

# Cost-Benefit Analysis of Spruce Monocultures Conversion: Evidence from the Ukrainian Carpathians

Oksana Pelyukh, Lyudmyla Zahvoyska

Ukrainian National Forestry University,

Gen. Chuprynky Str., 103, Lviv, Ukraine 79057

E-mail: [pelyukh.o@ntu.edu.ua](mailto:pelyukh.o@ntu.edu.ua); [lyudmyla.zahvoyska@ntu.edu.ua](mailto:lyudmyla.zahvoyska@ntu.edu.ua)

supported by

Visegrad Fund

## Introduction

A large forest area in Europe in the 19<sup>th</sup> century naturally dominated by broadleaves were reforested by Norway spruce (*Picea abies* [L.] Karst) which led to losing their vitality and resistance against destructive abiotic and biotic impacts. Spruce monocultures conversion into uneven-aged mixed stands is internationally thought as an urgent and efficient solution of the challenge posed by a former, yield-oriented forest management and climate change. Ecological, and to some extent - economic aspects of the conversion, are broadly presented in scientific literatures, while the attempts of assessing this silvicultural measure in terms of benefits and losses with respect to socio-cultural ecosystem services is almost nonexistent. With the aim to identify and understand all conversion benefits and losses and to gain insight into the conversion process using a monetary dimension a cost-benefit analysis (CBA) was applied.

## Materials and Methods

**1. Study area.** The study area is Rakhiv region (48°3'24.72"N; 24°11'48.35"E) in the Ukrainian Carpathians (Fig. 1). The region has a surface of 1.892 km<sup>2</sup> and a population of 93.053 inhabitants.

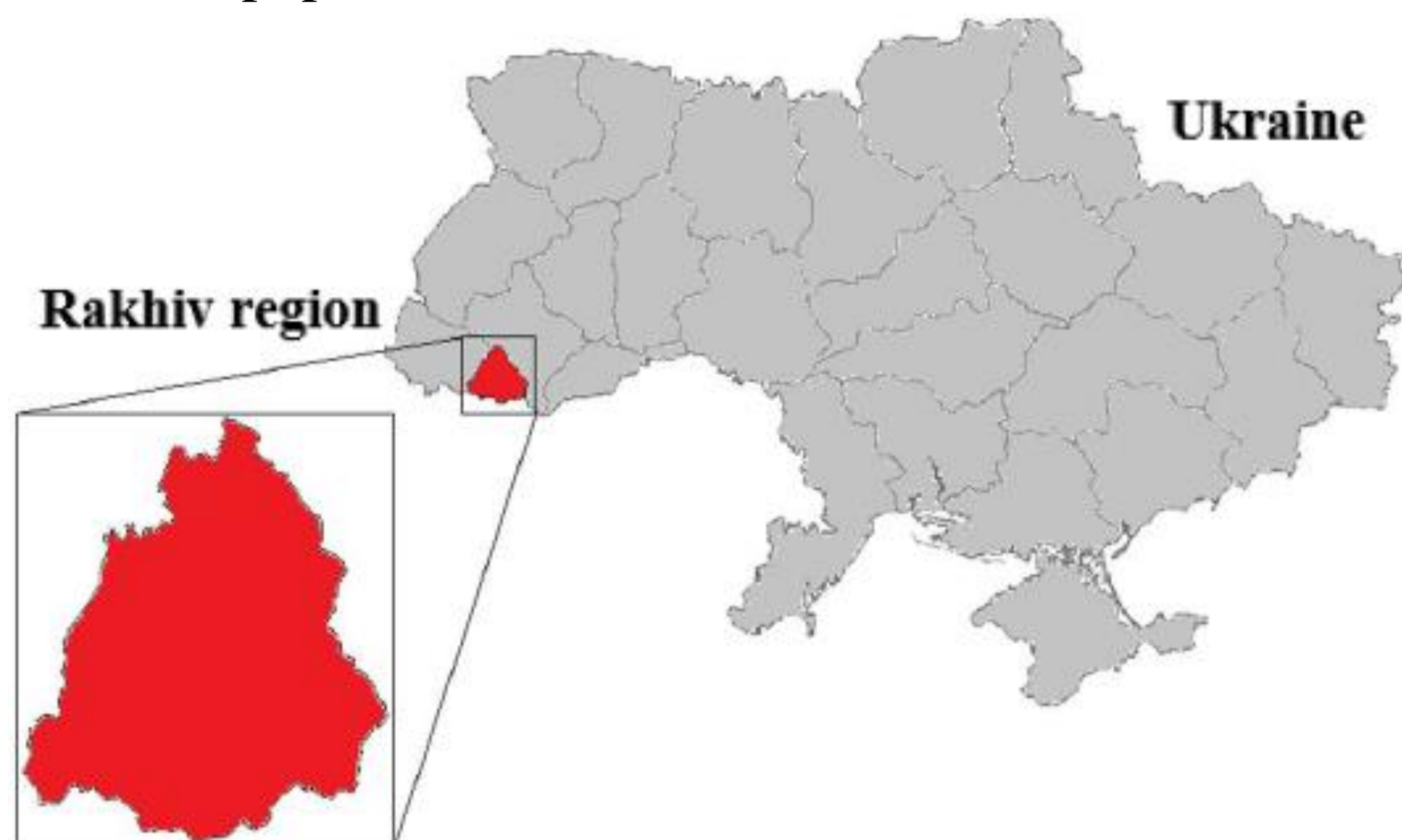


Figure 1. Location of the SE "Rakhiv Forestry"

The forests cover a surface area of 1.258 km<sup>2</sup> comprising 66.5% of the Rakhiv region territory with the average growing stock of 370 m<sup>3</sup>·ha<sup>-1</sup>.

