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The hidden value of non-timber forest products: income contribution of the Basilicata wild truffle

The Basilicata region (South of Italy) is land of truffles where the gastronomic, economic and cultural awareness has developed for this non-timber forest product only in the past decade. Little is known about truffle production and its social, economic and environmental implications. In this article we investigate the Basilicata truffle sector by devoting particular attention to the truffle hunters who gather the truffles from the forests. The data for the analysis were collected through a survey with the aim of describing the gathering activity (people involved, specie and quantities collected, etc.) and assessing its significance as a source of income. Results show that truffles can provide local communities with earning opportunities. However, the truffle sector needs to be protected and enhanced.

1. Introduction

Non-timber forest products (NTFPs), such as berries, mushrooms, nuts, saps and resins, aromatic, medicinal and decorative plant material, can represent an important source of income for rural and forest-dwelling (Angelsen et al., 2014; Shackleton and Pandey, 2014). NTFPs can also improve food security by off-setting seasonality of other food sources both in rural (Tata Ngome et al., 2017) and urban contexts (Clark and Nicholas, 2013), and play an important cultural and spiritual role (Shackleton and Pandey, 2014). In Europe, collected NTFPs represent a total economic value of 23.3 billion euro per year (Lovrić et al., 2020), with a high potential for new income generation, especially in Eastern European countries (Cai et al., 2011; Lovrić et al., 2020) and in Mediterranean region (Blondel, 2006; Masiero et al., 2016). Mainly collected for self-consumption, the total value of sold NTFPs in Europe is estimated at 3.5 billion euro per year, with the highest proportion of value made up of truffles (1.2 billion €·yr^{-1}), followed by forest nuts (775 million €·yr^{-1}), wild berries (685 million €·yr^{-1}) and wild mushrooms (518 million €·yr^{-1}) (Lovrić et al., 2020).

Truffles are one of the most famous and the most expensive foods in the world, with prices up to 4000 €·Kg^{-1} (Oliach et al., 2021). Specific growing habitat,

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unpredictable growth patterns and growing seasons, unique harvesting methods, limited natural resources, distinctive, desirable flavours highly appreciated in culinary and limited shelf life, altogether strongly contribute to the outstanding economic value of truffles and consequently truffle-based food products (Beara et al., 2021; Patel et al., 2017; Wang and Marcone, 2011). At least 180 species of truffles belonging to the genus *Tuber* (even if only about 13 have any commercial interest) are distributed in Europe, South-East Asia, Australia and North America, while desert truffles (genus *Terfezia* and *Tirmania*) grow mostly in the Middle East region (Patel et al., 2017; Reyna and Garcia-Barreda, 2014). In Europe and Australia, truffles are a multi-million euro industry (Reyna and Garcia-Barreda, 2014), whose importance is demonstrated by the growing diffusion of new activities such as truffle cultivation (Garcia-Barreda et al., 2018; Reyna and Garcia-Barreda, 2014; Samils et al., 2008), truffle tourism (Buntgen et al., 2017), production of new truffle products (Beara et al., 2021; Patel et al., 2017), technical consulting (Samils et al., 2008), not to mention the capacity to stimulates interdisciplinary research (Garcia-Barreda et al., 2019), and the increase of land value in rural areas (Samils et al., 2008).

Italy is one of the main countries for truffle production, processing and trade worldwide, with the largest number of edible truffles of commercial interest (nine species and varieties belonging to the genus *Tuber*), including the well-known Alba white truffle (*Tuber magnatum* Pico) and Norcia black truffle (*Tuber melanosporum* Vittad.). The Italian truffle market stands out locally and internationally (Pampanini et al., 2012), playing an important role for regional economies (Brun and Mosso, 2010; Marone, 2011). The local market refers to traditional food and wine specialties and its territories of origin. Today, truffle represents one of the main products of food and wine tours promoted by different Italian regions. Recent market research conducted by JFC[1] reports that truffle tourism generated a turnover of almost 63 million euro in 2018, due to the presence of foreigner tourists and activities related to truffle gathering and consumption. International trade also represents an important share of the Italian truffle market. In 2018, the economic value of export was about 49.2 million euro for "fresh or chilled truffles" and about 13.7 million euro for "prepared and/or preserved truffles" (ISTAT, 2019).

