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Is truffle-growing a response to sustainable development and heritage issues in Mediterranean territories? The case of Uzès, southern France

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Abstract

The northern part of the Mediterranean Basin recently experienced major transformations. Landscapes evolved along two contrasting trends: agricultural intensification and urbanization in the plains, and disuse of marginal areas. This led to a gradual disappearance of the natural and cultural heritages associated with Mediterranean scrublands. To revitalize rural areas,

promote sustainable development, preserve social-ecological heritages and cultural landscapes, decision-makers in Mediterranean France often support “traditional iconic activities”. Based on a case-study in Uzès (Languedoc-Roussillon *Région*, southern France), this paper attempts to characterize the potential of truffle (*Tuber melanosporum* Vitt.) production, a symbolic but agriculturally marginal production, to respond to decision-makers expectations. The multidisciplinary approach developed includes landscape analysis, social surveys and plant inventories. Beyond the truffle growers and local decision-makers discourses and strategies, this paper shows that truffle-growing has limited implications in maintaining farmers and ensuring a sustainable development of the study area. Truffle-growing reflects Uzès’ society transformation, now more influenced by recent urban needs and values than by rural aspirations and traditions. However, our study brings in favorable arguments regarding the roles of truffle-growing ecosystems for biodiversity and landscape heterogeneity conservation.

Keywords: *Tuber melanosporum*, natural heritage, cultural heritage, biodiversity, rural areas, landscape

Introduction

Truffles (*Tuber* spp.) are hypogeous (below-ground) fungi, generally restricted to calcareous soils, where they form ectomycorrhizal associations with a number of tree species, particularly with oak trees (*Quercus* spp.). The fruiting bodies of some *Tuber* species, actively collected for their special taste, are among the most expensive non-timber forest products (Bonet et al. 2009). In particular *T. melanosporum* Vittad., known as the “black diamond”, the “Périgord truffle”, or the “winter black truffle” (hereafter simply called “truffle”), has a considerable commercial value and can reach up to 1,500 US\$/kg¹. *T. melanosporum* is naturally distributed in the northern part of the Mediterranean Basin, where it is nowadays mostly harvested from “truffle orchards”, tree plantations² managed for the production of truffle (Callot 1999).

¹ *T. magnatum* Pico, the Italian white truffle, fetches even higher prices (ca. 5,000 US\$/kg), but it has a much limited distribution area (Italy)

² The main tree species used for truffle orchards are various *Quercus* spp. (especially *Q. ilex* L., *Q. pubescens* Willd., and *Q. pedunculata* Hoffm.), although other species are sometimes planted such as *Corylus avellana* L. or

In France, truffle orchards are reported since the mid-19th century both in the south-west (Périgord), and in the south-east (mainly Vaucluse and Drôme). These two regions still harbor the main truffle markets and are still the main truffle producing areas in France (Callot 1999). However, the country production suffered a dramatic drop, from about 1,000 tons/year in the early 20th century to about 50 to 100 tons/year in the 1950's, and to between 10 and 20 tons/year since the 1970's (Callot 1999). The latter drop in truffle production has been observed in the three main producing countries (France, Italy and Spain) and is generally attributed to climatic changes (Callot 1999). The initial drop, from 1900's to 1950's, is generally attributed to the mortality associated to the two world wars and to the rural exodus, which have led to considerable changes in both rural landscapes and rural societies during the first half of the 20th century in western Europe (Callot 1999).

Mediterranean landscapes, shaped by an age-old history of human presence, were until recently characterized by high levels of complexity and diversity, and by an important biological and aesthetical interest ([Farina 2000](#); [Myers et al. 2000](#); [Di Pasquale et al. 2004](#)). During the second half of the 20th century, the evolution of socio-economic conditions in the northern part of the Mediterranean Basin completed the drastic conversion of traditional rural landscapes. As everywhere in western Europe, the most favorable and fertile areas were reserved to, and strongly impacted by, agricultural intensification, while marginal lands were neglected and abandoned ([Debussche et al. 1999](#); [Aranzabal et al. 2008](#); [Hill et al. 2008](#)). These transformations of the Mediterranean landscapes led to decreasing patchiness and to an important biodiversity erosion, directly related to the gradual disappearance of low forest-cover habitats (Etienne et al. 1998; [Debussche et al. 1999](#)) –which were the habitats of *T. melanosporum*.

This evolution also led to changes in the values, practices and perceptions ([Antrop 2005](#)). With the urban sprawl, new functions were assigned to rural areas, from recreation in a healthy environment to biodiversity preservation and the maintenance of cultural and identity values. These roles were reinforced by the integration of the 'sustainable development' concept in public policies ([Austad 2000](#)). In parallel, territories marginalized by the economic

Cedrus atlantica (Manetti ex Endl.) Carrière. The production of fruiting bodies in *T. melanosporum*. being associated to a relatively open environment, truffle orchards should be maintained with a low canopy cover (Callot 1999).

globalization appropriated the ‘heritage’ concept³, using it to promote their local specificities and improve their cohesion (François et al. 2006; Di Méo 2008).

Marginal rural areas have to cope with the recent social-ecological transformations and integrate the principles of multi-functionality and sustainability (Vos and Meekes 1999). Decision-makers are requested to preserve cultural landscapes that are no longer maintained by traditional uses, to integrate biodiversity conservation issues in land-use planning, to promote the recognition of local natural and cultural heritage, and to encourage local development mainly through tourism and agriculture. One of the most popular pathways to integrate these issues is to support local iconic agricultural activities such as truffle-growing.

According to the national professional union of truffle growers -*Fédération Française des Trufficulteurs*-, truffle-growing in France has a sizeable economic impact in marginal areas (Escafre and Roussel 2006). It contributes to retain the rural population through the set-up of agro-tourism activities related to truffle and truffle-growing. It allows farmers to use marginal lands that cannot be cultivated for other crops and to diversify their agricultural activities and sources of income. Truffle-growing is also often currently featured as a factor of social cohesion, local culture upholding and as a fire-preventing tool in Mediterranean areas (Escafre and Roussel 2006). Those arguments, equally highlighted by truffle growers at local scale, have also captured the attention of local politicians, as they respond to their concerns about the maintenance and revitalization of neglected rural areas (Région Languedoc-Roussillon 2007).

What reality underpins the highlighting in such discourses of the heritage character and of the social-ecological benefits of truffle-growing? This question is addressed here through a case study undertaken in the city of Uzès (Languedoc-Roussillon *Région*, Gard *Département*, southern France) and in its surroundings. Although Uzès is located outside of the two main historical regions of French truffle production (Périgord and Vaucluse-Drôme), it was selected because (i) truffle-growing is an obviously important land-use clearly visible in the Uzès landscape for any initiated visitor, (ii) there is a very active local professional union of truffle growers, -*Syndicat des Producteurs de Truffes du Gard*- hereafter called the “Syndicat”, and (iii) Uzès is often portrayed as the capital of truffle-growing in the Languedoc-Roussillon *Région*. In addition, the Syndicat recently echoed back the sustainable development and heritage discourses by adding to its range of activities the promotion of

³ We define ‘heritage’ here as a « *complex and willing social construction* » (Di Méo 2008), recognized for a number of more or less normative values, protected and managed in the interest of all.

truffle-growing as a natural and cultural heritage and as a tool to promote an harmonious economic, social and environmental development of the territory (Aumeeruddy-Thomas et al. 2012).

