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The forest incentive policy in Argentina. Case-study: Santiago del Estero

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Abstract

The development of planted forests in Argentina was brought about by a range of State-maintained incentive programmes throughout the 1990s. These initiatives sought to relieve pressure on native forests and reduce dependence on imported wood by subsidising actually attained plantations of fast-growing species.

In many regions of the country, the policy generated real and effective responses. There are today over a million hectares of forest under cultivation. The benefits of forest incentives went to waste in the province of Santiago del Estero, however, despite its having a large surface apt for forestry uses in both irrigable and dry areas.

There appears to be insufficient information and, therefore, scant producer response to the incentives. Also in evidence is a need to update the value of the subsidy in the light of the realities faced by producers in the province.

This paper pursues two aims: (a) to analyse the social and economic consequences of the forest incentive policy at the national level, and (b) to evaluate the response of producers in Santiago del Estero to those incentives.

Key words: forest policy, subsidies, forest economic.

Resumen

La política de incentivos forestales en Argentina: el caso de Santiago del Estero

El fomento de las repoblaciones forestales en Argentina ha sido llevado a cabo por medio de un amplio programa de subvenciones, que a nivel estatal se ha desarrollado a lo largo de los años 90. Estas iniciativas han pretendido disminuir la explotación de los montes ya existentes y reducir la dependencia de las importaciones de madera a través de las subvenciones a las nuevas plantaciones de especies de crecimiento rápido.

En muchas regiones de Argentina, esta política de subvenciones ha generado respuestas concretas y efectivas. Actualmente existen más de un millón de hectáreas repobladas. Los beneficios de las subvenciones forestales no se han dejado sentir en la provincia de Santiago del Estero, a pesar de disponer de grandes superficies adecuadas para usos forestales, tanto en secano como en regadío.

Parece que ha habido una insuficiente información y, por lo tanto, una escasa respuesta de los productores a las subvenciones. También es evidente la necesidad de actualizar las cuantías de las subvenciones a la vista de las vicisitudes a las que tiene que enfrentarse los productores de la provincia.

Este trabajo persigue dos objetivos: a) analizar las consecuencias económicas y sociales de una política de subvenciones forestales, a nivel nacional, y b) evaluar la respuesta de los productores forestales de Santiago del Estero a estos incentivos.

Palabras clave: política forestal, subvenciones, economía forestal.

Introduction

Since the early 1990s, the Government of the Argentina Republic has shown a clear interest in the forestry sector through a range of legal and economic initiatives aimed at growth. The main forest incentive instruments include the Forest Plantation Incentive System (the «RPPF»), the Cultivated Forest Investment Act (no. 25,080) and the Forest Land Real Property Rights Act (no. 25,509).

In 1992, the Argentine Secretariat of Agriculture, Livestock, Fisheries and Food («SAGPyA») created the RPPF in order to encourage the introduction

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of cultivated forest throughout the entire national territory.

The benefits of the system consisted of granting non-refundable financial aid to landowners who attained plantations through suitable silvicultural management.

Throughout the lifetime of the forest incentive system, the SAGPyA promoted in the province of Santiago del Estero the species eucalyptus (*Eucalyptus sp*) and *Melia sp* in dry areas and poplar (*Populus sp*) in irrigable areas.

This paper pursues two aims: (a) to analyse the social and economic consequences of the forest incentive policy at the national level, and (b) to evaluate the response of producers in irrigable areas of Santiago del Estero to those incentives.

Placing the province of Santiago del Estero in the national context

Santiago del Estero, the oldest Argentine province, is located in the semi-arid region of Argentine Republic. From the geopolitical point of view, the province belongs to the northwest region of Argentine (NOA). This province has an extension of 136,351 km^2 that represents 3.6% of the national territory. Figure 1 shows the province of Santiago del Estero in the Argentina Republic.

Santiago del Estero is one of the country provinces with a smaller relative development. Its economic dynamics has low own initiative; because is strongly centralized, with a great dependency of the public expenditure. Its Gross National Product participates with a 0.8% in the national GNP. The demographic and social rates also explain its development low level. Below in Table 1, is shown the values of some social-demographics rates of Santiago del Estero and their comparison with the national average.

The Argentine forestry sector

The Argentine forestry sector is included in the agriculture and livestock sector, and accounts for 2% of Argentine GDP.

