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The economics and optimal management regimes of eucalyptus plantations: A case study of forestry outgrower schemes in Brazil

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ABSTRACT

The main aims of this study are to assess the economic viability and identify the optimal management regimes of eucalypt forests within the framework of an outgrower scheme, at Minas Gerais State, Brazil. Outgrower schemes are partnership contracts that encourage smallholders/farmers to consider reforestation in addition to their agricultural crops. The company provides inputs and seedlings for planting in exchange for the exclusive right of timber purchase at harvest time. The cash flows of tree growers and forest company are evaluated using the Net Present Value and Average Production Cost for the project, with and without the outgrower scheme. The management regimes are evaluated by Linear Programming (LP), the objective function of which is to maximize the Equivalent Annuity (EA) of 144 farms with outgrower schemes. There has been an increase in the profitability of tree growers enrolled in the program for an economic radius of 160 km, showing the importance of incentives for eucalyptus plantations in small and medium farms. By LP, 10 management prescriptions common to the 144 farms were selected. It was observed that 15% of the 144 outgrower schemes analyzed did not have an economical prescription. A 10% reduction in the current wood price would increase this amount to 39%. Furthermore, with discriminant analysis of the 10 selected management prescriptions, it was possible to create a classification rule for new partnership contracts, with a 80% success rate.

1. Introduction

Forest planning models are currently well suited for reforestation companies, as they help in controlling the present and future of the forest stock (Pittman et al., 2007; Beaudoin et al., 2008). In areas of outgrower schemes for smallholders, such techniques are not common in Brazil. Their involvement in supplying industrial raw material is much lower when compared to the planting in areas owned by the companies (ABRAF, 2013).

An outgrower scheme is defined as a contractual partnership between tree growers and a private forest company. The forestry outgrower schemes supply some of the industrial demand, while in other sectors of processing the raw material comes to be fully acquired by contracts with farmers, like in the food industry based in poultry and swine raising. One particularity of the forest sector concerns to longer rotation lengths. While agricultural crops have more than one production per year, the forest within the framework of an outgrower scheme needs between five and seven years to deliver the final product to the processing industries (Basso et al., 2012).

In Brazil, most of the potential partners are not yet familiar with outgrower scheme programs for establishing timber plantations on their farms. This kind of partnerships started in the 1960s (Fujihara, 1991; Oliveira et al., 2006) and has consolidated in the 1980s (Basso et al., 2012). There are two types of outgrower scheme initiatives: (1) Private partnership arrangements, who promoted mainly pulp and steel production (Souza et al., 2009; Oliveira et al., 2006) and (2) Public ones, largely supported by government incentives through rural credit, specific to forestry (Basso et al., 2012; Rochadelli et al., 2008).

The public outgrower schemes aim to meet domestic timber demand, used on their own farms, and industrial demand as well. The private outgrower scheme objective is to stimulate the production and ensure supply of industrial wood through contracts with tree growers located in the surrounding areas of large forest-based enterprises (Cordeiro et al., 2010).

The private outgrower scheme type addressed in the present study refers to the private tree growers who sign a contractual partnership with a forest company. This contract refers to a specific area of the farm whose owner intends to make available to this program.

The main reasons cited by companies to promote outgrower schemes are: greater integration with tree growers, fixation of labor available in

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the rural areas, reduction or elimination of the need to purchase land and infrastructure costs, salaries, and social burden (Canto et al., 2009; Rochadelli et al., 2008). As a result, there is also the expectation of reducing the negative pressure of public opinion (Oliveira et al., 2006) and conflicts with social movements and non-governmental organization (NGO) networks (Kröger and Nylund, 2012).

Within the lifespan of an outgrower scheme, the company provides clonal seedlings, fertilizers, financial resources, and technical assistance. In return, the tree growers are responsible for the planting and maintenance of the forest stands (Silva et al., 2009). Another contractual requirement is that the farmer would be responsible for the harvesting and log trucking to the company's mill. These costs and especially the transport distance largely influence the decision of smallholders signing or not partnership contracts (Hlaing and Inoue, 2013).

Another common contract provision dictates that the tree growers should sell 97% of their wood production to the company. If they wish to sell timber in other markets, they must pay a fine for contract rescission (Souza et al., 2009).

Reforestation in small and medium-sized farms are more likely to be sustainable, in that it generates wider social benefits and contributes to mitigate environmental impacts, compared to large industrial forest plantations (Oliveira, 2003). As a complementary activity, reforestation enables the use of degraded, unproductive and underused land, usually unsuitable for agriculture, therefore providing additional alternative income to farmers (Bull et al., 2006; Siqueira et al., 2004). A number of studies indicate the economic, social, and environmental benefits of fostering timber production on small farms (G.C. and Mehmood, 2010, 2012; Vainio and Paloniemi, 2012; Martins and Borges, 2007; Bull et al., 2006; Kittredge, 2005; Kurttila and Pukkala, 2003; Pykäläinen, 2000).