In this paper, we focus on truffle-growing as a potential natural and cultural heritage that could play a role in both social and ecological local issues: biodiversity conservation, local development, land-use planning and identity construction. Our specific objectives were (i) to assess the level of appropriation of truffle and truffle-growing as a local socio-cultural heritage, and (ii) to assess plant biodiversity in truffle-growing ecosystems as an indicator of their potential as natural heritage.

Material and methods

Study site

The study area included three adjacent municipalities: Uzès (northern part), Montaren et St Médières, and St Quentin la Poterie (see Figure 1). The landscape is characterized by a fertile plain surrounded by hills covered with “garrigues”, a Mediterranean scrubland with a more or less open tree canopy. Garrigues are the result of a long history of coupled social-ecological processes that converted Mediterranean forests into open savanna-like tree-formations (Quézel and Médail 2003). Black truffles were traditionally, and are still occasionally, gathered in the garrigues surrounding Uzès (Prat 2002). The first truffle orchards, inspired by modern arboriculture practices, appeared in the 1950’s, more than one century later than in the two main truffle producing regions of France. The Syndicat was established in 1971 and has since been active in disseminating technical information on truffle-growing and in looking for funds to support the plantation of truffle orchards. It also supported the development of truffle silviculture and the conversion of closed canopy garrigues into truffle-growing systems, known as “truffle-renovation systems” (Diette and Lauriac 2004).

[insert Fig1 here]

Methods

We used a multidisciplinary approach (ecology and geography) including landscape analysis, semi-directive interviews, closed questionnaires and plant inventories.

The first phase of the study consisted in reconstructing the transformations of the landscape that accompanied the social-ecological transformations of the Uzès region, to check that the land-use changes in the study area matched the dynamics of emergence of a dichotomous landscape as described in the introduction. We analyzed a temporal series of aerial photographs (1946, 1954, 1963, 1970, 1996 and 2001) and satellite images (2009). Field observations allowed the identification of all the land-uses found on the most recent image, which in turn allowed mapping the various land-uses making up the current landscape. The evolution of the social context that came with the landscape changes was then assessed through interviews with truffle growers (see below).

In a second phase, we conducted semi-directive interviews with twenty five (25) truffle growers and resource stakeholders (mainly truffle professional organizations officials), and we analyzed their socio-economic profiles and their expectations. This allowed us to describe the evolution over time of the main truffle growers' social characteristics. Data collected were also used to build a typology of truffle growers in the study area (using a Multiple Correspondence Analysis – MCA, and a Hierarchical Clustering Analysis).

The third phase of the study consisted in the assessment of truffle and truffle ecosystem as elements of the Uzès region's cultural identity. A questionnaire with closed questions was prepared and tested before being implemented on a sample of eighty one (81) people, randomly encountered in the study area. The aim of this questionnaire was to understand how people consider the contribution of truffle-growing ecosystems and truffle to the local natural and cultural heritage. Interviews were conducted between May and July 2009, in the streets of Uzès and Saint-Quentin, mostly during the weekly markets.

Our research hypothesis was that the perception of truffle and truffle ecosystem varies according to the historical link of the interviewee with the region. The sample thus included three (3) equally represented categories:

- local people, born and grown in the study area,
- recent immigrants, established in the area for less than 15 years,
- tourists.

[insert Fig2 here]

Finally, to assess the importance of truffle-growing for the plant biodiversity of the Uzès region, we carried out plant inventories in truffle ecosystems and in the various other land-uses. We identified sixty seven (67) representative plots distributed over the whole study area. We used a plant inventory protocol based on the point-centered-quarter method ([Cottam and Curtis 1956](#); see Figure 2), chosen because it allowed a fast characterization of plant diversity at plot scale.

Results of the plant census were first analyzed by a Non-Symmetric Correspondence Analysis (NSCA; [Kroonenberg and Lombardo 1999](#)), which gives more weight to the most abundant species. We then explored the variation of specific composition across the various land-uses using a Between Class Analysis which allows quantifying the proportion of the NSCA inertia explained by a qualitative instrumental variable (in our case: the various land-uses) ([Lebreton et al. 1991](#)). Finally, we compared the observed biodiversity of the various land-uses by using three diversity indices (species richness, Shannon index and Gini-Simpson index). All statistical analysis were made using the R free software (<http://www.r-project.org/>) and the ade4 package (<http://cran.r-project.org/web/packages/ade4/index.html>).

Results

From agro-sylvo-pasture to urbanization

At the beginning of the 20th century, the livelihood of most inhabitants in the Uzès region was based on a traditional agro-sylvo-pastoral model ([Chabaud 1967](#)). The plain was the domain of cereal crop fields, vegetable gardens, orchards, and vineyards. The garrigues were mainly used as grazing ground for sheep and goats flocks, and for collecting fodder for the animals in winter. They were also used for firewood and charcoal production ([Prat 2002](#)). The semi-open environment associated to these garrigues, coupled with the Uzès sandy and shallow soils, rich in limestone, provided optimal conditions for the development of the winter black truffle ([Callot 1999](#)). Truffles provided the mainly rural population a significant supplementary income in winter ([Byé and Chazoule 1998](#); [Callot 1999](#)).

As in other marginal Mediterranean areas during the second half of the 20th century, the rural society in Uzès was affected by important changes ([Figure 1](#)). In the 1970's, tourism gradually became a prominent economic activity; in parallel, a new population, mainly composed of wealthy retired persons originating from outside the region, settled in the city and in the neighboring rural areas. This immigration process led to marked changes in the

landscape, with the extension of urban areas and the disappearance of many agricultural plots, replaced by settlements. In the meantime, agriculture modernized and the contrast became more and more obvious between the plain, characterized by agricultural intensification and by urbanization, and the drier surrounding hills, gradually abandoned to garrigue. Traditional uses of the garrigues gradually vanished. Marginal fields were abandoned to fallow and replaced by garrigue, which itself gradually evolved from an open scrubland to a small forest with a closed canopy cover, incompatible with truffle production.

The landscape changed as did the identity of the region, from a declining agricultural region to a prized tourist landmark area. These changes had an impact on truffle-growing, on truffle growers' socio-economic profiles, on the areas dedicated to truffle, and on the place of truffle in the making of the region's identity.

The advent of the “rurban” truffle grower

Based on our qualitative and quantitative data (Table 1), the Multiple Correspondence Analysis and the Hierarchical Clustering Analysis show that truffle growers are distributed into 4 distinct groups in our sample (Figure 3).

