

# : The economic outcomes of high pedunculate oak (*Quercus robur* L.) forest management in Croatia

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## ■ ABSTRACT

Pedunculate oak (*Quercus robur* L.) is an important economic species in forestry and in forest-based industry in Croatia because it covers 4.07% of the total forest area (105,090 ha). This species is highly susceptible to changes in habitat conditions that occur due to unfavourable biotic and abiotic factors. In changing climate conditions, as well as in disrupted ecological balance, the vitality of pedunculate oak stands is impaired. The signs of decay are becoming visible, and are manifested through impaired tree vitality, irregular and increasingly low seed yield, and impaired natural regeneration of forests. Difficult conditions have a long-term effect on the decrease of yield and the increase of management costs. Therefore, this study analyses the economic components of sustainable forest management as a long-term investment, including Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP) and Discounted Payback Period (DPP). According to the calculation parameters used, it is not justified to invest capital in an investment with the estimated values of the stands and the prescribed rotation of 140 years.

## ■ KEYWORDS

**Economic valuation, long-term investment, revenues, costs, oak stands**

## ■ 1 INTRODUCTION

Pedunculate oak is a climatogenic species and it forms permanent forest communities. Due to changes in habitat conditions, the dieback of oak significantly affects the quality and consequently the value of assortments. Oaks are threatened by the oak lace bug (*Corythucha arcuata*), a pest which was first recorded in Spačva forests in 2013, and was transmitted by global transport. It originates from North America and has no natural

enemies in Croatia, while no means have proven to be effective enough to suppress its spread. Pedunculate oak stands with even-aged structure compose regular high forests. In the same development stage of even-aged forests, trees are of similar height, diameter, and age (Anić, 2007). The bell-shaped distribution of trees by breast diameters and the clearly expressed horizontal or vertical shape of the assembly characterizes regular management (Čavlović, 2013). According to the first National Forest Inventory, in Croatia, the stand class of floodplain oak forests amounts to 4.07% of the area or 105.09 thousand ha, i.e. it amounts to 13.01% of the growing stock in state and private forests, which is in total 71,830 million m<sup>3</sup>. Recently, the economic consequences of the dieback of oak stands (in forestry and wood processing) in relation to the impact of climate change have not been investigated. As stated in the National Report of the Republic of Croatia according to the UN Convention on Climate Change (OG 347/2014), it is necessary to observe long-term resilience, i.e. the natural ability of the ecosystem to adapt as a result of climate variability, extreme weather and natural phenomena (floods, droughts, fires, pests etc.), as well as changes in land use, soil pollution and unsustainable exploitation of natural resources. Further, Nabuurs et al. (2015) are referring on the same postulate when it comes to a role for forests and the forest sector in the EU post-2020 climate targets.

In 2021, Croatian Forests Ltd. performed a prescribed cut in the amount of 6.08 million m<sup>3</sup> of gross wood volume. Deviation by tree species in relation to the average prescribed cut in the General Forest Management Plan for the Republic of Croatia in the period 2016-2025 is present in fir, spruce, field ash and pedunculate oak. Higher than the average prescribed felling for each species is a result of the occurrence of natural disasters and invasive pests, which is both a direct and indirect consequence of climate change. In 2021, the company produced 5.2 million m<sup>3</sup> of wood assortments: 2.3 million m<sup>3</sup> of roundwood, and 2.9 million m<sup>3</sup> of stacked wood for processing and firewood. The largest amount of wood assortments of 1.97 million m<sup>3</sup> were produced from beech, followed by 733,389 m<sup>3</sup> from oak. In 2021, Croatian Forests Ltd. sold 5,617,931 m<sup>3</sup> of wood assortments, including energy wood, and thus achieved sales revenue of 281 million EUR. A significant increase in sales compared to the previous year was achieved in the amount of 409,000 m<sup>3</sup>, and sales revenue increased by 26.15 million EUR. In 2021, a huge increase in demand for wood assortments was recorded, especially for high-value assortments such as pedunculate oak and sessile oak (FMP, 2016; Croatian Forests Ltd, 2021).

## ■ 2 METHODS

Professional services of the state forest company (Croatian Forests Ltd.) established standard technologies for raising stands of individual forest management classes. The cost of raising per hectare is determined by multiplying the price of labour from the price list of works for the accounting year by the multiplicity coefficient for the work and by summing the calculated amounts. For the growing stock above the first age class, the present cutting value method was used. Estimation of the growing stock value by this method is determined according to the value of growing stock with the assumption that everything is cut, made into assortments and sold at average prices established in the

accounting year, minus operating costs. Assortments table and the price list of the main forest products of Croatian Forests Ltd. (2019) are the primary inputs when estimating value.