The Argentine forest resource is made up of approximately 40 million hectares of forest, of which only about 780,400 hectares are plantations, according to figures from the first National Inventory of Forest Plantations - *Inventario Nacional de Plantaciones Forestales* 1998 (SAGPyA, 2001). Table 2 shows the main

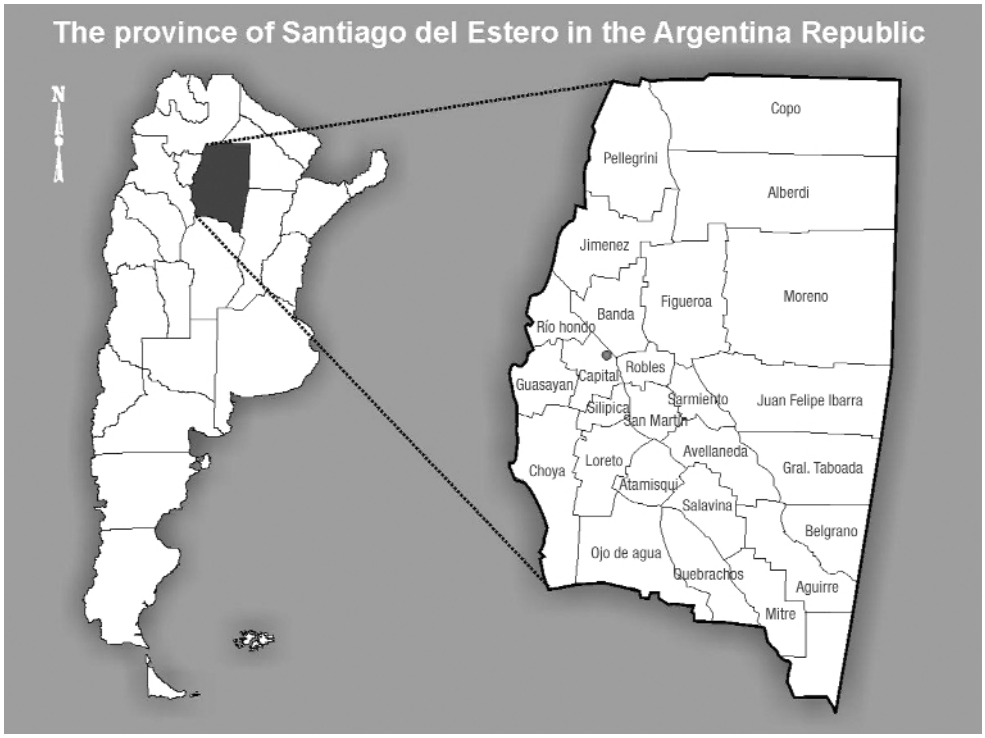


Figure 1. Location of the province of Santiago del Estero in the Argentina Republic. *Source:* FCF-UNSE, 2003. Remote Sensing Laboratory Files.

Table 1. Demographic and social indicators of Argentine and Santiago del Estero

Indicators	Country total	Santiago del Estero
Population (inhabitants)	36,260,130	804,457
Density (inhab/km^2)	9.7	5.9
Rate of population increase (‰)	11.0	18.4
Gross rate of natality (‰)	18.2	21.1
Gross rate of mortality (‰)	7.6	6.1
Population under line of poverty (%)	40.2	58.9
Population under line of indigence (%)	15.0	31.1
Rate of Illiteracy (%)	4.0	9.5
Rate of unemployment (%)	12.6	11.8

Source: INDEC. Department of Economy, 2004.

Table 2. Argentine forest production. Years 1980, 1990 and 2000

Year	Logged wood (m^3 sc '000s)		Firewood (m^3 sc '000s)	Sawn wood (m^3 sc '000s)	Boards (m^3 sc '000s)	Wood pulps (m^3 sc '000s)	Paper and Cardboard (m^3 sc '000s)
	Conifers	Broadleaf					
1980	1,222	3,565	5,592	908	392	387	789
1990	2,043	4,444	4,332	1,446	386	605	891
2000	2,319	2,320	1,103	1,800	754	616	978

Source: Agrarian Statistics Annuals. MAPA 1981, 1991, 2002.

data on total Argentine forest production for the years 1980, 1990 and 2000.

The native forests of Argentina are chiefly made up of broadleaf species. They generally produce a low volume of raw materials, although some formations have high productive potential. There are several reasons for this. Throughout the entire history of forestry uses in the native forests of Argentina, investment in silviculture has been insufficient and inadequate. Historically, forestry uses have been limited to extraction of products for which there was an existing market. In addition, large surfaces have been turned into arable and grazing land.

Wood is extracted from native forest chiefly for the production of billets, firewood, posts, charcoal and crossties. The historical series 1995-2001 for extractions of all primary forest products is shown below (Table 3).

The share of the provinces of the country in the total extraction of billets differs widely. Chaco and Misiones are significant, as shown in Graph 1 for extractions in 2001.

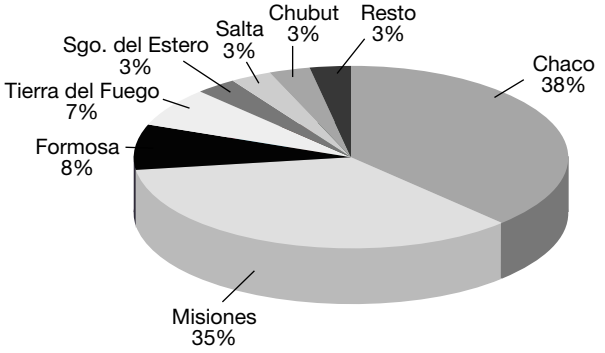
Unlike native forests, planted forests —which comprise fast-growing foreign species— are now in rapid expansion.

