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J. Čavlović, M. Božić, N. Lukić: Trends in forest and timberland values in the dynamic system of an even-aged forest of pedunculate oak ... Glas. šum. pokuse 37: 83–93, Zagreb, 2000.

UDK 630*613+652 (Quercus robur L.)

TRENDS IN FOREST AND TIMBERLAND VALUES IN THE DYNAMIC SYSTEM OF AN EVEN-AGED FOREST OF PEDUNCULATE OAK IN THE MANAGEMENT UNIT "JOSIP KOZARAC"

JURO ČAVLOVIĆ, MARIO BOŽIĆ, NIKOLA LUKIĆ

Faculty of Forestry, University of Zagreb,
Svetošimunska 25, HR-10000, Zagreb, Croatia

In terms of multiple functions, the value of a forest varies dramatically over time and depends on a large number of influences and relationships. Some of the most important factors that influence trends in the timberland value of an even-aged forest within its economic function are the rotation period and trends in the age structure. The aim of this paper is to study the relations in forest value, forest rent and interest percentage over time as a consequence of variations in the rotation and age class area.
The subject of the research is the forest of pedunculate oak in the first site class with a total area of 3894.29 ha. The forest contains a surplus of mature understocked stands, and the management is based on a 140-year rotation period.
The value of forest land and stands has been determined using accepted methods, while trends in the entire forest and timberland value have been obtained using the SD model of even-aged forest management.
The relationship of forest value trends, forest rent and interest percentage has yielded the following result: the value of pedunculate oak forest would increase by 5-7 monetary units (6%) if the rotation period were lengthened from 140 to 160 years.

Key words: pedunculate oak, forest timberland value, age class distribution, income, costs

INTRODUCTION

Forests and forest land as specific renewable resources are goods of special social importance. This renewable natural resource is a goods that cannot be enlarged, at least not infinitely. Therefore, it has a monopolistic importance, and its value increases with the increase of population. The importance and role of forests can be estimated on the basis of various criteria, of which the most significant are physical, economic and social ones (Klepac 1963). According to these criteria, forest functions are classified into protective, economic and social ones. Present day forest management is directed solely at the production of two basic products: non-market forest services and timber. However, it is difficult to differentiate between forests that yield only generally useful benefits and those that serve exclusively for the production of wood. These two functions are mutually intertwined and, depending on a situation, have different relationships. Not all forests have economic functions, while the function of general benefit is present to a lesser or higher degree in all forests.

AIM OF RESEARCH

The value of a forest is a function that changes over time and depends on a large number of influences and relationships. The value of generally useful forest functions depends on several factors: the degree of demand for these functions, the awareness of people about the role of forests in maintaining ecological stability, the wealth of a society, willingness to invest into services provided by the non-market values of a forest, and others. The value of generally useful forest functions is very high and is constant for all forests that are managed in a proper and sustainable manner. As it is difficult to evaluate exactly the value of forest functions of general benefit, the value of forest stands, forests and forest land is assessed on the basis of timber value.

The value of an economic forest, viewed solely in the light of timber production, is a function that changes over time and is dependent on a series of factors. These include supply and demand for raw wood material, development of timber processing technology, costs of forest production, structure and quality of wood assortments, age ratio and condition of stands. Forest managers can directly or indirectly influence the last three elements. In recent times, extensive research has been done in pedunculate oak forests (Dekanić 1962, 1975; Klepac 1964, 1971, 1982, 1988; Pranjić 1970; Prpić 1974; Pranjić et al. 1988; Meštrović 1989; Meštrović at al. 1996; Matić and Skenderović 1993; Mayer 1993; Prpić et al. 1997), although trends in the values of these forests have been studied in far less detail. The aim of this paper is to study trends in forests values, forest rent and the rate of interest in the function of time and of changed management with even-aged forest (varied rotation periods) on the example of the management unit "Josip Kozarac". Trends in values, that is, in the receipts and expenditures over time as a consequence of trends in age class areas are also worth studying.