[insert Tab1 here]

[insert Fig 3 here]

Through the analysis of these 4 groups, it is possible to retrace the evolution of the truffle growers' realm in Uzès, as well as the way it adapted to the changes of the local natural and cultural environment. Confronted with the closing of the canopy in the garrigues and the resulting truffle production drop-off, some passionate people established the first truffle plantations in the 1970's (group 1, 8 persons). Mostly native from the Uzès region, they all own inherited lands that they tried to valorize. Their passion for truffle is most often a family inheritance and they have been actively involved in the Syndicat since its creation. Most of them (2/3) are farmers. They currently own the largest plantation areas (between 4 and 20 ha,

generally distributed into a few plots), and their truffle production provides them with a complementary income which can be significant in favorable years⁴.

The second group (group 2, 7 persons) is mostly composed of farmers who planted truffle orchards on the fringe of their fertile lands, where soil was less fertile and could not sustain cereal cropping. The wine producing crisis deterring them to invest and plant grapevine, they chose to plant truffle orchards. They most often own few truffle plantations, with a total area ranging between 1 and 4 ha. Their membership to the Syndicat is sometimes motivated only by the possibility to get financial support. Most of them have planted in anticipation of their retirement, expecting truffle to provide them a leisure activity and a small additional income. Young farmers investing in truffle orchards are rare⁵, as they usually cannot afford to use their lands for a so uncertain production with such a long unproductive period (10 to 15 years in the best cases).

The two previous categories have strong rural and farming roots. This is not the case with the third group (group 3, 6 persons) composed of « rurbans », wealthy people either working in the tertiary sector of the economy or retired. They own inherited or purchased properties they like to improve through olive trees and truffle orchards. Some of them, native of the region, started truffle-growing after discussion with their relatives. Others, recently settled, have been seduced by different facets of truffle-growing, such as the connection with nature, or the link to perceived local traditions and heritages. They have, often recently, planted small areas – less than 1 ha – close to their home, and when they already harvest, they keep truffles for their own consumption. Only half of them received financial support for planting, and they mostly perceive the Syndicat as a source of information. For people in this « rurban » category, truffle is first of all a leisure activity and a way to show off their attachment to what they perceive as local identity and cultural heritage.

The last group (group 4, 4 persons) is composed of working people whose main economic activity is directly related to truffle (catering, selling local products, truffle trading, truffle tree seedling production). They all own small plantations for their pleasure, but the bulk of their income comes from truffle products and services, in relation with the enthusiasm for truffle in the Uzès region and with the intense tourist activity in the city.

To summarize, almost two third of the truffle growers in our sample are retired (60%), mostly native from the *Gard Département* (64%) where Uzès is located. Forty-four (44%)

⁴ We could not obtain detailed figures: profitability of truffle growing being a highly sensitive subject, our interviews did not include any related detailed question.

⁵ Only 2 among the 7 farmers in group 2.

percent of them are or have been farmers, the others either work or have worked in the tertiary sector. None of them makes a living only from truffle production. For the majority, truffle provides a relatively small income complement (84%), or is only a leisure activity.

Truffle as a cultural heritage?

As exposed earlier, the Syndicat highlights truffle-growing as an integral part of the local cultural identity. The truffle growers interviewed confirmed this perception: for them, truffle is representative of Uzès heritage. However, the results of our survey among randomly encountered people lead to moderate the importance of truffle and truffle related activities in making the local cultural identity.

[insert Fig4 here]

We first dealt with the place of truffle-growing in the landscape (Figure 4A and 4B). Our results show that 96% of the natives, 78% of the recently settled, but only 26% of the tourists, know about truffle tree plantations in the Uzès region. Among tourists, some even ignore that “truffle trees” can be cultivated. The survey thus reveals a straight distinction between the Uzès region inhabitants, familiar with truffle-growing ecosystems, and the tourists who, for most of them, have at best a very vague idea of what a truffle production landscape could look like. Figure 4B shows the ranking of the various land-use components of the local landscape, in terms of their representativeness of the cultural identity of the Uzès region. For the three respondent categories in our sample, truffle plantation ranks fourth, behind garrigue, vineyard, and olive orchards. In addition (data not shown), the reputation of Uzès and its touristic attractiveness are attributed to its architecture, its mild and sunny climate, its landscapes, and its proximity to famous tourist spots such as the “*Pont du Gard*”.

We then tried to understand how truffle itself is perceived. Among a list comprising 14 terms, respondents had first to choose 3 terms that they associate with truffle, and then to rank the 3 terms : 3 points were attributed to the term having the closest link to truffle, 2 points for the second and 1 point for the third. Figure 4C shows that the perception of truffle is relatively homogenous among the three respondent categories, with the three most cited terms being « luxury product », « mushroom », and « gastronomy ». At the opposite, the terms « heritage », « family tradition », or « pleasure of harvesting » have very few citations, whatever the respondent category.

To summarize, it seems that, contrary to the situation in famous truffle-growing areas such as Périgord, truffle represents a marginal component in the cultural identity of Uzès, although

collecting wild truffles in the garrigues and, more recently, cultivating oak trees for truffle production have left obvious traces in the history and in the landscapes of the region. Truffle is not – yet? – a specificity commonly associated with Uzès reputation, as are wine and olives.

Truffle-growing and biodiversity

Floristic specificities of truffle-growing ecosystems

In the last facet of this study, we assessed the ecological heritage value of truffle-growing at the landscape scale, through an analysis of the contribution of truffle-growing areas to the plant biodiversity of the Uzès region. We encountered a total of 372 species across the 67 sample plots, representative of the eight major land-uses encountered in the study area (cereal crop, fallow, garrigue, meadow, olive orchard, road edge, truffle orchard, and vineyard). 60 species could not be identified, the individual plants being either too young or damaged.

[insert Fig5 here]

The two first component axis resume almost 65% of the NSCA inertia (Figure 5A). It appears that, in spite of the numerous species encountered across the different plots, the global vegetation is mainly dominated by about 15 abundant species and that there are important variations in species composition across the different plots. The first axis explains 43.5% of the total inertia and discriminates plots characterized by a herbaceous and open canopy vegetation, dominated by *Bromus diandrus* Roth and *Cynodon dactylon* (L.) Pers., from plots characterized by a closed canopy garrigue vegetation dominated by species such as *Rubia peregrina* L., *Quercus coccifera* L. and *Quercus ilex* L. The second axis explains 21.1% of the inertia and discriminates plots dominated by *Medicago minima* (L.) Bartal. and *Arenaria serpyllifolia* L. from other plots.

The Between Class Analysis shows that the different land-uses have significantly different species compositions (Figure 5B). Cereal crops (Cc) were excluded from the analysis because they were highly dominated by distinctive cultivated cereals and too poor in terms of total species richness (see Table 2). Vineyards (V) were also excluded because they had a too distinctive specific composition, largely dominated by three species (*Solanum nigrum* L., *Lolium strictum* C. Presl. and *Tragus racemosus* (L.) All.) that were almost lacking in the other land-uses.