The inventory of forest plantations drawn up for late 1998 estimated commercial stocks (up to 10 cm excluding bark) of over 94 million m^3 (SAGPyA, 2001). This volume is concentrated in the provinces of Mesopotamia and Buenos Aires. The provinces of Misiones, Corrientes, Entre Ríos and Buenos Aires contain over 89% of total planted commercial stocks.

Table 3. Extraction of products from native forest. Country total. Historical series 1995-2001 (in tonnes)

Year	Billets	Firewood	Posts	Charcoal	Crossties	Other
1995	1,338,817	887,282	70,433	233,966	3,943	42,658
1996	1,144,891	762,789	48,251	259,017	3,093	47,339
1997	1,102,898	761,327	55,092	251,647	2,573	24,738
1998	1,201,346	1,078,371	45,808	364,977	29,199	40,737
1999	941,746	1,026,471	43,839	320,201	28,174	19,271
2000	894,343	793,783	33,381	255,186	27,151	18,832
2001	736,512	970,901	40,887	293,585	16,508	25,214

Source: Series Estadísticas Forestales 1995-2001. Especies Nativas. DRFN, 2002

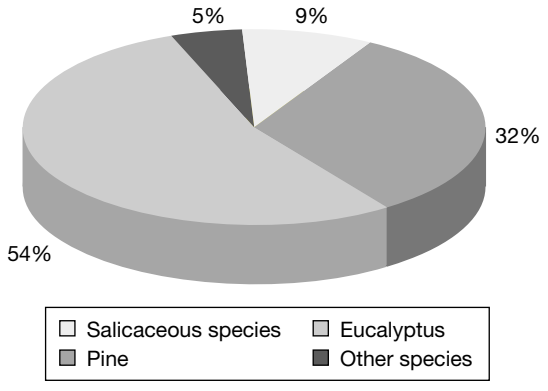


Graph 1. Relative share of provinces in total extraction of billets from native forests, 2001. *Source:* Anuario de Estadística Forestal, 2001. Especies Nativas. DRFN, 2002.

As regards species, almost 90% of afforestations are pine and eucalyptus. The 780,400 hectares of planted forest comprise 9% of salicaceous species (*Populus sp* and *Salix sp*), 32% eucalyptus (*Eucalyptus sp*) and 54% pine (*Pinus sp*) (SAGPyA, 2001). Graph 2 is a visual expression of the share of each species group in planted commercial stocks.

The mean annual wood harvest from cultivated forests is 5.6 million m^3. This value is less than the annual growth of forest, which totals about 8.06 million m^3. Therefore, the country is becoming capitalized, since raw materials are increasing, and planted forest resources are being managed sustainably (SAGPyA, 2001).

Argentina also has 5 million hectares of land with forestry potential that does not compete with other agribusiness activities. Many such properties offer the soil and climate conditions to provide the highest forest species yields in the world. Furthermore, low prices per hectare and the various government incentives encourage rapid growth of planted forest resources.



Graph 2. Percentage share of species groups in the commercial volume of planted forests. *Source:* preparated by the authors, based on SAGPyA Forest data, 2001.

Argentina has a negative balance of trade for forestry, with the deficit strongly concentrating in wood, pulp, paper, cardboard and wood products and publishing and printing products. Since the devaluation of the Argentine peso in early 2001, imports dropped off, while competitiveness gains on the international market boosted exports. Statistical measurements of Argentine overseas trade show the progress of forestry product transactions from 1990 to the first half of 2002 (Table 4).

The composition of exports has changed over time. While in 1992 exports mostly consisted of billets, by 2002 boards, pulp, paper, cardboard and sawn wood were also exported.

The instruments of forest incentives

The forest incentive mechanisms put in place by the Government since the 1990s include the Forest Plantation Incentive System (*Régimen de Promoción de Plantaciones Forestales* - RPPF), the Cultivated Forest Investment Act (no. 25,080) and the new Forest Land Real Property Rights Act (no. 25,509).

The Forest Plantation Incentive System was in force from 1992 to 1999. It was aimed at increasing the forest surface area of the country. The experience of those years showed that, although the existence of plantations is a necessary condition, it does not of itself ensure the establishment of processing industries, because business decisions are strongly influenced by the prevalent economic and legal environment.

Table 4. Development of overseas trade in forest products. Series 1989-2002 (dollar '000s)

Year	Exports	Imports	Balance
1989	240,000	120,000	–120,000
1990	310,000	140,800	–169,200
1991	181,100	334,400	–153,300
1992	162,500	544,400	–381,900
1993	240,002	774,813	–534,811
1994	324,568	943,789	–619,221
1995	589,413	1,118,532	–529,119
1996	584,440	1,183,389	–598,949
1997	615,949	1,441,262	–825,313
1998	595,357	1,620,495	–1,025,138
1999	523,293	1,438,621	–915,328
2000	609,377	1,428,520	–819,143
2001	518,896	1,183,364	–664,468
1st half 2002	257,143	232,727	24,416

Source: SAGPyA, 2002.

