glavnu sastojinu*	
				Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	DBH $D_{1.30}$ (cm)	Vol. (m^3)
1	Šestiver	I	43	1,032	3	1,035	19.30	-	19.30	16.6	0.12
		II	58	1,287	11	1,298	24.07	0.24	24.31	18.7	0.17
2	Kraljeva kleka	I	47	732	20	752	13.07	1.34	14.41	16.2	0.12
		II	62	785	102	887	14.02	1.68	15.70	17.9	0.15
3	Orlov kuk	I	23	1,804	8	1,812	22.60	0.08	22.68	10.9	0.04
		II	38	2,060	62	2,122	25.80	0.67	26.47	12.5	0.06

I - Data from the first inventory - *Podaci prve inventarizacije*
II - Data from the second inventory - *Podaci druge inventarizacije*

Table 3. Timber mass per hectare
Tablica 3. Volumen po jednom hektaru

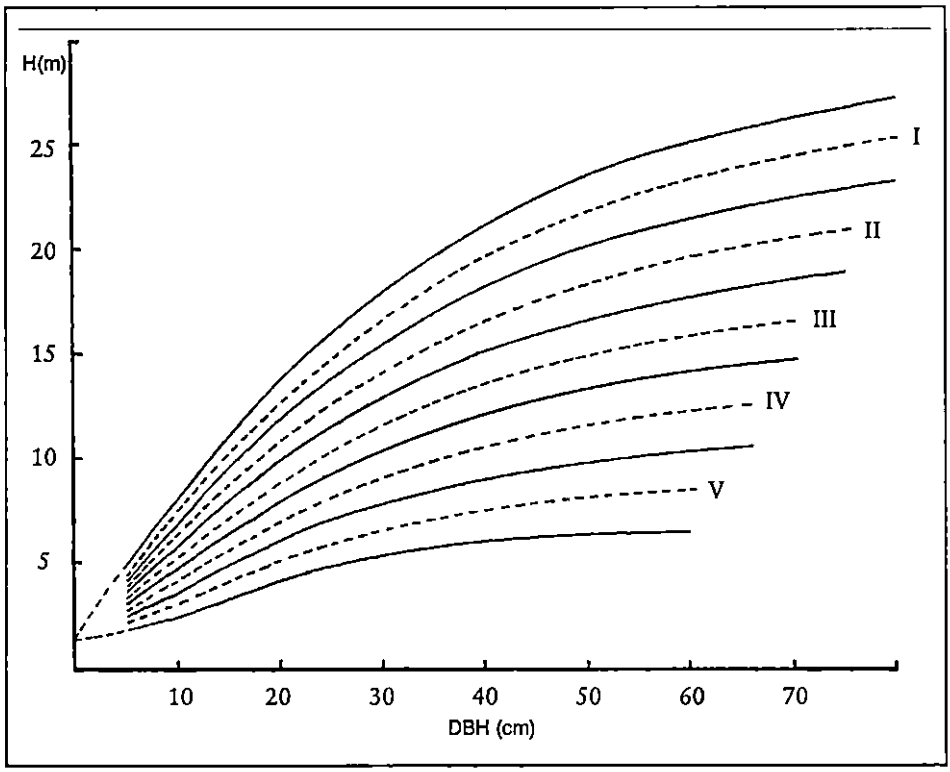
No. of plot *Broj plohe*	Soil type *Tip tla*	Age *Dob*	Timber mass *Volumen* (m^3)			Average age increment *Prosječni dobni prirast* (m^3)		
			Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*
1	Brown on limestone *Smeđe na vapnencu*	43	128.00	-	128.00	2.98	-	2.98
		58	214.31	-	214.31	3.70	-	3.70
2	Humus on limestone *Crnica na vapnencu*	47	85.00	5.00	85.00	1.81	0.11	1.92
		62	117.31	7.85	125.16	1.89	0.13	2.02
3	Rendzina on dolomite *Rendzina na dolomitu*	23	85.00	5.00	90.00	3.70	0.22	3.92
		38	127.18	7.70	134.88	3.35	0.21	

tree species and stands" by D. Klepac, Zagreb 1963. For each of the experimental plots, one tree was analysed using the accepted methodology and practice. The results and the indicators for all analysed trees are shown in Tables 12, 13, and 14, and in Graphs 4, 5 and 6.

THE RESULTS OF THE RESEARCH
REZULATI ISTRAŽIVANJA

TREE HEIGHTS AND SITE QUALITY CLASS
VISINE STABALA I BONITET STANIŠTA

The mean tree height per diameter degree of 5 cm was calculated on the basis of the measured heights of Bosnian pine trees in the experimental plots. The mean tree breast diameter was also calculated for the same diameter classes as the arithmetic mean of tree diameters of adequate diameter classes. The mean diameter obtained in this way is, as is well known, always lower that the mean diameter calculated by using the basal area. The results were compared with the results for tree heights and site class curves according to Drinić & Prolić 1979. These authors limited the obtained height curves from the bottom and top side with two thicker lines, which should, in their estimation, limit the intervals of tree height variations per diameter degrees in pure stands of Bosnian pine in Herzegovina. To do this, they used the curves of the site class for the black pine (Drinić 1963). They tried to approximate as closely as possible the intervals of tree height variations per diameter degrees for the Bosnian pine in Herzegovina and the black pine in Bosnia. They mentioned two reasons for this: *first*, the Bosnian pine and the black pine are biologically very close tree species, and *second*, their research, like the present research, did not include the best and the worst site conditions in which Bosnian pine occurs in natural stands in Herzegovina. For this reason, the height of Bosnian pines is in general slightly lower than the height of black pines. After that, the obtained intervals were divided according to diameter degrees into five parts of equal width and received a bundle of site class curves for pure stands of Bosnian pine in Herzegovina. Broken lines denote the height of trees in the centre of an adequate site class, and full lines denote the borders between individual site classes. The bundle of site class curves for pure stands of Bosnian pine according to Drinić & Prolić 1979 is shown in Graph 1. Unlevelled mean Bosnian pine heights for all experimental plots, inserted on the basis of mean diameters per diameter degrees, are shown in Graph 2. Bosnian pine stands were classified on the basis of the mentioned bundle of site class curves. The part of the height curve relating to diameter degrees possessing the largest participation of stand volume was decisive. The evaluated site classes of the stands in experimental plots are shown in Table 16. Table 5 shows the heights of Bosnian pine trees in the centre of the related site class (I to V) and the tree volume for the related breast diameter and height, that is, for the



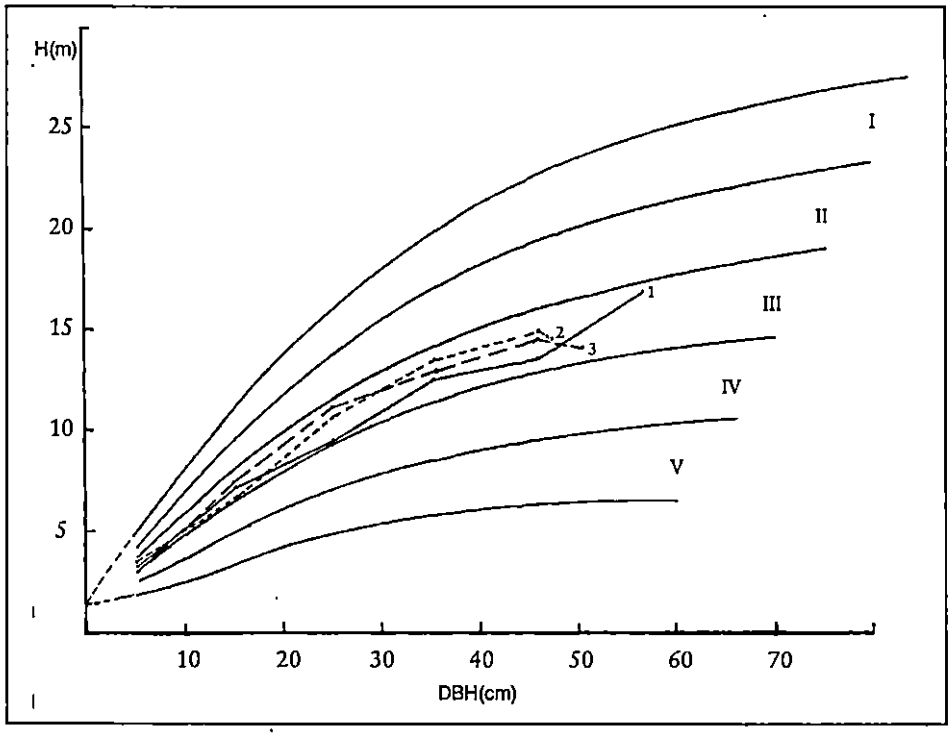
Graph 1. Curves of site quality classes for pure stands of Bosnian pine in Herzegovina (Drinić & Prolić 1979)
Grafikon 1. Krivulje bonitetnih razreda za čiste munikove sastojine u Hercegovini (Drinić & Prolić 1979)

site class according to Drinić & Prolić (1979). The table was marked as a volume table for Bosnian pine in Herzegovina because, in our opinion, the table can be used for management purposes in these forests. The tree volume in the table is expressed in total timber mass (with small branches). The tree volume was obtained, as already said, by using Bohmerl's tables for the black pine.

The differences in the height of Bosnian pine and black pine in Herzegovina are seen from the following comparison of mean tree heights for the III site class of both tree species, shown in Table 6.