Despite that, the social, economic and environmental implications of the truffle sector are largely unknown because of a substantial lack of data. Official statistics are scarce and, in any case, not very representative. Indeed, truffle production is represented under the heading "Mushrooms and truffles" without any distinction between the two product categories. According to different authors, a lack of systematic data on NTFPs leads to a lack of awareness of their importance, which leaves them not being fully considered in rural development, forest and land-use related plans and policies (FAO, 2014; Lovrić et al., 2020). For example, Lovrić et al. (2020) highlight that "*If forest management is geared towards optimizing only wood production, this may lead to sub-optimal solutions as this typically involves different management decisions than co-production of wood and of NWFPs*". In the case of truffle,

[1] JFC is a tourism consultancy and territorial marketing company (online: https://www.jfc.it).

the knowledge of the market and actors involved is fundamental to implement adequate actions to preserve, promote and enhance products and territories (Marone, 2011). Past studies tried to give a comprehensive picture of truffle supply by evaluating national production and its distribution among Italian regions. According to Pampanini et al. (2012), truffles production in Italy was about 81.4 tons in 2007; Umbria and Abruzzo, with annual productions estimated at 25.2 and 21.6 tons respectively, are the most important producing regions, representing 57% of the total. Similar results are reported in Brun and Mosso (2010), that indicated a national production of about 82.2 tons in 2007 with 55 % of the total represented by Umbria and Abruzzo, followed by Marche (9%), Lazio (8%), Toscana (6%) and Molise (6%). However, the available data are underestimated and not updated. Firstly, they mainly refer to formally marketed truffles, and do not take into account informally marketed and those used for self-consumption. Moreover, in the last years, new areas of production are gaining attention and new regions participate in the market.

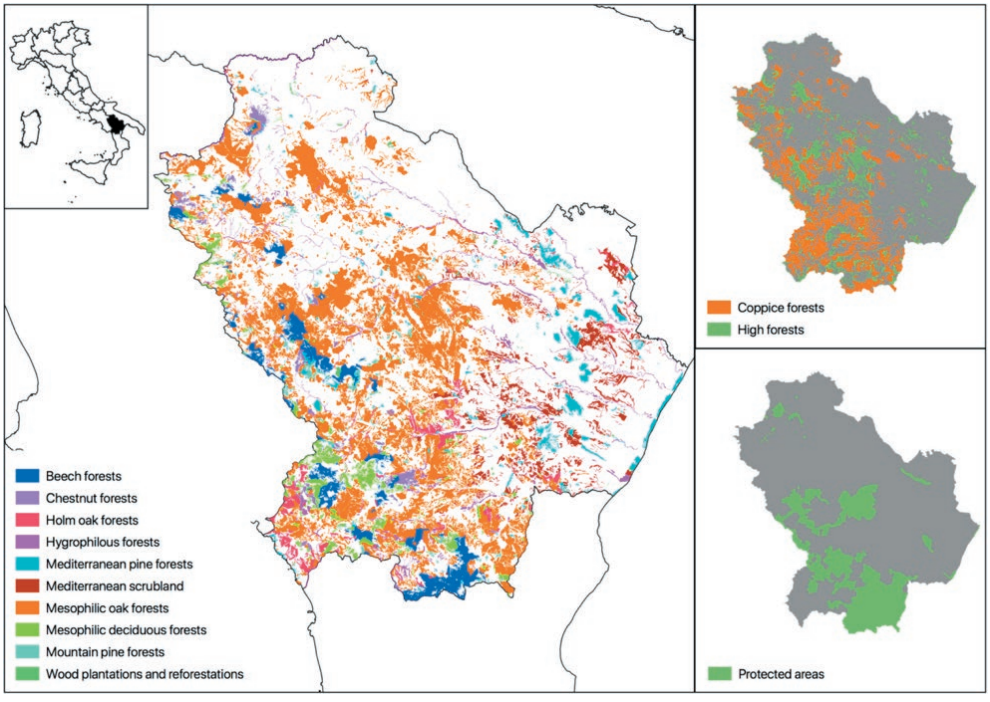
The Basilicata region (South of Italy) is a land of truffles (Pomarico et al., 2007; Rana et al., 2015), whose gathering, cultivation and trading is regulated by the National Law no. 752 of December 16th 1985 and by the Regional Law no. 35 of March 27th 1995. However, gastronomic, economic and cultural awareness has developed for this NTFP only in the past decade, as demonstrated by the high number of badges issued for gathering activities (constantly growing in recent years) and the presence of truffle hunter associations that count numerous members. As for other Italian regions, the truffle sector can represent an important opportunity for the regional economy. However, little is known about truffle production and its social, economic and environmental implications. For this reasons, in line with other studies conducted in Piemonte (Brun and Mosso, 2010), Toscana e Abruzzo (Marone, 2011), and more recently in Sicilia (Calvo et al., 2020), our work aims to investigate the truffle sector in the Basilicata region, devoting particular attention to the truffle hunters who gather the truffles from the forests. The truffle hunter includes very diversified profiles, from the hobbyist to the professional one (Marone, 2011), according to the aim of the gathering activity and the truffle hunter behavior (types of gathered truffles, occasional versus more constant activity, income function of this activity). In such context, we try to answer the questions (I) who is involved in gathering activity, (II) which truffles and what quantity are collected in terms of weight and economic value, and (III) can truffle represent an important source of income? To that, we conducted a survey involving truffle hunters of Basilicata. The survey was designed to account for one year of truffle gathering in the region. Because the availability of truffle is intrinsically variable, a survey of the truffle hunters may produce estimates of quantities collected that are remarkably different depending on whether the research hits a favourable or an unfavourable year. In this respect, the 2018 season was average and, to some extent, can be taken as representative of a typical year. This can help to provide some useful insights to promote the truffle sector in Basilicata.

