

# The Socioeconomic Impact of Truffle Cultivation in Rural Spain<sup>1</sup>

NICKLAS SAMILS<sup>\*,2</sup>, ANTONI OLIVERA<sup>3</sup>, ERIC DANELL<sup>4</sup>, SUSAN J. ALEXANDER<sup>5</sup>,  
CHRISTINE FISCHER<sup>3</sup>, AND CARLOS COLINAS<sup>6</sup>

<sup>2</sup>Department of Forest Mycology and Pathology, Swedish University of Agricultural Sciences (SLU),  
Box 7026, SE-750 07, Uppsala, Sweden

<sup>3</sup>Centre Tecnològic Forestal de Catalunya Pujada del Seminari, s/n E-25280, Solsona, Spain

<sup>4</sup>Museum of Evolution, Botany section, Uppsala University, Norbyv.16, SE-752 36, Uppsala, Sweden

<sup>5</sup>Alaska Region, USDA Forest Service, P.O. Box 21628, Juneau, AK 99802, USA

<sup>6</sup>Department Prod. Veg. I C. Forestal, Av. Rovira Roure 191, E-25198, Lleida, Spain

\*Corresponding author; e-mail: Nicklas.Samils@mykopat.slu.se

---

**The Socioeconomic Impact of Truffle Cultivation in Rural Spain.** Commercial black truffle (*Tuber melanosporum*) plantations have been promoted in Europe with the intention of benefiting rural economies while conserving biodiversity through the expansion of oak woodlands. In this context, a socioeconomic study was conducted around the town of Sarrion in eastern Spain, where government subsidies have supported oak reforestation and truffle cultivation in unproductive hilly areas since 1987. Currently there are about 4,500 ha of truffle orchards in the surrounding county and 530 members in the local truffle association, which has provided a key forum for truffle cultivators to share technical, financial and administrative experiences. Structured interviews were carried out in 2002 with a number of orchard owners, as well as representatives of financial and governmental institutions. Truffles, which are harvested using trained dogs, typically fetch local cultivators average prices of 220–670 EUR/kg, although retail prices of high-quality specimens may reach twice this amount. In addition to the direct economic impact, an increase in local land prices was also documented, as well as a tendency for continued expansion of truffle orchards, and thus oak reforestation. In conclusion, the promotion of truffle cultivation through autonomous community and provincial government subsidies, in conjunction with support by local banks, a dedicated local truffle association, and growing interest on behalf of local farmers, seems to have achieved the mutual goals of biodiversity conservation and improving the rural economy in this region of Spain.

**Impacto Socioeconómico del Cultivo de la Trufa en España.** Las plantaciones orientadas hacia la producción de trufa negra (*Tuber melanosporum*) se impulsaron en Europa con el objetivo de favorecer las economías rurales, así como de conservar la biodiversidad a través de la expansión de los encinares. Dentro de este contexto, se llevó a cabo un estudio socioeconómico en la zona del municipio de Sarrion y su contorno localizada en el la parte oriental de España, donde existen subvenciones para la reforestación y el cultivo de la trufa desde el año 1987. En la zona estudiada, actualmente hay alrededor de 4.500 ha de plantaciones de trufa, además de una asociación de cultivadores de trufa con 530 miembros, la cual sirve de plataforma para que sus socios compartan experiencias técnicas, financieras y administrativas. En el año 2002 se llevaron a cabo entrevistas a propietarios de plantaciones, así como a los representantes de instituciones financieras y gubernamentales. Las trufas, que son recolectadas con perros adiestrados, generalmente son vendidas por los propios cultivadores a precios que oscilan entre los 220–670 EUR/kg, aunque en la venta al detalle, el precio de las trufas de alta calidad puede doblar dichas cantidades. Además del impacto económico, también observamos un incremento en el precio del suelo rústico, así como la expansión continuada de plantaciones de trufa y de reforestación. En conclusión, el progreso del cultivo de la trufa a través de las subvenciones de la Comunidad Autónoma y la Diputación Provincial, con la colaboración de los bancos locales, una comprometida asociación de cultivadores de trufa y un creciente interés por parte de los agricultores locales, parece que ha alcanzado los objetivos comunes de biodiversidad y conservación junto con la mejora de la economía de esta región de España.

**Key Words:** *Tuber melanosporum*, ethnomycology, ethnobotany, edible fungi, rural development, truffle.

---

<sup>1</sup>Published online 21 August 2008.