Across the remaining land-uses, garrigue plots (G) have a distinctive species composition, dominated by *R. peregrina*, *Q. coccifera* and *Q. ilex*. Plots of the other land-uses are distributed on a relatively regular vegetation transition. Truffle orchards (P) and truffle renovations (RA and RB) contain species that are characteristics of closed canopy vegetation similar to garrigue, whereas permanent meadows (M) or road edges (R) contain only species of open canopy vegetations. Unmaintained and maintained truffle renovations (RB and RA) and truffle orchards (P) are also characterized by a relative richness in *M. minima*, *A. serpyllifolia* and *Vulpia ciliata* Dumort., and a relative poorness in more typical garrigue species. Then, from olive orchards (O) to road edges, passing by permanent meadows (M) and fallow lands (F), the species composition changes with a decrease in *M. minima*, *A. serpyllifolia* and *V. ciliata* and an increase in the two Poaceae *C. dactylon* and *B. diandrus* , marking the transition towards a more herbaceous vegetation.

Interestingly, the three types of truffle-growing ecosystems (RA, RB and P) are characterized by species commonly associated to both open and closed canopy environments.

[insert Table 2 here]

This specificity in the floristic composition of truffle-growing ecosystems goes hand in hand with the highest species richness of our samples (Table 2). On average, 39 to 47 species per inventory (thus for 250 sampled individual plants) have been recorded in the truffle-growing plots, which is quite remarkable when compared to the average species richness of the other major land-uses, such as cereal crop (8 species), vineyard (24 species), and garrigue (24 species). Similar trends are observed for the other diversity indexes (Table 2). In all cases, cereal crop appears as the poorest ecosystem, followed by vineyard and garrigue. Truffle-growing areas, be they plantations or renovations, systematically have the highest biodiversity values, although differences with some other land-uses are rarely significant. With their intermediate level of canopy closure and their intermediate level of management –and thus of disturbance - truffle-growing areas represent, in the agriculture realm, an interesting example of the “intermediate disturbance hypothesis”, which postulates that the highest species diversity occurs for intermediate disturbance regimes ([Blondel 2006](#)).

Truffle-growing ecosystems and the landscape scale

[insert Fig6 here]

The above results take an additional significance when they are interpreted at the landscape scale (Figure 6). The plain itself is a fertile area, mainly covered by urban areas, cereal crops and vineyards. Surrounding hills are mainly covered by a closed canopy garrigue. These two different landscapes both harbor a number of – generally small - areas of truffle-growing ecosystems. What do these truffle-growing “spots” represent in terms of sustainability and biodiversity of each landscape?

In the closed canopy garrigue, the presence of a truffle-growing ecosystem allows the maintenance of an open environment with trees, which in turn allows enrichment in species, plants and animals, commonly associated with slightly disturbed open environments. To this biodiversity enrichment, and to the economic valorization of lands that otherwise would be abandoned, should be added another important service: the presence, in such fire prone areas, of a relatively large open area reachable by car or truck, more or less regularly maintained and often equipped with irrigation facility, is of utmost importance for fire prevention and control.

In the plain and its matrix of intensive crops marked by a strong urban pressure, truffle-growing ecosystems bring in species commonly associated with slightly disturbed or undisturbed environments, both open and closed – species that are lacking in the other land-uses. They also allow the establishment and the maintenance of open woods which can serve as habitat for birds and other animals.

All the above is true as far as the truffle-growing plantations and renovations do not bear any chemical treatment, are maintained through simple mowing down and a very superficial tillage. Then, and in both landscapes, the truffle-growing ecosystems confer heterogeneity to otherwise very uniform landscapes, making up “islands” that differ from the landscape matrix by their richness in species and by the specificity of their species composition.

Discussion

Synergism of truffle growers adaptation strategies with local authorities development strategies

Rural areas in the northern part of the Mediterranean Basin have been confronted with major social-ecological changes during the 20th century. The traditional agro-sylvo-pastoral system collapsed after the second world war, with the traditional agricultural landscape turned into either intensive agriculture or closed canopy systems ([Debussche et al. 1999](#); [Aranzabal et al. 2008](#)). In a context of globalization and competition between territories, the construction

and adaptation of heritages is a widespread strategy to promote local specificities and identity, and to support sustainable development (François et al. 2006; Di Méo 2008). In particular, economically unsustainable societies based on traditional agriculture could find a resurgence through agro-tourism, quality labels and the preservation of their cultural landscapes and natural heritages (Bessière 1998; Frayssignes 2008). Reyna-Domenech and Garcia-Barreda (2008), and Aumeeruddy-Thomas et al. (2012) describe how Mediterranean rural forests and their associated production (such as truffle) faced a major crisis but currently contribute to revive the territories they fall within.

In Uzès, the promotion of truffle-growing is one of the answers of the local and regional decision-makers concerning their territories' challenges. The regional government actively supports this “typical traditional culture of Languedoc-Roussillon” which “responds to the double challenge of economic development and land-use planning”, combines “culture and gastronomy”, allows to “bring back to life neglected and fallow lands”, and “restore biodiversity [...] while limiting fire propagation” (Région Languedoc-Roussillon 2007).

This political discourse was inspired by the network of professional truffle growers. Several authors have underlined the serious difficulties encountered by the truffle sector since the 1950's: fall in production, abuses connected to the opacity of the markets, competition with the China truffle⁶, recently introduced on the European markets (Byé and Chazoule 1998; Callot 1999; Escafre and Roussel 2006). Encouraged by the national professional union, many efforts have been made to respond to this crisis, such as improving the openness of the sector and developing sustainable development and heritage related arguments for a new positioning of truffle-growing (Escafre and Roussel 2006). The mobilization of these central issues allowed truffle growers to be acknowledged for their good practices and their participation in public programs. The truffle growers' professional network in turn identified these opportunities to increase its visibility: visibility towards public authorities, to obtain the allocation of funds for new truffle plantations and for reviving production; visibility as professionals, fighting against theft and fraudulent utilization of China truffle. This strategy was especially effective in the Languedoc-Roussillon Région, where truffle-growing got significant financial supports (Région Languedoc-Roussillon 2007).

The alliance between truffle growers and public authorities highlights a mutual interest for collaboration. Whereas the former find a financial support to revive a declining activity, the

⁶ Truffle species (*T. himalayense* B.C. Zhang and Minte, and *T. indicum* Cooke and Masee) produced in China, with a morphology very similar to *T. melanosporum*, but with very different organoleptic properties (Garcia-Montero et al. 2010).

later see truffle-growing as a potential solution to the environmental, social and economic issues facing neglected garrigue areas. Beyond political discourse and collective strategies, our study allows clarifying, in the case of the Uzès region, the roles of truffle-growing in economic development and agricultural activity maintaining, cultural heritage construction, natural heritage and cultural landscape preservation.

Truffle-growing in Uzès: a social-ecological heritage for a sustainable development?

