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GROWTH CHARACTERISTICS OF EUROPEAN BEECH (*Fagus sylvatica* L.) ON *Isopyro-Fagetum* KOŠ. 62 SITE

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Abstract

In this paper, growth characteristics of European beech (*Fagus sylvatica* L.) stands on site of *Isopyro-Fagetum* KOŠ. 62 are analysed. The research was carried out in Zasavje, where in mature beech stands five plots measuring 30x30 m were set. All trees above 10 cm were measured and cut for stem analyses. Increment of the last 10 years is statistically significantly influenced by (chronologic) age of trees, shade effect, diameter at breast height, social class and very rarely by crown dimensions. The time of current increment culmination is dependent on age, diameter at breast height, social class and on shade effect. As regards site productivity of the analysed site, a very broad range was ascertained. Variation is almost completely explained by altitude. On three plots sites, productivity increase was confirmed, whereas on one plot the changes were not significant and on one plot site productivity decreased, probably due to the transmitter on Mt Kum.

Key words: site productivity, height increment, diameter increment, volume increment, *Fagus sylvatica, Isopyro-Fagetum*

RASTNE ZNAČILNOSTI BUKVE (Fagus sylvatica L.*) NA RASTIŠČU Isopyro-Fagetum KOŠ. 62*

Izvleček

Prispevek obravnava rastne značilnosti bukovih (Fagus sylvatica L.*) sestojev na rastišču Isopyro-Fagetum KOŠ. 62. Raziskavo smo opravili v Zasavju, kjer smo v bukovih debeljakih postavili 5 ploskev velikosti 30x30 m. Vse nadmersko drevje smo izmerili in posekali za debelne analize. Na prirastek drevja v zadnjih 10 letih imajo statistično značilen vpliv (kronološka) starost drevja, učinek zastrtosti, prsni premer, socialni razred in presenetljivo redko dimenzije krošnje. Čas kulminacije tekočega priraščanja je odvisen od starosti, prsnega premera, socialnega razreda in učinka zastrtosti. Ugotovili smo izredno širok razpon produkcijske sposobnosti analiziranega rastišča. Variiranje v produkcijski sposobnosti je praktično v celoti odvisno od nadmorske višine. Na treh ploskvah smo potrdili dvig produkcijske sposobnosti rastišča, na eni spremembe niso statistično značilne, na eni izmed ploskev pa se je produkcijska sposobnost rastišča, domnevno zaradi vpliva oddajnika na Kumu, znižala.*

Ključne besede: produkcijska sposobnost rastišča, višinski prirastek, debelinski prirastek, volumenski prirastek, Fagus sylvatica, Isopyro-Fagetum

INTRODUCTION
UVOD

European beech (*Fagus sylvatica* L.) is indubitably one of the ecologically and economically most important tree species in Central Europe, including Slovenia. This importance is also reflected in the extensive research work carried out on beech. As a many-sided interesting tree species, its growth characteristics have been intensively studied (*e.g.* KELLER 1978, KOTAR 1989, DITTMAR *et al*. 2003). The majority of beech sites have been already analysed, but - unfortunately - more extreme or rare azonal sites have been missed out till now (KOTAR 2005). From the economic point of view, these sites are not likely to be very important, however, they are extremely valuable due to their ecological and indicative role.

In this work, growth characteristics of beech on *Isopyro-Fagetum* KOŠ. 62 site are analysed. This syntaxonomic unit was chosen for the following reasons:

- These sites have »semiprotective« character. This means that they perform protective function, but harvesting activities are generally allowed (Pravilnik o gozdnogospodarskih...1998). Forests with such a status usually develop differently from the classic managed forests.
- On these sites, weak intensity or even no felling is performed, which enables us to establish site productivity change at the exclusion of forest management activities.
- Sites within this azonal association could/should have more unified growth characteristics in comparison with zonal site units covering larger areas.

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- Eventual differences between the analysed site unit and comparable zonal site units could show which site variables affect the tree growth.