## Introduction

A fresh black truffle has an incomparable aroma that is much appreciated in European gastronomy, where it is celebrated as the culinary “black diamond.” The black truffle is the hypogeous mushroom or fruiting body of the perennial ectomycorrhizal fungus, *Tuber melanosporum* Vittad. The subterranean growth habit makes truffles highly resistant to desiccation and frost (Pegler et al. 1993), but makes them dependent upon animals like wild boars and moles for spore dispersal (Trappe 1988). *T. melanosporum* prefers calcareous, well-drained soils and can live in ectomycorrhizal symbiosis with a broad range of hosts, including *Carpinus*, *Castanea*, *Cedrus*, *Cistus*, *Corylus*, *Fagus*, *Helianthemum*, *Ostrya*, *Pinus*, *Populus*, *Quercus*, and *Tilia* (Hall et al. 1994). *T. melanosporum* produces phytotoxic compounds that inhibit the growth of vegetation in the soil under the host tree, producing a bare zone called the *brûlé* or “truffle burn” (Pacioni 1991) that is an indicator of its presence.

Although historical data regarding truffle supply and demand is limited, it is clear that wild truffle production in Europe has suffered a catastrophic decline over the past century (Callot 1999). This decrease can be explained by the interaction of ecological and social factors. The exodus of the rural population in the 1960s meant that the collection of firewood, which served to clear the forest understory of fallen trunks and branches, dramatically decreased. Concurrently, there was a rapid decline in traditional shepherding practices and hence grazing, while crop fields ill-suited to mechanized farming were gradually replaced by forest vegetation. The consequence has been that forest cover has increased, while forest-pasture transitional areas maintained by moderate levels of human interference—precisely the kind of open woodland conditions that favor truffles—have decreased (Reyna 2007). Another contributing factor has been the clearing of oak woodlands and reforestation with faster-growing conifers, mostly pines intended for timber production when market conditions were more favorable. Finally, the harvesting of unripe truffles with inadequate tools by unskilled collectors may have also contributed to the destruction of existing truffle beds (Estrada and Alcántara 1990).

Declining production of wild truffles coupled with high consumer demand led to research and

experimentation with truffle cultivation via the planting of ectomycorrhizal tree hosts, especially oak and filbert, inoculated with black truffles (Bencivenga and Di Massimo 2000; Hall et al. 1994; Olivier et al. 2002). The inoculated host seedlings are first grown in controlled conditions in greenhouses, where they require ten months to two years to develop abundant *T. melanosporum* mycorrhizae within the roots. These seedlings are then outplanted in orchards at densities of up to 300 seedlings per ha (Olivier et al. 2002). Truffles frequently appear between the fifth and sixth years after the seedlings are planted.

The first plantations where truffles were produced by this method were in Italy in 1975 and then in France in 1977 (Chevalier and Grente 1979). The largest truffle orchard in Spain, covering 600 hectares, was established in 1979 and still maintains an important production (Oliach et al. 2005). Experimental truffle orchards in Sweden were established with the black truffle species, *T. aestivum* Vittad. (= *T. uncinatum* Chatin) in 1999, followed by commercial production of inoculated seedlings in 2000 (Wedén et al. 2001). The inoculation technique has also made it possible to establish truffle plantations in places with suitable truffle-growing climates like New Zealand where esteemed *Tuber* species do not occur naturally (Hall et al. 1994; New Zealand Truffle Association 2001).

Total global production of all truffle species was estimated to be 260 metric tons for 2000 (a low production year), with black truffle production estimated at 44 metric tons (Olivier et al. 2002). The European production of black truffle experiences large yearly variations mainly due to weather factors. Annual European production has been estimated to vary from 45 to 150 metric tons (Olivier and Van Griensven 2000). Even though Asian black truffles have recently penetrated the European market (Riouisset et al. 2001), it is nonetheless expected that an increase in European production to 200 metric tons could still be absorbed by the growing demand without significantly depressing prices (J.M. Olivier, pers. comm. 2002). Indeed, the spread of truffle cultivation to new regions such as Sweden and New Zealand has resulted in increased local awareness and appreciation of truffles in areas where they were not traditionally consumed, which may, in turn, lead to increased demand over the long term.

From November to March when black truffles are in season, they fetch up to 920 EUR per kg at wholesale markets within Europe (Wedén and Danell 1998), while off-season truffles from New Zealand can go for as high as 1,413 EUR per kg (Lefevre and Hall 2001). Because of these extraordinary prices, black truffle cultivation beckons as a tempting alternative to the more mundane crops (cereals, almonds, olives) grown in regions with conditions suitable for truffles. Truffle cultivation does entail significant financial risks, however. While truffle-inoculated oaks may occasionally produce some truffles as early as four or five years after outplanting, production typically does not begin for seven to ten years, and full production can take as long as 20 years to achieve (Lefevre and Hall 2001). Truffle-inoculated filberts, on the other hand, can begin producing as early as the fourth year (Hall et al. 1994), but production tends to decline early, leading most cultivators to choose oak (García et al. 2007).