Truffles were initially a non-timber forest product collected from the wild in the garrigues by a rural population of farmers, for which truffles could represent a significant source of income in winter. The current situation is completely different, reflecting the transformation of both the landscape and the population in the Uzès region. In the abandoned garrigues the canopy gradually closed, preventing truffle production. With the urban sprawl, the development of tourism and the concentration of farming in a few hands, the population is now mainly urban or “rurban”, with a high proportion of newcomers either retired or working mostly in the tertiary and leisure sectors. Truffles are now produced in specialized truffle orchards, owned and managed by truffle growers, whose profiles reflect this transformation of the society. Compared to the portrait of truffle growers in the Gard *Département* proposed by Dalonis in 1996 and Prat in 2002, our study reveals rapid changes. The proportion of native truffle growers considerably declined, whereas the proportion of retired people increased. Truffle-growing, initially adopted by local farmers whose lifetime had been marked by truffle, is more and more practiced by newcomers to truffle and to the area. While motivations of the former were essentially financial, today, almost all of the truffle growers consider truffle-growing more as a leisure activity than as an economic activity. We cannot confirm that truffle-growing is an effective solution for maintaining agricultural activities. Truffle-growing can hardly be the main agricultural activity in a farm, because of the length of the pre-productive period, and of the unpredictability of production. In contrast, truffle-growing fulfills the expectations of rurbans and retired people: for most, it is a leisure activity in connection with nature, while for newcomers to the region, it also represents a link with the perceived local traditions, heritage and identity. This situation however cannot be generalized: for instance, [Samils et al. \(2008\)](#) highlighted the economic importance for farmers of truffle cultivation in a non-tourist rural area in Spain. Truffle growers’ claim, that truffle and truffle-growing represent an important local cultural heritage for the Uzès region, is not supported by our general population survey. As social construction, heritage doesn’t exist *a priori*: the

construction process of a heritage requires its adoption by a social group, that identify itself through it (Leniaud 1992). To characterize truffle, items like “heritage” and “tradition” were rarely chosen by local inhabitants, who mostly associated truffle with its luxury image. Until recently, truffle related activities were indeed very much discreet, with most of the production sold outside the Gard *Département*⁷. The situation is very different in Périgord and Drôme-Vaucluse, where truffle orchards and truffle business are attested for more than 150 years. In Uzès, the Syndicat made great efforts to «*create a culture of truffle*». This quotation, extracted from one of our interview with a member of the Syndicat, clearly demonstrates their will to construct a cultural heritage around truffle, which may never have existed in Uzès. The construction of truffle and truffle-growing as a local heritage is well illustrated by the very popular “*Journée de la Truffe d'Uzès*” (*i.e.* the Uzes truffle day), organized by the Syndicat since 1994, which nowadays welcomes more than 15,000 visitors every year. Despite this annual event, truffle has not been adopted – yet - by the inhabitants as a component of their identity, and cannot be considered as a common heritage in Uzès.

The study of truffle-growing ecosystems has confirmed their importance for the maintenance of a high plant biodiversity at Uzès landscape scale. Truffle-growing ecosystems are indeed characterized by high species richness and by an original species composition, including species usually associated to closed canopy forests as well as species associated to open canopy forests. The numerous truffle orchards planted in the plain since the 1950's represent something new in the history of truffle production in the Uzès region, where truffle harvesting was until then restricted to the garrigues. A few truffle orchards and renovation plots have also been set-up in the garrigues, reviving their initial truffle production role, although under a very different format –private individual vs. community ownership and management. Whether located in the plain or in the garrigues, truffle-growing plots increase landscape heterogeneity, and represent spots of high biodiversity, in an otherwise intensive agriculture landscape in the plain, and in an otherwise very homogeneous closed canopy forest in the garrigues area.

Conclusion

To enhance their visibility and promote their activities, the network of professional truffle growers used arguments focusing on local development, natural and cultural heritage and

⁷ Interestingly, there had never been any truffle cannery in Uzès (Tournayre M. personal communication).

sustainability of marginal territories. This discourse was taken up by decision-makers to respond to social-ecological issues related to the management of neglected garrigue areas. In Uzès, our study confirms the favorable role of truffle-growing ecosystems for biodiversity and landscape heterogeneity conservation. But it leads to question the potential of truffle-growing for local sustainable development. Although it allows the maintenance of savanna-like tree-formations and can be used as a fire-preventing tool in the garrigues, truffle-growing can hardly be adopted as their main agricultural activity by farmers, and thus can hardly be promoted as a stand-alone solution to maintain farmers and ensure sustainable development in rural areas. Our study also leads to moderate the cultural heritage character of truffle-growing. Although the winter tourism activity is boosted and the social link favored by the Uzès truffle-day, truffle is not *-yet?-* part of the local cultural heritage

Truffle-growing in Uzès reflects Uzès' society: it essentially responds to urban and "rurban" needs and values such as leisure, landscape quality and biodiversity preservation.