THE OBJECT OF RESEARCH

The research was targeted at the management class of pedunculate oak in the management unit “Josip Kozarac”. The management class consists of pedunculate oak stands in the first quality site class. The total area of the management class is 3,894.29 ha, the total growing stock is 1,327,407 m^3 and the measured annual increment is 30,633 m^3 (8.62 m^3/ha). Compared to the normal age class distribution, there is a surplus of mature understocked stands (the last two age clases) (Table 1)

Table 1. Data of real forest of even-aged stands (Management class of pedunculate oak-Management unit "Josip Kozarac").

	AGE CLASS							Total
	0-20	21-40	41-60	61-80	81-100	101-120	121-140	
	years							
Actual area	341.37	257.63	126.61	327.03	544.4	1398.57	898.68	3894.29
Normal area	556.32	556.32	556.33	556.33	556.33	556.33	556.33	3894.29
Actual growing (m^3)	-	40087	28001	121163	233656	579036	325464	1327407
stock (m^3/ha)	-	156	221	370	429	414	362	341
Norm. growing (m^3)	-	79554	156885	223088	266482	295411	313214	1334634
stock (m^3/ha)	-	143	282	401	479	531	563	343

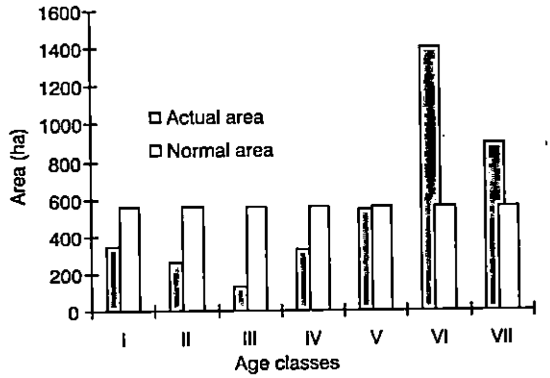

Figure 1. Age class distribution per area

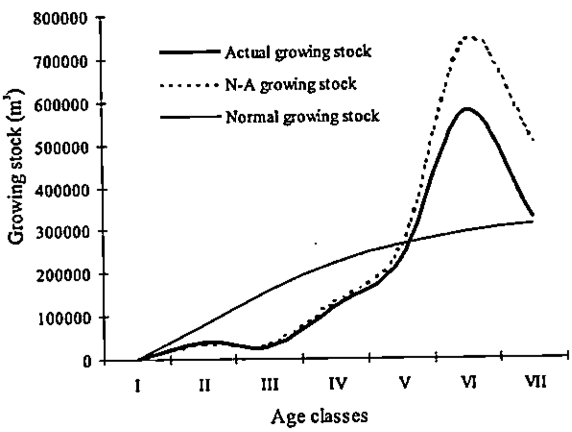

Figure 2. Age class distribution per growing stock

The surveyed and classified data present the initial states in the course of simulation research on the behaviour of the given even-aged forest system.

METHOD OF WORK

As the aim of this paper was to study the value of an even-aged forest as a changeable dynamic system, the research was based on the dynamic processing model of management with an even-aged forest (Čavlović 1995, 1996; Čavlović and Benko 1998). This model gives the condition of an even-aged forest (stand ratio according to age structure) at every point of time with assumed management. Almost every regular forest is characterised by an irregular initial age structure, and the same is true for the forest "Josip Kozarac". Assuming that an even-aged forest is managed regularly, the normal condition will be gradually achieved through qualitative and quantitative changes in the age structure, growing stock and increment of a stand.

The value of a forest is determined on the basis of:

a) estimating the average value per hectare of an individual age class,

b) capitalised value of permanent forest rent of a forest over time.

ESTIMATING THE AVERAGE VALUE OF AN INDIVIDUAL AGE CLASS PER HECTARE

A method of stand cost (Sabadi 1992) to calculate a stand value has proved to be the most adequate for stands of up to 30 years of age. For this reason, the average value per hectare in the first age class has been determined using the cost method for 10-year-old stands, and the value of the second age class has been determined using the same method for a 30-year-old stand.

The evaluation of the average stand value per ha in the I age class is shown in the following example:

Assuming that a 10-year-old stand has no timber yield, the estimated costs of the stand represent its cost value.