2. Materials and methods

2.1 The Basilicata truffle sector: the context

Basilicata is an Italian region located in the south of the country, rich in natural resources, ecosystems with a high value and high amenity landscapes, where the agri-food (Viccaro et al., 2018) and forestry (Viccaro et al., 2019) sector play an important role for the rural economy. The region, characterized by a very heterogeneous territory for cenotics diversity deriving from its great geomorphologic complexity, has been lately discovered to be rich in truffle species (Pomarico et al., 2007; Rana et al., 2015). In the last two decades, several researches have been carried out on biodiversity of hypogeous fungi of Basilicata that, according to Rana et al. (2015), now occupies the first positions among Italian regions for the number of *Tuber* species, varieties or forms (up to 29 of non-edible and edible *Tuber* taxa) naturally growing in its woodlands and Mediterranean scrubland areas (Fig. 1). All the commercial species, varieties and forms of truffles are present in the region, namely *T. brumale* Vittad. and *T. brumale* var. *moschatum* De Ferry, *T. aestivum* Vittad. and *T. aestivum* var. *uncinatum* Chatin., *T. borchii* Vittad., *T. macrosporum* Vittad.,

Figure 1. Basilicata forests by type, management systems and protected areas (source: Viccaro et al., 2019) (Note: forests cover a surface of 354,895 ha, with an index of woodiness equals 35.6%, consisting mainly of oak (51.8%), followed by beech (10%) and Mediterranean scrubland (7.9%)).



T. mesentericum Vittad., as well as the prized black truffle *T. melanosporum* Vittad. and white truffle *T. magnatum* Pico.

However, in line with the rest of the country, the social, economic and environmental implications of the truffle sector are unknown because of a substantial lack of data. The available data on productions date back to 2007, indicating a total amount of about 1.4 tons (Brun and Mosso, 2010), while information about the final destination of the product – species and relative quantities self-consumed or sold (not only informally but also formally marketed) – is completely missing.

As for the market, the only available data are limited to the number of the main players operating on the supply side, namely the truffle hunters that, based on the number of badges issued for gathering activities, rise from 215 in 2005 to 1652 in 2016, and five industries engaged in truffle collection, processing and sale. However, it is important to point out that we don't know if all the truffle hunters participate in the market due to the presence of possible hobby activities. Moreover, no information about the demand side, represented by catering activities and final consumers, is available.

2.2 Questionnaire preparation and data collection

Whether they are hobbyist or professional truffle hunters, very little is usually known about their socio-economic characteristics, their practices, and any return from the activity. So, we ran a survey of truffle hunters of the Basilicata region to identify what types of people engage in gathering truffle, quantifying the time devoted to the activity, the amounts collected, and assessing the economic significance of this source of income.

Data were collected using a questionnaire that was structured in 25 questions and divided into 3 sections, concerning respectively:

1. the sociodemographic information of respondents and general aspects of the gathering activity (personal data, profession, etc.);
2. information on truffle hunting activity (time devoted to and costs incurred in the activity, travel distance, species and amounts collected, etc.);
3. information relating to the marketing and/or processing of the product (final destination, retail and/or wholesale price, etc.).

The first section aims to outline a general profile of the truffle hunter, based on age, profession and motivational characteristics. It also includes questions on different activities performed in natural environments (i.e., fishing, hunting, mushroom gathering, …). In the next section, all the activities related to research and collection are investigated, to know the operating methods and related costs. In this part, there is also a question to evaluate the perception of the state of truffle habitats concerning external disturbance (climate change, land-use change, human activities, etc…). The third part aims to analyse the final destination of the product (self-consumption or sale) to be used for some economic considerations. Finally, an open question is devoted for collecting suggestions to promote and enhance the natural truffle production in the region. The draft questionnaire was

pre-tested twice, firstly with a group of experts of the truffle sector (mycologists, presidents of truffle hunter associations, truffle hunters), and secondly with about ten respondents using the online layout of the questionnaire. The purpose of the pre-testing (Collins, 2003; Lovrić et al., 2020) was to account for a shared understanding of the questionnaires' text, possible missing response categories, and for checking the online version. Pre-testing was performed from September to November 2018.

The survey of the truffle hunters was conducted from January to June 2019, by administering the online version of the questionnaire to members of "*Associazione Micologica dei Sostenitori della Cultura Idnologica Lucana*" (A.M.S.C.I.L), a truffle hunter association that, from 2014, operates to preserve the truffle habitats and valorise the truffle sector in Basilicata. Since people collecting NTFPs from the forest, including truffle hunters, are unwilling to share information about their activities because of a combination of jealously guarding good sites, awareness that they access the resource without a required authorization, and worries about possible changes in regulations (Cai et al., 2011; Marone, 2011), the participation in the survey was incentivized with a prize draw, managed separately to maintain anonymity. The prize consisted of a "vanghetto", a special gathering tool similar to a small shovel. Of the 112 questionnaires handed out, about 66% were returned, but 4 (3.5%) of them were excluded due to incorrect and uncompleted questions. Thus, the analysis was conducted on a total of 70 valid questionnaires which amounts to a 63% response rate.

