Financial evaluation of the tree-oriented silviculture

The software for the evaluation of the investments proposed by PProSpot

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The paper aims to present the methodology and the first results of the study implemented by the Department Land and Agro-forestry Systems of the University of Padua in the project PProSpoT. A user-friendly software for assessing the financial profitability of investments related to tree-oriented silviculture is presented. At the same time, the study provides information on the real profitability indicators of investments in a number of selected forest typologies and on the impacts that different variables can have on the financial results of such investments.

The LIFE + PProSpoT project (LIFE09 ENV/IT/000087) (**www.pprospot.it**) aims to introduce the technique of the tree-oriented silviculture in order to manage and conserve trees of so-called "sporadic" species (i.e. secondary species, mainly broadleaves, that can produce high-quality timber and that, at the moment, can be only occasionally found as scattered trees in the forest stands). The tree-oriented silviculture is a set of techniques in order to select target trees for the production of assortments of high quality (Mori *et al*. 2007).

In the project PProSpoT (*Policy and Protection Sporadic species of tree in Tuscany forests*), the species identified as target are typical broadleaf trees of Tuscany forests (such as cherry, ash or *Sorbus* sp.[1]) which, due to simplification of the structure of forest areas, are poorly represented. The sporadic tree species have great potential, for the production of high value timber and for the environmental/social benefits that they can generate.

Since in Italy there are not consolidated experiences on the implementation of the tree-oriented silviculture and on their related economic aspects, the project has given a special attention to the financial evaluation of tree-oriented silvicultural treatments in a selected number of forest typologies.

The study has been jointly implemented by the Department Land and Agro-forestry Systems (TESAF) of Padua University and by the Department of Agricultural, Food and Forest Systems Management (GESAAF) of Florence University. In particular TESAF Department has analyzed the tree-oriented silviculture highforest models, while GESAAF Department focussed on coppice models. Associated to the field work, a user-friendly software have been developed to provide an tool for private or public operators to evaluate

(1) *White beam (*Sorbus aria *L.), European mountainash (*S.aucuparia *L.), servicetree mountainash (*S. domestica *L.) and Checkertree mountainash (*S. torminalis *L.).*

BOX 1 - PROFITABILITY INDICATORS

The **Net Present Value (NPV)** is the difference of the discounted revenues and costs associated with the investment. The NPV is an absolute indicator of investment convenience. An investment is convenient if the NPV is greater than 0.
The **Internal Rate of Return (IRR)** is the rate that, applied in discounting costs and revenues, makes the NPV = 0. Unlike NPV that the assumption of a discount rate (not always easy), the IRR is not providing a clearcut signal on the investment profitability, but has to be compared with a threshold rate defined by the investor.
The **Revenues and Costs Ratio (R/C)** calculates the ratio between revenues and costs. It is an indicator of efficiency and productivity of the capitals invested. An investment is profitable when R/C is greater than 1.
The **Net Benefit (NB)** represents the value of the forest asset (soil and forest) in a given year n, which in this case coincides with the year 0, i.e. the starting year of the ordinary rotation period, after the initial transition period of the investment. This indicator is derived by the sum of the value of bare soil during the ordinary rotation period (calculated as the compounded sum of the discounted annual net income) and the difference between annual costs and revenues of the transition period of the investment referred to the year 0.

Years	0-30	31-75	76-125	126-200	201-300	> 301
Discount rate	3,5%	3%	2,5%	2%	1,5%	1%

Table 1 - Discount rates suggested by The Green Book: Appraisal and Evaluation in Central Government.

the profitability of investments based on the tree-oriented silviculture.
This paper aims to present the methodology used and the first results of the study conducted by the TESAF Department. Meanwhile it will provide indications on the impacts that different variables (such as timber prices and costs of silvicultural operations) have on the final financial results.

The methodology

The financial analysis of the tree-oriented silvicultural investments has to consider several variables, such as the prices of high-quality timber and the long-term costs of silvicultural operations, which are not so transparent in the reference markets (i.e. the Tuscany region, but similar problems occur in all the other Italian regions) and they vary considerably according to the stand conditions of the forestry areas and their accessibility. In order to make the evaluations more transparent and less complex a software called VESA (*Valutazione Economica Selvicoltura d'Albero* - Economic evaluation of tree-oriented selvicolture) has been developed, which can be freely download from the website of the project (***www.pprospot.it***). The evaluation tool, implemented through Excel®, allows to process the various silvicultural parameters of the stand and the economic values (the timber and fuelwood prices and the costs of the silvicultural operations) to calculate the conventional set of indicators of financial profitability (Gregersen and Contreras 1992, EC 2000), i.e. the Net Present Value (NPV), the Revenues-Costs ratio (R/C), and the Internal Rate of Return (IRR). In addition to these indicators, the software automatically calculates also another indicator, the Net Benefit (NB).