If the establishment cost is c^*=2431.4 m.u. (monetary units)/ha; cultural improvement cost is $c_{1\text{-}20}$=347.3 m.u./ha; annual costs of administration, protection, taxes v= 22.4 m.u. /ha; purchase cost of land r = 131.42 m.u./ha, with interest p = 1.75%, the total costs of a stand can be calculated:

$$C.V._{10} = 2431.4 * 1.0175^{10} + \left(347.3 * \frac{1.0175^{10}-1}{1.0175-1} * 1.0175\right) + \left(22.4 * \frac{1.0175^{10}-1}{1.0175-1}\right) +$$

$$+ \left(131.42 * \frac{1.0175^{10}-1}{1.0175-1}\right) = C.V._{10} = 8382.69 \text{ n.j.}$$

For stands over 30 years of age, the expected value method or the yield value method was applied. The same method was used to estimate the average value of the III, IV, V, ... X age class (average stand age 30, 50, ..., 190 years).

The felling value of expected intermediate standing yields and mature standing yields has been determined for the mentioned stands using yield tables for pedunculate oak in the first site class (Špiranec 1975), the assortment structure table, and unit prices of timber assortments.

The estimate of a 50-year-old stand value is as follows:

Expected stand value = expected discounted receipts-expected discounted expenditures

$$E.V._{50} = \frac{(D_{60} * 1.0175^{80} + D_{70} * 1.0175^{70} + ... + D_{130} * 1.0175^{10} + A140) - ((B_u + V) * (1.0175^{90} - 1))}{1.0175^{90}}$$

$E.V._{50} = 22075.29$ n.j., where:

$D_{60}, D_{70}, \ldots, D_{130}$ – net value of thinnings
A_{140} – value of major harvest cut at rotation age
Bu – income land value
V – capitalised value of annual costs (administration, protection, taxes)

At any moment, the total value of an even-aged forest of pedunculate oak is calculated in the model using the formula:

$$T.V._F = ((a_I * C.V._{10}) + (a_{II} * C.V._{30}) + (a_{III} * E.V._{50}) + ... + (a_N * E.V._{u-10}))$$

where:
$a_I, a_{II}; \ldots a_N$ – the area of the first, second, ..., last age class at a given moment
$C.V._{10}, C.V._{30}, \ldots, E.V._{u-10}$ – average value per ha of the first, second, ... last age class at a given moment

CAPITALISED VALUE OF A PERMANENT FOREST RENT OF A FOREST OVER TIME

The value of a forest is a function that depends on the permanent forest rent that a given forest yields annually at a defined interest rate. The rent depends on the size of the receipts and expenditures in the forest. When only the yields from timber and the improvement costs, costs of administration, protection, and taxes, and purchase cost of land are assumed, it can be said that the forest rent will depend on the age structure of stands in a real even-aged forest at a given moment. When a normal age structure in an even-aged forest is achieved, constant receipts and expenditures can be expected within the forest surrounding.

Since the mentioned model can show trends in age structures over time within a longer period for assumed management with a real even-aged forest, trends in forest rent, that is, forest value over time, can be monitored by inserting the value of wood material and costs into the model.

The establishment (regeneration) costs of stands will depend on the annual surface cut of the main yield, the improvement costs of young stands will depend on the area of the first age class, while the costs of administration and protection, as well as the purchase cost of land for the total forest area, will be more or less constant (assuming that the forest surface does not change).

Starting from these assumptions, the net annual income in the model has been calculated using the formulae:

Year expenditures=$(c^{**}I.F.)+(c_{1\text{-}20}{}^{*}a_{I})+(v^{*}a_{T})+(r_b{}^{*}\ a_T)$

Year receipts=$(a_{II}{}^{*}D_{30})+(a_{III}{}^{*}D_{50})+...+(a_{n\text{-}1}{}^{*}D_{u\text{-}30}))/10)+\ I.F.{}^{*}A_{u\text{-}10}$

where:

I.F. - annual surface cut of the main yield (ha/year)

RESEARCH RESULTS

The average value of stands in a given age class under management with rotation periods of 60, 80, 100, ... 200 years has been calculated using the method described above. These values, shown in Table 2, were used as input data in the SD model.

