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COST-BENEFIT ANALYSIS OF ESTABLISHMENT OF SCOTS PINE, AUSTRIAN PINE AND SPRUCE FOREST PLANTATIONS

Mihailo Ratknić[1], Sonja Braunović[2]

Summary

The cost-benefit analysis, which contributes to finding best solutions and helps in making decision on acceptability of treatment, has been used as an instrument in the assessment of afforestation impact on the environment. It has been established that a cost-effective investment into Scots pine, Austrian pine and Spruce afforestation is viable solely on the basis of wood production. Wood production, depending on tree species and soil quality, can bear even slightly higher interest rates in the areas of good soil quality in comparison to previous estimates, which mostly ranged around 3%. In the areas of poor soil quality, the interest rates can drop even below the 3% rate. At lower discount rates, the break-even point is extended in time, whereas at higher discount rates, it is shortened. The length of production cycle performs an important role in determining the cost-effectiveness of an investment, particularly from the aspect of the relation between the length of production cycle and production purposes (type and quality of wood assortments that are produced). Based on the analysis of non-quantifiable benefits and costs, it has been established that the benefits surpass the costs, therefore, afforestation projects can be acceptable.

Key words*: cost-benefit analysis, discount rate, afforestation, cost-effectiveness, financial analysis, economic analysis.*

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Introduction

In forests, concurrently with wood production, a large or small scale production of numerous non-wood products takes place and several significant generally-beneficial functions are fulfilled. In such a complex production, a tendency towards bearing the burden of costs by the highest possible number of forest products and functions, finds its place through implementation of the Multiple Use Forestry Concept. In this manner, ways are explored for valorisation of multiple forest products and functions, since wood alone is not capable of fully carrying the burden of production costs.

[1] Mihailo Ratknić, Ph.D., Senior Scientific Associate, Institute of Forestry, Kneza Višeslava no. 3, 11000 Belgrade, Serbia, Phone: +381 11 355 33 55, E-mail: mihailoratknic@yahoo.com
[2] Sonja Braunović, M.Sc., Research Associate, Institute of Forestry, Kneza Višeslava no. 3, 11000 Belgrade, Serbia, Phone: +381 11 355 33 55, E-mail: sonjabrunovic@yahoo.com

A problem of obtainment of funding and creating an assessment of the cost-effectiveness of the investment is commonly encountered upon establishing new forest cultures and plantations. Although this problem can be examined from several different aspects, the basic questions that need to be answered are the following:

- What and to what extent will be produced, in other words, what products will bear the burden of repayment of financial obligations?
- How to assess cost-effectiveness of investment into such projects?
- What discount rates should be applied when assessing cost-effectiveness?

Importance and aim of the study

By setting the target to attain the 41.4% afforestation level in Serbia by 2050, the forestry acquired a number of tasks, while afforestation, regeneration and improvement of quality of existing forests being among the priorities. The agriculture and urban planning represent the main competitors to forestry. The urban planning fulfils its needs by using the best quality agricultural land, while the agriculture, in order to maintain the existing production, extends along far larger areas of forest land (since they are less productive). Given the fact that, based on a spatial distribution, the agriculture and forestry are the primary users of the land production potential in Serbia, their demarcation represents the basic issue regarding a rational use of space. Based on all parameters, (by reconciliation of plans, measures and works with the defined needs), it has been concluded that it is necessary to perform afforestation of 1,293,500 ha of new forests in Serbia.

The primary aim of this paper, while considering the wood as the most important forestry product, is to analyse and identify the potentials of wood production in forest cultures, and to make it a principal holder of repayment of financial obligations, under local conditions. Next, on selected samples (Scots pine, Austrian pine and Spruce), to assess the cost-effectiveness of such investments and to determine an objective discount rate, which would enable attaining the cost-effectiveness of such investment in forestry projects.

The aim of the study, based on the acquired knowledge, is to enable an objective assessment of economic and financial effects of investment into projects of establishment of forest cultures.

Work method

In the analysis of afforestation projects, two aspects of analysis have been examined. In one instance, the focus is on total benefits attained by the realisation of projects (economic analysis), while in the other instance, the focus is given to a financial analysis, from the aspect of benefits for institutions or individuals who invest financial assets into the realisation of a given project.