Table 5. Drinić & Prolić, 1979. Volume tables for Bosnian pine in Herzegovina
Tablica 5. Drinić & Prolić, 1979. Volumne tablice za muniku u Hercegovini

DBH *Prsni promjeri* (cm)	Site class - *Bonitetni razred*									
	I		II		III		IV		V	
	Height *Visina* (m)	Volume *Volumen* (m^3)	Height *Visina* (m)	Volume *Volumen* (m^3)	Height *Visina* (m)	Volume *Volumen* (m^3)	Height *Visina* (m)	Volume *Volumen* (m^3)	Height *Visina* (m)	Volume *Volumen* (m^3)
5	4.3	0.0083	3.7	0.0066	3.2	0.0051	2.6	0.0035	2.1	0.0023
6	4.9	0.0147	4.3	0.0114	3.5	0.0087	2.9	0.0072	2.2	0.0049
7	5.6	0.0222	4.8	0.0200	3.8	0.0172	3.2	0.0156	2.4	0.0132
8	6.3	0.0300	5.3	0.0272	4.2	0.0240	3.5	0.0220	2.6	0.0193
9	6.9	0.0379	5.8	0.0348	4.7	0.0315	3.8	0.0288	2.8	0.0259
10	7.4	0.0461	6.3	0.0434	5.2	0.0400	4.1	0.0365	3.0	0.0330
12	8.6	0.0660	7.3	0.0607	5.9	0.0558	4.7	0.0516	3.4	0.0490
14	9.7	0.0973	8.3	0.0886	6.6	0.0796	5.3	0.0734	3.9	0.0730
16	10.7	0.1364	9.2	0.1258	7.3	0.1122	5.9	0.1036	4.4	0.1020
18	11.7	0.1819	10.0	0.1674	8.0	0.1514	6.5	0.1391	4.8	0.1310
20	12.6	0.2346	10.8	0.2150	8.8	0.1946	7.0	0.1770	5.1	0.1670
22	13.5	0.297	11.5	0.269	9.4	0.242	7.4	0.217	5.5	0.200
24	14.3	0.368	12.2	0.331	10.0	0.295	7.8	0.258	5.8	0.234
26	15.1	0.454	12.8	0.402	10.6	0.356	8.2	0.305	6.1	0.271
28	15.9	0.543	13.4	0.483	11.1	0.427	8.6	0.362	6.3	0.315
30	16.6	0.645	14.0	0.575	11.5	0.499	9.0	0.428	6.5	0.358
32	17.3	0.760	14.6	0.670	12.0	0.581	9.4	0.495	6.8	0.409
34	17.9	0.879	15.2	0.775	12.4	0.669	9.7	0.560	7.0	0.465
36	18.5	1.009	15.7	0.884	12.8	0.765	10.0	0.641	7.2	0.532
38	19.1	1.145	16.1	1.002	13.2	0.868	10.3	0.737	7.4	0.610
40	19.6	1.285	16.5	1.126	13.5	0.975	10.5	0.825	7.5	0.691
42	20.1	1.454	16.9	1.261	13.8	1.086	10.7	0.917	7.7	0.779
44	20.5	1.621	17.3	1.411	14.1	1.211	10.9	1.015	7.8	0.872
46	20.9	1.794	17.7	1.571	14.4	1.336	11.1	1.114	7.9	0.970
48	21.3	1.986	18.0	1.731	14.7	1.470	11.3	1.226	8.0	1.070
50	21.7	2.181	18.3	1.901	14.9	1.612	11.5	1.335	8.1	1.172
52	22.0	2.389	18.6	2.071	15.2	1.760	11.7	1.443	8.2	1.277
54	22.3	2.600	18.9	2.252	15.4	1.898	11.9	1.529	8.3	1.385
56	22.6	2.826	19.1	2.442	15.6	2.063	12.0	1.670	8.4	1.495
58	22.9	3.061	19.3	2.647	15.8	2.236	12.1	1.797	8.5	1.605
60	23.2	3.311	19.5	2.852	15.9	2.407	12.2	1.931	8.5	1.715
62	23.5	3.577	19.7	3.072	16.1	2.594	12.3	2.065		
64	23.7	3.845	19.9	3.300	16.3	2.789	12.4	2.233		
66	23.9	4.115	20.1	3.537	16.4	2.981				
68	24.1	4.395	20.3	3.784	16.5	3.162				
70	24.3	4.695	20.5	4.039	16.6	3.358				
72	24.5	4.989	20.7	4.289						
74	24.7	5.303	20.8	4.531						
76	24.9	5.570								
78	25.1	5.809								
80	25.2	6.031								



Graph 2. Mean unadjusted heights of Bosnian pine trees in experimental plots of site quality classes (Drinić & Prolić 1979)
Grafikon 2. Srednje neizravnate visine munikovih stabala na pokusnim plohama bonitetnih razreda (Drinić & Prolić 1979)

Table 6. The height of Bosnian pine and black pine
Tablica 6. Visina stabala munike i crnoga bora

DBH *Prsni promjer stabla*	(cm)		
	10	30	50
Mean height of Bosnian pine for the III site class *Srednja visina stabala munike za III. bonitetni razred* (m)	5.7	10.1	12.8
Mean height of black pine for the III site class *Srednja visina stabala crnoga bora za III. bonitetni razred* (m)	6.8	11.8	15.0
Difference between mean heights of Bosnian pine and black pine *Razlika između srednjih visina stabala munike i crnoga bora* (m)	1.1	1.7	2.2

The mean values of Bosnian and black pine tree heights for the third site class on the mountain Čvrsnica in Herzegovina are shown in Table 6. According to Drinić 1979, tree heights in pure Bosnian pine stands in Herzegovina are lower than tree heights in pure stands of black pine outside Herzegovina by about one third. This is

basically the result of worse site conditions in which the Bosnian pine stands in Herzegovina grow. When we compare the mean tree height measured in a 58-year-old Bosnian pine stand in experimental plot Number 1, compartment 23, subcompartment "a", and the mean tree height measured in a 64-year-old stand of black pine in experimental plot Number 4, compartment 26, subcompartment "a", we see that the difference in height decreases considerably. The trees in the pure stand of Bosnian pine are by about one-sixth shorter than the trees in the pure stand of black pine in Herzegovina. The basic reason is that the site conditions of black pine stands in Herzegovina are worse than those of black pine stands outside Herzegovina. Therefore, our results show a smaller difference in mean heights of Bosnian pine for the area of Čvrsnica in Herzegovina compared to the mean heights of black pine according to Drinić 1963. The difference in mean heights of Bosnian pine and black pine would be even smaller if the stands of these tree species were of the same age.

EXPERIMENTAL TREE MARKING
PROBNA DOZNAKA STABALA

The principles have already been mentioned on which so-called experimental tree marking was carried out in the experimental plots of Bosnian pine and comments have been made on the initial assumptions referring to the management system. Experimental tree marking was aimed at obtaining information on the possible extent of cutting and on the proportion of the existing volume to be removed from the stands and replaced by the new volume in the regeneration process. Finally, the dynamics at which all this could be carried out was determined. The diameter and qualitative structure of tree volumes in experimental marking is shown in Table 7.

Table 7. Structure of tree volumes in experimental tree marking
Tablica 7. Struktura volumena stabala probne doznake

Diameter degree *Debljinski stupanj* (cm)	Quality classes *Kvalitetni razredi*			Total *Ukupno* (m^3)	%
	I	II	III		
	Experimental marking per hectare (m^3) *Probna doznaka po hektaru* (m^3)				
5 - 30	-	0.6	4.5	5.1	10.8
30 - 50	0.1	2.4	9.6	12.1	25.7
Over 50	-	5.0	24.9	29.9	63.5
Total - *Ukupno*	0.1	8.0	39.0	47.1	100.0
%	0.2	17.0	82.8	100.0	

It can be concluded from the above that on average, the tree volume encompassed by experimental marking is 47.1 m^3/ha of the total timber mass. This is about 30% of the present average stand volume, which is 152.93 m^3/ha, or approxi-

mately a thirteen-year average volume increment, which is 3.5 m³/ha/year. Trees over 50 cm in diameter account for almost two-thirds (63.5%) of the tree volume encompassed by experimental marking. The trees in the third silvicultural-technical quality class account for over four-fifths (82.8%) of the volume, while the trees in the first silvicultural-technical quality class were not even marked. This approach is logical, because experimental marking primarily included trees of poor quality. Of these, the thicker ones were marked. The spatial arrangement of all existing trees in experimental plots was also taken into account, as well as the management system - the kinds of felling and regeneration methods - which it was assumed were applied in the studied stands.

YOUNG GROWTH IN BOSNIAN PINE STANDS
POMLADAK U SASTOJINAMA MUNIKE

The method of counting the quantity of young growth (trees below the taxation limit of 5 cm) used in the research on experimental plots of Bosnian pine was mentioned earlier. In the studied stands, the number of young trees varies considerably. In some stands, the number of young trees ranged from 2,896 to 4,748 (3,822 trees on average per hectare). The number of young spruces varied from 21 to 576, with an average of 299 trees per hectare. There were between 124 and 432 young firs, averaging 278 trees per hectare. The number of young beeches ranged from 78 to 495, making an average of 287 trees per hectare. Other conifers are classified with trees of Bosnian pine, and other deciduous trees with young beeches. The average number of young trees for all stands in experimental plots per classes and tree species is shown in Table 8.

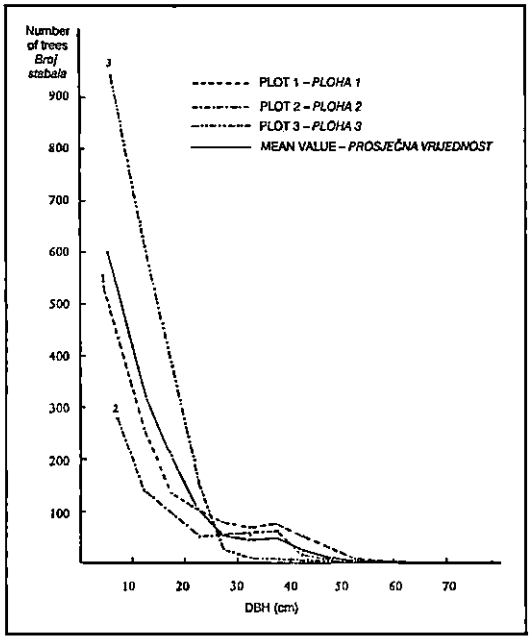
Table 8. Number of young trees in Bosnian pine stands
Tablica 8. Broj biljaka pomlatka u sastojinama munike

Tree species *Vrsta drveća*	Height classes *Visinske klase*		Diameter *Promjer*	Total *Ukupno*
	10-50 cm	50-130 cm	0-5 cm	
	Number of young trees per hectare *Broj biljaka pomlatka po hektaru*			
Bosnian pine *Munika*	1,324	1,128	1,370	3,822
Other conifers *Ostale četinjače*	212	196	169	577
Beech *Bukva*	107	97	83	287
Other deciduous *Ostale listače*	18	25	32	75
Total *Ukupno*	1,661	1,446	1,654	4,761

Needless to say, such numbers of young trees allow the studied stands of Bosnian pine to regenerate successfully in a natural way.