According to the data of the Ukrainian governmental forest inventory association "Ukrderzhlisproekt", spruce is the main damaged tree species in the Rakhiv region. The dead spruce trees amount to a volume of 2.220 m<sup>3</sup>; 1.440 m<sup>3</sup> damaged by a windstorm and 8.490 m<sup>3</sup> by insects.

**2. Research method.** CBA is an analytical tool for discovering attractiveness of an investment decision from the investor and society perspectives by comparing costs and benefits attributable to the proposal (Fig. 2).

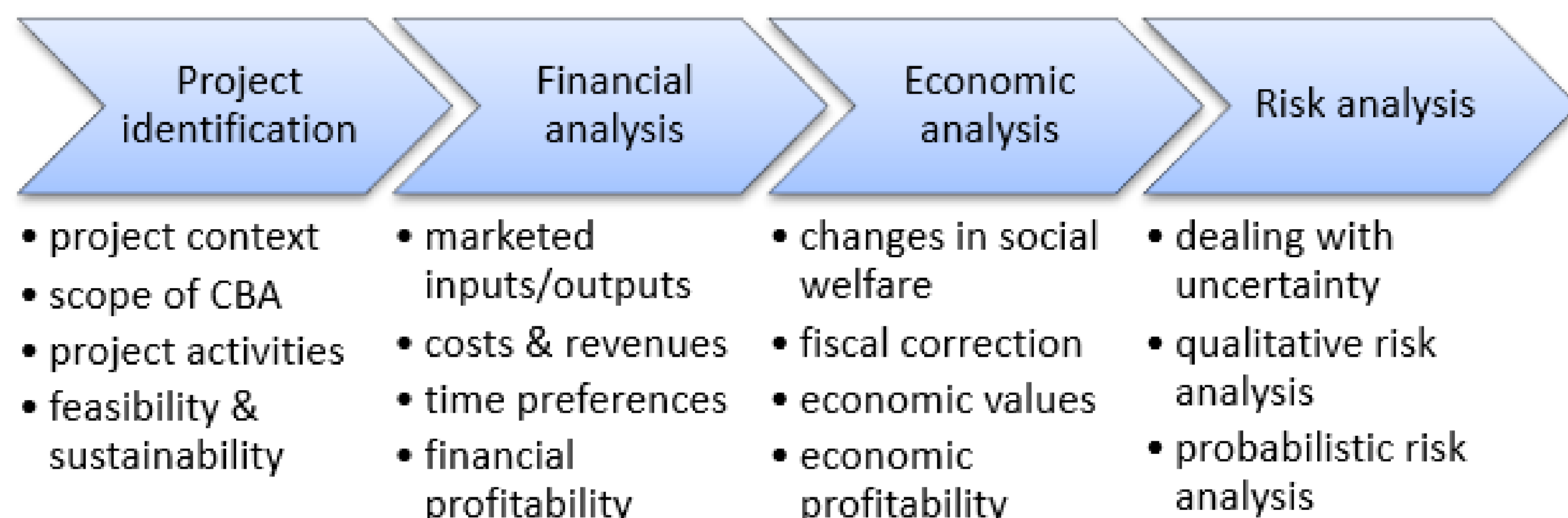


Figure 2. Main steps of cost-benefit analysis

CBA of spruce monocultures conversion is based on a modelling of this silviculture measure in the Ukrainian Carpathians (Pelyukh et al., 2018) by calibrated tree growth simulator SIBYLA (Fabrika & Ďurský, 2005).

Methodological approach rooted in ecological economics perspective (Zahvoyska et al., 2017) was applied to evaluate the spruce monocultures conversion benefits. To identify benefits of conversion project we applied the ecosystem service framework that allow us to reveal benefits in a systemic and comprehensive way.

In economic analysis of CBA such benefits has been valued:

- carbon sequestration and release (this market is not established in Ukraine);
- soil protection (Sinyakevich & Vrublevska, 2007); and
- recreational value of the forest by the choice experiment method and contingent valuation method (Pelyukh & Zahvoyska, 2017, 2018).

To evaluate efficiency of spruce monocultures conversion net present value (NPV), internal rate of return (IRR) and payback period (PP) were calculated.