3. Results

3.1 Truffle hunters and gathering activity in Basilicata

Table 1 presents summary statistics for key socio-economic characteristics of the sample and measures of truffle gathering activity. In line with the total distribution of regional forest areas, the origin of the interviewed sample is almost all of the province of Potenza (94.3%). Almost 93% of the respondents are male and, a great part of interviewees (59%) falls within the age range between 36 and 65 years. The most represented occupations are those of the wages clerk (24%), the worker (23%) and the self-employed (18.6%), followed by "Other" professions (15.7%), pensioners (13%) and students (6%). The greatest part of respondents (64%) has been carrying out truffle hunting for more than 5 years (34% from 5 to 10 years, 30% for more than 10 years), and about 57% of the interviewees declared to be alone when carrying out this activity. 59% of respondents approached the gathering activity due to their inclination towards natural environments, declaring to practice at least one other outdoor activity such as mushroom picking (38%), hunting (14%) or more than one (39%).

As regards the gathering activity, it is carried out only in the province of residence for 44% of the interviewees and in the whole region for 31% of them; only 26% state also to go outside the region. This affects the truffle gathering trips to

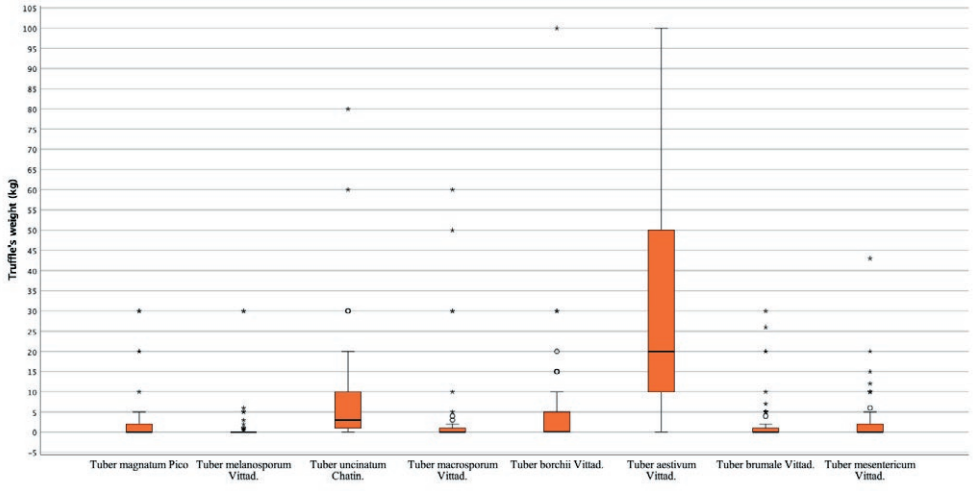
Table 1. General statistics of truffle hunters and gathering activity.

A. Truffle hunters' characteristics		
Variable	Description	Relative frequency (%)
Sex	Male	92.9
	Female	7.1
Age	18 - 35	30.0
	36 - 65	58.6
	> 65	11.4
Province of residence	Potenza	94.3
	Matera	5.7
Occupation	Self-employed	18.6
	Worker	22.9
	Wages clerk	24.3
	Student	5.7
	Pensioner	12.9
	Other	15.7
Years of experience	< 1	5.7
	1 - 3	8.6
	3 - 5	21.4
	5 - 10	34.3
	> 10	30.0
Motivations	Delicacy of truffles	7.1
	Contact with nature	58.6
	Down from parents/relatives	15.7
	Profitable business	4.3
	More than one answer	10.0
	Other (research, curiosity, …)	4.3
B. Truffle gathering activity		
Variable	Description	Relative frequency (%)
Gathering area	Province	41.4
	Region	32.9
	In and outside the region	25.7
Days	Up to 10	10.1
	10 - 20	15.9
	21 - 50	26.1
	51 - 100	33.3
	> 100	14.5
Hour per day	< 1	2.9
	2 - 3	64.3
	3 - 5	24.3
	> 5	8.6

the forests which varies from a minimum of 1 km to a maximum of 250 km, with an average of 36 km. The time (hours) dedicated to the gathering activity ranges from a minimum of 1 hour to more than 5 hours per day. However, a very high percentage (64%) declares to devote on average 2-3 hours per day while only 24% of the respondents dedicate 4-5 hours per day. One-third of interviewees dedicate to gathering activity from 51 to 100 days, while 26% of them engage in it from 21 to 50 days. A good percentage (14.5%) even exceeds 100 days, a value that immediately suggests more than the recreational activity.