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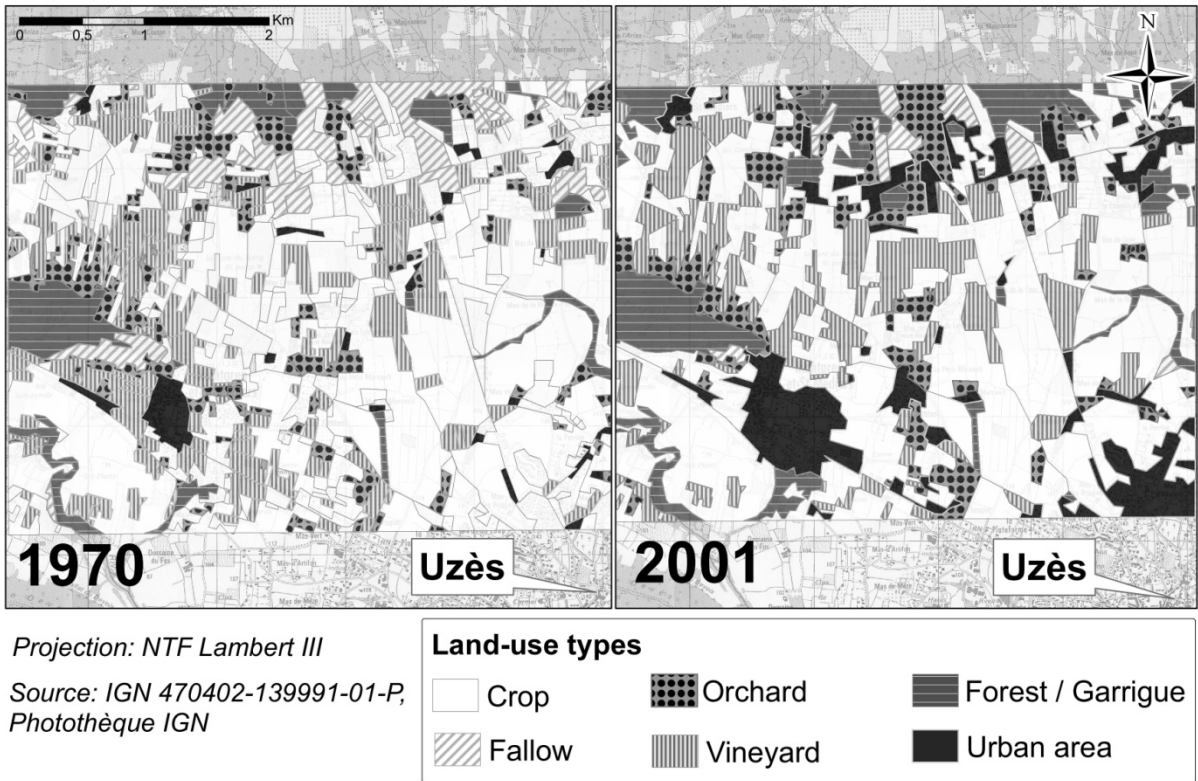
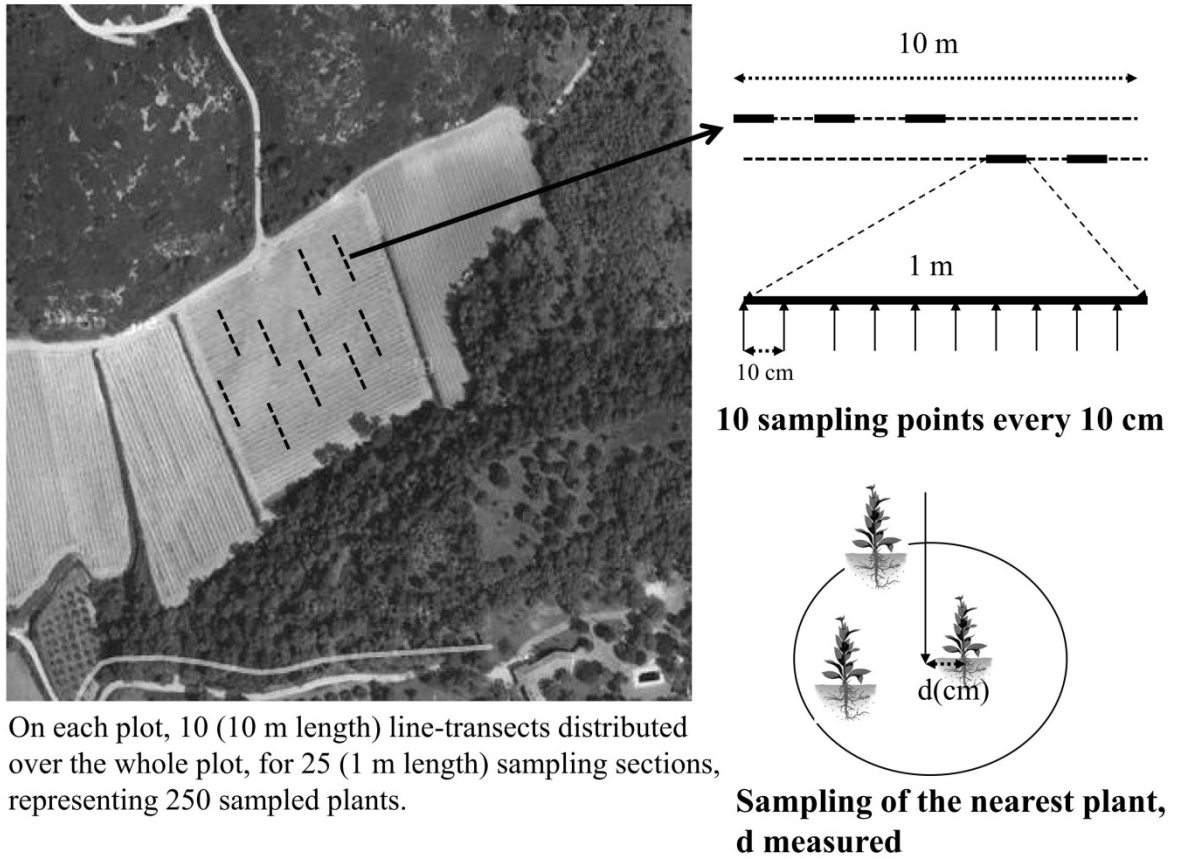


Figure 1: Land-use changes in Uzès between 1970 and 2001



On each plot, 10 (10 m length) line-transects distributed over the whole plot, for 25 (1 m length) sampling sections, representing 250 sampled plants.

Figure 2: Methodology used for floristic inventories

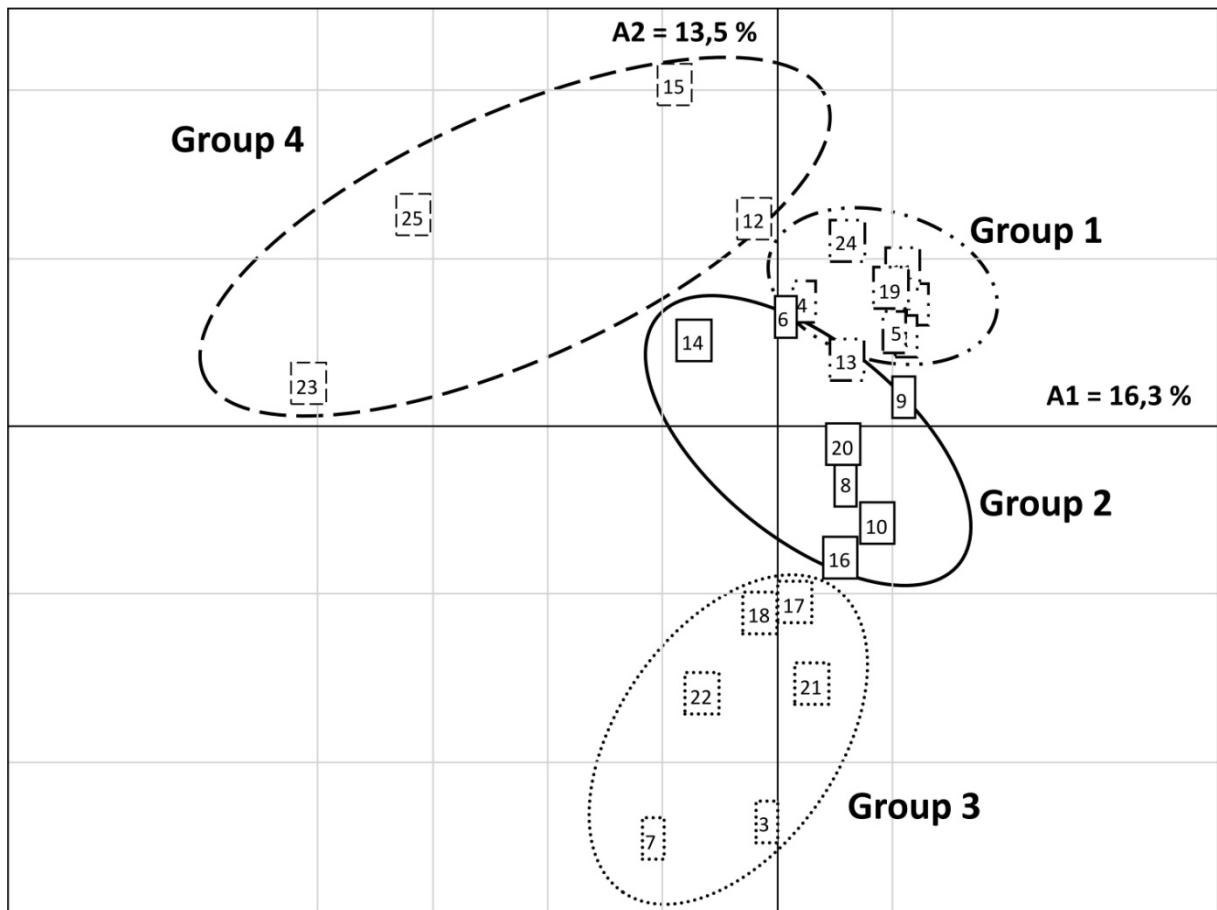


Figure 3: Results of the Multiple Correspondence Analysis. Each number corresponds to one truffle-grower respondent. The four groups of truffle-growers have been distinguished by a hierarchical clustering analysis.