The economic and financial analysis represents an important part in making decision on optimum use of land. According to the postulates of the International Assessment System with respect to land value in use, the economic and financial analysis participate in formation of suitability class (indirectly and suitability order), which testifies to a

considerable importance that the said analysis bears.

Financial analysis

The cost-benefit analysis has been used for the assessment of cost-effectiveness of an investment in the establishment of forest cultures. The basic postulate of this method is to present all the costs incurred, on the one hand, and, on the other hand, the values of all revenues in that production. By comparing the values obtained in such manner, the rate of cost-effectiveness is determined. In the framework of the cost-benefit analysis, costs and revenues are discounted by a relevant discount rate, for the purpose of determining their current value, with respect to the period when they are incurred or generated. The values of costs and revenues discounted in such a manner are adequately used for expressing the cost-effectiveness (Jakovljević, K., 2009).

Limitations of application of cost-benefit analysis

The cost-benefit analysis method has been used with certain limitations. Production values are calculated without taking into account the costs of their exploitation, since their inclusion makes the analysis far more complex (in longer periods, they can be changed significantly, in accordance with the possible changes of technology), which also has an impact on change of the rate of productivity. In addition, as the trend of separation of exploitation from cultivation is prevailing in forestry, the prices of standing timber are used for the calculation of wood value ("Srbijašume" Price list). As an additional argument for the omission of examination of exploitation, it could be stated that the funds invested in exploitation do not affect to a great extent the amount and cost-effectiveness of the committed funds, as they remain tied in production for a relatively short period, while the costs of establishment of cultures remain tied far longer, until the end of production cycle. The second limitation refers to the costs and revenues of thinning. Costs related to thinning, partially or in their entirety are compensated from the revenue generated from the thinning material, and they are tied in production for a very short time, and do not affect cost-effectiveness.

Costs

Taken into account were the costs of establishment of forest cultures (costs of land preparation, the value of seedlings, the costs of plantation) and the costs of soil loosening and weeding out. The said costs were expressed as per area unit (1ha) in the amount recognised by the Ministry of Agriculture, Forestry and Water Management – Forest Administration.

Establishment of cultures (afforestation)

• These costs also include tending of cultures, which includes low and regular soil loosening, within a three year period since the establishment	85,000 RSD/ha
• Weeding out of cultures, (performed once, at the age ranging from 6to14 years, since the establishment)	35,000 RSD/ha

Costs presented in a manner take into account the average costs in terms of conditions under which the works on establishment of forest cultures are performed and usage of material, energy and workforce. The costs of purchase of forest land have not been taken into account, as it has been planned that afforestation is conducted on areas with defined proprietary relations.

Revenue

Tree species, relevant for the areas on which establishment of forest cultures and plantations has been planned, include Scots pine, Austrian pine and spruce. In the examination of financial analysis, wood production has been set as the primary production goal within forest cultures, and, consequently, the revenue derived from such production has been assessed through the value of forest products at their relevant age. Based on the data on wood yield in forest cultures and the relevant prices of forest products, wood value spreadsheets for species on different soil quality have been created. The obtained values were discounted at discount rates (ranging from 2-10%), by means of which several different 'current values', depending on the applied discount rate, have been obtained. The wood production value has been calculated for different lengths of production cycle (ranging from 20 to 140 years), while all calculated values were expressed as per area unit (1ha).

For wood assortments taken into account for calculation of the value of wood production, prices of standing timber for veneer and rotary cutting (class 1a), saw logs class I (class 1), saw logs class II (class II), saw logs class III (class III) and pulpwood, have been used (JP “Srbijašume” price list).

Non-quantifiable benefits and costs (Economic analysis)

In the framework of cost-benefit analysis, the costs that cannot be valued in monetary terms have been expressed separately (economic analysis). Unlike the financial analysis, the economic analysis examines an impact of afforestation on biodiversity (including species, eco-system and genetic diversity), environmental impact, impact on the living community and economy (Popović, G., et al., 2011; Cvijanović, D., et al., 2011).