As an azonal and rare syntaxonomic unit, the association *Isopyro-Fagetum* has been studied only phytosociologically till now. As a nonintensively managed and ecologically narrow-defined association (KOŠIR 1979), it represents very interesting object of growth studies. With regard to productivity, Košir (1976) ranged the association among slightly below average sites. The aims of the present research are to answer the following questions:

1. Which tree, stand and site factors influence the height, diameter, basal area and volume increment of beech trees on selected site?
2. On which factors is age at the culmination of height, diameter or volume increment dependent?
3. Does the range of SI_{100} (SI_{100} is defined as average height of 100 thickest beech trees per ha at the reference age of 100 years) exceed 2 m? If it does, which factors influence SI_{100}?
4. Does $SI_{100,}$ established for the analysed association, deviate from SI_{100} derived from the function, which presents the dependency of SI_{100} on altitude for the same bedrock type (KADUNC / KOTAR 2008)?
5. Has SI_{100} changed in the last 30 years due to climate/ environmental changes?

Understanding the growth or productivity on more extreme or rare sites becomes indispensable for the contemporary forest management.

MATERIALS AND METHODS
MATERIALI IN METODE

DESCRIPTION OF THE RESEARCH AREA
OPIS RAZISKOVALNEGA OBJEKTA

The research was carried out in the region of Zasavje, more precisely on the slopes of Mt Kum (1,220 m), where five research plots were set. All plots were selected in mature beech stands on the sites classified as *Isopyro-Fagetum*. The plots are situated in the upper mountain belt on limestone bedrock (Table 1). The share of beech in growing stock amounts to 84.7%.

METHODS
METODE DELA

On the sites of *Isopyro-Fagetum* association, five plots measuring 30x30 meters in mature, fully stocked stands dominated by beech were selected. All trees on the plots with dbh (diameter at breast height) equal or bigger than 10 cm were measured and cut (altogether 271 trees). Before felling for each tree dbh, crown width (four radii), social class by Kraft, degree of crown isolation (ASSMANN 1961) and tree species were recorded. After this procedure, stem analyses were carried out. Stem analyses – including stem discs preparation – were performed as proposed by Kahle *et al.* (2008), with the exception of the fixed section lengths. At the felling, the height of the first primary green branch thicker than 3 cm was established. Crown projection was calculated as circle's surface with radius, which represents an average of four measured crown radii. Subtracting the height of the first primary

Table 1: Basic characteristics of research plots

Preglednica 1: Splošne značilnosti raziskovalnih ploskev

Characteristics *Značilnost*	Research plot / *Raziskovalna ploskev*				
	1	2	3	4	5
Altitude (m) / *Nadm. viš. (m)*	1,200	1,200	1,010	1,025	980
Aspect / *Ekspozicija*	SE	NE	W	W	SE
Slope (°) / *Naklon (°)*	22	28	17	21	27
Stoniness (%) / *Kamnitost (%)*	15	10	30	40	20
Stand density (N/ha) / *Gostota sestoja*	611	633	711	679	379
Age of stand canopy (years) *Starost dreves iz strehe sestoja (leta)*	123.2 ± 4.5*	129.5 ± 4.5	117.0 ± 3.9	114.5 ± 2.7	117.7 ± 5.7

*confidence interval at 0.95significance level

green branch from (total) tree height gives us the length of the tree crown. Furthermore, subtracting the share of the crown length in tree height from 1 gives us crown ratio (hereafter: crown ratio 1). The surface and volume of crowns were calculated with methods proposed by Pretzsch (2002). The ratio between the crown's surface and volume is called crown ratio 2. Shade effect (developmental age was subtracted from chronologic age) was established according to Pothier *et al*. (1995).

On each plot, dead trees and stumps were measured as well. On that basis, the mortality for the last (approximately) 30 years was estimated. The mortality before that was calculated in a very conservative way following calculations by Kotar (1989). Using the sum of growing stock and total mortality we estimated the yield level and also the total volume production of the analysed stands.

The productivity was established on the basis of site index at the reference age of 100 years (SI_{100}). Moreover, we estimated the productivity expressed as total volume production (TVP) using SI_{100}, yield level and Slovakian yield tables (HALAJ *et al*. 1987).

In order to answer the last question, we used two approaches, first at the stand and second at the tree level.