## Results

Presenting all conversion benefits as matrix of a conversion impacts (Table 1) allowed to capture existing dichotomies among beneficiaries and in valuation approaches. The proposed matrix could serve as a checklist for an appraiser and be further developed to value the benefits.

Table #1 Matrix of the conversion project impacts

		Beneficiary	
		Investor	Society
Valuation of Benefits	Marketed	<p>1</p> <p>Project incomes:</p> <ul style="list-style-type: none"> <li>Increased revenues from sales of timber, and firewood (Provisioning / Materials / Biomass)</li> <li>Decreased financial risks due to forest species diversification</li> </ul>	<p>2</p> <p>Marketed social benefits of the conversion projects that stakeholders obtain:</p> <ul style="list-style-type: none"> <li>Taxes on revenues from sales of timber and firewood which go to local budgets (in case of clear cuttings these taxes go to the state budget)</li> <li>Changes in productivity of non-wood forest products (Provisioning / Nutrition / Biomass)</li> <li>Increased productivity of cultivated crops on sites which border sites under conversion (Provisioning / Nutrition / Biomass)</li> <li>Increased supply of water for drinking Provisioning / Nutrition / Water</li> </ul>
	Nonmarketed	<p>3</p> <ul style="list-style-type: none"> <li>Know-how gained by project performers</li> <li>Social value of business,</li> <li>Image and reputation of investor</li> <li>Other non-marketed benefits, that investor gains due to successful implementation of a conversion project</li> </ul>	<p>4</p> <p>Non marketed benefits of a conversion project that stakeholders obtain:</p> <ul style="list-style-type: none"> <li>Enhanced biodiversity Provisioning / Materials / Biomass</li> <li>Better quality of the environment Regulation &amp; Maintenance (R&amp;M) / Mediation of waste and toxics</li> <li>Flood and storm protection R&amp;M / Mediation of flows / Liquid flows and Air flows</li> <li>Improved habitats for biodiversity R&amp;M / Maintenance of Conditions (M&amp;C) / Lifecycle maintenance</li> <li>Benefits from avoided costs for biological protection of drying sites from pests R&amp;M / M&amp;C / Pest and disease control</li> <li>Benefits from prevention of soil erosion R&amp;M / M&amp;C / Soil formation &amp; composition</li> <li>Benefits from climate regulation by reduction of greenhouse gas concentrations R&amp;M / M&amp;C / Climate regulation</li> <li>Higher recreational / aesthetic value of forests Cultural / Physical and intellectual interactions (II) / Representative &amp; II</li> <li>Benefits from nonmarketed changes of human and natural capital derived due to a conversion project implementation</li> </ul>

\* CICES (2013) classification of ecosystem services is applied. CICES v. 4.3 categories are listed in italic.

Indicators of financial and economic analysis (Table 2) reveal attractiveness of spruce monocultures conversion implementation both from the forest enterprise and society point of view.

Table #2 Main results of CBA. Project of spruce monocultures conversion at the SE "Rakhiv Forestry"

No	Type of analysis	NPV, thou. UAH	IRR, %	PP, years
1	Financial Analysis ( <i>d</i> =17,5%)	0.04	18	20
2	Economic Analysis ( <i>d</i> =10%)	1229.40	36	4

*d* – discount rate.

Sensitivity analysis (range of value changes ±10%) of the forest conversion performance indicators, based on the financial analysis, revealed their high sensitivity to the timber price, which is a critical variable (reduction of the timber price by 10% (up to UAH 1.39 thou./m<sup>3</sup>)) would lead to a negative value of NPV (-6.40 thou. UAH). While according to economic analysis there are no critical variables.

## Conclusions

Performed CBA confirms the efficiency of spruce monocultures conversion both from the point of forest enterprise and society. It is important to note that the accomplished CBA does not consider all conversion benefits because they do not yet have a reliable value (such as enhance biodiversity, landscapes attractiveness, climate regulation, etc.). Integrating these values into CBA may increase the validity of the evaluation of spruce monocultures conversion efficiency and thus provide forest decision-makers and society with important information on the attractiveness and necessity of the conversion process.

## Acknowledgement

Presentation of the research was supported by the International Visegrad Funds.

## Bibliography

- Pelyukh, O., Fabrika, M., Kucbel, S., Valent, P., Zahvoyska, L. (2018). Modelling of secondary even-aged Norway spruce stands conversion using the tree growth simulator SIBYLA: SE "Rakhiv Forestry" case study Bulletin of the Transilvania University of Brasov. Forestry, Wood Industry, Agricultural Food Engineering. Series II, 11(2), 29–46.
- Pelyukh, O., & Zahvoyska, L. (2018). Investigation of Lviv region population's preferences regarding recreational forests using choice experiment method. Scientific Bulletin of UNFU, 28(9), 73–80.
- Zahvoyska, L., Pelyukh, O., Maksymiv, L. (2017). Methodological considerations and their application for evaluation of benefits from the conversion of even-age secondary Norway spruce stands into mixed uneven-aged woodlands with a focus on the Ukrainian Carpathians. Austrian Journal of Forest Science, 134, 251–281.