Study results

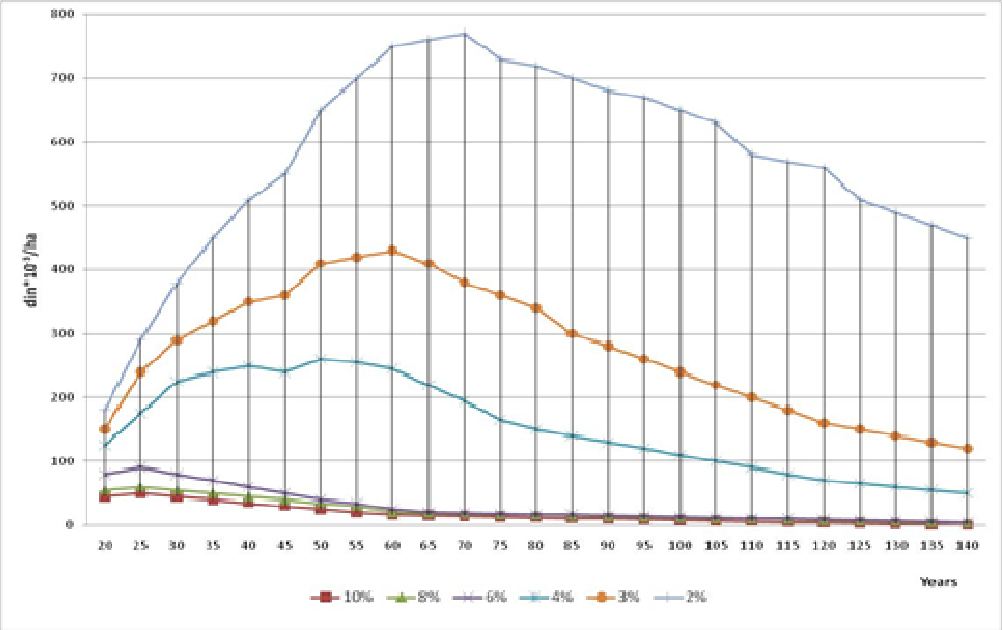
Afforestation costs and benefits that are expressed in monetary terms

The values of production of the observed tree species have been analysed for different soil quality classes (I to V), in different production cycle lengths (20-140 years) and for the 2, 3, 4, 5, 6, 8 and 10% discount rates, since it has been established that wood production in forest cultures can be cost-effective only at discount rates lower than 10% (Brumelle, S.L., et al., 1991).

In order to enable a better understanding of current values of wood and costs in different periods, graphs (graphs 1, 2, 3, 4, 5 and 6) have been drawn up, which include curves that describe changes of current wood values for specific species and different soil qualities, depending on the length of a production cycle, for the 6 above-mentioned discount rates. By

analysing the data for all soil qualities, it can be noted that the above mentioned species in certain soil qualities exhibit a favourable cost-effectiveness of an investment even at slightly higher discount rates, although most frequently for relatively short rotations.

Graph 1. Changes of current values of wood in relation to the age, at different discount rates (Scots pine, Soil quality I)



Source: The original

Table 1. Maximum values for discount rates and break-even points as per tree species and soil quality

Soil quality	Discount rate	Break-even point	Discount rate	Break-even point	Discount rate	Break-even point
	%	year	%	year	%	year
	Scots pine		Austrian pine		Spruce	
I	6.74	30	9.67	15	9.54	25
II	5.60	35	7.66	25	9.19	25
III	4.54	40	6.60	25	6.74	25
IV	3.37	50	5.34	30	5.21	35
V	2.35	70	3.62	30	3.75	50

Source: The original

Based on the condition of equality of costs and revenues, maximum values for discount rates and lengths of production cycle have been determined (break-even point), (Table 1), which clearly indicate that the discount rates enabling cost-effectiveness of an investment are still far lower than it is common for similar projects (for instance, in the agriculture). Consequently, wood production is not capable of bearing common interest rates, a fact which should be taken into account when deciding on the level of interest rates.

When determining the cost-effectiveness of an investment into forest cultures, a goal to be attained represented the starting point. It has been established that the cost-effectiveness of an investment, if wood production is selected as the primary production goal, can be attained at different discount rates, depending on species, soil quality and length of production cycle (Table 2).