Table 2. Value per hectare of even-aged pedunculate oak stands in first quality site class in relation to the rotations

Rotation	Timberland value of an even-aged stand in age (monetary unit/ha)									
	10	30	50	70	90	110	130	150	170	190 year
60	8590	17115	23585							
80	8882	18169	25716	33935						
100	8740	17657	24680	32157	41004					
120	8543	16946	23243	29692	37084	45808				
140	8383	16369	22075	27689	33901	40953	49018			
160	8271	15964	21258	26287	31671	37554	43963	51029		
180	8180	15640	20601	25160	29879	34821	39900	45083	51147	
200	8122	15428	17196	21549	25976	30505	34999	39355	44250	50701

As was said earlier, the trend in age class distribution with regard to management with 60 to 200-year rotation periods (Figure 3) has a direct impact on the trend of the overall value of the studied forest.

The value of a forest equals the sum values of all stands (age classes) over time. Likewise, the value of a forest represents the capitalised value of the net annual income. The question remains what rate of interest will be applied in the process of capitalisation. The SD model searched for the rate of interest at which the capitalised value of the forest rent would be equal to the value of all stands at the moment the normal age structure is achieved. Figure 4 shows the ratio between the forest rate of interest obtained in this manner and the rotation.

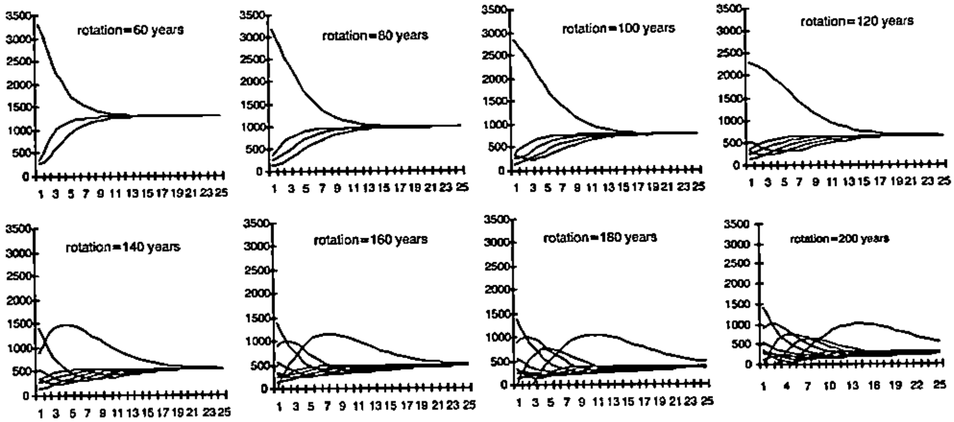

Figure 3. Trends in age class distribution per area under different rotation

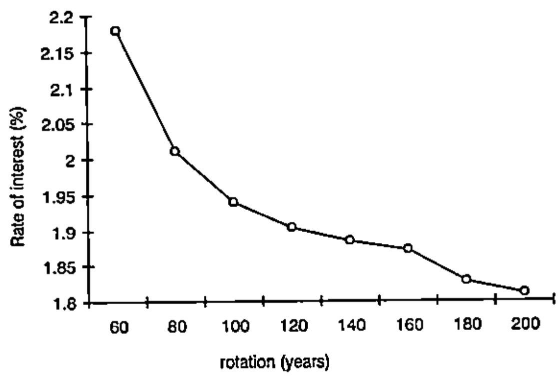

Figure 4. Relationship between the forest rate of interest and rotations

A trend in the value of a pedunculate oak forest as the sum values of all stands (age classes), and as the capitalised value of a permanent forest rent is seen in Figure 5.

Figure 6 shows the total value trends of a forest of even-aged pedunculate oak stands under eight different rotation periods.

With rotation periods of 120 years or less, the value of a forest quickly decreases, so that in the first part of the simulation period it achieves a constant amount at a low level in relation to a 140-year rotation period. The shorter the rotation period, the lower the level is. With a 140-year rotation period normally applied in this forest, the value gradually decreases from the initial 138 million to 111 million monetary units. By prolonging the rotation period to 160 years, the value of the forest is increased by 5-7 million monetary units in relation to a 140-year rotation during the entire simulation period. The timberland value of the forest will decrease if the rotation is prolonged to over 160 years.