The aim of the Incentive System was not only to enlarge forest surface area but also to enhance the productivity of plantations by encouraging the use of genetic material of selected quality and improve the quality of forest produce (SAGPyA, 1992).

The benefits of the system consisted of non-refundable financial aid to landowners who attained plantations through suitable silvicultural management.

In the social respect, the RPPF favoured diversification in production activities carried on by small producers, as this would complement rather than compete with other agribusiness production and, in addition, demand labour of various skill levels, especially in areas where offers of employment were scarce.

Against that background, the Cultivated Forest Investment Act (no. 25,080) aims to move beyond the objective of the incentives system by including industrial projects within its sphere of influence. The Act introduces a new paradigm of encouraging projects that integrate forestry production with wood industrialization.

The Act creates a system to encourage forest investment, ranging from acquisition of seeds, forest planting, forest management and research activities through to industrialization of the wood produced, where that process forms part of an integrated forestry project. The Act defines forestry-industry projects as any processing of wood that includes forest planting.

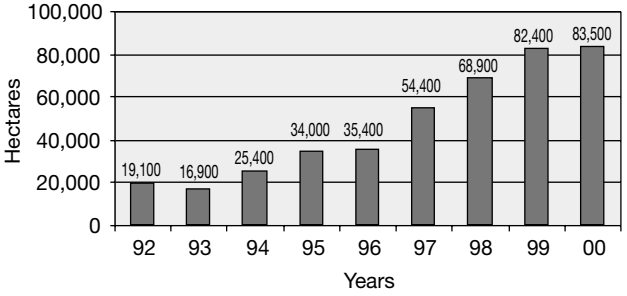
The recent Act no. 25,509, for its part, will enable the establishment of plantations on leased land and the acquisition of ownership of plantations on land owned by third parties. Act no. 25,509, called the Forest Land Real Property Rights Act, was enacted in 2001, and allows for afforestation of land owned by third parties. The new statute makes it possible to treat separately the rights of the owner of an afforested estate and the rights of the afforester (the plantation owner).

Social and economic effects of the forest incentive system

Although the benefits of Act no. 25,509 cannot yet be quantified, the social and economic effects of the other two instruments of forest promotion are already apparent, such as the increase of forested surface, the job creation and the generation of investment.

Increase of forested surface

In recent years, 780,396 hectares of forest have been planted in Argentina, making for a wood volume of 94 million m^3 (SAGPyA, 2001) and now supplying over 95% of the industrial raw materials of the country. The surface area is modest, however, when regarded in relation to the available stock of land apt for afforestation.



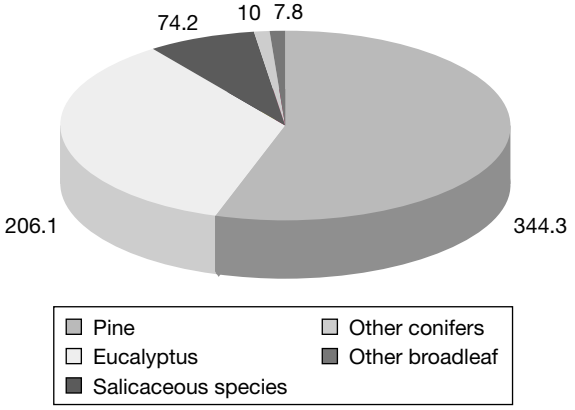
Graph 3. Surface planted annually under the Forest Plantation Incentive System from 1992 to 2000. *Source:* SAGPyA, 2001.

Undoubtedly, the Forest Incentive System accounts to a significant extent for the development of this wood volume available for consumption by industry and for export. An analysis of the official data on the development of forested surfaces from 1992 to 2000 shows a clear growth trend (Graph 3).

The results of the Forest Inventory indicate that the surface area of planted forest in 1998 was 780,400 ha, mainly in the provinces of Mesopotamia and Buenos Aires. Pine is predominant over other species, like eucalyptus, salicaceous species and other broadleaf trees (Graph 4).

Job creation

It is estimated that by the end of the 1990s the forestry-industry sector generated almost 90,000 direct jobs and about 300,000 indirect jobs.



Graph 4. Planted forest surface throughout the country, by species group (hectare '000s). *Source:* SAGPyA, 2001.

By agreement with the SAGPyA and pursuant to the RPPF scheme, the Employment and Occupational Training Office of the Ministry of Labour and Social Security implemented from 1995 to 1998 the National Programme of Intensive Afforestation, *Forest Ar*. Using a fast-track mechanism, the programme allowed for the creation of a great many jobs for family breadwinners in forest nurseries, planting, forest management and exploitation and other primary forest activities.

While the Forest Ar programme was running, jobs were created for about 33,000 beneficiaries (SAGPyA, 2001).

In the context of the SAGPyA's National Forestry Plan, it is estimated that if afforestation proceeds through to 2004 at a rate of 200,000 ha annually, about 100,000 new jobs a year will be created, bearing in mind that the sector uses more labour than the construction industry. It has been calculated that each hectare planted generates half a job. Forest development is especially significant for the regional economies, and Argentina has 15 million hectares that do not compete with agriculture or livestock activities, because they are located in marginal areas of the country (SAGPyA, 2001).