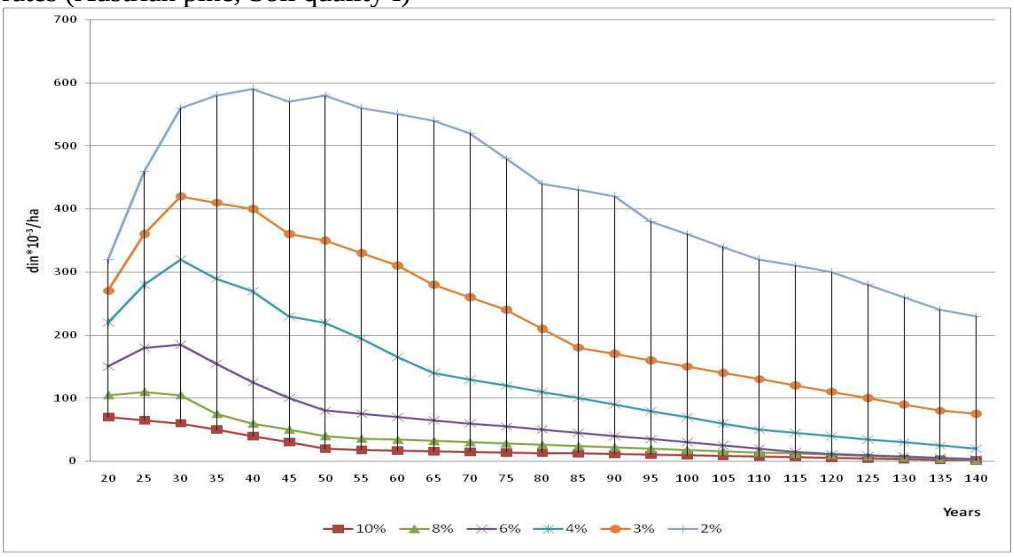
Table 2. Break-even point for wood production in Scots pine, Austrian pine and spruce cultures at different discount rates (within a year)

Discount rate	Soil quality I	Soil quality II	Soil quality III	Soil quality IV	Soil quality V
Scots pine					
2%	Over 140	Over 140	Over 140	Over 140	120-125
3%	Over 140	130-135	110-115	85-90	/
4%	95-100	85-90	70-75	/	/
6%	50-55	/	/	/	/
8%	/	/	/	/	/
10%	/	/	/	/	/
Austrian pine					
2%	Over 140	Over 140	Over 140	Over 140	125-130
3%	115-120	110-115	100-105	85-90	60-65
4%	75-80	75-80	65-70	50-55	/
6%	55-60	40-45	35-40	/	/
8%	40-45	25	/	/	/
10%	/	/	/	/	/
Spruce					
2%	Over 140	Over 140	Over 140	Over 140	Over 140
3%	Over 140	Over 140	135-140	120-125	100-105
4%	110	100-105	90-95	80-85	/
6%	65-70	60-65	50-55	/	/
8%	40-45	30-35	/	/	/
10%	/	/	/	/	/

Source: The original

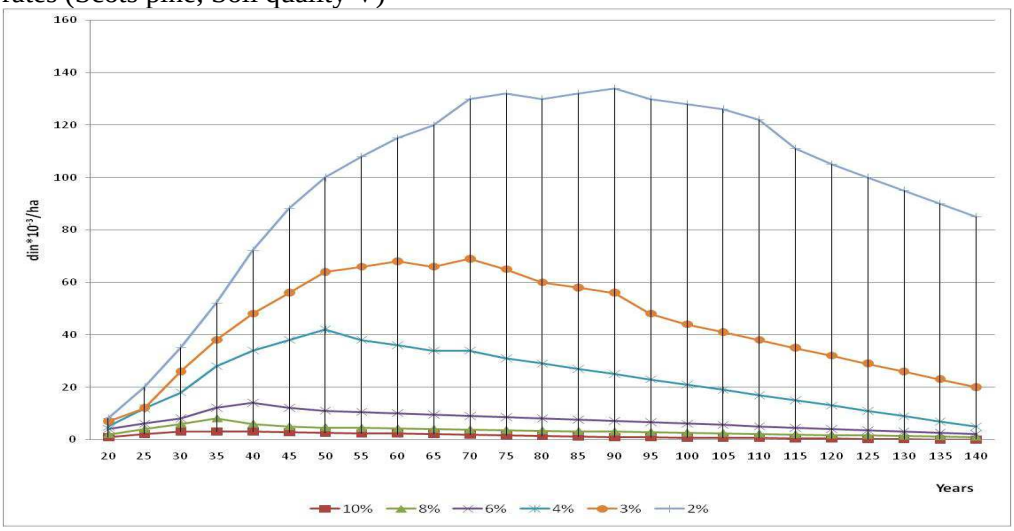
The maximum discount rates determined in such manner are related to a rotation length, while the most common instance is that with the increase of a discount rate a rotation length decreases. That means that, if long rotations must be selected from the aspect of the goal that is to be attained, a solution for the cost-effectiveness of an investment should be a discount (interest) rate that is lower than the maximum.