In Box 1 the four indictors are briefly described. The "With-without approach" is implemented by VESA in order to compare the tree-oriented silvicultural treatments with the conventional forest management regime.
The calculations that have been carried by the software VESA refer to the so-called "financial analysis", considering the cash flows of the revenues and the costs, with reference to the market values. The financial analysis allows supporting the entrepreneurs (the owners forest, for example) decision making process who look to all direct costs and revenues, including taxes and public incentives. So in contrast to the "economic analysis", the financial analysis does not take into account the positive (such as improving of biodiversity for example) and negative externalities that can be connected with the tree-oriented silviculture. Since the procedure for calculating the profitability indicators are the same in the financial and in the economic analysis, it should be noted that VESA could also be used for an economic analysis, obviously adapting the appropriate values of costs and revenues in order to take into consideration a broader concept of profitability, i.e. the public benefits associated to the investments. It is worthwhile to mention that normally, in forest investments, positive externalities exceed by far the negative ones, so the indicators of financial profitability tend to be, for the same investment, lower than those for the economic analysis.
Furthermore, given that the tree-oriented silvicultural investments, as most of the forest activities, are characterized by extremely long payback period, a special attention has been given to the selection of the proper discounting procedure. Indeed, the adoption of high discount rates entails reducing remarkably the discounted values of the items in later phase of the investment, i.e. the revenues, while has lower reduction effects on the items that are closer to the initial phase, i.e. the costs. For this reason long-term investments are rarely profitable if calculated with the conventional discounting techniques based on relatively high discount rates (Hepburn and Koundury 2006, Price 1993). To avoid this problem, a discount rate decreasing over time, following the directions suggested in the guide The Green Book: Appraisal and Evaluation in Central Government (HM Treasury 2003), realized by the UK Government in 2003 and revised in June 2011 with the aim of promoting a correct evaluation of long-term investments.
The software is organized in four spreadsheets that represent the different steps of the analysis. Data and formulas of the spreadsheets are linked to allow re-processing automatically the values that can be introduced in the appropriate cells (with yellow background) by users. Obviously the use of Excel allows doing simulations related to the effects on profitability indicators of different assumptions in data selection ("Sensitivity analysis" or "What …if analysis").
The 4 spreadsheets present in each Excel file are:

- the starting spreadsheet with the necessary instructions for a correct file utilization;
- the spreadsheet "Cost-price and results";
- the spreadsheet "Financial analysis";
- the spreadsheet "Results".

1) The first spreadsheet contains the project title, the silvicultural models (whose charac-

BOX 2 - THE SILVICULTURAL MODELS

They are theoretical descriptions of forest typologies characterized by specific composition and forest management practices. Specifically 6 different silvicultural models were identified in the investigated Tuscany forests: 2 models concerning an oak coppice, 2 models concerning mixed oak and chestnut aged forest, and finally 2 beech high forests traditionally managed with a shelter-wood system). The tree-oriented silviculture will be adapted to the different forest typologies and the site conditions (age, health conditions, quality and number of tress) with the main objective of keeping and improving the presence of sporadic species. The silvicultural models described are all characterized by a period of transition that starts with the selection of the first target trees until the number of these various stages becomes stable. Afterwards, the ordinary rotation periods of tree-oriented silviculture start and the silvicultural and economic parameters are assumed to be stabilized and repeated in a constant way. The 6 silvicultural models considered in the VESA software are inspired by real forest conditions, but they represent only few of the potential forest typologies. Software user should be aware of the need of controlling and, if needed, changing the assumption related to the silvicultural treatments in order to avoid inapplicable or even counterproductive forest practices.