Well-documented case studies on the benefits of truffle production are lacking. This study aims to investigate the socioeconomic impact of the

establishment of truffle orchards in the Spanish town of Sarrión and its rural surroundings. Beginning around 1995, farmers in and around Sarrión have taken advantage of government subsidies to plant truffle orchards with the hope of growing and selling this culinary treasure.

### Study Area and Methods

This study was carried out primarily in and around the town of Sarrión, in the county of Gúdar-Javalambre, in the province of Teruel, within the autonomous community of Aragón, which is situated in eastern Spain (Fig. 1). Sarrión lies at an altitude of 981 m, with an average annual precipitation of 467 mm and a mean temperature of 12.8°C (Instituto Nacional de Meteorología 2002). The municipality of Sarrión had 1,021 inhabitants in 2002, of whom 40% were retired. Among the active working population, 70% were in the industrial sector, 15% in the hotel business, and 15% in the agricultural sector (Sarrión City Council 2002). According to the Sarrión City Council, there was zero unemployment. However, young people often move

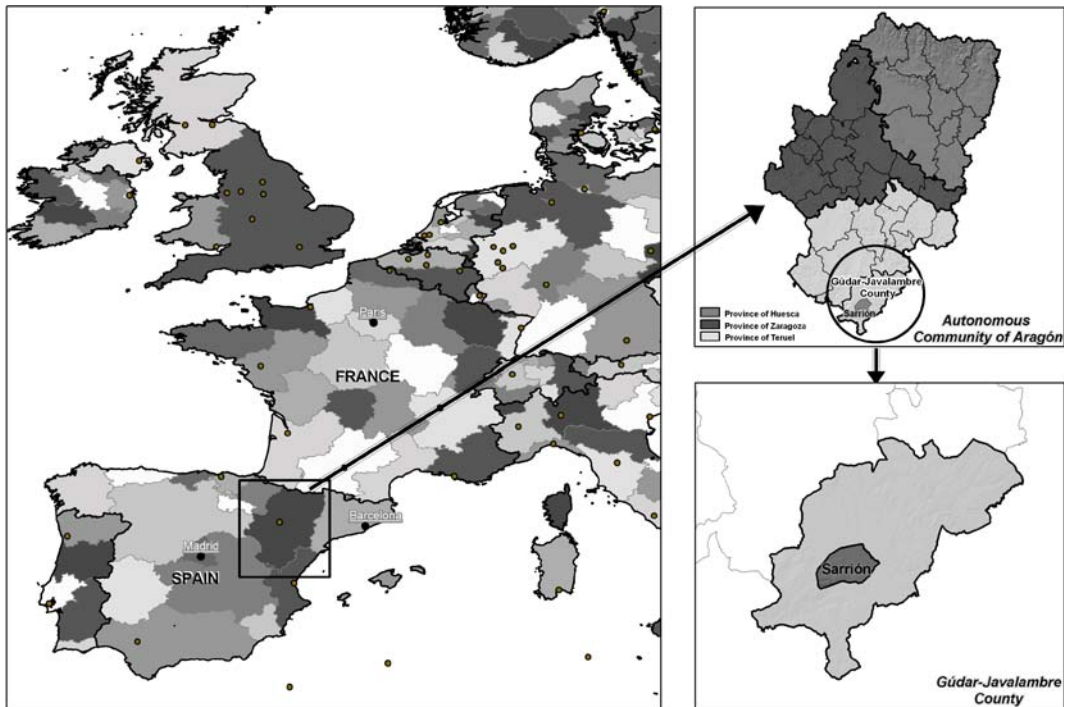


Fig. 1. Sarrión is situated in the county of Gúdar-Javalambre, in the province of Teruel within the autonomous community of Aragón, which is located in eastern Spain.

away for work or education and usually do not return. Population grew 1.3% in the year 2001 despite emigration of young people and a higher death rate than birth rate. The deficit is apparently made up by significant numbers of temporary foreign immigrants who provide manual labor and domestic help, some of whom stay.

The truffle plantation economy has developed relatively recently in the county of Gúdar-Javalambre among a rural population which has not traditionally been involved in truffle commercialization or consumption. A standardized questionnaire was developed and administered in July 2002 to 18 owners of truffle orchards, as well as to four members of the Sarrión City Council, all of whom were chosen randomly. In addition, we interviewed two bank officials, a notary public, and a representative of the *Asociación de Truficultores y Recolectores de Trufa de Teruel* (Truffle Cultivators' and Collectors' Association of the Province of Teruel). The results presented below refer mostly to data collected in 2002 (Samils 2002); where more recent information is included, the year has been specified.