Generation of investment

Forestry has undergone far-reaching change in Argentina in recent years. From 1992 to 2001, investments totalling $4.8 billion were made in the forestry-industry sector (wood manufactures, pulp and paper and afforestation). It is expected that in the coming decade close on $4 billion of new investment will be made (ADI-SAGPyA, 2001).

Responses to forest policy in Santiago del Estero

Planted forests in Santiago del Estero are only incipient, but nonetheless occupy large irrigable and dry areas with good forest aptitudes for the planting of fast-growing species of high economic value. The available surfaces in the province that are potentially suitable for artificial plantations are: 120,000 ha in the River Dulce catchment area, 100,000 ha on the banks of the River Salado, 100,000 in the eastern zone and 100,000 in areas scattered throughout the province.

Throughout the lifetime of the forest incentive system, the SAGPyA promoted in the province of Santiago del Estero the species eucalyptus (*Eucaliptus sp*) and *Melia sp* in dry areas and poplar (*Populus sp*) in irrigable areas.

The scant surface area afforated in the province up until 1998 under the Incentive System comprised 4,202 ha (DEAyF, 2000), 55% of this correspond to afforestations with poplar trees planted in the irrigated area.

Subsequently, the acceptance of the National Law No. 25080 brought the dictation of Provincial Law No. 6466 of adhesion in 1999. The Act included among its benefits subsidies for afforestation. According to the report of the Santiago del Estero Agriculture, Livestock and Forest Economy Office, from 1999 to the present the province has received numerous afforestation plans in the context of the benefits afforded under Act 6466. The afforestation projects applied for total 17,302 ha.

Materials and Methods

Study area

The rural producers aim of study belong to the irrigated area of Río Dulce in Santiago del estero. This area is located in the west-centre of the province, between coordinates 27º 25' and 28º 15' of latitude south, and 63º 50' and 64º 20' longitude west, in both riverbanks of the river. The area has a surface of 300.000 hectares, also has the biggest agrarian production in the province and generates the 60% of the provincial Gross Agrarian Production (UESRRD, 1992).

The study area counts with the higher number of afforestations produced under the subsidies system (DEAyF, 2000). The Río Dulce irrigable area is shown in Figure 2.

Primary data and applied techniques

The field data were gathered through a structured survey on 152 agriculture and livestock undertakings selected from a satellite image of the Santiago del Estero catchment area. The variables making up the survey covered a range of social and economic, structural, productive and environmental-sustainability characteristics describing the realities of rural producers in the study area.

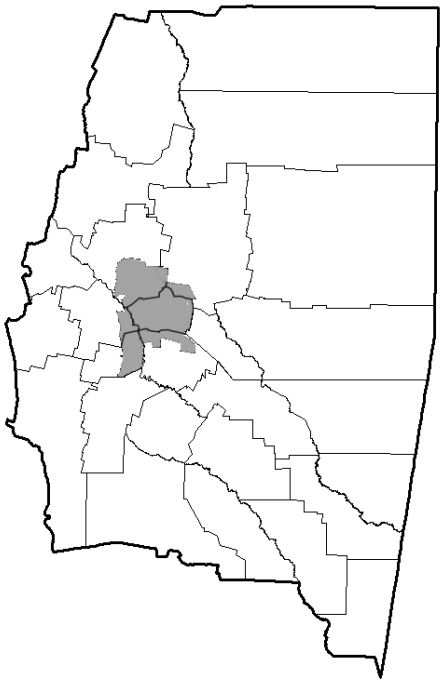


Figure 2. Location of the Río Dulce drainage area in Santiago del Estero. *Source:* FCF-UNSE, 2003. Remote Sensing Laboratory Files.

The sample was put together by a random sampling technique: two-stage conglomerates sampling (González García *et al.*, 1993).

The information obtained through the surveys was utilized to identify the farm-type or representative farms in the area. Later on optimization mathematical models were designed to be used for each type of representative farms or farm-types.

The rural undertakings were then classified and typified (Escobar and Berdegué, 1990) using multivariate statistical analysis. Based on the survey data, we selected a range of key variables and redefined synthetic variables and factors so as not to lose information on the set as a whole; this allowed for a reduction of the problem. Factors in common were redefined using factorial analysis (Manly, 1986; Afifi and Clark, 1999). To classify the sample into homogeneous groups of undertakings, cluster analysis techniques were used (De Olivera *et al*., 1990; Afifi and Clark, 1999).

There exist similar papers on typification applying the multivariate statistical analysis, such as Rodríguez Ocaña *et al.*, 1998; McKenna, 2003; Jenkins and Anderson, 2003, among others. A multiple-variable typification has been scarcely applied to the agrarian sector in the province analyzed. Álvarez y Paz (1997), Radrizzani (2000), Montenegro (2000) and Paz (2002) are a few exceptions to this fact.