The economic viability analysis in forestry outgrower schemes is important for identifying costs that most affect cash flow, allowing it to propose alternatives and alerting the tree grower about project risks. The economic evaluation of the outgrower scheme, under different management regimes, allows identifying the best forest management alternative to the producer. As the main goal is to get the maximum income from the stand, different ages and cutting regimes can compose a mathematical programming model to maximize one economic variable. Knowing the most appropriate regime and the variables that influence it, a classification rule can be created to facilitate the identification of an ideal regime for new tree growers.

This study evaluates the economic viability of formal partnership arrangements between farmers and a forest company, determines the optimal management of the forest stands, and obtains a classification rule for the management regime of new contracts.

2. Material and methods

2.1. Outgrower information

This study was conducted using the information from forest contracts established between tree growers and a forestry-based company in the Minas Gerais State, Brazil. In total, 144 farms that had contracts with the forestry outgrower scheme initiative were evaluated.

These contracts are agreements between the company and the tree growers for buying and selling wood. The main goal is to promote forestry using eucalyptus species to increase the wood supply for the company. Thus, this study involves the information provided by the company that is carrying out the outgrower scheme program.

The outgrower scheme contract is structured as follows: the farmer is called SELLER, while the company is called BUYER. The SELLER performs the activities of preparing the farmland followed by planting of the seedling, being still responsible for the maintenance of the stand. The stand consists of eucalyptus trees, of the species provided by the BUYER, using all the resources (inputs, assistance, etc.) available. The SELLER is obliged to sell 95% of the volume produced, in the form of small logs, and deliver them to the BUYER's log yard.

There are two outgrower initiatives carried out by the company. The situation where the forest company provides seedlings, fertilizers, topographical surveys, and all the necessary technical assistance for the forest stand establishment characterizes one of them. The company will not charge the tree grower, as long as he complies with the agreement to sell 95% of the wood exclusively to it.

Another type of arrangement entails financial loan for forest establishment and maintenance services, such as weeding and ant control. This loan is provided by the company and deducted from the payment made to the tree grower, upon wood delivery.

Eucalyptus plantations within the framework of an outgrower scheme are managed under either a single-rotation or a coppice regime. The costs of silvicultural treatments as set on contract and used in this study are presented in Table 1, according to the management regimes. For the coppice one, the figures are the same, but with no seedling costs.

In this study, the company provided all the information about area, age, yield, and distance. The total area of the 144 outgrower schemes was 2445 ha, with an average of 17 ha planted by tree growers. The smallest property has 2.6 ha and the largest is 219 ha. Most outgrower schemes were seven-year old, while others were five and six years old at the time of acquired data.

The distance between the farm and the company's mill is of paramount importance for the outgrower scheme project to be viable. The observed average distance is 150 km. In this study, the pavement quality of all roads is considered the same, with traffic allowed during all seasons.

The outgrower scheme yield was estimated with data from the continuous forest inventory held by the company and adjusted with the logistics yield function. Due to local variability (15–60 m^3/ha/year at 7 years), a model was set for each outgrower scheme.

The coefficient of determination (R^2) of the models ranged from 0.89 to 0.94. An example of the fitted model is given by:

$$Y = \frac{379.6463}{1 + 3.12049e^{-0.0627.I}} + \varepsilon$$

where: Y = yield (m^3/ha), I = age, and ε = error.

2.2. Economic analysis

The economic analysis encompassed the evaluation of the cash flows over a period of 15 years, for stands managed under two-rotation regimes. The first rotation was originated by seedlings and the second one by coppicing. In both cases, the rotation was set at seven years.

On this first analysis the differences in the company's and the tree grower's cash flows are investigated. Three forestry project scenarios were then compared: (a) forestry project outside of the outgrower program (independent landowner), (b) landowner's cash flow component for a project within the outgrower program, (c) company's cash flow

Table 1
Outgrower scheme costs for the first (seedling) and second (coppice) rotations.

Description	Year	Seedling	Coppicing	Costs paid by
		(USD/ha)	(USD/ha)	
Supplies	0	984.54	787.15	Company
Technical assistance	0	66.05	66.05	Company
Stand establishment	0	532.99	220.30	Tree grower[a]
Maintenance	1	121.83	121.83	Tree grower[a]
	2	106.60	106.60	
Land annual cost	0 − n	60.91	60.91	Tree grower
Harvest (USD/m^3)	n	7.83	7.83	Tree grower
Transport (USD/m^3/km)	n	0.12	0.12	Tree grower

[a] Financed.