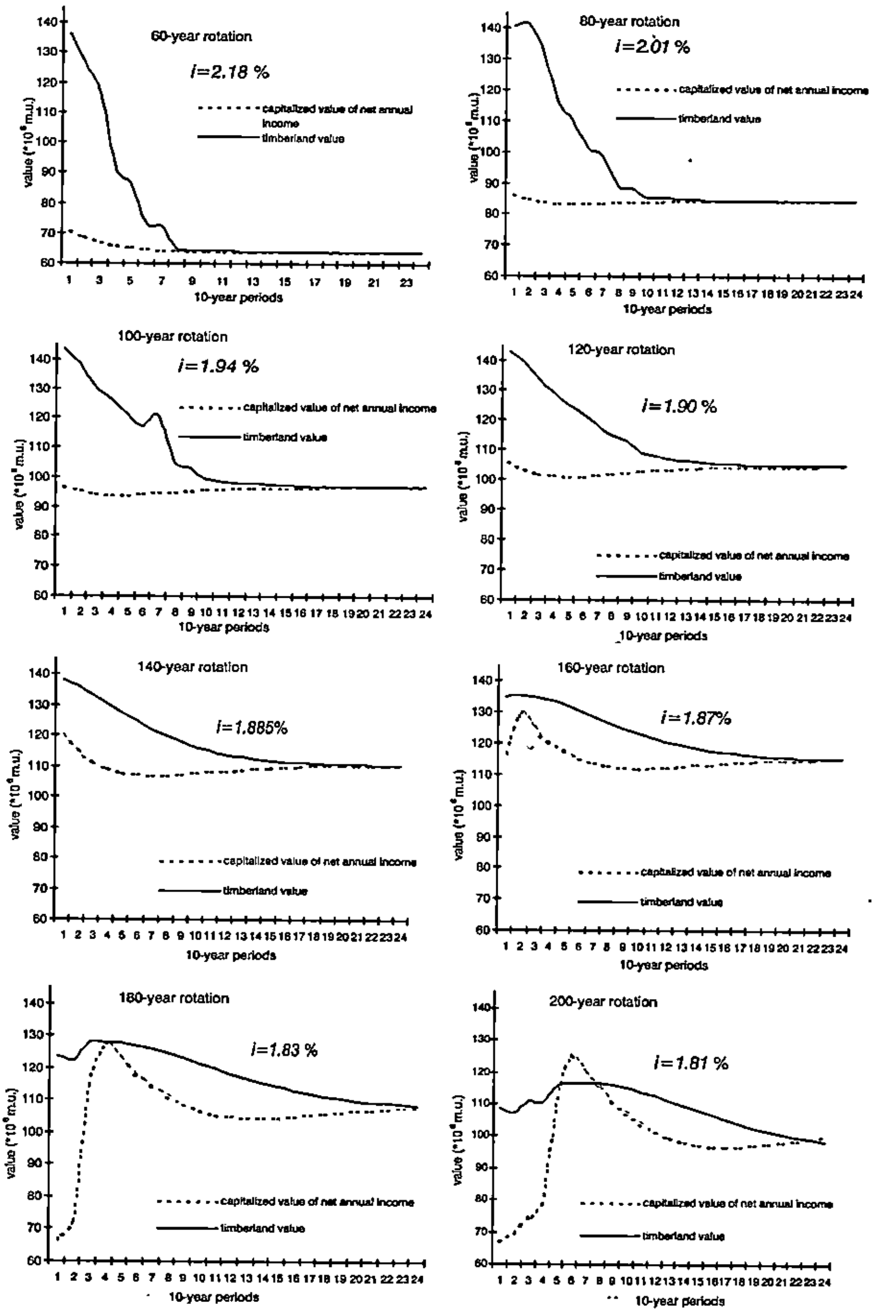

Figure 5. Trends in the values (capitalized v. of net annual income, timberland value) of a pedenculateoak forest under diferent rotations