For each representative undertaking we designed a mathematical model and solved the optimization problem, i.e., a production plan was found optimizing use of available resources. For the purpose, we used linear programming techniques (Schrage, 1999; Rehman, 2001). As to the application of the linear programming techniques, the following experiences can be mentioned: Donini and Barbiroli, 1997; Díaz Balteiro and Prieto Rodríguez, 1999; Gargano *et al.*, 1999; Lam and Moy, 2003, among others.

To formulate a linear programming optimization model was necessary: 1) to formulate an objective function under a maximization principle; 2) to calculate technical coefficients for different production possibilities; and 3) to determine the restrictions due to resources limitations on the farms. For each alternative activity the input-output coefficients were calculated, as well as the income and expenses associated to each activity. As income was taken the gross margin of the productive activity. The costs (from the activities that contribute as resources) were considered as the direct costs.

For all models, the activity of afforestation was included as another option to be assessed, on the assumption that the producer benefits from the Central Government subsidy (US$253/ha for the irrigable area) within the forest plantation incentive policy, and is not willing to devote more than 30% of total surface area of the estate to that activity.

After determining the optimal solution, we performed sensitivity analysis (Frank, 2001) in order to quantify the extent to which the solution might vary if any data were changed.

Results

The survey results provided the information needed to assess the response of producers in the Santiago del Estero catchment area to the afforestation subsidy scheme.

The response of producers in the irrigable area

Surveys of producers in the irrigable area of Santiago del Estero allowed for an appraisal of the state

of affairs. Statistical processing of the data collated in the surveys brought forth the following results:

Productive orientation

The producers in the sample were classified according to their productive orientation: agriculture, livestock, afforestation or mixed. The results indicate that 60% had agriculture as their main activity, 10% were devoted exclusively to livestock farming and 30% carried on mixed activities (agriculture and livestock). As for forestry production activities, none of the producers engaged in afforestation as their sole productive strategy; rather, it was included as a supplement to their core activity.

Awareness of the subsidies scheme

75% of the producers surveyed were unaware that there existed State subsidies to afforestation.

Subsidised afforestation

Only 5% of the sample responded to the stimuli of State afforestation subsidies. Eight producers were recorded as having given over some portion of their land to planting forest species such as poplar, eucalyptus or carob. All eight did so under the auspices of the Government's Incentive System.

Representative undertakings

The results of clustering allowed for identification of four typical or representative undertakings in the study area, which were described and typified by the quantitative and qualitative characteristics of their respective clusters of reference (Table 5).

The matrices for the corresponding mathematical models were constructed for the representative undertakings of the area. The criterion for inclusion of alternative activities in the models was to incorporate those that were feasible in the light of ecological, social and economic conditions of each rural undertaking. Once the optimal solution was obtained for models it was verified, that only the farm-type 1 may have the forest activity as a productive alternative in the optimal production play. Accordingly only the results of this farm model (type 1) are presented here.

Optimization model parameters

For this model, the farm-type 1, parameters are set down in Table 6. Table 7 presents the respective mathematical model for linear programming.

In Table 7, objective function Z (total gross margin) is represented as the addition of the individual gross margins multiplied by the respective levels of each activity. The restrictions on the righ hand side were calculated on the base of the availability of the existing resouces. For resource «land» several restrictions were formulated accordingly to different requirements along the year, with the objective of representing adequately its use. With identical criterion were formulated the restrictions for the resources «labor» and «mechanical labor», taking into account different periods along the year. When is was necessary to hire additional labor due to an insufficient available labor, this restriction was introduced into the matrix. Adittional labor was treated as an activity which value, into the function Z, is its direct cost. The activity

Table 5. Characterization of the four farm types

Aspects	Farm-type 1	Farm-type 1	Farm-type 3	Farm-type 4
Surface	700 ha	150 ha	50 ha	80 ha
Productive system	Agriculture exclusively	Agriculture and livestock	Agriculture exclusively	Agriculture exclusively
Labour	Permanent labour	Permanent labour	Family labour	Temporary labour and family labour
Machinery	Modern and full	Modern and full	Old, rudimentary	Old and basic
Availability of capital	No restriction	No major restriction	Major restriction	Some restriction
Experience in activity	17 years	30 years	45 years	40 years
Income from other sources	None	Exist	None	None

Source: Coronel, 2003.

Table 6. Parameters of the model type property

Aspects	Parameters	Additional remarks
Surface	700 hectares.	Up to 210 ha may be afforested.
Permanent labour	3 employees.	7,200 man-hours/year.
Temporary labour	When required.	
Family labour	NO.	
Tractors	4 units of 109 HP.	7,200 tractor-hours/year.
Activity	Agriculture exclusively.	
Production alternatives	Early maize-Late maize. Wheat- Soy-Cotton. Alfalfa (non-seasonal bales). Alfalfa (seasonal bales). Poplar afforestation.	Lifetime of alfalfa is 4 years. Afforestation felling age is 12 years.
Availability of capital	No major restriction.	More than one annual occupation can be allocated to land. Choice of immediate or deferred sale of alfalfa bales.
Technology used	Mid-to High-(mechanized tasks and harvesting).	For large producers.