Graph 2. Changes of current wood value in relation to the age, at different discount rates (Austrian pine, Soil quality I)



Source: The original

Graph 3. Changes of current wood value in relation to the age, at different discount rates (Scots pine, Soil quality V)



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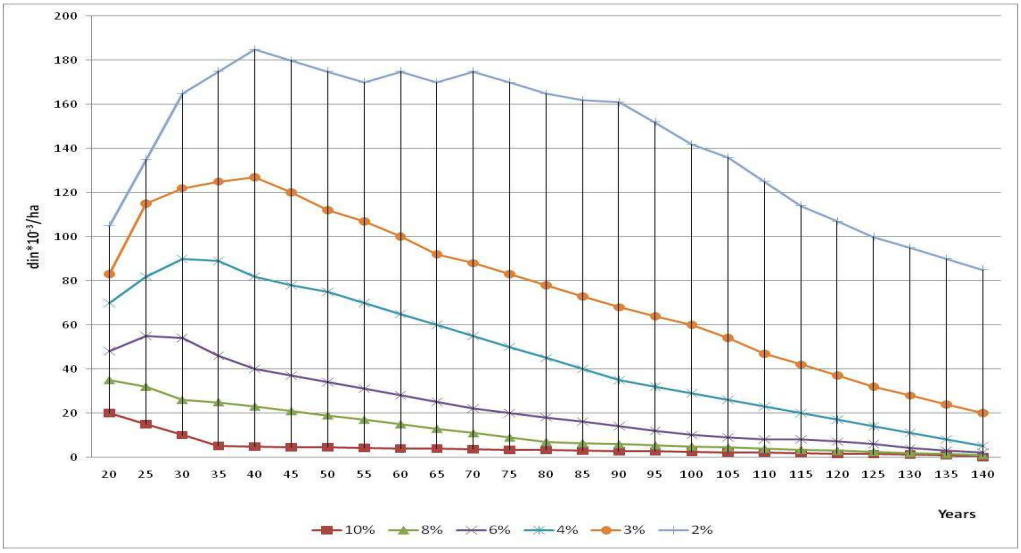
That points out to a considerable complexity of the problem and to the fact that finding out an appropriate solution is not simple; furthermore, in every specific instance, a question occurs that concerns selection of the most favourable alternative, out of several possibilities, for fulfilling financial and economic goals.

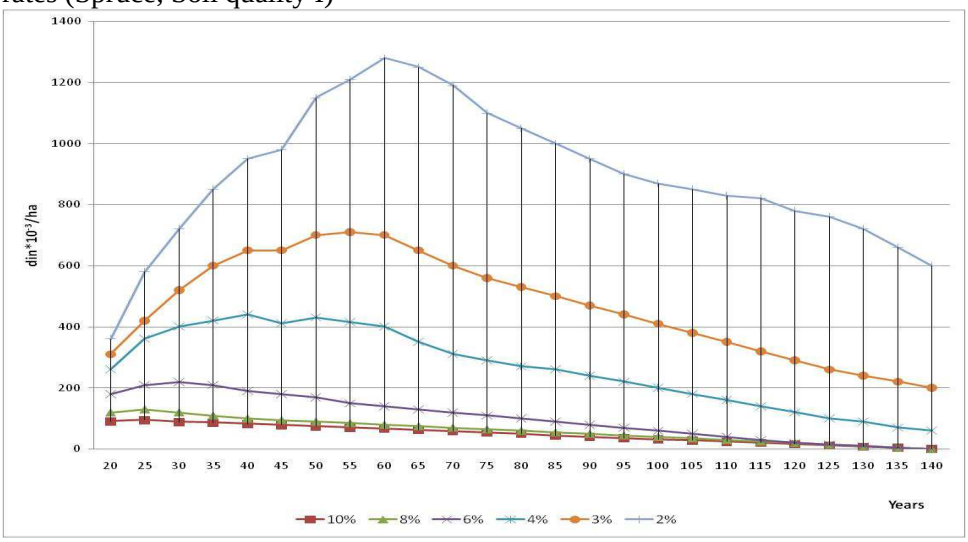
Graph 4. Changes of current wood value in relation to the age, at different discount rates (Austrian pine Soil quality V)



Source: The original

Under certain conditions (tree species, soil quality and rotation), there is a possibility that cost-effectiveness of an investment can be attained even at higher discount rates (6-10%).