## Results and Discussion

### THE BEGINNINGS OF TRUFFLE CULTIVATION

Black truffles occur naturally in the area surrounding Sarrión, but truffle trade and consumption is a relatively new phenomenon. Several inhabitants of the region became interested in truffle hunting in the 1960s. Previous to that decade, truffles were gathered locally only by seasonal collectors who came mostly from northern Spain and who had direct contact with the long-standing, vibrant truffle markets in France. As the French crop declined, these markets began seeking new sources for fresh truffles. In 1987, a truffle cultivation class was offered in Sarrión by The National Employment Office, followed by an organized visit to recently-established cultivated truffle orchards in France. This event launched truffle cultivation in Sarrión.

Of the truffle orchard owners interviewed, 72% had engaged in truffle gathering prior to knowing about the possibility of establishing cultivated truffle orchards. A third of these observed that wild truffle production had declined in recent years, another factor contributing to local interest in truffle cultivation. The reasons given for this decline varied among those interviewed: some blamed it on a decrease in summer

rainfall, others on an increasing population of wild boars that destroy natural truffle beds, and still others on overexploitation or incorrect harvest methods by commercial truffle-hunters.

### THE TRUFFLE ASSOCIATION

The Truffle Cultivators' and Collectors' Association of the Province of Teruel was founded in 1997 by twelve members with the stated intention of strengthening the truffle sector and improving institutional support. Sarrión's annual December truffle fair (FITRUF) began in 2001 and has continued to cultivate local interest while drawing national and international attention. In 2002, when these interviews were conducted, the association had 148 members, and by 2007 membership had grown to 530. The total land area dedicated to truffle orchards has likewise grown, though not proportionally to the membership in the truffle association. The Sarrión City Council estimated that there were about 1,400 ha of truffle orchards in 2002, and that area had expanded to 4,500 ha by 2007. Using the 2002 data, the average orchard size per owner was about 9.5 ha, while more recent data yields an average orchard size of about 5 ha. This decline in average orchard size is due to the large number of smaller landowners who have invested more recently in truffle orchards after witnessing the success of the initial, larger orchards.

According to the truffle association representative interviewed, the association hopes to represent both wild truffle collectors and truffle orchard owners in their dealings with different public agencies. The association has helped members apply for government subsidies from both the province of Teruel and the autonomous community of Aragon. It has negotiated regulations concerning the gathering and marketing of truffles, and has cooperated with other local truffle cultivators' associations throughout Spain and elsewhere in Europe. The truffle association has organized "open house" meetings, symposia, lectures, and other events to share scientific and technical information related to truffle cultivation among members and with the broader public. It also published a map of the truffle region for tourists. So far, the association has not promoted experimentation with other truffle species, maintaining that much is still to be achieved in improving *T. melanosporum* cultivation before attempting to diversify production. Despite its

many successes, however, the association representative noted that interest among the local youth has so far been weak.

#### FINANCING A TRUFFLE ORCHARD

Favorable tax legislation and government subsidies have clearly contributed to the growth of truffle orchards around Sarrión. Although truffle orchards might technically be considered plantations, they are treated in the property registry as tax-free shrublands. Moreover, the government of the autonomous community of Aragón has been subsidizing the reforestation of land not suitable for cereal production since 1995. Currently, the subsidies for reforestation applied to establishing truffle orchards amount to 2,300 EUR per hectare. These subsidies are used mainly to purchase truffle-inoculated tree seedlings, although, depending on annually changing provincial and regional governmental rules, some subsidies have also been directed towards fencing (to keep out wild boar) as well as labor costs (planting, maintenance).

The Sarrión City Council members interviewed clearly believe that truffle orchards will continue to proliferate and expressed an interest in supporting their expansion, for example, by improving irrigation infrastructure. In order to finance irrigation systems and other unsubsidized costs associated with truffle orchards, the majority of the orchard owners (72%) relied exclusively on personal savings. Only one orchard owner relied exclusively on bank loan money, while four (22%) used a combination of bank loans and personal savings.

Bank relations were considered good by 83% of the truffle orchard owners interviewed. Furthermore, since government subsidies to truffle growers are paid through the banks, the latter have an active interest in promoting the truffle business. Truffle orchard owners were noted for their continually improving financial situation, and typical loan repayment was expected within 10–15 years since truffle production begins 6–8 years after the inoculated seedlings are planted. Just over half (56%) of the interviewed truffle orchard owners did not yet have any production as of 2002, but most of them were optimistic about future profits. Of those whose orchards were already producing at the time of the interviews, nearly half had invested their profits in new orchards.