Table 7. Linear programming matrix for the model type property

Activities	Early maize (ha)	Late maize (ha)	Wheat (ha)	Cotton (ha)	Soy (ha)	Hired labour (hs H)	Alfalfa planting (ha)	Alfalfa production (ha)	Alfalfa storage (bales)	Green alfalfa sale (bales)	Dry alfalfa sale (bales)	Poplar planting (ha)	Wood production (ha)	*RHS (unit)
Z Maximum =	1,030.09	928.94	535.84	1,177.91	577.13	–2.02	-443.50	–496.92	–0.242	2.01	3	–627.99	1,044.15	$
Land July-Sept	1		1	1	1		1	1				1	12 ≤	700 ha
Land Oct-Dec	1	1	1	1	1		1	1				1	12 ≤	700 ha
Land Jan-Mar	1	1		1	1		1	1				1	12 ≤	700 ha
Land Apr-June		1	1				1	1				1	12 ≤	700 ha
Labour Dec-Feb	0.6	0.45		3.42	0.38		3.55	7.54					3.25 ≤	1,800 m-h
Labour Mar-May		1.45	3.35	3.6	0.6		0.74	5.03				5.27	≤	1,800 m-h
Labour June-July			1.03				1.04	0.51				1	≤	1,200 m-h
Labour Aug-Nov	3.71	2.51	1.52	5.44	4.78		1.04	5.03				0.95	3.25 ≤	2,400 m-h
Total annual labour	14.31	14.41	15.9	22.46	15.76		16.37	28.11				17.22	16.50 ≤	7,200 m-h
Hired labour	36	36	36	44.8	28	–1	24	36.5				107.8	515.8 ≤	0 m-h
Machine Dec-Feb	0.6	0.45		3.42	0.38		3.55	7.54					3.25 ≤	1,800 t-h
Machine Mar-May		1.45	3.35	3.6	0.6		0.74	5.03				5.27	≤	1,800 t-h
Machine June-July			1.03				1.04	0.51				1	≤	1,200 t-h
Machine Aug-Nov	3.71	2.51	1.52	5.44	4.78		1.04	5.03				0.95	3.25 ≤	2,400 t-h
Total annual machine	4.31	4.41	5.9	12.46	5.76		6.37	18.11				7.22	6.50 ≤	7,200 t-h
Alfalfa prod. permit							–4	1					≤	0 ha
Alf (green bales)							–312	–728	1	1			≤	0 bales
Alf (dry bales)									–0.9		1		≤	0 bales
Storage space									0.126				≤	7,200 m^3
Wood prod. permit												–1	1 ≤	0 ha
Max. forest surface												12	≤	210 ha

«alfalfa» was divided in three parts (implantation, production and storage) with the purpose of differenciate the economic usefulness of producing and them delay its sale. The activity «afforestation» was divided in two parts (implantation and wood production) since it is a multi-annual activity with a wood cutting rotation of 12 years: for each hectare planted with poplars 12 hectares of land are required (one hectare for each year required until the poplars reach the wood cutting age).

The optimal solution

The mathematical solution of the linear programming models gave the target function value, the activities within the optimal solution and their respective proportions. Table 8 illustrates those results for the model type.

According to Table 8, the optimal economic plan entails engaging in the early-maize activity on a surface area of 503 ha only, and eschewing the other production alternatives. The value of the target function at the optimal point totals $481,674 and represents the total gross margin for the model representing the first undertaking.

Table 8. Optimal production plan for the model type property

Response report Target cell (maximum)	
Name	**Value**
Maximum Z ($)	481,674.09
Activities	
Name	**Level**
Early maize (ha)	503.14
Late maize (ha)	0
Wheat (ha)	0
Cotton (ha)	0
Soy (ha)	0
Hired labour (man-hours)	18,113.20
Alfalfa planting (ha)	0
Alfalfa production (ha)	0
Alfalfa storage (green bales)	0
Green alfalfa sales (green bales)	0
Dry alfalfa sales (dry bales)	0
Poplar planting (ha afforested)	0
Wood production (ha felled)	0

Sensitivity analysis

Sensitivity analysis provides information about the use of resources with their respective opportunity costs and activity replacement costs with the corresponding validity ranges for coefficients. Table 9 sets out the sensitivity report for the model type.

Table 9 shows resource utilization levels. The optimal plan uses only 503 ha out of the 700 ha available, and occupies the land during the period July through March.

Opportunity cost of resources

Table 9 (continuation) shows that opportunity costs are zero for non-constraining inputs. For the model type, neither land nor hours of mechanized labour are constraining resources because under the optimal plan both are available to excess. This means that these resources can be reduced to some extent without reducing the value of the target function.

Updated value of afforestation subsidy

Analysis of the «wood production» activity shows that it carries a very high replacement cost and very broad ranges of increase and decrease (Table 9). The coefficient of the target function is $1,044.15/ha, and the permissible coefficient increase is $1,102.24/ha. This means that its gross margin measured in terms of net current value (NCV) must increase by 105.5% and reach at least a value of $2,146.4/ha ($1,044.15 + $1,102.24) to become part of the optimal solution.