As shown in Figure 2, the region is particularly suited for black truffles, such as *T. brumale* Vittad., *T. aestivum* Vittad., *T. aestivum* var. *uncinatum* Chatin., *T. macrosporum* Vittad., *T. mesentericum* Vittad., and *T. melanosporum* Vittad. No truffle hunter claims to collect *T. brumale* var. *moschatum* De Ferry. There is a high variability of collected truffle amount among truffle hunters. The *T. aestivum* is the most collected species in the region, all the interviewees declare to collect it and for 13% of them, it represents the only species collected. Quantities range from a minimum of 1 kg to a maximum of 200 kg; the average value per truffle hunter is 34 kg. The *T. aestivum* var. *uncinatum* is another species collected by a large percentage of the respondents (83%), with an average amount of around 10.5 kg, with a minimum value of 0.5 kg and a maximum of 80 kg. The other truffle species collected in Basilicata are the *T. macrosporum* (on average 10.2 Kg per truffle hunter), the *T. mesentericum* (on average 8.3 Kg per truffle hunter), and the *T. brumale* (on average 6.4 kg per truffle hunter). Only 18.5% of the sample collect the prized black truffle (*T. melanosporum*) from the regional forests. The average quantity of the latter is 6.6 kg per truffle hunter. As regards the white truffle species, the *T. borchii* is collected from 51% of the sample with values ranging from 0.1 kg to 30

Figure 2. Species and amount of truffle collected in Basilicata (data expressed in kg, year 2018) (our elaboration on survey data).



kg (the average quantity is 10 kg), while the *T. magnatum*, the most valuable species by far, is collected by 41% of the interviewees with a minimum value of 0.3 kg and a maximum of 30 kg. For this species, the average annual amount collected is around 4.6 Kg per truffle hunter.

Although only 4% of the interviewees declared to carry out the gathering activity for economic reasons, about 74% of them sell the collected truffles. On average, hunters sell 46% of the collected truffle (with values ranging from a minimum of 20% to the total), while the rest is self-consumed or given away.

The market tends to develop in two ways: wholesale and retail. The first form is the most developed and affects almost all of the products, despite the retail sale it is possible to obtain higher prices because buyers usually require truffle of greater aesthetic and quality. For wholesale, the main buyers are intermediate figures who collect the product subsequently sold to large processing companies, located mainly in the areas of central Italy, or to the markets of northern Italy and abroad. Both for the wholesale and the retail market (Figure 3a), the buyers are mainly local (41% and 50% respectively), followed by regional and national buyers; only a small percentage is represented by international ones. The local final consumers (43%) and the catering sector (28%) represents the main customers (Figure 3b), followed by other figures and tourists. The sale is mainly carried out at home (58.4%), sold for the most part fresh (87%) and the remainder processed (9%) and frozen/deep-frozen (4%). The wholesale and retail prices are reported in Figure 4. There is high variability among species that depends on the characteristics of sold truffles (i.e., size. aesthetic and quality). In general, retail prices are twice as high as wholesale prices. The average prices per kg are (in decreasing order): 1,473 € - T. magnatum; 428 € - *T. melanosporum*; 164.5 € - *T. aestivum* var. *uncinatum*;138 € - *T. borchii;* 137 € - *T. macrosporum*; 106 € - *T. brumale;* 74.5 € - *T. aestivum;* 66 €- *T. mesentericum*.

As regards the main costs associated with the gathering activity (Table 2), they are related to the purchase and care of the dog (fixed costs), and the travel costs (variables costs), the latter according to the number of gathering trips and relative distance. The truffle hunters have declared to have on average two dogs (mini-

Figure 3. Basilicata's truffle market location (a) and final customers (b) (year 2018) (our elaboration on survey data).

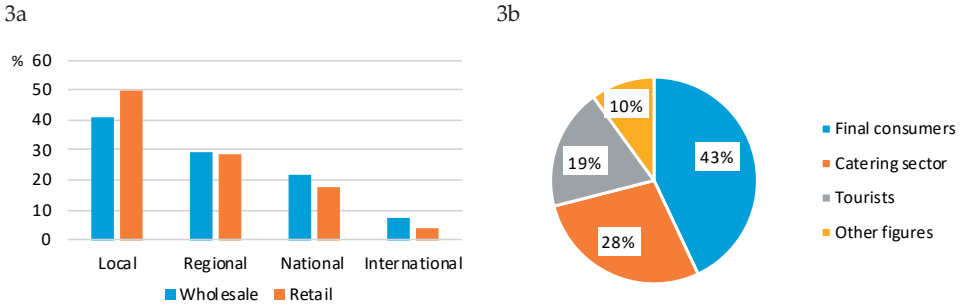


Figure 4. Wholesale and retail price of truffle species (euro, year 2018) (our elaboration on survey data).