Graph 5. Changes of current wood value in relation to the age, at different discount rates (Spruce, Soil quality I)



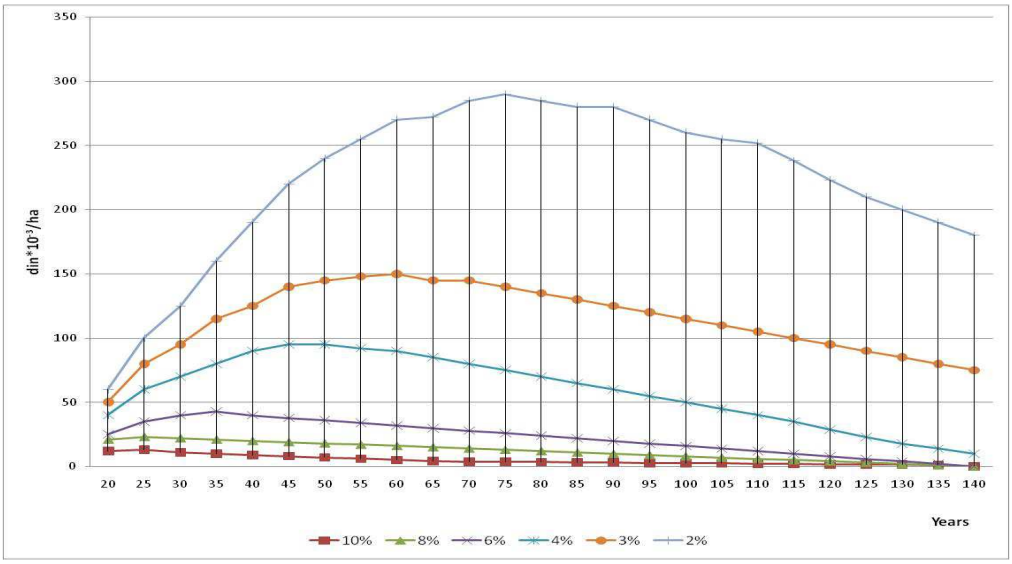
Source: The original

This fact modifies, to a certain extent, the previous conception that an investment into production in forest cultures, or, in forestry in general, can be cost-effective only at

interest rates equal or lower than 3%. Higher interest rates can be borne only in good quality soils, while in poor quality soils (III-V) the level of interest rate ranges at about 3% or even lower.

That indicates that in every specific case a relevant discount rate, appropriate for the tree species, soil quality and length of production cycle should be calculated, and, based on the value determined in such manner, the cost-effectiveness of an investment into establishment of forest cultures should be estimated.

Graph 6. Changes of current wood value in relation to the age, at different discount rates (Spruce, Soil quality V)



Source: The original

With regard to the presented analysis, it is important to note that the term 'project duration' in this case can be difficult to define, as, in forest cultures, regeneration and production, of both wood and other forest functions, are naturally established in the course of time, which is a process that can take place for an indefinitely long period, without any further investments. That is an important and essential difference when compared to standard industrial or agricultural projects, which, most frequently, have clearly defined duration, which, after its expiration, requires new investments.

Non-quantifiable benefits and costs

Along with the analysis of afforestation benefits and costs that can be valued in monetary terms, a so-called method of non-quantifiable benefits and costs has been developed. By the application of this method, it is aimed at determining values that afforestation brings to a broader social community, which cannot be expressed in monetary terms. By evaluation of non-quantifiable benefits and costs, the value of an impact on condition of biodiversity, the environment, social community and economy has been determined. For evaluation of non-

quantifiable benefits and costs for society, the ordinal scale has been used in cost-benefit analysis, while for their quantitative processing (arithmetic operations), the transformations, which enable such processing, have been used (Hastie, T. et al, 2013; Štrbac, M., 2008). The transformation has been performed according to the results quantified based on the point awarding of the intensity of certain impacts (Table 3).