At the stand level, we obtained site indices at the age of 70 years for two datasets by plots. First dataset (I) includes only height growth data of nine thickest beech trees per plot up to the age of 70 years, while the second dataset (II) includes height growth data of the same trees up to the age of 100 years. Using Paired-Samples T Test, we tested the difference between both datasets in SI_{70}.

At the tree level, the closest site index curves from yield tables (HALAJ *et al*. 1987) at the age of 70 and at the age of 100 years for each dominant beech trees were determined. Differences between pairs of SI_{100} established from two age points were tested at the plot level.

Concerning statistical methods, we used multivariate regression (we selected backward procedure with regard to the arguments of LEGENDRE / LEGENDRE 1998), nonlinear regression (the function of Chapman-Richard, for details see ZEIDE 1993) and statistical inference.

RESULTS
REZULTATI

GROWTH AND INCREMENT
RAST IN PRIRASTEK

Using multivariate regression, we tried to establish which factors influence different increments (height, diameter, basal area and volume) of the last 10 years (hereafter: HI_{10}, DI_{10}, BAI_{10} and VI_{10}; table 2). As independent variables, dbh, tree height, (chronologic) age, shade effect, crown projection,

Table 2: Influential variables on height increment (HI_{10}), diameter increment (DI_{10}), basal area increment (BAI_{10}) and on volume increment (VI_{10}) of adult beech trees

Preglednica 2: Spremenljivke, ki vplivajo na višinski prirastek (HI_{10}), debelinski prirastek (DI_{10}), temeljnični prirastek (BAI_{10}) in volumenski prirastek (VI_{10}) odraslih bukovih dreves

Variable / *Spremenljivka*	HI_{10}		DI_{10}		BAI_{10}		VI_{10}	
	β	*p*	β	*p*	β	*p*	β	*p*
Dbh / *Dbh*	n.s.	n.s.	0.0566	0.0000	6.9851	0.0000	0.0111	0.0000
Tree height / *Višina drev.*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.0070	0.0009
Age / *Starost*	0.0062	0.0001	-0.0111	0.0037	-1.0333	0.0000	-0.0015	0.0065
Shade effect / *Učinek zastrtosti*	n.s.	n.s.	n.s.	n.s.	3.2355	0.0012	0.0067	0.0045
Crown projection / *Tloris krošnje*	0.0047	0.0001	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Crown ratio 1 / *Razmerje krošnje 1*	-0.4506	0.0080	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Crown ratio 2 / *Razmerje krošnje 2*	0.4988	0.0000	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Social class 2 vs. 5 / *Soc. razred 2 vs.5*	n.s.	n.s.	0.2854	0.0138	n.s.	n.s.	-0.0690	0.0432
Social class 3 vs. 5/ *Soc. razred 3 vs.5*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.0858	0.0029
Social class 4 vs. 5/ *Soc. razred 4 vs.5*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.0658	0.0106
Crown isolation / *Utesnjenost krošnje*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
SI_{100}	n.s.	n.s.	-0.0244	0.0486	n.s.	n.s.	n.s.	n.s.
Basal area / *Temeljnica*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.0069	0.0145
R^2 (the share of explained variance by the model)	0.348		0.475		0.754		0.710	

crown ratio 1, crown ratio 2, social class (broken into dummy variables), degree of crown isolation (broken into dummy variables), SI_{100} (calculated for plot level), and basal area (calculated for plot level) were tested.

Height increment is positively dependent on age, crown projection and crown ratio 2, and negatively influenced by crown ratio 1. Trees with longer and bigger crowns, which are usually older, grow better in height.

Understandably, thicker and younger trees have higher diameter increments. On more productive sites, diameter increments are lower, which could be explained by more intensive height growth. Interestingly, the influence of wider or longer crowns on diameter increment was not confirmed. As regards basal area increment, it reacts very similarly as the diameter one.

Volume increment is positively affected by dbh, tree height and shade effect, while age, basal area and higher social class (suppressed trees have relatively high increments due to their lower age) negatively affect volume increment.

Using the same independent variables, we tested which factors influence the age of current increment culmination (height, diameter and volume; Table 3).