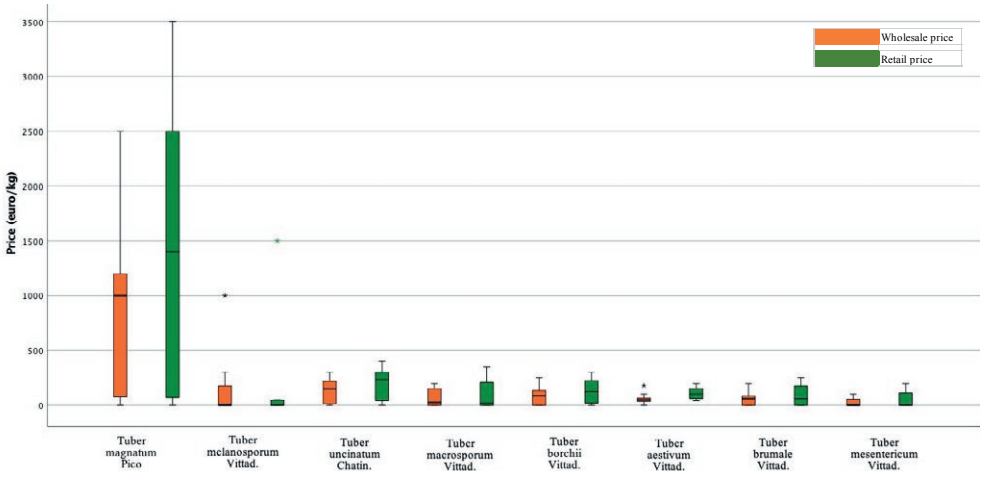


Table 2. Fixed and variable costs associated with the truffle gathering activity.

Fixed costs	Unit	Value
Regional tax	€/year	93
Vanghetto*	€/unit	100
Dog		
*purchase cost**	€ per dog	1,017
keeping costs	€/year per dog	575
Variable costs	Unit	Value
Travel costs	€/km	0.13

*To calculate the annual costs, we considered an amortisation period of 5 years for the vanghetto and 8 years for the dog.

mum 1, maximum 10). The most represented breed is the "Lagotto romagnolo": 76% of the sample replied to have at least 1 dog of this breed. The average cost of a trained dog was found to be around 1,017 € (67% of the sample released information). However, it is an average value that certainly is influenced by some characteristics such as the lower/higher ability of the dog, breed, experience, etc. The average cost of keeping a dog is around 575 €/year. This value includes the expenses for food, veterinary visits and care, and other costs (e.g., clipping, collars, etc.). The other fixed costs are the payment of the regional tax (93 €/year) and the purchase of the "vanghetto" (about 100 €).

3.2 Truffle hunters' profiles and economic consideration

Considering the average prices and the number of collected truffles in Basilicata in 2018, the economic value (EV) of the collected truffles per hunter is equal to 9,436 €, 42% of which is from prized truffles (*T. magnatum* and *T. melanosporum*). If the truffles collected in other regions are also considered, EV reaches around 13.6 thousand euro. Net of the quantities self-consumed and/or given away, the economic value of the sold truffles is equal 4,341 € (6,264 € with the truffle collected outside the region). However, given the high variability of the quantities and species collected among truffle hunters, the economic relevance of the truffle gathering activity should be better assessed regarding different hunters' profiles. For this reason, we performed a cluster analysis to identify groups that are homogeneous about some truffle gathering characteristics. In particular, we carried out a Twosteps cluster procedure[2] that uses an agglomerative hierarchical clustering method and is adequate when clustering variables are both categorical and continuous. Clustering variables used in the work are the EV of truffle collected, the percentage of EV of prized truffle, the percentage of truffle that is sold, area and range of days of gathering activity. The optimal number of clusters has been based on the Schwarz's Bayesian Criterion (BIC)[3]. Based on BIC, three groups of truffle hunters were identified that can be characterized by the mean values of clustering variables (more frequent values for categorical variables), as well as by the collected socio-demographic and activity information. They can be named as Professional (*Pro hunter*), Semi- Professional (*Semi-pro hunter*) and Hobby hunter (*Hobbyist)* (Table 3).

Pro hunter: young truffle hunter (age 18–35), the professional truffle hunter carries out the gathering activity alone both in the region and outside it, dedicating from 50 to over 100 days per year but generally not more than three hours per day. With three dogs, the amount collected is approximately 105 kg per year (53% of which are for sale). The total economic value is about 20 thousand euro/year, reaching about 33 thousand euro with the amount collected outside the region (56 kg).

Semi-pro hunter: with an age between 35 and 65, the semi-professional truffle hunter prefers to carry out the activity alone, but does not despise the company. He devotes between 21 and 100 days per year to the gathering activity and, unlike the pro hunter, sometimes more than 4 hours per day, preferring the regional territory. With two dogs and just under half of the quantities collected by the pro hunter in the region (about 48 kg), the average EV of collected truffle is equal to 5,763 €. The semi-pro hunter sells 56% of the truffles.

Hobbyist: the hobbyist limits the gathering activity to the province of residence, dedicating no more than 50 days per year and no more than three hours per day.

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[2] This procedure was carried out with SPSS 20

[3] BIC is log-likelihood value obtained, according to the formula -2*log-likelihood + k*npar, where npar represents the number of parameters in the fitted model, and k = log(n) (n being the number of observations). BIC is computed for each potential number of clusters: the "best" clusters solution has the smallest BIC.