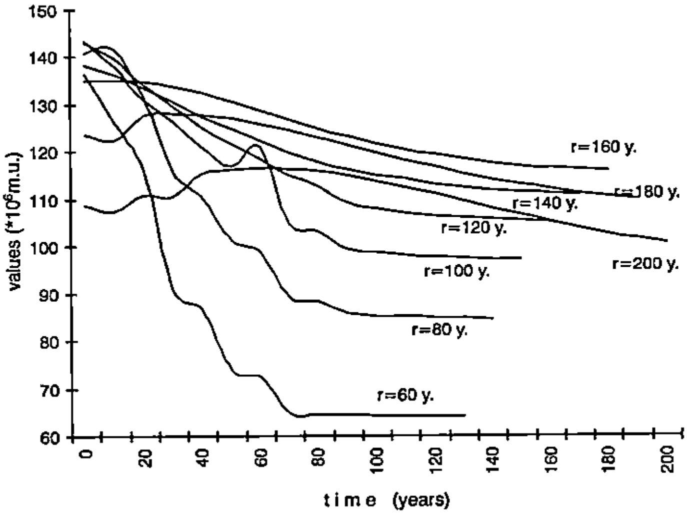

Figure 6. Trends of timberland value under different rotations

CONCLUSION

The value of an economic forest, when only the production of timber is taken into account, is a function that changes over time. One of the important factors affecting the trend in values of an even-aged forest is the trend in age class distribution under management with different rotation periods.

The forest of pedunculate oak in the management unit "Josip Kozarac" has an irregular age structure with a surplus of mature understocked stands.

During a given rotation period, the value of the forest changes (decreases) until it reaches a normal age structure, when it becomes constant. Other factors that might influence the value of the forest and forest land are assumed to be excluded.

The forest rate of interest is obtained by equalising the value of the forest as the sum values of all stands and the capitalised forest rent after the moment the normal age structure has been reached. This rate ranges from 2.18% for the 60-year rotation period to 1.82% for the 200-year rotation period.

Shortening the rotation period to below 140 years (the period used today) would decrease the *timberland value,* while lengthening the rotation period to 160 years would increase the *timberland value* by 5-7 million monetary units (6%). However, further lengthening of the rotation to over 160 years would again lower the *timberland value.*

The next important step involves introducing other forest functions and influential factors into the dynamic model for determining trends in forest and timberland values.

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KRETANJA VRIJEDNOSTI ŠUMA I ŠUMSKOGA TLA U DINAMIČNOM SUSTAVU JEDNODOBNE ŠUME HRASTA LUŽNJAKA U GOSPODARSKOJ JEDINICI "JOSIP KOZARAC"

S obzirom na višestruke funkcije vrijednost šume značajno varira kroz vrijeme i ovisi o velikom broju utjecaja i o raznim odnosima. Neki od najvažnijih čimbenika koji utječu na kretanje vrijednosti šumskoga tla jednodobne šume u njezinoj ekonomskoj funkciji jesu ophodnja i promjene u dobnoj strukturi. Cilj je ovoga rada proučavanje odnosa vrijednosti šume, šumske rente i postotka kamata tijekom vremena kao posljedica promjena u ophodnji i dobnom razredu.

Predmet je izučavanja šuma hrasta lužnjaka u prvom bonitetu ukupne površine 3894,29 ha. Šuma sadrži višak zrelih nedovoljno popunjenih sastojina, a gospodarenje se temelji na ophodnji od 140 godina.

Vrijednost šumskoga zemljišta i sastojina određena je upotrebom prihvaćenih metoda, dok su kretanja u vrijednostima cijele šume i šumskoga tla dobivena pomoću SD modela gospodarenja jednodobnom šumom.

Iz odnosa kretanja vrijednost šume, šumske rente i postotka kamata dobiven je sljedeći rezultat: vrijednost bi se šume hrasta lužnjaka povećala za 5–7 novčanih jedinica (6 %) ako bi se razdoblje ophodnje povećalo sa 140 na 160 godina.

Ključne riječi: hrast lužnjak, vrijednost šumskoga tla, distribucija dobnih razreda, dohodak, troškovi