#### TRUFFLE ORCHARD PLANTING AND MANAGEMENT

The host trees used in the county are mainly *Quercus ilex* L. (reported by 100% of orchard owners interviewed), *Q. humilis* Mill. (55%), *Corylus avellana* L. (44%), and *Q. coccifera* L. (11%). Of the orchard owners interviewed, 61% inoculate their own seedlings, while the rest buy inoculated seedlings from authorized commercial nurseries, taking advantage of government subsidies. Seedlings purchased with government reforestation subsidies are required by law to remain in the soil for at least 20 years, even if they do not produce truffles. Therefore, proper inoculation and professional verification are crucial.

The first farmers in Sarrión to plant truffle orchards bought inoculated seedlings from nurseries in other regions of Spain or across the border in southern France. As of 2007, there are seven nurseries that specialize in truffle-inoculated seedlings in Sarrión and two more in nearby towns. Inoculated seedlings are typically sold for 6 EUR each, but a few of the orchard owners said they had acquired seedlings at discounts of up to 50%. Given that 300 seedlings are typically planted per ha, seedling purchase represents a significant initial investment, justifying the importance of government subsidies while also creating a profitable business for the truffle nurseries.

"Truffle dogs," specially trained to scent and locate these underground delicacies, also represent a significant investment, at 2,400–3,240 EUR for a fully-trained dog. Some farmers prefer to train their own dogs, while others rent a skilled dog to search their orchard in the first years after establishment. Eventually, care and training of a good truffle dog is an essential investment.

Our interviews as well as field observations in the orchards indicated highly variable rates of success in truffle production, possibly due to the difficulties in managing a crop that cannot be seen until it is ready for harvest, and to the absence of proven cultivation procedures. In 2002, the only sources of training available to local cultivators were technical assistance provided by the local truffle association, advice provided by the nurserymen at the time of seedling purchase, and the informal exchange of knowledge among orchard owners. Only 5% of the truffle orchard owners had had any direct contact with scientists, although nearly 80% have books about truffles.

It is not known precisely how many of Sarrion's inhabitants own truffle orchards. Given the small population and the large number of truffle association members, the proportion is certainly high. Some of those interviewed estimated that more than 50% of the inhabitants own a truffle orchard, while others claimed that every family had at least one orchard. Considerable variation was noted in the proportion of the interviewees' total land holdings that were converted to truffle production. On the one hand, 28% of orchard owners had dedicated all of their land to truffle production, while on the other, 22% had dedicated less than a quarter of their land to truffles. Cereals, almonds, and olives were most frequently mentioned as traditional agricultural crops that remain under cultivation. When asked if truffle cultivation demanded more work and effort than the traditional crops, 66% answered in the affirmative; however, 28% also believed that once the plantation matured, overall work would ultimately decrease when compared with traditional crops.

The reported ages of the orchards owned by interviewees varied from 0–15 years. Just over half (56%) had orchards older than 7 years, while 39% had only new orchards with no production yet. Proper maintenance and irrigation are crucial for successful truffle production (Bencivenga and Di Massimo 2000; Olivier et al. 2002). The potential life span of a productive truffle orchard is unknown since this is a relatively new crop. The oldest orchard in Spain, established in 1968 with *Q. ilex* (Reyna 2007), is actively managed and is still producing. Fencing and establishing wells for irrigation were the two investments most frequently undertaken by the larger landholders. Orchard maintenance involves mechanical harrowing with tractors between the rows of trees, and manual hoeing close to the trees to remove weeds until the phytotoxic effects resulting in the "truffle burn" develop. Our survey suggested that some truffle growers spent more time than was strictly necessary tending their orchards in order to create an aesthetically pleasing, garden-like environment.

#### ECONOMIC IMPACT

The most common venue for selling truffles is a weekly market held at a local restaurant in Estación de Mora, just outside Sarrión, during the truffle harvest season from November 15 to

March 15. This market was in operation in 2002 and has continued to operate through 2007. Sellers of both wild and cultivated truffles congregate at the market to sell to wholesale dealers or to consumers directly. Prices for black truffles vary greatly, depending on demand and quality. During the previous six years (2001–2006), the mean price paid for truffles throughout the season in this market varied from a low of 220 EUR/kg in 2002–2003 to a high of 670 EUR/kg in 2005–2006. The mean price paid in 2006–2007 was 470 EUR/kg (Daniel Bertolín, president of the truffle association in Teruel, pers. comm.). The majority of the truffles at the market are sold to wholesale buyers in France and Italy; thus, these prices have remained roughly two-thirds the typical retail value of fresh black truffles. In addition to this main marketplace, some truffle buyers visit orchard owners in their homes. Other outlets for local truffles include markets in Morella (Castellón), Vic (Barcelona), or as far away as Carpentras (Provence, France). In 2004, a business operated by four Sarrión women began selling locally-purchased fresh truffles and other truffle products to national and international customers.