Current height increment culminates later at higher and older trees, especially when they have grown for a longer period of time under the canopy. On the other hand, thicker and codominant (in comparison with suppressed trees) trees culminate earlier.

Culmination of diameter increment depends solely on age, older trees culminate later. Interestingly, volume increment is positively dependent on dbh and age.

SITE PRODUCTIVITY
PRODUKCIJSKA SPOSOBNOST RASTIŠČA

The range of the established SI_{100} exceeds 10 m (Table 4). Additionally, we tested the differences between the established site indices and calculated ones. The latter were obtained by regression model with altitude as an independent variable (KADUNC / KOTAR 2008). Differences were not statistically significant (t = -2.061; p = 0.108). Nevertheless, it can be stated that the first and second plots have extremely low SI_{100} with regard to their altitude.

In addition, the correlations between SI_{100} and several stand or site variables were tested (Table 5). Taking nonsignificant correlation between SI_{100} and basal area or density index into account, it can be assumed that the confirmed positive relationship between SI_{100} and growing stock should be interpreted in the way more productive sites have higher growing stock and not *vice versa*. On the other hand, negative correlation between SI_{100} and altitude is a direct and fully

Table 3: Influential variables on the age at the culmination of current height increment (HI_{10}), diameter increment (DI_{10}), and on the age of volume increment culmination (VI_{10}) of adult beech trees

Preglednica 3: Spremenljivke, ki vplivajo na starost v času kulminacije tekočega višinskega prirastka (HI_{10}), debelinskega prirastka (DI_{10}) in volumenskega prirastka (VI_{10}) odraslih bukovih dreves

Variable / *Spremenljivka*	Age of HI_{10} culm. *Starost ob kulm. HI_{10}*		Age of DI_{10} culm. *Starost ob kulm. DI_{10}*		Age of VI_{10} culm. *Starost ob kulm. VI_{10}*	
	β	*p*	β	*p*	β	*p*
Dbh / *Dbh*	-0.8734	0.0011	n.s.	n.s.	0.2687	0.0195
Tree height / *Višina drev.*	1.5219	0.0052	n.s.	n.s.	n.s.	n.s.
Age / *Starost*	0.4097	0.0030	0.4058	0.0000	0.8560	0.0000
Shade effect / *Učinek zastrtosti*	3.8274	0.0000	n.s.	n.s.	n.s.	n.s.
Crown projection / *Tloris krošnje*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Crown ratio 1 / *Razmerje krošnje 1*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Crown ratio 2 / *Razmerje krošnje 2*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Social class 2 vs. 5 / *Soc. razred 2 vs. 5*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Social class 3 vs. 5/ *Soc. razred 3 vs. 5*	-7.6177	0.0378	n.s.	n.s.	-5.2253	0.0023
Social class 4 vs. 5/ *Soc. razred 4 vs. 5*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Crown isolation / *Utesnjenost krošnje*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
SI_{100}	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Basal area / *Temeljnica*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
R^2 (the share of explained variance by the model)	0.227		0.126		0.804	

Table 4: SI_{100} and mean annual volume increment at the culmination time (MAI_{max}) on the plots

Preglednica 4: SI_{100} in povprečni starostni volumenski prirastek v času kulminacije (MAI_{maks}) na ploskvah

Plot *Ploskev*	MAI_{max}/ MAI_{maks} ($m^3ha^{-1}a^{-1}$)	SI_{100}		Difference *Razlika*
		Established *Ugotovljen*	Calculated on the basis of regression model (Kadunc/Kotar 2008) with altitude as indpendent variable / *Izračunan na podlagi regresijskega modela z nadmorsko višino kot neodvisno spremenljivko*	
1	4.5	16.08	21.67	-5.59
2	4.5	15.60	21.67	-6.07
3	7.2	23.79	24.63	-0.84
4	6.5	22.25	24.45	-2.20
5	8.0	25.82	24.96	0.86

expected connection. The relationship between age and productivity was indicated but not statistically confirmed. This relationship is probably based on the influence of altitude (within this research, older stands grow at higher altitudes), but due to the small number of analysed plots the partial correlation was not applied.

In order to answer the last question, we used two approaches, first on the stand and second at the tree level.