NUMBER OF TREES IN A STAND
BROJ STABALA U SASTOJINI

The number of trees per hectare in the studied stands varies from 785 to 2,060 trees. For all studied stands, the average number of Bosnian pines per hectare is 1,377 trees. The number of trees per hectare above the taxation limit of 5 cm is shown in Table 9. The table does not include deciduous trees and dwarf pines (plot no. 3) found in the experimental plots with Bosnian pine stands. On average, there are 58 trees of this kind per hectare. On the basis of the research results shown in the mentioned table, a "sloping" diameter structure of the trees in all experimental plots is apparent. Trees in the first diameter degree (7.5 cm on average) account for the biggest relative proportion of all trees. As the number of young trees immediately below the taxation limit (trees with a breast diameter of 0 to 5 cm) vastly exceeds the number of trees in the first (and the second) diameter class, (with the exception of plot no. 3), it can be concluded with a high degree of certainty that the arrangement of trees per diameter classes is "sloping". Apart from this, in some experimental plots (plots no. 1 and 2) there is a mild tendency to form the so-called other tree culminations in a higher diameter class (37.5 cm). However, this mild culmination (in compartments 22 and 23) comes as a result of the direct mutual height differentiation of trees. In other words, two storeys were formed. After the results were obtained, a question arose whether the "sloping" diameter structure of trees in the studied stands of Bosnian pine was a logical natural phenomenon. This seems likely, considering the relatively large size of the studied stands (the surface area of the smallest compartment is 24 ha, and the biggest 91 ha). Bosnian pines in these areas are represented in larger or smaller groups of trees. In individual groups, the trees are more or less equal in diameter and age. However, there are considerable differences in tree dimensions and ages among individual groups. Therefore, if we observe the entire stand in a large area or several stands together, it is logical that there are a larger number of thinner trees than thicker ones, or that the diameter structure in the stands of Bosnian pines is "sloping". Apart from this, it sometimes happens that only trees with almost equal diameters (dimensions) and ages occur in one stand or in a larger part of it. These are large, almost even-aged groups of trees, in which the diameter tree structure is characteristic for such stands. The diameter structure of Bosnian pines for all experimental plots individually, and the average diameter structure of Bosnian pines in all the studied stands are shown in Graph 3. The number of individual silvicultural-technical quality classes for all studied stands on average is shown in Table 10.



Graph 3. Diameter structure of trees in Bosnian pine stands
Grafikon 3. Debljinska struktura stabala u munikovim sastojinama

Table 9. Diameter structure of trees in the stand
Tablica 9. Debljinska struktura stabala sastojina

Name of area *Naziv predjela*	No of plot *Broj plohe*	Diameter degree - *Debljinski stupanj* (cm)										Total *Ukupno*	Trees per hectare *Stabala po hektaru*
		7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5	
		Number of trees - *Broj stabala* (%)											
Šestiver	1	34.1	20.3	11.0	8.4	6.4	5.6	6.2	4.4	2.6	0.9	0.1	100.0	1,287
Kraljeva kleka	2	36.1	17.8	12.6	7.3	7.3	7.4	8.2	2.8	0.5	-	-	100.0	785
Orlov kuk	3	42.2	29.3	18.6	7.9	1.4	0.5	-	-	0.1	-	-	100.0	2,060
Total - *Ukupno*		37.5	22.5	14.1	7.8	5.0	4.5	4.8	2.4	1.1	0.3	-	100.0	1,377

Table 10. The number of trees in silvicultural-technical quality classes
Tablica 10. Broj stabala uzgojno-tehničkih kvalitetnih klasa

Diameter class *Debljinski stupanj* (cm)	Quaity classes *Kvalitetni razredi*			Total *Ukupno*	%
	I	II	III		
	Number of trees per hectare *Broj stabala po hektaru*				
5 - 30	186	620	433	1,239	90.0
30 - 50	13	47	74	134	9.7
Over 50	-	2	2	4	0.3
Total - *Ukupno*	199	669	509	1,377	100.0
%	14.4	48.6	37.0	100.0	

The results shown in the table above allow us to conclude that a little over one third of the total number of trees in the studied stands of Bosnian pine occur in the third quality class. This class denotes those trees which should not even be in the forest in terms of quality tree production. Therefore, the quality of trees in Bosnian pine stands is slightly lower. The reason for this lies in adverse site conditions, where high altitude is the key factor. At such altitudes, trees are relatively small, tapering and distinctly knotty.

TREE GROWTH AND INCREMENT
RAZVOJ I PRIRAST STABLA

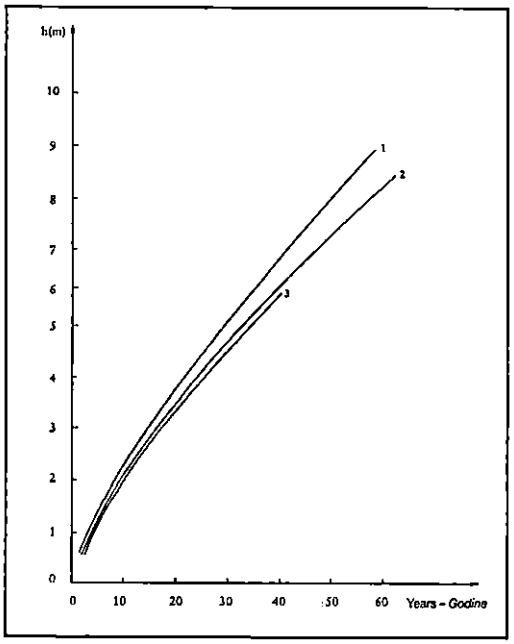
In this research, one tree from each of the experimental plots was analysed. The indicators of tree analyses are shown in Tables 11, 12, 13 and *14*, and in Graphs 4, *5* and 6.

Table 11. Diameter (d), height (h) and volume (v) growth of analysed trees
Tablica 11. Debljinski (d), visinski (h) i volumni (v) rast analiziranih stabala

No. of plot *Broj plohe*	Age *Dob*	Diameter at the age of - *Promjer u dobi od* (cm) / Height at the age of - *Visina u dobi od* (m)							
		Without bark *Bez kore*							With bark *S korom*
		10	20	30	40	50	60	Present age *Sadašnja dob*	
1	58	2.6 / 2.2	6.8 / 3.7	10.3 / 5.1	13.3 / 6.3	15.9 / 7.5	- / -	17.5 / 8.4	18.6 / 8.4
2	62	2.4 / 2.1	6.2 / 3.4	9.4 / 4.7	12.2 / 5.9	14.7 / 6.8	16.7 / 7.7	17.0 / 7.9	18.0 / 7.9
3	38	2.3 / 2.0	5.9 / 3.3	8.9 / 4.5	- / -	- / -	- / -	11.0 / 5.4	11.7 / 5.4

Table 12. Timber mass of analysed trees
Tablica 12. Volumen analiziranih stabala

No. of plot *Broj plohe*	Age *Dob*	Timber mass (m^3) at the age of - *Volumen* (m^3) *u dobi od godina*								Bark *Kora*	
		Without bark *Bez kore*							With bark *S korom*		
		10	20	30	40	50	60	Present age *Sadašnja dob*		m^3	%
1	58	0.0013	0.0075	0.0216	0.0487	0.0968	-	0.1541	0.1638	0.0097	5.9
2	62	0.0011	0.0054	0.0181	0.0430	0.0805	0.1304	0.1429	0.1514	0.0085	5.6
3	38	0.0010	0.0052	0.0205	-	-	-	0.0502	0.0534	0.0032	6.0



Graph 4. Curves of height growth of analysed trees
Grafikon 4. Krivulje visinskoga rasta analiziranih stabala

Table 13. Diameter (i_d), height (i_h), and volume (i_v) increment of analysed trees
Tablica 13. Debljinski (i_d), visinski (i_h) i volumni (i_v) prirast analiziranih stabala

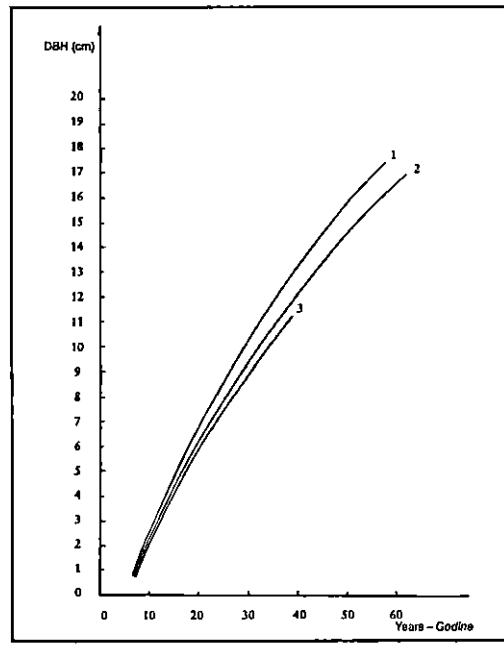
No of plot *Broj plohe*	Age *Dob*	Increment - *Prirast* diameter - *promjera* (cm) / height - *visine* (m) between individual years below *između pojedinih niže navedenih godina*						Average age - *prosječni dobni* With bark - *s korom*
		0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	
1	58	0.26 --- 0.22	0.42 --- 0.15	0.35 --- 0.14	0.30 --- 0.12	0.26 --- 0.12	- --- -	0.32 --- 0.14
2	62	0.24 --- 0.21	0.38 --- 0.13	0.32 --- 0.13	0.28 --- 0.11	0.25 --- 0.10	0.30 --- 0.09	0.29 --- 0.13
3	38	0.23 --- 0.20	0.36 --- 0.13	0.30 --- 0.12	- --- -	- --- -	- --- -	0.31 --- 0.14

Table 14. Timber mass average increment of analysed trees
Tablica 14. Prosječni prirast volumena analiziranih stabala

No. of plot *Broj plohe*	Age *Dob*	Average increment of timber mass (m^3) between years below *Prosječni prirast volumena* (m^3) *između pojedinih niže navedenih godina*						Average age increment with bark *Prosječni dobni prirast s korom* (m^3)
		0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	
1	58	0.0001	0.0006	0.0014	0.0027	0.0048	-	0.0028
2	62	0.0001	0.0004	0.0013	0.0025	0.0038	0.0050	0.0024
3	38	0.0001	0.0004	0.0015	-	-	-	0.0014