Species	Price	Specific weight	Year of cutting											
	€/m³	q/m³	40°	48°	56°	64°	72°	80°	88°	96°	104°	112°	120°	
Cherry	340	7,1	1	1	1	1	1							
Pear, wild service tree	665	7,1												
Ash	340	6,2												
Maple	300	6						1	1	1				
Lime	225	5,3												
Elm	340	6,2									1	1	1	
			1	1	1	1	1	1	1	1	1	1	1	11
Beech	80	7				9	9	9	9	9	9	9	9	72

Price	€/t
Fuelwood	0,5

Period	120	years
Area	1	ha

	€	Totale
Public funding (€/sporadic tree)	0	0

Silvicultural operation costs (€)	
Identification and marking of 1 target tree	1
Marking of the main competitors	5
Localized thinning of 1 target tree	44
Hauling wood from localized thinning	18
Thinning in beech stand (1ha)	2.000
Seed cut (1ha)	5.000
Overstory removal cut (1 ha)	4.500
Compulsory of hauling (yes/not)	yes

Silvicultural data	
Percentage of target trees utilizable	90%
Percentage of target trees can not be used for timber production	10%
Fuelwood obtainable from the overstory removal (shelter wood system)	900 q/ha
Fuelwood obtainable from thinning in the beech stand	400 q/ha
Fuelwood obtainable from the seed cut (shelter wood system)	1.000 q/ha
Fuelwood (in quintals) by thinning per target tree	11 q/pianta

Volume (in m³) of timber	sporadic	beech
40th year	0,36	
48th year	0,5	
56th year	0,6	
64th year	0,72	0,84
72th year	0,78	1
80th year	0,86	1,28
88th year	0,98	1,5
96th year	1,1	1,8
104th year	1,25	1,8
112th year	1,36	1,8
120th year	1,4	1,8

Table 2 - Technical parameters considered in the simulations.

teristics are in Box 2) and the operating instructions needed for VESA correct use.

2) The spreadsheet "Cost-price and results" is the most important for an analytical evaluation the investment profitability, since in this spreadsheet all the single basic variables that can be modified (the number of trees of sporadic species chosen as target trees, the cost of silvicultural operations, etc.) are reported. On the right of the spreadsheet it is possible also to find the financial indicators (purple background) obtained from the tree-oriented silviculture, with a possible comparison with the results obtained from the ordinary silvicultural management.

3) In the spreadsheet "Financial analysis" the summary cash flows of revenues and costs are presented in the case of the tree-oriented silviculture and in the case of ordinary forest management ("With-without approach").

4) The spreadsheet "Results" is divided into two sections; the upper part presents the results of the tree-oriented silviculture, while the lower part lower concerns the ordinary forest management. In addition to the results, for both situations the spreadsheet presents:

- the cash flow with the annual net costs and net revenues and their difference;
- the discounted costs, revenues and their differences.

For the investment in tree-oriented management system, VESA can provide another indicator: the payback period, which is the number of years needed in order to have the sum of discounted costs starting from the year zero is compensated by the sum of discounted revenues.

EXAMPLE OF SOFTWARE UTILIZATION

VESA was tested applying the software to some case study areas; in this way some quite interesting results on the financial profitability of tree-oriented silvicultural investments have been obtained as well. The evaluation of an investment based on a tree-oriented silviculture in a beech stand, for an investment period of 120 years, has been carried out. In the stand localized thinnings are foreseen every 8 years in order to support the growing of a selected number of target trees. 72 beech and 11 trees of sporadic species have been identified as target trees. The transition period starts at year zero and end at the 108th year. After the 108th year the ordinary series of constant rotation start, in which every 8 years one tree of sporadic species and nine beech trees will be harvested. All the values of the variables used in the simulation are presented in Table 2.

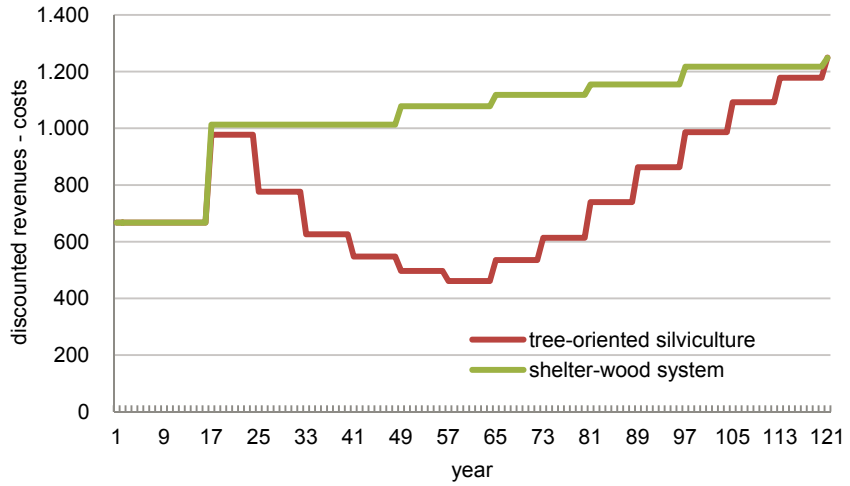
In order to check whether the introduction of the tree-oriented silviculture could lead to a real economic advantage for a beech high-forest, it has been assumed a fuelwood road side price that entails a NPV at the 120th year under the ordinary forest management equal to 0. It is important to emphasize that, in the case of ordinary management, the wood derived from thinnings and from the seed cut will be used for energy, while in the case of the tree-oriented silviculture, the target trees of beech will be used as timber for building. Assuming the same price (0,5 €/t), which gives a NPV equal to 0 in the case of ordinary management, the NPV of the 120th year of the tree-oriented silviculture is negative (Table 3). However, it is also interesting to note (Table 4) that a small increase in the fuelwood price (equal to 6.1% of the base price) to make the NPV of the tree-oriented silviculture positive. It is even