Table 3. Evaluation of non-quantifiable impacts on environment

Activity impact	Impact intensity	Point awarding
Positive or negative	Very low	0-2
	Moderate	3-5
	Significant	6-8
	Very high	9 – and over

Forty types of non-quantifiable impacts, which constitute benefits and costs and are of relevance for Scots pine, Austrian pine and spruce afforestation, have been selected (Table 4).

Table 4. Evaluation of non-quantifiable benefits and costs of the planned treatment by means of a quantitative method

Impact as per the type of activities	Non-quantifiable benefits and costs (impacts)	Impact relevance	Impact type	Transformation
Impact on biodiversity (includes species, ecosystem and genetic diversity)	Impact on macromycetes	4	Negative	0.1875
	Impact on lichens	4	Negative	0.0875
	Impact on moss	3	Negative	0.1375
	Impact on vascular flora	10	Negative	0.2375
	Impact on rotatories	3	Negative	0.0875
	Impact on earthworm fauna	4	Negative	0.0875
	Impact on snail diversity	2	Negative	0.0625
	Impact on harvestman fauna	2	Negative	0.0625
	Impact on insect diversity	8	Negative	0.1875
	Impact on amphibian and reptile diversity	9	Negative	0.2125
	Impact on bird diversity	9	Negative	0.2375
	Impact on mammal fauna	6	Negative	0.1875
	Impact on ecosystem diversity	10	Negative	0.2375
	Stand fragmentation	9	Negative	0.2375
Impact on environment	Securing functioning of water regime (hydrological function)	9	Positive	0.2125
	Protection of water against pollution	7	Positive	0.1625
	Protection against harmful emissions	7	Positive	0.1625
	Regulation of soil composition and fertility (and reduction of erosion)	6	Positive	0.1375
	Impact on micro-climate	3	Positive	0.0625

Impact as per the type of activities	Non-quantifiable benefits and costs (impacts)	Impact relevance	Impact type	Transformation
	Generating oxygen and purification of atmosphere	10	Positive	0.2375
	Atmospheric carbon sequestration into produced wood volume and into humus matter created in forests	10	Positive	0.2375
	Soil acidification	5	Negative	0.1375
	'Unstable' forest stands, susceptible to adverse impact of biotic and abiotic factors (snow-breaks, windbreaks, entomological and phytopathological damage, etc)	6	Negative	0.1625
	Impact on appearance of scenery in the course of exploitation	7	Negative	0.1625
	Rehabilitation of devastated areas	8	Positive	0.1875
	Protection and mitigation of endangerment of natural forest ecosystems by afforestation and establishment of intensive forest plantations as sustainable and ecologically appropriate sources of renewable energy and industrial raw materials	9	Positive	0.2125
	Protection against noise	7	Positive	0.1625
Impact on living community	Creating conditions for recreation	6	Positive	0.1375
	Social benefits of treatment through an incitement of employment	3	Positive	0.0625
	Impact on people's health	6	Positive	0.1375
Impact on economy	Provision of raw materials for processing plant capacities	9	Positive	0.2125
	Creation of shelter belts	9	Positive	0.2125
	Impact on road infrastructure	5	Positive	0.1125
	Introduction of additional economic activities	5	Positive	0.1125
	Loss of a part of the agricultural land	6	Negative	0.1875
	Construction of economic facilities of permanent importance	4	Positive	0.0875

Impact as per the type of activities	Non-quantifiable benefits and costs (impacts)	Impact relevance	Impact type	Transformation
	Impact on other economic activities (tourism, hunting, etc)	6	Positive	0.1375
	Use of other forest products (forest fruit, medicinal herbs and fungi)	8	Positive	0.1875
	Impact on animal husbandry	5	Negative	0.2125
	Non-covered infrastructure costs	2	Negative	0.0625

Source: The original

Summary data as per the type of activity are presented in the Table 5.