Table 3. Cluster statistic.

Profile	n	EV (€)	% EV prized truffle	% Sold	Gathering area	Days
Pro hunter	23	32,778	36.3	53.38	In and outside the region (100%)	50 - more than 100 (65%)
Semi-pro hunter	30	5,763	19.6	56.17	Region (87%)	21 – 100 (77%)
Hobbyist	17	1,556	4.2	18.63	Province (100%)	up to 50 (100%)

Table 4. Species and amount of truffle collected by different truffle hunter profile. Data are expressed in Kg.

	Pro hunter	Semi-pro hunter	Hobbyist	Pro hunter (Outside the region)
T. magnatum Pico	5.96	0.88	0.06	3.87
T. melanosporum Vittad.	3.39	0.25	0.03	3.17
T. uncinatum Chatin.	15.91	6.43	3.12	10.39
T. macrosporum Vittad.	7.35	1.14	0.07	6.22
T. borchii Vittad.	11.48	3.05	0.19	9.26
T. aestivum Vittad.	50.65	33.77	9.47	20.26
T. brumale Vittad.	4.83	1.31	0.56	2.52
T. mesentericum Vittad.	5.04	1.00	2.18	0.78
Total	104.60	47.83	15.67	56.47

With an age between 35 and 65, he prefers to carry out the activity with other people. With only one dog, the amount collected is equal to about 16 kg (EV equal to 1,556 €), which is destined almost exclusively for self-consumption and/or as a gift.

The gathering area and the time dedicated certainly affect the species and the quantities collected (Table 4) and, consequently, their economic value with strong differences between the profiles. Pro hunters collect truffles for an economic value almost six and twenty times higher than that recorded for semi-pro hunters and hobbyists, respectively. 36% of this economic value is represented by valuable species. The pro hunter collects on average more prized truffles (9.35 kg) than the semi-pro hunter (1.13 kg) and the hobbyist (about 0.1 kg), demonstrating greater specialization. Of course, their effort, as well as the costs (i.e., travel costs and costs for dogs), are larger.

It is therefore possible to make some assessments for the economic return of the truffle gathering activity, considering revenues and costs related to the differ-

Table 5. Economic results. Data are expressed in euro.

	Pro hunter	Semi-pro hunter	Hobbyist
Total revenues	17,372	3,227	296
Total cost	2,787	1,729	935
Net income	***14,585***	***1,498***	***-639***

ent truffle hunters' profiles. The annual revenues, namely the economic value of sold truffles, the total annual costs and the net income are shown in Table 5. The costs include the purchase and care of the dog, the travel cost, the annual regional tax and the purchase of a "vanghetto".

Truffle hunters who spend more time in truffle gathering appear to be driven by the possibility of earning some extra income. Time affects results much more than the area in which the gathering activity is carried out. Semi-pro hunters, devoting up to 100 days per year, earn on average 3,227 € (with a net income of 1,498 €), while the pro hunters, with over 100 days, earn on average 17,372 € (with a net income of 14,585 €). Of course, the semi-pro hunters limit the gathering activity only to the region, but if the revenues deriving from the sale of truffles collected outside the regional borders are excluded, the pro hunters still earn on average three times more than the semi-pro hunters (10,628 €), with a net income of 8,923 €. The hobbyists, devoting up to 50 days per year, gather only trivial amounts and their revenues are not even sufficient to cover the costs incurred. They mostly self-consume and/or give away the hunted truffle, and appear to have mostly recreational motivations, confirming what they stated in the survey, that truffle gathering activity is mainly due to their own inclination towards natural environments.

For young professional hunters, the truffle gathering activity seems to represent an important source of income that motivates them to dedicate time and go beyond the regional borders. However, there is no evidence that the type of occupation engraves to the choice of turning to intensive truffle gathering as a source of income.

4. Discussions

The truffle gathering activity in Basilicata can represent, for those who practice it professionally, an important source of income and, for this reason, the sector should be protected and enhanced. According to different studies (FAO, 2014; Lovrić et al., 2020), a lack of systematic data on NTFPs leads to a lack of awareness of their importance, which makes them not being fully considered in rural development, forest and land-use related plans and policies. As a fact, according to what was declared by the truffle hunters themselves, the protection actions should be implemented by local decision-makers and should particularly concern

the protection of natural environments. 84% of the interviewees declared to note variations in the truffle habitats, with a consequent decrease in truffle production. These variations, partly due to climate change, as demonstrated in other studies (Thomas and Büntgen, 2019), and to land-use changes, are attributed to a greater anthropogenic and wildlife pressure (i.e., wild boars). In recent years, the number of badges issued and, therefore, the number of truffle hunters have increased considerably, with greater pressure on the truffle resource which often leads to lower levels of care and protection of the truffle habitats. According to 29% of the respondents, it is above all the inexperience of the truffle hunters that negatively affects these habitats. The interviewees agreed that to protect the regional truffle sector there is the need for greater controls by the supervisory authorities to enforce current legislation, public interventions to reconstitute and/or improve degraded truffle habitats, and the promotion of training courses. In particular, the training and knowledge of the truffle resource are very relevant for preserving the natural environments and guiding the habits of the truffle hunters so that they feel responsible for the truffle resource and its habitats.