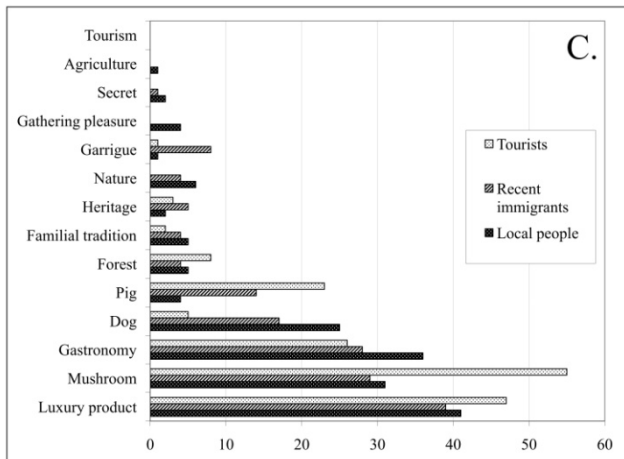
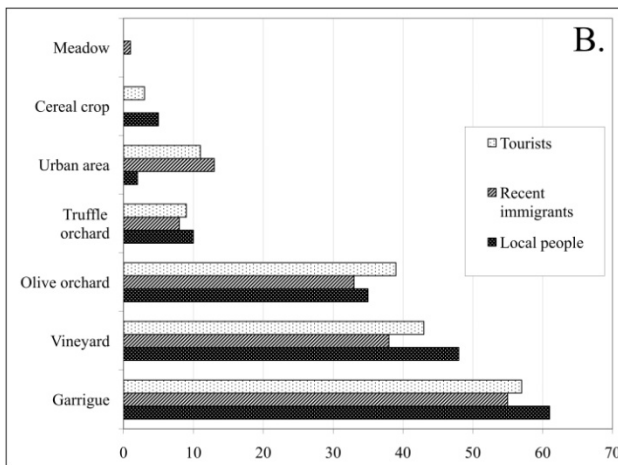
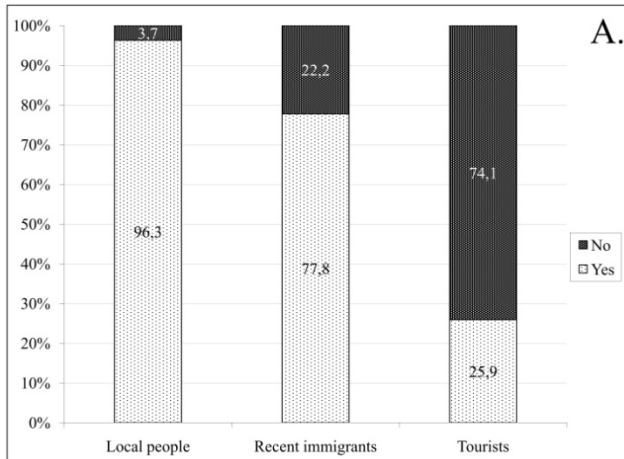


Figure 4: Results of the survey on the perceptions of truffle and truffle-growing in the Uzès region. **A:** knowledge about the presence of truffle plantations (Question: Do you know that there are truffle orchards in the Uzès region?). **B:** heritage value of the different land-uses types in the Uzès region (Question: in the following list, could you identify and rank the three land-uses that best represent the Uzès region in terms of local identity and heritage?). **C:** values associated to truffle (Question: in the following list, could you identify and rank the three terms that best represent truffle?).

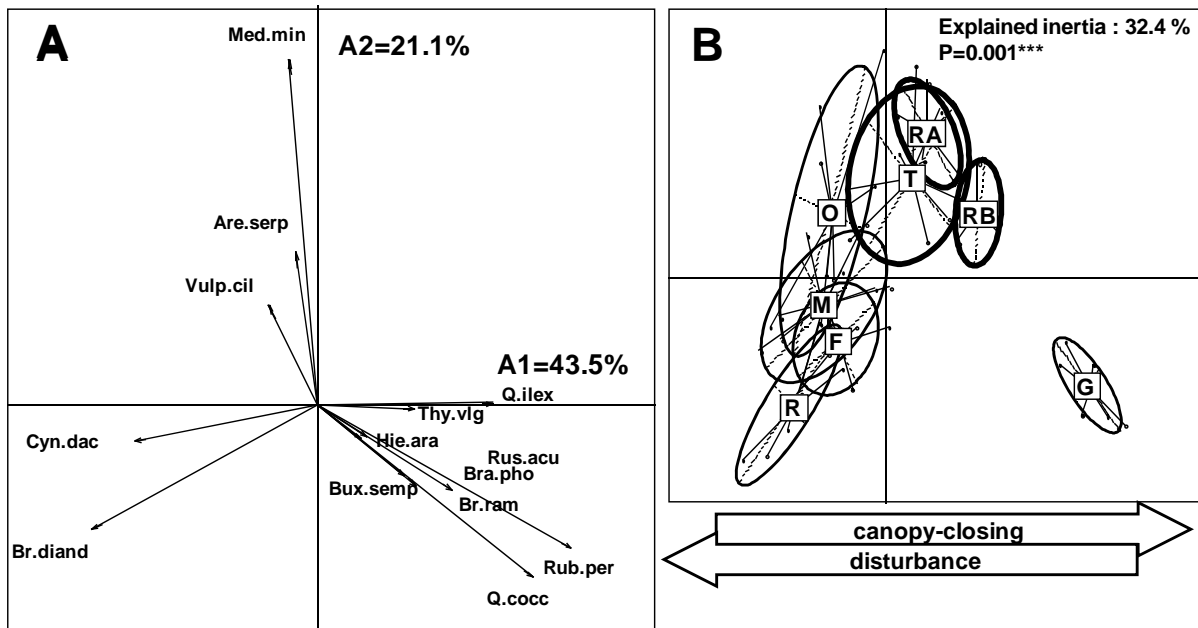


Figure 5: **A:** Results of the Non Symetric Correspondance Analysis. (Only species whose contributions to axis construction are superior to the mean of species contributions are represented). **Are.serp** *Arenaria serpyllifolia*; **Bra.pho** *Brachypodium phoenicoides*; **Br.diand** *Bromus diandrus*; **Br.ram** *Bromus ramosus*; **Bux.semp** *Buxus sempervirens*; **Cyn.dac** *Cynodon dactylon*; **Hie.ara** *Hieracium aragonense*; **Med.min** *Medicago minima*; **Q.cocc** *Quercus coccifera*; **Q.ilex** *Quercus ilex*; **Rub.per** *Rubia peregrina*; **Rus.acu** *Ruscus aculeatus*; **Thy.vulg** *Thymus vulgaris*; **Vulp.cil** *Vulpia ciliata*.