Table 5. Quantification of values of assessment of non-quantifiable benefits and costs

Impact as per the type of activity	The assessed value of cost	The assessed value of benefit
Impact on biodiversity	1.6250	
Impact on environment	0.2875	1.7750
Impact on living community		0.3375
Impact on economy	0.1625	1.0625
Results	2.0750	3.175
Assessment (Benefit – Cost)>0	3.1750 - 2.0750 = 1.1000	

Source: The original

In the assessment of non-quantifiable benefits and costs, it was preceded from the assumption (possibility) that they will be actually realised (although it does not always need to be a realistic option). Based on the analysis of non-quantifiable benefits and costs, it can be concluded that the benefits surpass the costs and, consequently, the afforestation projects can be acceptable. Naturally, it should be noted that in every specific case (micro-locality) an analysis should be performed and it should be determined whether non-quantifiable costs surpass the benefits.

Discussion and conclusion

A study on environmental impact should provide the answer concerning the acceptability or unacceptability of a treatment, while the cost-benefit analysis exhibits the total level of benefits and costs for the society and the environment. In addition, this analysis should reveal the cost of a certain treatment. This refers to the costs of an investor, but also of the society in its entirety. Non-quantifiable costs and benefits should be methodologically determined in an appropriate manner. Lastly, when making a final decision on acceptability of a treatment, it is necessary to appropriately relate non-quantifiable and quantifiable costs and benefits.

Based on the presented results, it can be concluded:

1. for Scots pine, Austrian pine and Spruce, it is viable to attain cost-effectiveness of an investment into projects of establishment of cultures solely on the basis of wood

production, and at different discount rates, depending on the type and soil quality.

2. wood production in forest cultures of the observed species, depending on species and soil quality, can bear even slightly higher interest rates in comparison to current estimates, which mostly range at around 3%. However, it should be noted that this predominantly refers to areas of good soil quality, while in the areas of poor soil quality, interest rates can drop below the 3% level.
3. the amount of interest rate and assessment of cost-effectiveness of an investment are closely related to the length of production cycle, as the break- even point changes in accordance with the amount of discount rate. At lower discount rates, the break-even point is extended in time, while at higher interest rates, it is shortened. From the above-mentioned, it can be seen that the length of production cycle performs an important role in determining the cost-effectiveness of an investment, particularly from the aspect of relation between the length of production cycle and production purposes (type and quality of wood assortments that are produced).
4. based on the analysis of non-quantifiable benefits and costs, it can be concluded that the benefits surpass the costs, therefore, the afforestation projects can be acceptable.

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ANALIZA RENTABILNOSTI PODIZANJA ŠUMSKIH PLANTAŽA BELOG BORA, CRNOG BORA I SMRČE

Mihailo Ratknić[3], Sonja Braunović[4]

Rezime

"Cost-Benefit" analiza korišćena je kao instrument u proceni uticaja pošumljavanja na životnu sredinu, koji doprinosi nalaženju najboljih rešenja i pomaže pri donošenju odluke o prihvatljivosti zahvata. Konstatuje se da je za beli bor, crni bor i smrču moguće ostvariti rentabilnost ulaganja u pošumljavanje isključivo na bazi proizvodnje drveta. Proizvodnja drveta, u zavisnosti od vrste i boniteta zemljišta, može podneti i nešto više kamatne stope na boljim bonitetima u odnosu na dosadašnje procene koje su se kretale uglavnom oko 3%. Na lošijim bonitetima može da padne i ispod granice od 3%. Pri nižim diskontnim stopama granica rentabilnosti se vremenski produžava, a pri višim skraćuje. Dužina proizvodnog ciklusa ima značajnu ulogu kod određivanja rentabilnosti ulaganja, naročito sa aspekta vezanosti dužine proizvodnog ciklusa za proizvodne ciljeve (vrsta i kvalitet drvnih sortimenata koji se proizvode). Na osnovu analize nemerljivih koristi i troškova konstatovano je da su koristi veće od troškova, tako da projekti pošumljavanja mogu biti prihvatljivi.

Ključne reči: *Cost-Benefit analiza, diskontna stopa, pošumljavanje, rentabilnost, finansijska analiza, ekonomska analiza.*

[3] Dr Mihailo Ratknić, Viši naučni saradnik, Institut za šumarstvo, Kneza Višeslava 3, 11000 Beograd, Srbija, Telefon: +381 11 355 33 55, E-mail: mihailoratknic@yahoo.com
[4] Sonja Braunović, M.Sc., Istraživač saradnik, Institut za šumarstvo, Kneza Višeslava 3, 11000 Beograd, Srbija, Telefon: +381 11 355 33 55, E-mail: sonjabrunovic@yahoo.com