Tree growth and height increment
Razvoj i prirast stabla u visinu

Tree growth and increment in height at an early age was observed in the young growth found in the experimental plots of natural stands of Bosnian pine in Herzegovina. In June 1998, the height of 255 young trees was measured and an average height of 17.5 cm for all experimental plots was obtained. The height was measured on trees of two years of age. In all experimental plots the height increment on 255 young trees aged 6 - 8 years was measured. To determine the relative age of Bosnian pines, reliance was given to the assumption that the Bosnian pine as a tree species has regular branch whorls. This assumption was confirmed during the research, and was practically applied in determining the relative age of the young growth. The height increment during the first 6 to 8 years of young trees in all experimental plots was about 20 cm a year on average. Further growth and increment in height were observed in the analysed trees for each of the experimental plots. On the basis of the indicators shown in Tables 11 and 13, and in Graph 4, the following can be concluded: height increment at a young age is slightly more intensive until the age of about thirty, and later remains steady or even slightly lower until the age of sixty. The culmination of height increment in the analysed trees occurred when the trees were between 0 and 10 years old. Bosnian pines in all experimental plots achieved the highest current annual height increment between



Graph 5. Curves of diameter growth of analysed trees
Grafikon 5. Krivulje debljinskoga rasta analiziranih stabala

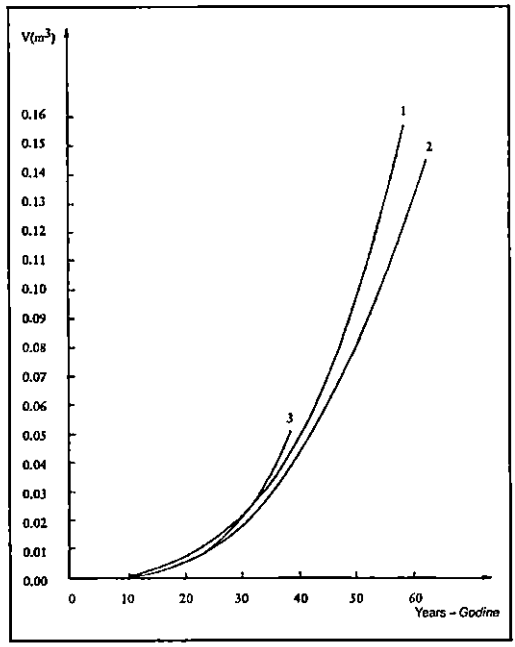
0 and 10 years of age. In plot No. 1 (Šestivar), the height increment was 0.22 m, in plot No. 2 (Kraljevska Kleka) it was 0.21 m, and in plot No. 3 (Orlov Kuk) it was 0.20 m. As a species, the Bosnian pine lives long and grows slowly, especially at a young age. Under optimal conditions in its natural distribution area it can theoretically reach a height of 30 m and a diameter of 1 m. The tallest tree, reaching 18 m, was found in plot No. 1.

Tree growth and increment in diameter
Razvoj i prirast stabla u debljinu

In all observed experimental plots the growth and increment in diameter is rather balanced, which is understandable considering the fact that pure natural stands of Bosnian pine in Herzegovina grow under similar natural conditions. Some individual deviations are the result of age differences in the stands, the number of trees per surface unit and the pronounced micro-spatial changeability of the production capacity of the soil under Bosnian pines. In general, Bosnian pine grows more slowly in diameter, especially in its youth, and retains this slow growth until its older age. As it has a narrow crown, this species does not require much space for diameter growth. Under optimal conditions, Bosnian pines can achieve a breast diameter of up to 1 m. The thickest tree, with a breast diameter of 56 cm, was measured in plot No. 1. Since Bosnian pine grows slowly, it can be concluded that no interventions and silvicultural treatments are needed in young stands. However, at a later stage, after the selection structure and several storeys have been differentiated in pure natural stands of Bosnian pine, suitable treatments should be undertaken to assist the successful natural regeneration of stands and of smaller groups of trees. The analysed Bosnian pine in plot No. 3 exhibited a mild decrease in diameter increment. The reason for this is a large number of trees per surface unit and the tall stand cover in this plot. The analysed Bosnian pine in plot No. 1 also exhibits a mild decrease in diameter increment, although this stand is much less stocked than the former one, and has a differentiated selection structure and two storeys. In our opinion, suitable measures should be undertaken in this stand involving low-intensity interventions in the upper storey, so that the understorey receives more light and space. In this way, individual trees from the understorey would respond with an increased diameter increment, and an opportunity for the balanced natural regeneration of the stand would be provided. Based on the indicators shown in Tables 11 and 13 and in Graph 5, the following can be concluded: the culmination of diameter increment in the analysed trees occurred in the period between 10 and 20 years. The diameter increment in middle-aged stands can be increased or at least maintained with silvicultural treatments. The highest current diameter increment of 0.42 cm was found in the analysed tree in plot No. 1 (Šestivar) in the period between 10 and 20 years.

Growth and increment of timber mass
Razvoj i prirast volumena stabla

This research confirmed the already known fact that timber mass increases with an increase in height and diameter, depending on the available space and the quantity of light at the disposal of a tree at a certain age. The curve of timber mass growth is typical, and has the shape of an elongated letter "S". On the basis of the indicators shown in Tables 12 and 14 and Graph 6, it can be concluded that timber mass grew the fastest in plot No. 1 (Šestivar). The total timber mass of the analysed tree in plot No. 1 (Šestivar) was 0.16 m^3 at the age of 58, while the total timber mass in plot No. 2 (Kraljeva Kleka) was 0.15 m^3 at the age of 62. However, if we consider the total timber mass minus bark in all analysed trees at the age of 30, a uniform pattern can be seen: in plot No. 1 the timber mass amounted to 0.022 m^3, in plot No. 2 it amounted to 0.018 m^3, and in plot No. 3 to 0.021 m^3, It can also be noted that the overall timber mass of the analysed tree in experimental plot No. 3 after the age of 30 reached the total timber mass of the analysed tree in experimental plot No. 1. At a certain point in age, it exceeded it. The total timber mass of the analysed tree in experimental plot No. 3 at the age of 38 amounts to 0.050 m^3, and the total timber mass of the analysed trees in experimental plot No. 1 at the age of 40 amounts to 0.049 m^3, and to 0.043 m^3 in experimental plot No. 2. The example in experimental plot No. 3 is due to the fact that the tree in the stand was already differentiated and had penetrated the upper storey, thus receiving more light and space which enabled



Graph 6. Growth curves of analysed trees timber mass
Grafikon 6. Krivulje rasta volumena analiziranih stabala

it to grow faster. The stand in plot No. 3 is in the initial stage of storey differentiation and selection structure. The increment of timber mass is slowed in the early years of life, and very intensive in later years. The culmination of volume increment has not occurred yet in any of the analysed trees, because the volume increment culminates much later than the height and diameter increment. On the basis of research results, it can be concluded that the biggest average annual volume increment was 0.0048 m^3 at the age between 40 and 50 in plot No. 1 (Šestiver), with a tendency of further growth, as seen in Graph 6. The average annual volume increment, amounting to 0.0050 m^3 at the age between 50 and 60 with a tendency of further growth was recorded in a tree in plot No. 2 (Kraljeva Kleka). However, there is little probability that the analysed tree in plot No. 2 will reach the average annual volume increment of the tree in plot No. 1. The analysed tree in plot No. 1 is likely to achieve a higher average annual volume increment of 0.0050 m^3 at the age of 60 than that achieved by the tree in plot No. 2 at the same age.

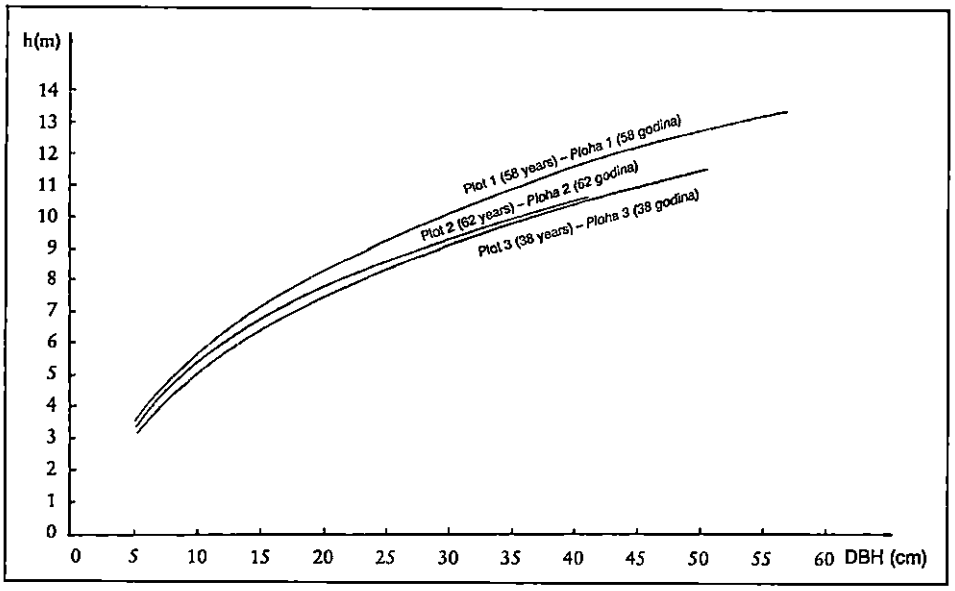
STAND GROWTH AND INCREMENT
RAZVOJ I PRIRAST SASTOJINE

Stand growth and increment in height
Razvoj i prirast sastojine u visinu

Stand growth and increment in height were calculated on the basis of measured tree heights in all experimental plots, and the constructed and measured height curves for individual experimental plots, shown in Graph 7. Indicators in the graph show that the height curve of the youngest stand moved downwards in relation to older stands, and that stand height curves in all experimental plots differed only slightly. The reason for this is that all studied stands are of approximately the same site quality class and that the trees in the youngest stand are of almost equal height and age, and have not yet differentiated into storeys and selection structure. The stand in plot No. 1 (Šestiver), where the soil is the deepest and the most productive, has the highest height curve.