B: Results of the Between Class Analysis. The inertia explained by the land-uses is tested using a permutation test ($n=999$) **F:** Fallow lands. **G:** Garrigue. **M:** Meadows. **O:** Olive orchards. **RA:** Maintained renovation. **RB:** Unmaintained renovation. **R:** Road edges. **T:** Truffle orchards.

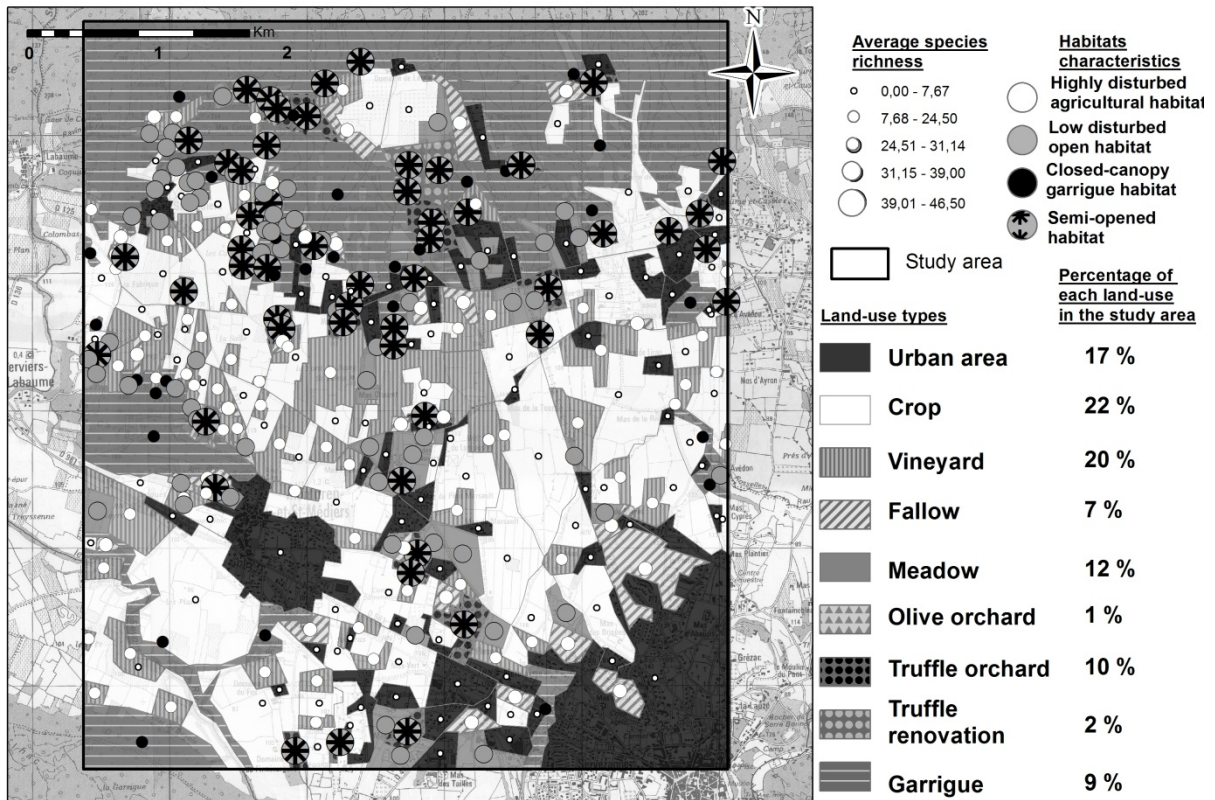


Figure 6: Distribution of plant species richness at the Uzès landscape scale in 2009. Average species richness per 250 plants estimated for each land-use on the basis of our 67 inventories (crops: 3; fallow: 7; garrigue: 6; vineyard: 13; road edge: 5; olive orchard: 8; truffle orchard: 8; meadow: 10, truffle renovation:7)

Age group	Nb	Profession	Nb	Origin	Nb	Land access	Nb
Adult	9	Farmer	11	Local	15	Inherited	13
Senior	16	Services, tertiary sector	10	Non-native	10	Bought	4
		Truffle professional	4			Inherited and bought	8

Link to truffle	Nb	Length of truffle experience	Nb	Practices	Nb	Income from truffle	Nb
Family	8	Pioneer	8	Planter	17	No	9
Science - Nature attraction	3	Intermediate	11	Planter and gatherer	8	Small income	8
Friends	10	New planter	6			Medium income	4
Professional	4					Considerable income	4

Choice of the land motivated by	Nb	Selling truffle to	Nb	Syndicat member	Nb	Had financial support	Nb
Valorization of otherwise unused land	10	Broker	13	Yes	22	Yes	19
Leisure/experimentation close to the house	6	Private	11	No	3	No	6
Ensuring the best possible conditions (soil, irrigation, etc.) for truffle production	9	Restaurant owner	6				
		Personal use	5				

Table 1: Variables used for the Multiple Correspondence Analysis

Type	Cc	V	G	F	R	O	M	RA	RB	T
Nb plots	3	13	6	7	5	8	8	4	3	10
Richness	7.6±2.5 ^a	24.3±7.3 ^b	24.5±4.3 ^{abc}	31.1±8.8 ^{bcd}	34.4±14.2 ^{bcd}	35.5±8.1 ^{cd}	37.5±6 ^{de}	47.5±5.8 ^c	39±4 ^{bcd}	44.1±6.9 ^c
H'	0.63±0.54 ^a	2.13±0.49 ^c	2.43±0.16 ^{bc}	2.57±0.41 ^{bc}	2.63±0.51 ^{bcd}	2.77±0.28 ^{bd}	2.81±0.34 ^{bd}	3.18±0.26 ^{bd}	2.93±0.15 ^{bd}	3.14±0.24 ^d
PIE	0.30±0.32 ^a	0.79±0.11 ^c	0.86±0.02 ^{bc}	0.86±0.06 ^{bc}	0.88±0.05 ^{bc}	0.89±0.03 ^{bc}	0.89±0.07 ^{bc}	0.93±0.03 ^{bc}	0.90±0.04 ^{bc}	0.93±0.02 ^b

Table 2: Species richness and diversity indexes of the main land-uses in the Uzès region (H' : Shannon index; PIE : Probability of interspecific encounter or « Gini-Simpson index »). Results are expressed in « mean±sd ». We found a significant inter-type difference for each variable (Kruskal-Wallis inter-type tests. Richness : $\chi^2=40.93^{***}$;H' : $\chi^2=40.17^{***}$; PIE : $\chi^2=34.82^{***}$). Letters indicate the significant differences between land-uses according to a post-hoc Tukey HSD test. **Abbreviations:** **Cc:** Cereal crops. **F:** Fallow lands. **G:** Garrigue. **M:** Meadows. **O:** Olive orchards. **R:** Road edges. **RA:** Maintained Renovation. **RB:** Unmaintained Renovation. **T:** Truffle orchards. **V:** Vineyards.