At the stand level, we obtained site indices at the age of 70 years for two datasets by plots. Surprisingly, for all plots higher values of SI_{70} were obtained for the second »older« (dataset with longer age range of height growth data) dataset

Table 5: Correlation between SI_{100} and stand or site variables

Preglednica 5: Povezanost med SI_{100} in sestojnimi oziroma rastiščnimi spremenljivkami

Variable / *Spremenljivka*	Pearson's correlation coefficient *Pearsonov korelacijski keoficient*	*p* / *Stopnja tveganja*
Age / *Starost*	-0.853	0.066
Stand density (N/ha) / *Gostota sestoja*	-0.371	0.539
Basal area (m^2/ha) / *Temeljnica*	-0.042	0.947
Growing stock (m^3/ha) / *Lesna zaloga*	0.911*	0.031
Density index[a] / *Indeks gostote*	0.057	0.928
Altitude (m) / *Nadmorska višina*	-0.991**	0.001
Inclination / *Naklon*	-0.261	0.671
Stoniness / *Skalovitost*	0.609	0.276

[a] Density index was defined by Kotar (1985; page 118)

Fig. 1: Differences in top height between dataset I (»older« trees) and dataset II (»younger« trees) by plots

Slika 1: Razlike v zgornji višini med podatkovno bazo I (»starejše« drevje) in podatkovno bazo II (»mlajše« drevje) na ploskvah

Table 6: Testing SI_{100} change in the last 30 years

Preglednica 6: Preizkus sprememb v SI_{100} za zadnjih 30 let

Plot *Ploskev*	Stand level / *Sestojna raven*			Tree level / *Drevesna raven*				
	SI_{70} (I)	SI_{70} (II)	Difference / *Razlika*	SI_{100} (70)	SI_{100} (100)	*t* value / *t vrednost*	*p*	N
1	11.48	11.92	-0.44	19.56	19.28	0.814	0.424	25
2	12.25	12.28	-0.03	17.57	16.14	10.954	0.000	21
3	17.19	18.06	-0.87	23.00	24.38	-3.667	0.002	16
4	16.25	17.29	-1.04	22.50	23.62	-3.922	0.001	16
5	19.22	19.91	-0.70	23.90	26.20	-2.913	0.017	10
Total / *Skupaj*	..	..	..	20.74	21.03	-1.427	0.157	88

(Table 6 and Figure 1). Differences were statistically significant (t = -3.484; p = 0.025).

At the tree level, the closest site index curves from yield tables (HALAJ *et al*. 1987) at the age of 70 and at the age of 100 years for each dominant beech trees were determined. Differences between pairs of SI_{100} established from two age points were tested at the plot level (Table 6). Only on the first plot, the site index has not changed. On plots 3-5, the indices have increased, while on the second plot the site index has decreased.

DISCUSSION
RAZPRAVA

The research into growth characteristics of beech stands on the site of *Isopyro-Fagetum* contributes to our knowledge of beech growth on extremer sites. Naturally, our understanding about extreme(r) sites is improved at the same time.

Regarding the influential factors on height increment, some quite expected results were obtained. On the other hand, the research did not confirm diameter increment to be dependent on crown dimensions or stand density, which is in contrast to basic knowledge in forest growth science (e.g. ASSMANN 1970). Our results could be explained by relatively old dominant trees with crowns that are already relatively inefficient regarding light use. Another at first sight surprising results concern suppressed trees having relatively high volume increments. These trees are much younger than trees from stand canopy and their growth rate usually decreases when they get older and bigger.

As regards culmination of current increments, older trees usually culminate later. These trees are usually in dominant position with crown of normal size and very persistent growth. . On the other hand, the growth of nondominant trees is to a higher degree dependent on age.

The analysis of site productivity showed very wide range of the established site indices. Our hypothesis about the narrow range of azonal association's site productivity is rejected. Even more, the established range of 10 meters exceeds the ranges of the majority of beech zonal associations (KOTAR 1995). Taking into account that the research was carried out in a small area, the results are even more difficult to understand. In addition, this range of site indices is almost completely explained by the altitude, which is in accordance with other researches (e.g. KELLER 1978, KADUNC / KOTAR 2008). Otherwise, the differences between site indices established on *Isopyro-Fagetum* sites and site indices calculated on the basis of regression model (KADUNC / KOTAR 2008) were indicated, but not statistically significant. On the other hand, the analysis confirmed site index change in the past 30 years. Site productivity has generally improved, which is in agreement with other European and Slovenian researches (e.g. SPIECKER *et al*. 1996, KOTAR 2002).