In order to examine possible changes that would enable this alternative to form part of the solution, we calculated the yield that wood production would have to attain: with a replacement cost of $1,102.24 and a net price of wood of $13.18/tn ($52/tn minus $38.82/tn), yield must rise by 83.62 tn/ha ($1,102.24/ha/ $13.18/tn). In other words, there would have to be a yield of 333.6 tn/ha, which is in fact unfeasible under the biological conditions of the irrigable area.

In addition, to see how the NCV of afforestation might achieve the minimum value of $2,146/ha, we calculated the amount that would have to be contributed by State aid. The results of the calculation show that instead of $720/ha, State aid would have to be $2153/ha. This is unsurprising, given that the amount set down ten years ago has become out of date due to the sharp devaluation of the Argentine peso, which increased the price of inputs.

Table 9. Sensitivity report on the model type property

Sensitivity report					
Activity	**Activity size**	**Replacement cost**	**Target coefficient**	**Allowable increase**	**Allowable decrease**
Early maize	503.14	0	1,030.09	1E+30	107.09
Late maize	0	–107.84	928.93	107.84	1E+30
Wheat	0	–600.62	535.83	600.62	1E+30
Cotton	0	–415.20	1,177.90	415.20	1E+30
Soy	0	–533.79	577.13	533.79	1E+30
Hired labour	18,113.20	0	–2.02	2.02	19.34
Introduction of alfalfa	0	–820.24	–443.49	820.24	1E+30
Alfalfa production	0	–661.80	–496.91	661.80	1E+30
Alfalfa storage	0	0	–0.24	0.90	0.44
Green alfalfa sale	0	–0.44	2.01	0.44	1E+30
Dry alfalfa sale	0	0	2.99	1.01	0.49
Poplar planting	0	–1,997.88	–627.98	1,997.88	1E+30
Wood production	0	–1,102.24	1,044.15	1,102.24	1E+30
Restrictions					
Name	**Resource use**	**Shadow price**	**RHS coefficient value (constraints)**	**Allowable increase**	**Allowable decrease**
Land July-Sept	503.14	0	700	1E+30	196.85
Land Oct-Dec	503.14	0	700	1E+30	196.85
Land Jan-Mar	503.14	0	700	1E+30	196.85
Land Apr-June	0	0	700	1E+30	700
Labour Dec-Feb	301.88	0	1,800	1E+30	1,498.11
Labour Mar-May	0	0	1,800	1E+30	1,800
Labour June-July	0	0	1,200	1E+30	1,200
Labour Aug-Nov	1,866.66	0	2,400	1E+30	533.33
Total annual labour	7,200.00	66.89	7,200	2,057.14	7,200
Hired labour	0	2.02	0	18,113.20	1E+30
Machine Dec-Feb	301.88	0	1,800	1E+30	1,498.11
Machine Mar-May	0	0	1,800	1E+30	1,800
Machine June-July	0	0	1,200	1E+30	1,200
Machine Aug-Nov	1,866.66	0	2,400	1E+30	533.33
Total annual machine	2,168.55	0	7,200	1E+30	5,031.44
Alfalfa prod. Permit	0	0	0	1E+30	0
Alf (green bales)	0	2.45	0	57,142.85	0
Alf (dry bales)	0	2.99	0	1E+30	0
Storage space	0	0	7,200	1E+30	7,200
Wood prod. Permit	0	0	0	1E+30	0
Max. forest surface	0	0	210	1E+30	210

Conclusions

Description and analysis of the mechanisms of forest incentives and their impact on the national economy show that:

1. Act no. 25,080 affords economic and tax certainty and benefits to forestry investments throughout the time required for such activities.

2. The benefits of Act no. 25,509 substantially improve the profitability of forestry undertakings, avoiding the need to invest capital in land purchases and thus encouraging institutional and private investors to take up holdings in forestry businesses.

As regards productive activities in the Santiago del Estero irrigable area, the following conclusions may be drawn:

3. Rural undertakings in the area are agricultural. There is no awareness or tradition of forestry.

4. Agrarian producers in the area do not tend to diversify their productive activities.

5. The benefits of forest incentives went to waste in the province of Santiago del Estero. Hence the opportunity to increase forest surface area in the province was lost, and is still being passed up. The forest incentive policy for the irrigable area of Santiago del Estero should be changed, for at least the two reasons arising from the results of this research work. First, there is insufficient information about the incentives and, therefore, scant producer response. Secondly, the value of the subsidy has not been updated to account for the effects of devaluation of the Argentine peso.

These conclusions about the productive activities of the province point up the need for technical advice and awareness-raising regarding the benefits of productive diversification, geared to sustainable long-term management of the resource, perhaps at the cost of giving up some degree of short-term profit. On this criterion, afforestation may be recommended not only by way of a long-term savings account for the producer but also as an ecological requirement, bearing in mind the scant replacement of natural forest in the province.

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