Stand growth and increment in diameter
Razvoj i prirast sastojine u debljinu

Diameter growth and increment of the mean tree in a stand were observed on the basis of two measurements. The indicators shown in Table 2 point to the following: stands in plots 1 and 2 developed best. The largest tree diameter distributions and the highest diameter growth of individual trees in stands were noted here. The stand in plot 3 was the most poorly developed. It is the youngest of all studied stands, has the largest cover and is therefore the thickest. At the age of 38, the diameter of the mean tree was 12.5 cm. According to the indicators in Table 2, the biggest average periodical annual diameter increment of the mean tree of 0.14 cm is found in plot No. 1 (Šestiver). Over a 15-year period, the diameter of the



Graph 7. Height curves of stands
Grafikon 7. Visinske krivulje sastojina

mean tree has grown from 16.6 cm to 18.7 cm in plot No. 1, and the average age increment of the mean tree in diameter, amounting to 2.1 cm, is the biggest.

Growth and increment of stand stemwood
Razvoj i prirast volumena sastojina

The calculation of growth and increment of stand timber mass was based on two inventories. The indicators of these inventories are shown in Tables 3 and 4. The annual stand volume increment in individual plots is shown in Table 15.

Table 15. Annual stand increment of Bosnian pine in plots
Tablica 15. Godišnji prirast sastojina munike na plohama

Plot number *Broj plohe*	Age *Dob*	Annual current increment (m^3) *Godišnji tečajni prirast* (m^3)			Average age increment (m^3) *Prosječni dobni prirast* (m^3)		
		Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*
1	58	5.63	-	5.63	3.70	-	3.70
2	62	2.09	0.18	2.27	1.89	0.13	2.02
3	38	2.79	0.17	2.96	3.35	0.21	3.56

Table 15 shows the total annual current and the total volume average age increment for stands in all experimental plots. The Bosnian pine stand in plot No. 1

(Šestiver) displayed the biggest current annual volume increment of 5.63 m³/ha. This is understandable, because this is a relatively young to middle-aged stand with a good cover growing on deep soil. However, the stand in experimental plot No. 2 (Kraljeva Kleka) displays the lowest current annual volume increment. The reasons are manifold: the cover is 0.53, the number of trees per surface unit is the lowest of all stands in experimental plots, and the productive area is lessened by frequent stone blocks on the surface of the rather shallow soil. If the obtained stand increment of 2.09 m³/ha in plot No. 2 is reduced to the total cover, the size of the increment of 3.94 m³/ha will be obtained, which corresponds to the stand age. According to the obtained indicators, the current annual volume increment has not yet culminated. The current annual volume increment could not reach the culminating point in view of the fact that it culminates long after the height and diameter increments reach their culmination. The culmination time of all mentioned increments in Bosnian pine is moved rightwards, that is, towards the older age. This is due to the biological properties of the species, to extremely bad site conditions and to the altitude at which it naturally occurs in Herzegovina and elsewhere. The survey of taxation element indicators in the studied Bosnian pine stands in Herzegovina (Čvrsnica) is shown in Table 16. The indicators in the table refer to the total timber mass of the studied stands in experimental plots.

Table 16. Indicators of stand taxation elements
Tablica 16. Pokazatelji taksacijskih elemenata sastojina

No. of plot *Broj plohe*	Plot area *Površina plohe* (ha)	Site class *Bonitetni razred*	Stand cover *Obrast sastojine*	Mean DBH *Srednji p.p.* (cm)	Mean height *Srednja visina* (m)	Per hectare *Po hektaru*			
						Number of trees *Broj stabala*	Basal area *Temeljnica* (m^2)	Timber mass *Volumen* (m^3)	Current increment *Tečajni prirast* (m^3/year - *god.*)
1	1,0	3.2	0.82	18.7	8.1	1,287	24.07	214.31	5.63
2	1,0	3.6	0.53	17.9	7.5	785	14.02	117.31	2.09
3	1,0	3.4	0.90	12.5	5.8	2,060	25.80	127.18	2.79
Total *Ukupno*	1,0	3.4	0.75	16.4	7.1	1,377	21.30	152.93	3.50

PRODUCTION
PROIZVODNJA

The annual production of timber mass for experimental plots 1, 2 and 3 was calculated on the basis of two inventories, or two measurements in experimental plots over a period of 15 years. The indicators of the annual production of the studied stands in all plots are shown in Table 17 for the total timber mass. The Bosnian pine stand in experimental plot No. 1 in the forest region of Šestivar is the most productive, with an annual production of total timber mass of 5.75 m³/ha. The young and fully developed stand of Bosnian pine in experimental plot No. 3 has an annual production of 2.99 m³/ha.

Table 17. Annual production of stand timber mass
Tablica 17. Godišnja produkcija drvne mase sastojina

No. of exp. plot *Broj pok. plohe*	Stand age *Dob sastojine*	Annual production (m^3) *Godišnja produkcija* (m^3)			Control period (year) *Kontrolno razdoblje (godina)*
		Bos. pine *Munika*	Other *Ostalo*	Total *Ukupno*	
1	58	5.75	-	5.75	15
2	62	2.15	0.19	2.34	15
3	38	2.81	0.18	2.99	15

CONCLUSION
ZAKLJUČAK

Based on the research into the growth of pure natural stands of Bosnian pine in Herzegovina, the following can be concluded:

- Bosnian pine is an endemic pine species and a Tertiary relict preserved during the glaciation period in the Balkan Peninsula. Its broken and disjunct natural area of 1,528 ha is situated in Herzegovinian mountain ranges 1,000 - 1,900 metres above sea level. The climate of the region is continental-mountainous, which is characterised by long winters and abundant snow, and sub-Mediterranean of a colder type. Bosnian pine has very modest growth requirements, which is seen in the fact that it has no competition from other tree species. This tree is the only species that can grow well and regenerate naturally under extremely harsh conditions and very poor productive capabilities of the soil.
- The wide ecological amplitude of the Bosnian pine enables this species to grow in a region of barren, waterless karst mountains, where even the black pine is absent. The reason for this is that Bosnian pine is a tree species with the lowest requirements in Europe and with distinct pioneering characteristics.
- Stands of Bosnian pine represent a natural, rare forest vegetation with a distinctive *protective (ecological) function* in terms of hydrology, anti-erosion and climate, a social function in terms of tourism, aesthetic beauty and recreation, and a *productive (raw material) function* in terms of the outstanding technical properties of its timber. Finally, its *pioneering function*, encompassing all the characteristic features of Bosnian pine as a tree species, should also be pointed out.
- The following soil types support pure natural stands of Bosnian pine in Herzegovina: brown soil on limestone (Šestiver - plot No. 1), humus on limestone (Kraljeva Kleka - plot No. 2), rendzina on dolomite (Orlov Kuk - plot No. 3), which is neutral to mildly alkaline with a pH of 6.9 to 7.8 (the area of the mountain Čvrsnica) with insufficient phosphorus content. A high per-

centage of free carbonates in rendzinas on dolomite are the result of large quantities of tiny skeletal particles.

- Since the rate of growth and increment of Bosnian pine is slow, the mean tree in a studied stand has a timber mass of only 0.15 m^3 at the age of 60. Compared to other pines, and particularly to the black pine to which the Bosnian pine is biologically close, the culmination of height and diameter increment occurs much later, while the culmination of volume increment occurs long after the culmination of height and diameter increment. In Herzegovina, Bosnian pine stands display a current annual increment of 2.3 to 5.6 m^3/ha of the total timber mass, while the average age increment of the total timber mass ranges from 2.0 to 3.7 m^3/ha at the age of 60. The production of the total timber mass also culminates at a late date. At the age of 60, production in the studied stands reaches 6.0 m^3/ha a year. The volume of the total timber mass (with small branches) varies from 127 to 214 m^3/ha, averaging 153 m^3/ha. The volume of annual current increment expressed in the total timber mass ranges from 2.09 to 5.63 m^3 per hectare.
- The average data for volume obtained by this research in pure natural stands of Bosnian pine in Herzegovina (Čvrsnica) (153 m^3/ha of the total timber mass on average) concord with the average data for volume obtained by the forest management basis by Ćurić (1967) in pure natural stands of Bosnian pine in Herzegovina (131 m^3/ha of large wood) and Čvrsnica (124 m^3/ha of large wood). The volume of large wood in pure natural stands of Bosnian pine is about 20% lower than its total timber mass.
- The volume and volume increment of natural stands of Bosnian pine in Herzegovina (Čvrsnica) are considerably lower than the volume and volume increment of natural pure stands of Bosnian pine in Kosovo and Montenegro (Jović, 1971). The deviations of average values in the above mentioned taxation elements are as follows:

	Volume in m^3/ha	Volume increment in m^3/year/ha
Bosnian pine in Herzegovina	214	5.63
Bosnian pine in Kosovo and Montenegro	380	5.84
Deviation	166	0.21

Pure stands of black pine in Herzegovina (experimental plot No. 4 - locality Lisac on Čvrsnica) confirm that the volume and volume increment there is higher than that in pure stands of Bosnian pine. The deviations are as follows:

	Volume in m^3/ha	Volume increment in m^3/year/ha
Bosnian pine in Herzegovina	214	5.63
Black pine in Herzegovina	242	6.10
Deviation	28	0.47

The studied stand of black pine is 64 years old on average, and that of Bosnian pine 58. The volume and volume increment of pure Bosnian pine stands in relation to the volume and volume increment of black pine stands is 88.4%, or 92.2%. The actual deviation is close to the estimated deviation, the reason being that the stand of black pine is older and grows in a site of a slightly better class quality. The indicators for the black pine and the Bosnian pine relate to the total timber mass. Compared to the productive capabilities of pure stands (forests) of Bosnian pine in the other regions of its natural distribution area and to those of high forests of other tree species, the productive capabilities of pure stands of Bosnian pine on Čvrsnica in Herzegovina are clearly lower.