Reliable data are not easily available for truffle production in the study area. Truffle orchard owners interviewed were reluctant to disclose this information, but our impression is that they do know their annual truffle production figures. Data from Italy reveal *T. melanosporum* production as high as 100 kg/ha/year in well-managed orchards, with more typical production in the range of 50–60 kg/ha/year (Bencivenga and Di Massimo 2000; Giovannetti et al. 1994). Black-truffle orchards thus appear to represent a promising rural economic alternative to the traditional cereal crops, especially considering that Aragón is not optimally suited to cereal production (typical harvests yield less than 3,000 kg/ha according to Departamento de Agricultura de la Diputación Aragón [2000]), while more suitable regions of Europe produce up to 10,000 kg/ha).

Table 1 compares typical gross annual income from cereal production in Aragón with the estimated potential gross annual income from a mature, well-managed truffle orchard. Truffles have the potential to generate some 6 to 50 times the gross income per hectare of traditional cereal crops. Although truffle plantations entail significant initial investments, require up to eight years

TABLE 1. ESTIMATED INCOME FROM CEREAL PRODUCTION OF NON-IRRIGATED FIELDS IN ARAGÓN COMPARED WITH ESTIMATED INCOME FROM TRUFFLE PLANTATIONS.

Crop	Yield (kg/ha/yr)	Price (EUR/kg)	Total Income (EUR/ha/yr)
Barley ( <i>Hordeum</i> "2cc")	2,535	0.116	294
Barley ( <i>Hordeum</i> "6cc")	2,780	0.114	317
Wheat ( <i>Triticum</i> "soft")	2,509	0.142	356
<i>T. melanosporum</i>	10–60	180–245	1,800–14,700

Cereal yields and prices are from Departamento de Agricultura de la DGA (2000); truffle yields are estimated from multiple literature sources (Bencivenga and Di Massimo 2000; Giovannetti et al. 1994; Olivier et al. 2002), while typical price ranges are from study data.

to enter production, and also involve significant risk, nonetheless the fledgling truffle economy generates high expectations, particularly when compared with the low economic yields from cereal cultivation.

Perhaps as a result of these expectations, there has been a marked increase in land values in the region. Until quite recently, far more people wanted to sell land than buy it, resulting in land so cheap that it was practically given away. Furthermore, much of the land throughout the province has been inherited through traditional family lines for generations and was never registered in the modern government land registries. The notary public whom we interviewed commented on a growing trend of property registration among the elderly, which he attributed to the sudden increase in land values: people want to ensure that their ownership is properly documented in anticipation of a future land sale.

Land price changes documented in the study area were compared to government estimates for the entire province (Secretaría General Técnica del MAPA 2005). Throughout the province, pasture lands (which are often rockier than agricultural lands and generally not as well suited to truffle cultivation) increased in price by an average of 54% from 1990 to 2004. However, when this increase is corrected for the 74% inflation rate of that same period, the net result is a decrease in actual land value. In the municipality of Sarrión, however, the corrected average price for agricultural lands (which are preferred for truffle orchards) increased by 300% during the same period. The bankers in town whom we interviewed could not definitely say whether the price increase was due solely to the establishment of truffle orchards, because land for cereal production and cattle grazing have also been in high demand in the region. However, one telling example occurred in 2004 when the

Spanish government expropriated part of a truffle orchard for road construction. The Government initially offered 1,200 EUR per ha, based on typical land prices for the province; the owner of the truffle orchard, however, took the case to court and the government eventually had to pay 30,000 EUR per ha.

Not surprisingly, half of the orchard owners interviewed claimed to look more positively upon the future since entering the truffle business; none reported seeing the future in negative terms, and all expected the truffle economy to remain important in the local economy. In a clear reflection of this optimism, 72% regarded truffles as a reliable income crop even though 39% reported no commercial production as yet. None of those interviewed believed that the price of truffles would decrease in the future, noting a continuing decline in wild truffle production in the midst of constant or growing demand. Fully 83% of those interviewed intended to expand their truffle orchards, and many expressed the hope that truffle cultivation would encourage young people to stay in Sarrión. Only one orchard owner among those interviewed had noted a significant overall improvement in the local economy as a direct result of truffle plantations; however, all believed that most business sectors in the area would eventually see economic benefits. It is also worth noting that the province of Teruel, where our study area is located, had an unemployment rate of 7.5% in 2002 (Instituto Nacional de Estadística 2004), while the town of Sarrión apparently had zero unemployment. It is unclear whether the truffle economy has contributed to this employment disparity, although some landowners mentioned hiring additional laborers to plant new orchards and carry out maintenance in established orchards.