With each economic component of forest management, the amount of income and expenses incurred in the production cycle should be known in advance (Beljan, 2015). Capital budgeting is the process of making decisions about long-term investments in active business assets of the company. It is a decision-making process, with focus on long-term projects. This process includes forecasting cash flows of projects and evaluating their financial efficiency by applying financial decision-making criteria (Orsag, 2002; Orsag and Dedi, 2011). The subject of capital budgeting are primarily projects that have a long-term character. In the case of long-term projects, the time disparity occurs between the creation and the effect of the investment. Based on the cash flow, an investment analysis of the initial investment is made, and information on the justification of the capital investment is obtained through calculations (Beljan, 2015). Investing in the present is necessarily associated with a certain degree of risk and uncertainty that the expected effect of the project will not be realized as planned, meaning that there is a possibility of accomplishing the project with a certain degree of variability of results (Knoke et al., 2001). In the case of a regular forest that consists of 100 stands and that is managed with a 100-year rotation period, intermediate yield is generated on an annual level, both in young and old stands, including one main yield from the old stands. That is, annually, at the level of the forest, a yield equal to the sum of all yields of one stand over a period of one hundred years is generated. The sum obtained in terms of monetary value is not completely the same due to the time preference of money, therefore the sum at the forest level is significantly higher, depending on the amount of forestry interest rate used.

In order to calculate and present the economic importance of pedunculate oak forests, several basic tools of capital budgeting according to Damodaran (2002) have been applied: Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP) and Discounted Payback Period (DPP). Firstly, the cash flow is created from the data presented in Table 2 and the tools for capital budgeting used. For those that are influenced by the cost of capital (NPV and DPP), the range of discount rates from 0.5 to 5% is used.

### ■ 3 RESULTS

According to the General Forest Management Plan for the Republic of Croatia in the period 2016-2025, a one-time or a regular management type has been prescribed for the oak stands. Most of the stands of pedunculate oak owned by the Republic of Croatia and managed by Croatian Forests are divided into two management classes: economic pedunculate oak high forests (167,563 ha) and pedunculate oak high forests with special purpose (36,562 ha). The total economic value of the stands of the management class of economic oak high forests, determined by the cost method for the stands of the first age class and the method of the current felling value for the stands of other age classes, amounts to 3.3 billion EUR, out of which around 323.8 million EUR accounts for the growing stock of the first age class, while around 2,884 billion EUR accounts

for growing stock on stumpage. The total growing stock of stands of this management class is around 49.55 million m<sup>3</sup> (296 m<sup>3</sup>/ha), and the average stumpage value is 58 EUR/m<sup>3</sup>. The largest growing stock is found in stands of age class VI (100-120 years), and the highest value of growing stock is in stands of age class VII, i.e. 120-140 years old (Table 1).

**Table 1. The economic value of oak stands (General Forest Management Plan for the Republic of Croatia in the period 2016-2025)**

Age class	Area	Wood volume	Total wood volume	Growing stock stumpage value	Total growing stock stumpage value	Raising costs for I age class stand	Total stand value
years	ha	m <sup>3</sup> /ha	m <sup>3</sup>	EUR/m <sup>3</sup>	EUR	EUR	EUR
I.	25,124					324682,976	324,682,976
II.	30,122	129	3,885,738	17.65	68,591,566	0	68,591,566
III.	10,068	252	2,537,136	24.29	61,622,654	0	61,622,654
IV.	15,006	342	5,132,052	49.90	256,108,773	0	256,108,773
V.	23,666	407	9,632,062	52.56	506,244,151	0	506,244,151
VI.	35,700	451	16,100,700	58.66	944,523,114	0	944,523,114
VII.	27,877	440	12,265,880	85.34	1,046,779,593	0	1,046,779,593
<b>Total</b>	167,563	296	49,553,568	58.13	2,883,869,850	324,682,976	3,208,552,826

In the stands of the management class of economic pedunculate oak high forests, General Forest Management Plan for the Republic of Croatia in the period 2016-2025 prescribes the average annual cut of previous yield of about 496 thousand m<sup>3</sup> and the average cut of the main yield of about 576 thousand m<sup>3</sup>, resulting in a total average annual cut of about 1.07 million m<sup>3</sup>. The average annual income from cutting in the stands of this management class is estimated at around 68.5 million EUR, i.e., around 63.8 EUR/m<sup>3</sup> of gross wood volume. The average annual cost of managing stands of this management class is around 45.8 million EUR.

Table 2. Cash flow assessment

Age class	Area	Total average annual cut	Total annual income from cut	Cost of fellings, production and skidding	Total cost of fellings, production and skidding	Total annual costs of silviculture, protection and management	Water fee	Forest fee	Total average annual cost	Economic result
years	ha	m <sup>3</sup>	EUR	EUR/m <sup>3</sup>	EUR	EUR	EUR	EUR	EUR	EUR
I	25,124		0.00	0.00	0.00	16,232,481.52	50,017.92	0.00	16,282,499.44	-16,282,499.44
II	30,122	120,488	3,502,139.76	23.89	2,878,103	823,562.55	59,968.15	185,661.42	3,947,663.15	-445,523.39
III	10,068	40,272	1,827,994.43	18.58	748,301.81	227,163.05	20,043.80	121,224.90	1,116,733.56	711,260.87
IV	15,006	60,024	3,441,551.26	18.58	1,115,317.54	338,578.54	29,874.58	245,210.56	1,728,981.22	1,712,570.04
V	23,666	94,664	6,244,343.75	18.58	1,758,970.07	533,973.06	47,115.27	460,221.91	2,800,280.31	3,444,063.44
VI	35,700	142,800	10,253,474.02	18.58	2,653,394.39	805,494.72	71,073.06	769,294.84	4,299,257.02	5,954,217.00
VII	27,877	614,688	43,239,041.87	18.58	11,421,633.69	873,179.64	55,498.71	3,230,690.69	15,581,002.72	27,658,039.15
<b>Total</b>	<b>167,563</b>	<b>1,072,936</b>	<b>68,508,545.09</b>	<b>0.00</b>	<b>20,576,088.53</b>	<b>19,834,433.07</b>	<b>333,591.48</b>	<b>5,012,304.33</b>	<b>45,756,417.41</b>	<b>22,752,127.68</b>