- Unlike the single tree selection management applied so far, the system of small-group shelterwood felling with a long regeneration period should be used to manage pure stands of Bosnian pine in Herzegovina. Group selection management is also applicable, but only on very small groups with a long regeneration period. The longer the regeneration period is, the closer the system is to the group selection forest management system. From the standpoint of the better and more efficient protection of pure natural stands of Bosnian pine in Herzegovina, the single tree management system is also suitable on very steep terrains. However, this system is economically questionable.
- From an economical standpoint, an average of 47.1 m^3 of timber mass per hectare should be removed from pure stands of Bosnian pine on Čvrsnica in order to achieve a better quality of stands and better natural regeneration. This quantity of wood mass relates to the volume of trees encompassed in the experimental tree marking in the stand. The timber mass obtained from experimental marking (47.1 m^3/ha) should be exploited over several occasions with a cutting intensity of up to 15% at the most. With regard to the relatively low volume and volume increment and the generally slow rate of growth and development of pure stands of Bosnian pine in the studied area, as well as to bad site conditions, at least 30 to 50 years are needed to exploit the above mentioned timber mass. This is the period needed for a stand to regenerate naturally if the group management system is applied. Artificial regeneration cannot be applied due to bad site conditions.
- According to the results of the research, the stands of Bosnian pine in Herzegovina have a mean diameter of 16.4 cm, a mean height of 7.1 m and a mean site quality class of 3.4 (the taxation border was 5.0 cm). The mean diameter was calculated as the arithmetic mean of the tree diameters, and the mean height as the arithmetic mean of the tree heights in the stands. The mean diameters and heights calculated in this manner are always lower than the mean diameters and heights calculated with basal areas. Apart from this, the mean diameter and height of the studied stands were also partially reduced by the lower taxation border.
- The Bosnian pine in pure natural stands in Herzegovina over an area of 1,528 ha should be protected by special management measures. Not only is

it a rare endemic Tertiary relict, but it also provides a variety of functions. Special attention should be paid to extending the distribution area of Bosnian pine to all ecologically viable places, and primarily to those of high, cold and karst mountain ranges in Herzegovina. The existing pure natural stands should be preserved as the primary nucleus for reproduction and as an outstanding monument of natural rarity.

- Pure natural stands of Bosnian pine in the whole of Herzegovina cannot be managed and regenerated with uniform procedures and methods. The kind of methods and procedures to be used will be the subject of some other research.
- The presented results are aimed at providing additional impetus for further research into the stands of Bosnian pine and at drawing attention to these forests composed of endemic, relict and rare tree species.

REFERENCES
LITERATURA

Adamović, L., 1907: Die Pflanzengeographische Stellung und Gielderung der Balkanhalbinsel-Denkschr. Mat. natw. Kl. Akad. Wissensch. Wien 1.XXX. P. 413.

Anić, M., 1954: Crni bor u sjevernom Velebitu. Glasnik za šumske pokuse br. 13, Zagreb.

Antoine, F., 1864: *Pinus leucodermis* Ant. - Oest. Bat. Zeit. Wien, XIV, P. 366.

Assmann, E., 1954: Die Standraumfrage und die Methodik von Mischbestanduntersuchungen. A. F. u. J. Ztg., 1954.

Blačić, V., & Horvatić, S., 1967: Gymnaspermae (Golosjemenjače), Analitička flora Jugoslavije. Sv. 1. br. 1, Zagreb.

Blečić, V., & Lakušić, R., 1969: Šume munike (*Pinus heldreichii* Christ) na Štitovu i Bjelasici u Crnoj Gori. Glasnik Republičkog zavoda za zaštitu prirode, No. 2, Titograd.

Bunuševac, T., 1951: Gajenje šuma. Naučna knjiga, pp 416, Beograd.

Christ, H., 1863: Übersicht der europaeischen Abietinen (*Pinus* L.) Verhandl. d. Nat. forsch. Gesell. Basel III. 4. P. 549.

Christ, H., 1867: Beitrag zur Kenntuis europaeisch. Pinus Arten.. "Flora" N. R. XXV, Regensburg. P. 83.

Ćirić, M., 1984: Pedologija. Svjetlost, Sarajevo.

Ćurić, R., 1967: Prilog poznavanju sastojina munike (*P. heldreichii* Chr.) na području Bosne i Hercegovine. Narodni šumar 3–4, Sarajevo.

Domac, R., 1958: Rasprostranjenje i sastav puma dalmatinskog crnog bora (*Pinus dalmatica* Vis.) u području Biokova. Acta Botanica chroatica 17, Zagreb.

Domac, R., 1994: Flora Hrvatske. Školska knjiga, Zagreb.

Drinić, P., Matić, V., Pavlić, J., Prolić, N., Stojanović, O., & Vukmirović, V. 1980: Tablice taksacionih elemenata visokih i izdanačkih šuma u SR Bosni i Hercegovini. Šumarski fakultet Univerziteta u Sarajevu, Posebna izdanja br. 13, Sarajevo.

Drinić, P., & Prolić, N., 1979:Taxationselemente als Anzeiger von produktiznsmöglichkeiten in Panzerkieferwäldern (*Pinus heldreichii* Christ.). Radovi Šumarskog fakulteta i Instituta za šumarstvo u Sarajevu, knjiga 23, sveska 3–4, 55–103, Sarajevo.

Fukarek, P., 1941: Munika. Hrvatski planinar 4: 81–91.

Fukarek, P., 1941: Povijest otkrića i istraživanja munike ili (bor) smrča (*Pinus heldreichii* Christ). G. Z. M., 195–210, Sarajevo.
Fukarek, P., 1941: Prvi prilog poznavanju munike ili smrča (*Pinus heldreichii* Christ var. *leucodermis*). Šum. list 8/9: 348–386.
Fukarek, P., 1942: Devedeset godišnjica botaničkog otkrića munike (*Pinus hedreichii* Christ). Priroda, 29–34, Zagreb.
Fukarek, P., 1942: Sjemenke i klice munike (*Pinus heldreichii* Christ.). G. B. I., fasc. 1–2, 21–41, Sarajevo.
Fukarek, P., 1951: Varietet munike na području Srbije i Sandžaka (Crna Gora) (*Pinus helreichii* Christ. var. pančići n. var.). G. B. I., fasc. 1, 41–50, Sarajevo
Fukarek, P., 1965: Nalazište prelazne ili hibridne svojte borova na planini Prenju u Hercegovini (*Pinus nigradermis* Fuk., Vid.). Radovi N. D. BiH 8: 61–87.
Fukarek, P., 1966: Zajednice endemne munike na planini Prenj u Hercegovini. Acta botanica croatica, Vol. XXV, Zagreb.
Fukarek, P., 1979: Savremeni pogledi na taksonomiju i nomenklaturu bjelokorog bora - munike. Posebni otisak Glasnika Zemaljskog muzeja, N. S. sv. XVIII - Prirodne nauke, Sarajevo.
Fukarek, P., 1985: Nekoliko napomena u vezi sa našom endemnom munikom (*Pinus heldreichii* Christ). Šumar br. 7–8, 483–487, Beograd.
Großmann, H., 1956: Untersuchungen zur Zuwachsermittlung auf der Versuchsfläge für Hollzvarratsaufnahmen in Spechthausen. A. f. F., 11/12, 1956.
Herman, J., 1971: Šumarska dendrologija. Stanbiro Zagreb, Zagreb.
Horvat, I., 1950: Šumske zajednice Jugoslavije. Zagreb.
Hufnagl, L., 1895: Kako se provodi uređenje u prebornoj šumi. Šumarski list, 173–188, Zagreb.
Hufnagl, L., 1926: Praktično uređenje šuma, Jugoslovensko šumarsko udruženje, 9–87, Zagreb.
Institut za šumarstvo i drvnu industriju Beograd, 1975: Simpozij o munici. Zbornik radova, Beograd.
Institut za istraživanje i projektovanje u šumarstvu "SILVA" Sarajevo, 1983: Šumskoprivredna osnova za područje krša S. O. Posušje, Sarajevo.
Institut za istraživanje i projektovanje u šumarstvu "SILVA" Sarajevo, 1985: Izvod iz šumskoprivredne osnove za šumskoprivredno područje "Srednje Neretvansko", Sarajevo.
Janković, M. M., 1958: Prilog poznavanju munikovih šuma (*Pinetium heldreichii*) na metohijskim Prokletijama. Arhiv bioloških nauka, X, 1/4, Beograd.
Janković, M. M., 1965: *Fritillario - Pinetum heldreichii*, nova zajednica munike (*Pinus heldreichii*) na planini Orjen iznad Boke Kotorske. Arhiv bioloških nauka, Beograd.
Janković, M., 1962: O specifičnostima u grananju munike (*Pinus heldreichii*) i njihovom ekološkom aspektu. Arhiv bioloških nauka, XIV(3-4): 169–184, Beograd.
Janković, M. M., & Stefanović, K., 1972: Ekološki odnos reliktne i subendemične balkanske vrste *Pinus heldreichii* prema karakteru geološke podloge i zemljišta u Jugoslaviji, Ekologija, Beograd.
Janković, M., 1962: O specifičnostima u grananju munike (*Pinus heldreichii*) i njihovom ekološkom aspektu, Arhiv bioloških nauka, XIV (3–4): 169–184, Beograd.
Jovanović, B., 1967: Dendrologija sa osnovama fitocenologije. Naučna knjiga, Beograd, 123–127, Beograd.
Jovanović, B., 1985: Dendrologija. Univerzitet u Beogradu, Šumarski fakultet, IV izmjenjeno idzanje, 136–140, Beograd.
Jovanović, S., 1988: Gajenje šuma. Naučna knjiga, pp 314, Beograd.