### OTHER BENEFITS

All of the owners interviewed believed that truffle orchards were beneficial for the overall natural environment since otherwise this land would be abandoned as agricultural fallow and remain treeless; all considered their plantation activities as a kind of reforestation. It is important to note that government subsidies do not support truffle plantations *per se*, but rather the reforestation of oak woodlands, an activity considered beneficial for animal, plant, and wild mushroom biodiversity (Gärdenfors 1994). Other environmental benefits of truffle orchards noted by owners include their function as a potential firebreak (due to the 4 to 6-meter spacing between oak trees as well as the “truffle burn,” which keeps the understory free of brush and weeds), and the creation of favorable habitat for partridge and other ground-dwelling game birds, since both cattle (who trample the terrestrial nests) and foxes (who prey on them) are excluded or at least deterred by protective fencing around the orchards.

### PESTS AND OTHER PROBLEMS

The most frequently-cited problem, reported by more than 70% of the truffle growers interviewed, was predation of truffles and destruction of truffle-inoculated seedlings by wild boar. One orchard owner, for example, had lost 20% of his seedlings to wild boar. A third of the growers also mentioned problems with rabbits feeding on young seedlings. More than 80% of the growers claimed to have experienced no serious problems with diseases or insect pests, although some reported the occasional presence of aphids, caterpillars, leaf pathogens, and/or trunk malformations. One orchard owner had experienced problems from drought. The overwhelming majority (89%) had never experienced theft of truffles, while the remainder considered it only a minor problem. Since truffles are so easily concealed and so valuable, one owner expressed his concern that theft could become a more serious problem in the future, as it is in France where truffle thieves have been shot on occasion by owners of truffle orchards (Rocchia 1992).

One orchard owner noted that the fences around the orchards create a negative visual impact. These orchard fences have also raised the ire of hunters, who are accustomed to freely traversing forested land on their outings. Although the Sarrión City Council receives no

property taxes from the truffle orchards because they are registered as tax-free shrublands, they do receive considerable fees (about 14,000 EUR per year) from the hunters’ association. The council members whom we interviewed anticipated future problems with the fencing of orchards, and suggested that orchard owners leave the gates unlocked so that hunters may cross more easily.

Other potential problems that were mentioned were conflicts with cattle owners (again, over fencing) and envy among different orchard owners, resulting in disagreements over access and passage through adjacent orchards under different ownership.

Aside from the fencing issues, Sarrión City Council members saw no environmental or other threats posed by truffle orchards. All of the orchard owners interviewed believed that their truffle orchards were environmentally sustainable for the long term. All but two (89%) of the owners interviewed claimed not to use any pesticides or other chemicals in their orchards; however, one noted using pyrethroid insecticides while another used a slow release fertilizer.

### Conclusion

Cultivation of black truffles using inoculated seedlings has been an enticing agricultural alternative proposed for rural areas for more than 30 years, especially in France and Italy, where local gastronomic traditions have honored the “black diamond” for centuries, and where truffle hunting has a widespread folk tradition. Because black truffles are not so central to traditional Spanish cuisine, interest in truffles developed late despite extensive natural habitat for them. The successful transformation of the small Spanish town of Sarrión into the “truffle capital of Spain”—providing economic and environmental rewards for both individual entrepreneurs and the community at large—is therefore noteworthy. The key components of this success story seem to be the positive participation and interaction at many levels, farmers’ receptivity to a new and potentially risky crop, the nurseries’ thriving business, financial investments from local banks, subsidies from local and regional governments, and the cooperation and mutual sharing of technical and practical information among members of the truffle association. A visit to this town during their annual Truffle Festival attests to the contagious enthusiasm for truffles. Despite the



fact that many orchards have yet to produce a single truffle, optimism reigns supreme.

### Acknowledgments

We wish to thank Mari Carme Vergés for invaluable support during fieldwork, Pablo Sebastián, secretary of *Asociación de truficultores y recolectores de trufa de la provincia de Teruel* (the local truffle association of Sarrión), who made this study possible by his generous cooperation, and David Arora and Glenn Shepard, Jr., for their helpful suggestions to improve the manuscript.