The exception is plot 2, where site productivity decreased. The possible explanation for that is the influence of the transmitter situated above the plot on the peak of Mt Kum. The strongest signals are transmitted just above the second plot, while the plot 1 is less affected. Only plot 1 has not changed site productivity. Perhaps the general improvement of site productivity is counterbalanced by (moderate or weak) transmission. But it must be noted that the above-mentioned explanation based on transmitter activity is of a speculative character. For a serious conclusion, special measurements should be performed.

In comparison with certain beech sites located at comparable altitudes (specifically *Anemone-Fagetum var. geogr. Luzula nivea, Omphalodo-Fagetum calamgrostidetosum, Omphalodo-Fagetum festucetosum*), the analysed association has similar productivity, whereas in comparison with other sites (*Cardamini savensi-Fagetum, Ranunculo platanifolii-Fa-*

getum, Luzulo-Fagetum abietetosum, Omphalodo-Fagetum maianthemetosum), its productivity is lower (KOTAR 2005).

The importance of extreme sites is increasing. Often, they are better preserved and, consecutively, provide suitable research objects for analysing natural processes and a variety of habitats usually lacking in managed forests. Recently, the obligations of the Kyoto Protocol concerning CO_2 (Zakon o ratifikaciji...2002) and obligations from local legal regulations regarding management limitations (Zakon o gozdovih...1993) increased the meaning of extreme sites.

In the past research activities, extreme sites have been usually overlooked. Nowadays, it is becoming clear that this knowledge gap needs to be filled up.

SUMMARY
POVZETEK

Prispevek obravnava rastne značilnosti bukovih sestojev na rastišču *Isopyro-Fagetum* KOŠ. 62. Raziskavo smo opravili v Zasavju, v pogorju Kuma. Postavili smo 5 ploskev velikosti 30x30 m v bukovih debeljakih. Na ploskvah smo izmerili in posekali vse drevje s prsnim premerom nad 10 cm. Na podlagi meritev stoječega drevja in debelnih analiz smo ugotovili potek priraščanja v višino, debelino ter posledično temeljnični in volumenski prirastek. Višinski prirastek je pozitivno odvisen od kronološke starosti drevja, tlorisa krošnje in razmerja med površino in volumnom krošnje. Drevje z daljšimi in večjimi krošnjami, ki je praviloma starejše, hitreje raste v višino. Debelinski prirastek je, razumljivo, večji pri debelejših in mlajših drevesih, zanimivo pa je, da je nižji na produktivnejših rastiščih. Vpliva dimenzij krošnje na debelinski prirastek presenetljivo nismo potrdili. Temeljnični prirastek reagira podobno kot debelinski, na volumenski prirastek pa pozitivno vplivajo prsni premer, višina drevesa in učinek zastrtosti, medtem ko imajo kronološka starost, temeljnica sestoja in socialni razred negativen učinek.

Tekoči višinski prirastek kulminira kasneje pri starejšem in višjem drevju, posebno če je dalj časa raslo pod zastorom. Nasprotno pa debelejše in sovladajoče drevje hitreje kulminira. Čas kulminacije debelinskega prirastka je (pozitivno) odvisen samo od starosti, volumenski prirastek pa tudi od prsnega premera.

Kar zadeva produkcijske sposobnosti, smo presenetljivo ugotovili izredno širok razpon med ploskvami, ki so ležale na razmeroma omejenem območju. Variiranje v produkcijski sposobnosti je praktično v celoti odvisno od nadmorske višine. Na treh ploskvah smo potrdili dvig produkcijske sposobnosti rastišča, na eni spremembe niso statistično značilne, na eni izmed ploskev pa se je produkcijska sposobnost rastišča, domnevno zaradi vpliva oddajnika na Kumu, znižala.

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