When observing the results (Table 2) on the economic outcomes, it is evident that economic result of forest management in the first two age classes (I and II) is negative. Furthermore, as the age of the stand increases, the dimensions of felled timber have higher selling price. All of this affects the economic result of forest management, which is most profitable in the situation when stands are classified by their age into age-class VII (from 120 to 140 years). However, that kind of economic calculation neglects the time preference of monetary values (Price, 2011).

Table 3. Investment analysis results

Valuation parameters	Discount rate (%)					
	0.5	1	2	3	4	5
NPV (EUR/ha)	142.34	-216.94	-512.24	-601.70	-631.01	-641.44
IRR (%)	0.66					
PP (years)	121					
DPP (years)	123	127	137		140<	

When the range of discount rates (from 0.5 to 5%) has been applied positively and negative net present values are revealed. The only calculation that can be considered as a good investment is the one with the minimal cost of capital (only 0.5%). All other types can be considered as an investment that will end in negative figures. Moreover, the internal rate of return equals only 0.66% and in comparison, to other low rate of

return investment possibilities (i.e., latest issued Croatian government bonds in year 2023 ensure return of 3.25%) seems relatively modest. Due to the long time period of this particular investment analysis, it should be clear that 1€ invested today will be worth 2.51€ in 140 years (according to the formula for calculating compound interest). Invested capital will be more than doubled, but the time preference is not an advantage when investing in forestry. Resulting values of payback period and the discounted version of payback period confirm that.

## ■ 4 DISCUSSION AND CONCLUSION

The presented economic figures on the management of pedunculate oak forests in Croatia are neglecting the costs of forest land purchase. Since the state company Croatian Forests Ltd. manages state-owned forests, i.e. forests that it was given for management, acquisition does not take place. This is especially important in business when it comes to commercial forestry in developed market-oriented countries (Posavec et al., 2020). If the calculations in this research considered the mentioned cost, it is to be expected that all of the economic indicators would be negative. Compared to a similar study related to high oak forests performed by Beuk (2012), it is clear that the internal rate of return is reduced from 1.98% to 0.66% (in nominal terms). The reason for this is the calculation of log prices below the market levels. In situation where the government supports wood processing industry with regulated raw material prices, this influences sustainable forest management and economic performance of state forest companies.

## ■ 5 REFERENCES

- // Anić I. 2007. Forest silviculture. University of Zagreb, Faculty of Forestry.
- // Beljan K. 2015. Economic analysis of even-aged silver fir (*Abies alba* Mill.) forest management. Doctoral thesis. University of Zagreb, Faculty of Forestry.
- // Beuk D. 2012. Game management in integral management of Spačva forests (in Croatian). Doctoral thesis, Faculty of forestry, University of Zagreb.
- // Čavlović J. 2013. Basics of forest management planning, University of Zagreb, Faculty of Forestry.
- // Croatian Forests Ltd. 2021. Annual bussiness report, HQ, Zagreb.
- // Damodaran A. 2002. Investment Valuation—Tools and Techniques for Determining the Value of Any Asset. 2nd ed. New York, John Wiley & Sons.
- // FMP - Forest Management Plan of the Republic of Croatia for the period 2016-2025, Hrvatske šume d.o.o., Zagreb, 2016.
- // Knoke T., Moog M., Plusczyk N. 2001. On the effect of volatile stumpage prices on the economic attractiveness of a silvicultural transformation strategy. *Forest Policy and Economics*, 2, 3–4: 229-240.
- // Nabuurs G.J. et al. 2015. A new role for forests and the forest sector in the EU post-2020 climate targets. From Science to Policy 2. European Forest Institute.
- // Orsag S. 2002. Capital budgeting - Assessment of investment projects. Zagreb.
- // Orsag S., Dedi L. 2011. Capital budgeting - Assessment of investment projects. Zagreb, Masmedia.

- // Posavec S., Pezdevšek Malovrh Š. 2020. Market Value and Timber Assortment Sale Models - Comparative Study. In: Jelačić D. (Ed.). Management Aspects in Forest Based Industries. WoodEMA, Zagreb.
- // Price C. 2011. Optimal rotation with declining discount rate. Journal of Forest Economics, 17, 3: 307– 318.

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