### Literature Cited

- Bencivenga, M. and G. di Massimo. 2000. Risultati Produttivi di Tartufai Coltivate di *Tuber melanosporum* Vittad. in Umbria. *Micologia Italiana* 2:38–44.
- Callot, G. 1999. La Truffe, la Terre, la Vie. Institut National de la Recherche Agronomique, Paris, France.
- Chevalier, G. and J. Grente. 1979. Application Pratique de la Symbiose Ectomycorrhizienne: Production a Grande Echelle de Plants Mycorrhizes par la Truffe (*Tuber melanosporum* Vittad.). *Mushroom Science* 102:483–505.
- Departamento de Agricultura de la Diputación Aragón. 2000. Anuario Estadístico Agrario. Gobierno de Aragón, Zaragoza, Spain.
- Estrada, J. M. and Alcántara, C. 1990. La Tòfona. Departament d'Agricultura, Ramaderia i Pesca, Generalitat de Catalunya. Barcelona, Spain.
- García, S., S. Reyna, R. Pérez, and J. A. Rodríguez. 2007. Ecología de la Trufa y las Áreas Truferas. In S. Reyna, ed., *Truficultura. Fundamentos y Técnicas*. Ediciones Mundi-Prensa, Madrid, Spain.
- Gärdenfors, U. 1994. Eken—Utnyttjad av Tusentals Organismer. Pages 77–82 in U. Olsson, ed., *Ekfrämjandet 50 år. Ekfrämjandet och Skogsvårdsstyrelsen*, Ronneby, Sweden.
- Giovannetti, G., N. Roth-Bejerano, E. Zanini, and V. Kagan-Zur. 1994. Truffles and Their Cultivation. *Horticultural Reviews* 16:71–107.
- Hall, I., G. Brown, and J. Byars. 1994. *The Black Truffle*. 2nd Ed. New Zealand Institute for Crop and Food Research, Christchurch, New Zealand.
- Instituto Nacional de Estadística. 2004. Encuesta de Población Activa. Instituto Nacional de Estadística, Madrid, Spain.
- Instituto Nacional de Meteorología. 2002. Aragón, La Rioja y Navarra. Instituto Nacional de Meteorología, Madrid.
- Lefevre, C. and I. R. Hall. 2001. The Status of Truffle Cultivation: A Global Perspective. *Acta Horticulturae* 556:513–520.
- New Zealand Truffle Association. 2001. Newsletter 26, 3.
- Oliach, D., J. A. Bonet, C. R. Fischer, A. Olivera, J. Martínez de Aragón, L. M. Suz, and C. Colinas. 2005. Guía Técnica para el Cultivo de la Trufa Negra (*Tuber melanosporum* Vitt.). Centre Tecnològic Forestal de Catalunya, Solsona, Spain.
- Olivier, J. M. and L. J. L. D. van Griensven. 2000. Progress in the Cultivation of Truffles. Science and Cultivation of Edible Fungi. Proceedings of the 15th International Congress on the Science and Cultivation of Edible Fungi, Maastricht, Netherlands, 15–19 May 2000: 937–942.
- \_\_\_\_\_, J. C. Savignac, and P. Sourzat. 2002. Truffe et Truficulture. Editions Fanlac, Périgueux, France.
- Pacioni, G. 1991. Effects of *Tuber* Metabolites on the Rhizospheric Environment. *Mycological Research* 95:1355–1358.
- Pegler, D. N., B. M. Spooner, and T. W. K. Young. 1993. *British Truffles: A Revision of British Hypogeous Fungi*. Royal Botanic Gardens, Kew, U.K.
- Reyna, S. 2007. Sostenibilidad de la Truficultura: Aspectos Ecológicos, Económicos y Sociales. In S. Reyna, ed., *Truficultura. Fundamentos y Técnicas*. Ediciones Mundi-Prensa, Madrid, Spain.
- RiOUSset, L., G. RiOUSset, G. Chevalier, and M. C. Bardet. 2001. Truffes d'Europe et de Chine. INRA, Paris, France.
- Rocchia, J. M. 1992. Des Truffes en Général et de la Rabasse en Particulier. Éditions A. Barthélemy, Avignon, France.
- Samils, N. 2002. The Socioeconomic Impact of Truffle Cultivation in Rural Spain. M.Sc. thesis. Department of Forest Mycology and Pathology, Swedish University of Agricultural Sciences, Uppsala, Sweden.
- Sarrión City Council. 2002. Sarrión City Council, Plaza de España, 1; E-44460 Sarrión (Teruel), Spain.
- Secretaría General Técnica del MAPA. 2005. Encuesta de Precios de la Tierra 2004. Subdirección General de Estadísticas Agro-

- alimentarias. Ministerio de Agricultura Pesca y Alimentación, Madrid. Spain.
- Trappe, J. M. 1988. Use of Truffles and False-Truffles around the World. Pages 19–30 in M. Bencivenga and B. Granetti, eds., *Atti del II Congresso Internazionale sul Tartufo*, Spoleto, Italy.
- Wedén, C. and E. Danell. 1998. Sommartryffel, *Tuber aestivum*, och Andra Tryfflar i Sverige. *Svensk Botanisk Tidskrift* 92:65–80.
- \_\_\_\_\_, L. Ericsson, and E. Danell. 2001. Tryffelnyheter från Gotland. *Svensk Botanisk Tidskrift* 95:205–211.