Jović, D., 1966: Dvoulazne zapreminske tablice za muniku. Šumarstvo br. 7–8, Beograd.
Jović, D., 1969: Dvoulazne zapreminske tablice za muniku na Koritniku i Kadžabalkonu. Šumarstvo br. 7–8, Beograd.
Jović, N., 1968: Karakter i grupno frakcioni sastav humusa genetsko evolucione serije zemljišta na krečnjacima pod munikom (*Pinetum heldreichii*). Zemljište i biljka No, Beograd.
Jović, N., 1968: Zemljišta na krečnjacima Koritnika pod asocijacijom munike (*Pinetum heldreichii*). Zemljište i biljka No 3, Beograd.
Kennel, R., 1965: Untersuchungen über der Leistung von Fichte und Buche im Rein – und Mischbestand. A. F. u. J. Ztg., H. 8, 1965.
Kern, A., 1898: Uređivanje prebornih šuma. Šumarski list, 300–326, Zagreb.
Kern, A., 1909: Proučavanje drvne zalihe i prirasta u prebornim šumama. Šumarski list, 142–151, Zagreb.
Klepac, D., 1963: Rast i prirast šumskih vrsta drveća i sastojina. Nakladni zavod Znanje, Zagreb.
Klepac, D., 1965: Uređivanje šuma. Nakladni zavod Znanje, Zagreb.
Knežević, S., 1958: Jedno nepoznato nalazište munike u Crnoj Gori. Narodni šumar br. 10–12, Sarajevo.
Kontić, V., 1962: Neka zapažanja o vremenu sazrijevanja sjemena munike (*Pinus heldreichii* Christ var. *leucodermis* (Ant.) Markgraf.). Narodni šumar br. 7–8, Sarajevo.
Köstler, J., 1954: Bildliche Darstellung des Bastandesgefüges. A. F. u. J. Ztg., 1954.
Köstler, J., 1955: Der Bestockungsaufbau in der Waldbaulichen Bestandesdiognase. A. F. Z., 1955.
Krenn, K., 1941: Die Hohenadelschen Mittelstamme als Zuwachsermittlung und ihre Bdeutung für die Praxis der Zuwachsermittlung an Bestnden. A. F. u. J. Ztg., 1941.
Lakušić, R., 1961: Nova nalazišta munike u crnogorskim planinama. Narodni šumar, XV, 623–630, Sarajevo.
Loetsch, F., 1953: Massenzuwachsermittlung durch Bohrspanproben unter Anwendung mathematisch-statistischer Methoden. Z. f. W., 3, 1953.
Magin, R., 1959: Struktur und Leistung mehrschichtiger Mischwölder in den Beyerischen Alpen. München, 1959.
Meštrović, Š., 1971: Uspijevanje primorskog bora (*P. pinaster* Ait.) u kulturama R Hrvatske. Magistarski rad, Zagreb.
Müller, M. K., 1928: Untersuchungen über *Pinus peuce* und *Pinus leucodermis* in ihren bulgarischen Wuchsgebieten. Mitt. d. Staatscfcrstverwaltung Bayerns, München.
Nežić, P., 1987: Načela uređivanja šuma. Šumarski list, 446–456, Zagreb.
Nežić, P., 1987: Uređivanje šuma. Šumarski list, 470–492, Zagreb.
Papaionnou, J., 1957: *Pinus heldreichii* Christ ihre geographische Verbreitung und ihre farstlichen Formationen auf dem griechischen Teil des südlichen Orvilos (Ali – Botonus), To Vouno. Zeit. d. Griech. Bergsteigervereines, 97–109, Athen.
Pejović, D., 1962: Prilog poznavanju prirasta munike (*Pinus heldreichii* Christ var. *leucodermis* Makgraf) na Prokletijama, Šumarstvo br. 10–12, Beograd.
Petračić, A., 1955: Uzgajanje šuma – ekološki osnovi. Zagreb.
Pipan, R., 1953: O kontrolnim metodama uređivanja prebornih šuma. Šumarski list 57–65.
Pranjić, A., 1977: Dendrometrija. Zagreb.
Pranjić, A., 1986: Uređivanje i izmjera šuma. Šumarski list 7–8: 319–321.
Pranjić, A., 1990: Šumarska biometrika, Sveučilišna naklada Liber, Zagreb.
Radanović, M. Ž., 1967: Prostiranje, ekološki uvjeti, struktura i prirast munike (*Pinus heldreichii* Christ) na planini Koritnik. Zaštita prirode br. 34, Beograd.

Ritter-Studnička, R., 1963: Biljni pokrov na serpentinima Bosne. Godišnjak biol. ins. univ. XVII, Sarajevo.

Ritter-Studnička, R., 1968: Reliktgesellschaffen auf Dolomitböden in Bosnien und der Hercegovina. Vegetatio XV, Den Haag.

Ritter-Studnička, R., 1970: Die Vegetation der Serpentinvarkommen in Bosnien. Vegetatio XXI, Fosc. 1–3, Den Haag.

Stefanov, B., 1932: Notes systematique sur le *Pin leucodermis*. Bilet. de la Soc. Dendral, de France No 88, P. 8–15.

Stefanović, V., 1977: Fitocenologija sa pregledom šumskih fitocenoza Jugoslavije. Svjetlost, Sarajevo.

Stefanović, V., 1986: Fitocenologija sa pregledom šumskih fitocenoza Jugoslavije. II prošireno i dopunjeno izdanje. Svjetlost, Sarajevo.

Stefanović, V., 1986: O ugroženosti munike (*Pinus heldreichii* Christ) u Hercegovačkom dijelu areala. ANU BiH, Posebna izdanja, LXXXIII, Knj. 4., 209–213, Sarajevo.

Stöhr, F., 1968: Die einzelstammweise Bestimmung von Kreisfläche, Masse und laufendem Zuwachs pro ha mit Hilf der varioblen Winkelzählprobe. A. F. u. J. Ztg. H., 12.

Šafar, J., 1963: Uzgajanje šuma. Zagreb.

Šilić, Č., 1988: Atlas drveća i grmlja. "Svjetlost", OOUR Zavod za udžbenike i nastavna sredstva Sarajevo i Zavod za udžbenike i nastavna sredstva Beograd, III izdanje, 18–20, Sarajevo.

Škorić, A., 1965: Pedološki praktikum. Zagreb.

Šumarski institut Jastrebarsko, 1996: Bibliografija (1986–1995). Zagreb.

Tomić, K., 1965/66: *Pinus heldreichii* (munika) u vegetaciji Lovćena. Zbornik Filozofskog fakulteta u Prištini, knj. III, Priština.

Vidaković, M., 1993: Četinjače morfologija i varijabilnost. Grafički zavod Hrvatske, 442–450, Zagreb.

Walter, H., 1931: Die Kryoskopische Bestimmung des osmotischen Wertes bei Pflanzen. Abder. Handb. d. biol. Arbeit. Abt., XI, T. 4.

Walter, H., 1936: Tabellen zur Berechnung des osmatischen Werrtes von Pflanzensäften Luckerlösungen und einiger Salzlösungen, Ber. dtsch. bat. Ges., 54.

Walter, H., 1964: Die Vegetation der Erde in öko – physiologiscer Betrachtung. VEB Gustav Fischer, Verlog, Jena.

Wandelberger, H., 1963: Die Relikt – schwarzföhrenwälder des Alpenostrades. Vegetatio, Vol. XI, Fasc. 5–6, Den Haag.

Wandelberger, H., 1963: Die Schwarzföhrenwälder Arbeitsgemainschaft. Bd. 10, Stolzenau/W.

Zundel, R., 1960: Ertragskundliche Untersuchungen in Zweialtrigen Bestanden Nortwourtemberges. Stuttgart.

A. Meštrović: The Growth of Bosnian Pine (*Pinus heldreichii* Christ) in Herzegovina.
Glas. šum. pokuse 35: 191–236, Zagreb, 1998.

USPIJEVANJE MUNIKE (*Pinus heldreichii* Christ) U HERCEGOVINI

SAŽETAK

U uvodnom dijelu posebice je istaknuto unošenje munike (*Pinus heldreichii* Christ) kao tercijernoga relikta općenito, a na istraživanom području posebno. Postavljeni cilj istraživanja sastoji se u utvrđivanju uvjeta za uspijevanje munike te u utvrđivanju proizvodnih svojstava čistih prirodnih sastojina u Hercegovini. Dosadašnji nazivi pod kojima su autori obrađivali tu vrstu na različitim lokalitetima, na kraju njihovo usaglašavanje oko jedinstvenoga naziva pod kojim se munika i ovdje obrađuje prikazani su u poglavlju o dosadašnjim spoznajama.

Utvrđeno je da se najveći broj radova o munici odnosi na biljnozemljopisna istraživanja, istraživanja tala i biljnih zajednica, dok su istraživanja strukture sastojina i proizvodnih obilježja gotovo neznatna.

Podrobno je opisana prirodna i umjetna rasprostranjenost munike. Svaki je od lokaliteta opisan, a nalaze se na mediteranskim i submedteranskim planinama Balkanskoga poluotoka i u južnoj Italiji. S nalazišta u Hercegovini opisane su četiri fitocenoze u kojima prirodno uspijeva munika. Ukupna je površina na kojoj raste munika bilo u čistim bilo u mješovitim sastojinama 5865 ha. Od toga čiste sastojine zauzimaju 1528 ha. Klima areala u Hercegovini obrađena je temeljem podataka za četiri meteorološke postaje: Mostar, Konjic, Posušje i Tomislavgrad. Ti podaci potvrđuju uspijevanje munike u uvjetima kontinentalno-planinske i izmijenjene submediteranske klime hladnijega pojasa. Analizom tla na pokusnim plohama prikazana su kemijska i mehanička svojstva smeđega tla na vapnencu, crnice na vapnencu i rendzine na dolomitu. Sva spomenuta tla pokazuju manjak fosfora, neutralnu do slabo alkaličnu reakciju (pH 6,9 do 7,8) i velik postotak slobodnih karbonata kod crnica na vapnencu i rendzina na dolomitu, koji je nastao zbog velike količine sitnih skeletnih čestica. Na svim potrebnim ekosustavima obrađena su biološka svojstva, reproduktivnost i adoptivnost, pri čemu je utvrđena jako široka ekološka amplituda munike kao vrste bora.

Sve pokusne plohe (ukupno 4) detaljno su opisane u poglavlju o metodama rada, a opisan je i rad na njima. Na svakoj od pokusnih ploha analizirani su rast i prirast po jednoga stabla sa svake plohe. U dijelu obrade podataka rezultati su tabelično prikazani i za pokusne plohe i za analizirana stabla. Broj stabala u istraživanim sastojinama kretao se od 785 do 2060 komada po hektaru, promjer srednjega stabla munike za glavnu sastojinu kretao se od 12,5 do 18,7 cm, volumen srednjega stabla za glavnu sastojinu kretao se od 0,06 do 0,17 m3, volumen se kretao od 125,16 do 214,31 m3 po hektaru, a sastojine su imale od 38 do 62 godine (tablica 3).