Another critical element that emerged from the survey is the poor organization of the actors involved in the collection and marketing of truffles. Most of the time, the product ends up in an undifferentiated market without the right enhancement. As for other Italian regions (Brun and Mosso, 2010; Marone, 2011), the creation of a regional truffle supply chain, which identifies itself with the product of the territory, represents an opportunity to protect and promote the local truffle sector and, consequently, producers, with adequate remuneration, and final consumers, through the safety of the origin of the product. A future implementation of this work could be oriented towards a dedicate marketing plan to promote the above-mentioned truffle chains. This could benefit not only the truffle market, but in general all related activities able to promote the related ecosystem services (e.g., landscape enhancement, biodiversity and hydrogeological protection).

A relevant role for the enhancement of the product and, more generally, of the entire supply chain, is represented by the system of associations and cooperatives that can create critical mass and increase economic results. It constitutes a valid springboard for the development of the sector and can be a useful way to organize the enhancement of the truffle (e.g. using fairs, events, etc.), by framing it in a coordinated pattern of promotion and valorisation of the product and defending its origin. A way to enhance the product is the TAP (Traditional Agri-food Product) recognition, as for it is happening for the “Fragno truffle” in the province of Parma (Italy). Some other new initiatives of interest, from which to draw inspiration, appear to be those of the “Truffle Roads”. Oliach et al., (2021) identified strengthening the link between truffles, tourism, and gastronomy as the most important action to be taken. Indeed, tourism and gastronomy linked to production are a new opportunity to promote the truffle sector (Buntgen et al., 2017; Latorre et al., 2021). Another aspect that could help in the promotion of truffles, is the development of the gourmet market, which can be complemented with quality branding to better identify the product. Ensuring that the product consumed comes from a specific territory, understanding the characteristics and expectations

of the collectors, as well as the marketing channels, may soon represent forms of guarantees for the final consumer as well as the basis for careful planning of the production sector. The most suitable tools to achieve these results, therefore, lie precisely in the acquisition of ever greater knowledge of the entire supply chain.

One of the strengths of this work is the analysis of a sector where real data are lacking (in Italy). Many studies analyse the ecosystem services in Italy (Agnoletti et al., 2022; Canedoli et al., 2020; Riccioli et al., 2019, 2020; Salata and Grillenzoni, 2021). However, national statistics provide silvicultural data that essentially refer to timber harvests. Indeed, as stated by Pettenella et al. (2021), for several years, the National statistical institute (ISTAT) has stopped collecting data on the production of non-wood forest products.

So, the added value of this study is to highlight an hidden sector that has been "forgotten" but at the same time is threatened by wildlife. Cozzi et al. (2015, 2019), point out like wild boars represent a serious problem in Basilicata. Therefore, urgent actions to stem the problem are needed to protect the truffle sector.

5. Conclusions

The general objective of the research was to broaden the knowledge on the truffle sector of the Basilicata region, determine its main characteristics, productive and economic consistencies, with the specific aim of providing quantitative elements of evaluation, useful to regional institutions from a perspective of product enhancement. In recent years, in Basilicata, the truffle sector has registered a growing interest; in just over 10 years we have gone from a few hundred truffle hunters with an authorization badge for gathering activities to more than 1600 units. The positive trend in the number of people who have approached the truffle sector can be associated, in large part, with the search for profit and income. In this direction, we tried to answer to three main questions: (i) who is involved in gathering activity? (ii) which truffles and what quantity are collected in terms of weight and economic value? (iii) can truffle represent an important source of income? The answers to these questions reveal the presence of professional truffle hunters in the region, for whom the truffle represents an important source of income.

From the considerations of the economic results obtained, it is desirable to protect the production sector, through the establishment and strengthening of the production and processing chains. These initiatives may be able to connect the various actors and create new opportunities for food services and the tourist sector of the rural areas. A better use of the truffle resource can also be hoped to produce additional value and ensure adequate economic development for the territory. However, what has been stated is only possible following careful planning in the use of this NTFP. A higher level of knowledge, extended in space and time, may be able to safeguard and protect the regional truffle heritage. The reconstitution of degraded truffle fields, improving them with forestation interventions with mycorrhizal plants, carrying out more checks to enforce the legislation in force, are just some of the initiatives to begin to preserve the resource.

The most important objectives to be pursued are the following: (i) protection and promotion of the local products; (ii) protection and safeguarding of the territory; (iii) product certification to protect the consumer.

It is not possible to continue to consider the truffle a product of little economic interest since it is able to provide a rather significant income. Even if in the forests of Basilicata it is present in good quantities and undisputed quality, to date this product doesn't represent an added value for the regional territory and its rural contexts.

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