Hypothesis	Fuelwood price (€/t)	Tree-oriented silviculture	Shelterwood system
		NPV/ha at the 120th year	NPV/ha at the 120th year
NPV shelterwood system = 0	5,0	-1.040	0

Table 3 - Financial profitability of the tree-oriented silviculture and the ordinary shelterwood system when the fuelwood price is equal to 0,5 €/t.

Hypothesis	Fuelwood price (€/t)	Tree-oriented silviculture	Shelterwood system
		NPV	NPV
NPV tree-oriented silviculture	5,3	0	575.5
NPV tree-oriented silv>NPV shelterwood system	5,7	1,248	1,249

Table 4 - Comparison between the economic convenience between the tree-oriented silviculture and shelterwood system



Graph 1 - Comparison between revenues less discounted costs between the traditional forestry and treeoriented silviculture in case the firewood reaches a price of 0,57 € /t.

more interesting to underline that, in the case a price of fuelwood equal to 0,5667 €/t (or higher), the tree-oriented silviculture investment is even more profitable compared to ordinary forest management. Thus increasing the price of fuelwood, the NPV of the tree-oriented silviculture activity increases as well, because localized thinning operations become more sustainable with higher prices of the by-products, considering also the fact that these operations are concentrated in the first phase of the investment (see the limited impact of discounting).

Therefore, despite tree-oriented silviculture is aiming to produce high quality timber, the price of fuelwood plays an important role in determining the overall profitability of the investment. Fuelwood prices are playing even a more relevant role than the price of timber derived from beech or sporadic trees. Indeed, in the case study, only the doubling the price of timber from target trees (ceteris paribus) can make NPV of the tree-oriented silviculture positive. The other main factors that can influence the overall financial results of tree-oriented silviculture are the topography of the forest area, the distribution of target trees and the efficiency of the team carrying out harvesting operations.

As already mentioned, the presence of positive externalities (e.g.: improved conditions of biodiversity protection) associated with tree-oriented silviculture, could motivate a public incentive for the localized thinning for the target trees. Assuming a fuelwood price of 0,5 €/t, a public incentive for covering the thinning costs of 42,1 €/tree (€ 4.167 in total), during the transition period required to get to a regular production of target trees (108 years), will make the investment based on the tree-oriented silviculture economically viable.

Conclusions

The main objective of the study was to create a tool for private or public operators involved in implementing tree-oriented silviculture investments and wishing to assess the financial profitability under different alternatives. Analyzing the results from first tests based on selected case studies, the profitability indicators of the tree-oriented silviculture appear strongly dependent on the price of fuelwood, more than the prices of high-quality timber from sporadic species. Some factors such as the efficiency of silvicultural operations (with the associated costs) and the presence of public funding (justified by the positive environmental effects) can have relevant positive impacts on the profitability of tree-oriented silviculture investments.

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Abstract: ***Financial evaluation of tree-oriented selvicolture. A software for the estimation of the economic convenience of investments proposed by pprospot.*** *This article presents the methodology used and the first results of the study developed by TESAF Department of Padua University during the action 7 of the LIFE+ project PProSpoT ("Policy and protection of sporadic tree species in Tuscany forests"). To facilitate the estimation of financial profitability of the" tree-oriented silvicolture" it has been developed a software named VESA. As clearly documented by the implementation of VESA with field data, the price of woodfuel is the most important factor in the evaluation of the financial feasibility of tree-oriented silvicolture.*

Keywords: *Economics, finacial analysis, tree-oriented sylvicolture, sporadic scpecies, beech highforest, PProSpoT.*