Rezultati istraživanja detaljno su analizirani tako da u prvom redu utvrđuju bonitete staništa na temelju visina stabala na pokusnim plohama u poredbi s bonitetima koje su u svojim radovima izradili Drinić i Prolić 1979. godine, te je

utvrđeno da se sve mjerene sastojine nalaze u trećem bonitetnom razredu. Istražena je i struktura volumena probne doznake u sastojinama, a posebno su značajni utvrđeni rezultati prirodnoga pomlatka u sastojinama. Broj je stabala razvrstan po debljinskoj strukturi i prikazan tabelično i grafički (tablica 9, grafikon 3). Probna doznaka u istraživanim sastojinama munike obavljena je zato da bi se mogla dobiti informacija o mogućem opsegu sječa, odnosno o tome koji bi dio od postojećega volumena trebalo ukloniti kako bi se zamijenio novim volumenom u procesu obnavljanja tih sastojina, te kojom bi se dinamikom sve to moglo provesti i ostvariti. Za sve istraživane sastojine volumen stabala obuhvaćenih probnom doznakom u prosjeku iznosi 47,1 m^3/ha ukupnoga volumena. To čini oko 30 % postojećega volumena sastojina koji iznosi 152,93 m^3/ha ili približno trinaestogodišnji prosječni volumni prirast koji iznosi 3,50 m^3/ha/godišnje. Na stabla deblja od 50 cm otpada gotovo 2/3 ili 63,5 % volumena stabala obuhvaćenih probnom doznakom, a na stabla III. uzgojno-tehničke klase otpada preko 4/5 ili 82,8 % spomenutoga volumena (tablica 7). Broj stabalaca pomlatka munike za sve istraživane sastojine u prosjeku iznosio je 3822 komada/ha. Broj stabalaca pomlatka smreke u prosjeku iznosio je 299 komada/ha. Broj stabalaca pomlatka bukve u prosjeku iznosio je 287 komada/ha, a broj stabalaca pomlatka za sve vrste drveća i sve pokusne plohe u prosjeku iznosio je 4761 komad/ha (tablica 8).

Posebno je ocijenjena kakvoća svih stabala na pokusnim plohama razvrstanih u tri razreda (tablica 10). Za sve istraživane stastojine broj stabala u III. razredu u prosjeku iznosio je nešto malo više od 1/3 ili 37,0 %.

Razvoj i prirast stabala analiziran je i iskazan tablično i grafički (tablica 11, 12, 13, 14, grafikon 4, 5, 6) po ustaljenim kriterijima. To isto vrijedi i za sastojine. Visinski prirast analiziranih stabala oko njihove tridesete godine malo je veći, a nakon toga je isti ili nešto manji. Najveći tečajni godišnji visinski prirast analizirana stabla munike na svim pokusnim plohama imala su u dobi od 0 do 10 godina. On je na 1. plohi iznosio 0,22 m, 2. plohi 0,21 m i na 3. plohi 0,20 m. Razvoj i prirast stabala u debljinu dosta je ujednačen, a najveći tečajni godišnji debljinski prirast iznosio je 0,42 cm kod analiziranoga stabla na 1. plohi u dobi od 10 do 20 godina. Ukupni je volumen analiziranoga stabla na 1. plohi iznosio 0,16 m^3 u dobi od 58 godini, dok je ukupni volumen analiziranoga stabla na 2. plohi iznosio 0,15 m^3 u dobi od 62 godine. Najveći prosječni volumni prirast kod analiziranoga stabla iznosio je 0,0048 m^3 u dobi od 40 do 50 godina na 1. plohi s tendencijom daljnjega porasta. Visinske krivulje sastojina općenito se malo razlikuju, a istodobno najnižu visinsku krivilju imala je najmlađa sastojina. Visinska krivulja sastojine na pokusnoj 1. plohi pomaknuta je znatno naviše. Najbolje se u debljinu razvijala sastojina na 1. plohi, a najveći tečajni godišnji debljinski prirast zabilježilo je srednje stablo također na 1. plohi a iznosio je 0,14 cm. Prosječni dobni prirast srednjega stabla u debljinu najveći je na 1. plohi i iznosio je 2,1 cm. Na 1. plohi sastojina munike zabilježila je najveći tečajni godišnji volumni prirast koji je iznosio 5,63 m^3/ha, a najniži sastojina na 2. plohi koji je iznosio 2,27 m^3/ha. Ta ploha ima najmanji obrast koji iznosi 0,53 (tablica 15).

Pokazatelji taksacijskih elemenata istraživanih sastojina s pokusnih ploha vidi se na tablici ????, a ukupno dobivena proizvodnja na tablici 16.

Bonitetni razred istraživanih munikovih sastojina kretao se od 3,4 do 3,2 (u prosjeku 3,4), obrast se sastojina kretao od 0,53 do 0,82 (u prosjeku 0,75), srednji se promjer kretao od 12,5 do 18,7 cm (u prosjeku 16,4 cm) i srednja visina kretala se od 5,8 do 8,1 m (u prosjeku 7,1 m). Munikova je sastojina na 1. plohi najproduktivnija s godišnjom proizvodnjom drva od 5,75 m^3/ha, a sastojina na 2. plohi svedena na potpuni obrast imala bi ukupnu godišnju proizvodnju drva od 4,42 m^3/ha. Sastojina na 3. plohi imala je godišnju proizvodnju 2,99 m^3/ha (tablica 17). Svi navedeni rezultati dobiveni su pri taksacijskoj granici od 5 cm.

Munika kao vrsta drveća u šumama i šumarstvu u Hercegovini zauzima posebno važno mjesto, posebice u svezi sa staništem i malom površinom koju zauzima, te sa zaštitnom i pionirskom ulogom. Munikove sastojine na istraživanom području čine prirodnu rijetkost šumske vegetacije s izraženom zaštitnom (ekološkom) funkcijom, pri čemu treba naglasiti hidrološku, protuerozijsku i klimatsku ulogu, društvenom (socijalnom) funkcijom, osobito turističkom, estetskom i rekreacijskom ulogu, pionirskom funkcijom, pri čemu treba istaknuti nezamjenjivu ulogu u pošumljavanju vrlo siromašnoga visokoga-planinskoga bezvodnoga krša, gdje crni bor ne dolazi i gdje samo munika može dati normalno izrasla stabla, i na kraju proizvodnom (sirovinskom) funkcijom zbog izvanrednih tehničkih svojstava munikovine.

Zaključci pokazuju da je odgovoreno postavljenom cilju istraživanja. Prikazano je uspijevanje munike kao reliktne i endemne vrste drveća u Hercegovini, gdje nastava terene vrlo surovih uvjeta i slabih proizvodnih mogućnosti tla. U takvim uvjetima ima pionirsku ulogu, štiti tlo i stvara povoljne uvjete za uspijevanje i drugih vrsta drveća. Posebno je vrlo slikovita i atraktivna u pejzažu. Proizvodne su mogućnosti na planini Čvrsnici manje od onih u drugim dijelovima njezine rasprostranjenosti, ali su za dane uvjete zadovoljavajuće s granicama od 2,0 do 6,0 m3 po hektaru godišnje uz prirodnu progresiju na pašnjačke površine.

Ključne riječi: uspijevanje, munika (*Pinus heldreichii* Christ), tercijarni relikt, endemna vrsta, rasprostranjenost, munika u Hrecegovini, klima, tlo, stanište, biološka svojstva, bonitet, pomladak, razvoj i prirast stabala, razvoj i prirast sastojina, produkcija

Photograph 1. Bosnian pine in a pioneering function on barren karst
Fotografija 1. Munika u pionirskoj funkciji na ljutom kršu

Photograph 2. Bosnian pine on the mountain Čvrsnica in the initial stage of natural progression to pastureland
Fotografija 2. Munika na planini Čvrsnici u početnoj fazi prirodne progresije na pašnjačke površine

Photograph 3. Bosnian pine in compartment 26 of the Management Unit Čvrsnica (part) in natural progression to mountain pastureland
Fotografija 3. Munika u odjelu 26 gospodarske jedinice Čvrsnica (dio) u prirodnoj progresiji na površine planinskih livada

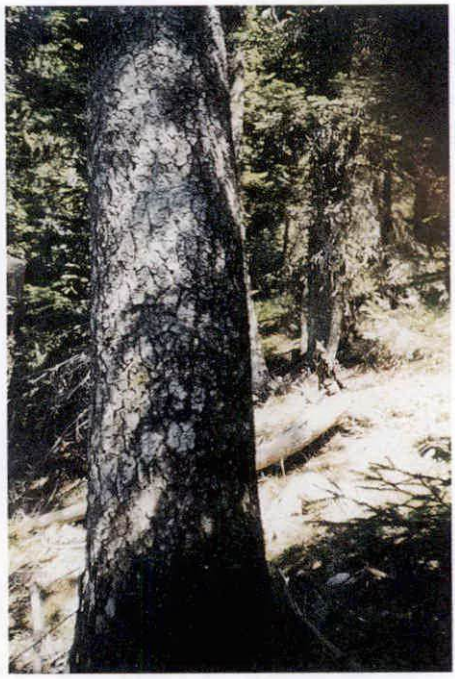
Photograph 4. Natural young Bosnian pine in experimental plot 2, compartment 22b in the Management Unit Čvrsnica (part)
Fotografija 4. Prirodni pomladak munike na pokusnoj plohi 2, odjel 22b, u gospodarskoj jedinici Čvrsnica (dio)

Photograph 5. Young Bosnian pine with a characteristic pyramid-shaped crown invading the maquis

Fotografija 5. Mlado stablo munike svojstvene piramidalne krošnje u osvajanju šikare

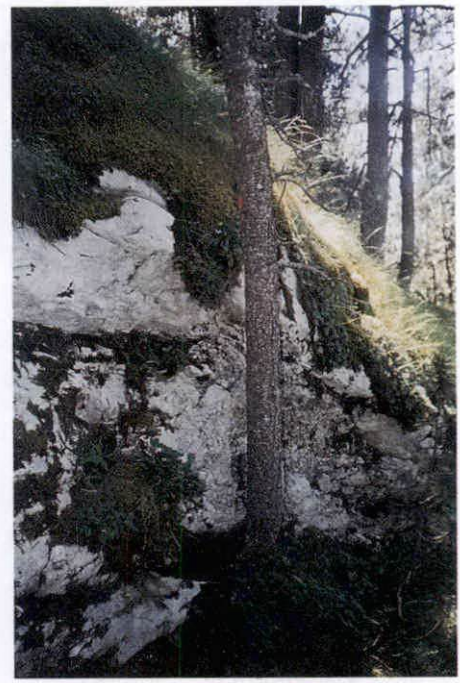
Photograph 6. The tallest Bosnian pine in experimental plot 1 with characteristic bark

Fotografija 6. Najviše stablo munike na pokusnoj plohi 1 s prepoznatljivom korom



Photograph 7. Bosnian pine with the largest diameter in experimental plot 2 with characteristic "bullet-proof" bark

Fotografija 7. Stablo munike najvećega promjera na pokusnoj plohi 2 s karakterističnom "pancir" korom



Photograph 8. Bosnian pine in experimental plot 2 growing from a crevice in a calcareous stone block

Fotografija 8. Stablo munike na pokusnoj plohi 2 izniklo iz pukotine na vapnenastom kamenom bloku