



## Cognitive social capital and local forest governance: community ethnomycology grounding a mushroom picking permit design

✉ Elena GORRIZ-MIFSUD<sup>1,2,3\*</sup>, ✉ Laura SECCO<sup>3</sup>, ✉ Riccardo DA RE<sup>3</sup>, ✉ Elena PISANI<sup>3</sup> and ✉ José Antonio BONET<sup>1,2,4</sup>

<sup>1</sup>Forest Science and Technology Center of Catalonia (CTFC). Ctra. St. Llorenç de Morunys km.2. 25280, Solsona, Spain.

<sup>2</sup>University of Lleida, Avda. Alcalde Rovira Roure, 191, 25298 Lleida, Spain. <sup>3</sup>University of Padova, TESAF Department, Agripolis, Viale dell'Università, 16, 35020 Legnaro, Padova, Italy. <sup>4</sup>AGROTECNIO-CERCA, Avda Alcalde Rovira Roure, 191, 25198 Lleida, Spain.

\*Correspondence should be addressed to Elena Gorriz-Mifsud: [Elena.gorriz@ctfc.cat](mailto:Elena.gorriz@ctfc.cat)

### Abstract

*Aim of study:* The local ecological knowledge shared in rural communities shapes their norms for using their nearby open-access natural resources. We suggest a method to analyse this form of cognitive social capital with an application to a mushroom picking permit.

*Area of study:* Poblet forest in Catalonia (NE Spain).

*Materials and methods:* We applied semi-structured questionnaires to pickers in four municipalities and to the governing body of the protected area. Our methodology assesses cognitive social capital combining three instruments: (i) inter-quartile ratio indexes for community cohesion, (ii) pair-wise comparisons across social groups: pickers and decision-makers (DM), and (iii) correlations for mental models linking perceived ecological, social and economic challenges with foreseen solutions.

*Main results:* Analogous perceptions between DM and local pickers were found in most mushroom-related problems, which align with most picking permit design features. The perceived dissimilar behaviour between local and foreign pickers, the need for forest tending –addressing the wildfire risk–, and trash left in the forest are shared among pickers and DM. Moreover, some mental models of the DM showed statistical consistency. At the individual picker level, mushroom eco-literacy relates to family learning and proximity to DM, while links between pickers and DM correlate with increased forest profitability expectations.

*Research highlights:* Strong convergence in cognitive indicators aggregated at the town level indicate a single hermeneutic community among local pickers, which seems to underlie the large permit acceptance but did not explain the differential permit uptake –thus, structural social capital emerges as complementary predictor.

**Additional key words:** non-wood forest products; norms; institutional evolution; rural knowledge; regulation; mental models; wild mushrooms.

**Abbreviations used:** DM (Decision-Makers); Ecol (ecological aspects); Econ (economic aspects); For (forestry aspects); IQR (inter-quartile ratio); LEK (Local Ecological Knowledge); SC (Social Capital); Soc (social aspects); TEK (Traditional Ecological Knowledge).

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## Introduction

The socio-ecological systemic approach features the inter-relations between ecosystems and people –through ecosystem management contributing to people’s welfare– and among people –through formal and informal norms underlying such management (Hahn et al., 2006). If these inter-relations require coordination of actors and organizations, the so-called Social Capital (SC) emerges as a central characteristic influencing collective action. SC represents the features of social organizations that facilitate cooperation for mutual benefit of their members (e.g. Putnam, 1993) and conceptualizes individuals interacting with other societal actors. SC is grounded on the networks of information and collaboration flows among actors, which set the norms for their interaction (Bourdieu, 1986; Putnam, 1993).

In socio-ecological systems, the flows among network members relate to the biocultural transfer regarding ecological processes –including natural resources management–, and norms that rule such management. Norms aim to align community members’ behaviours to maintain the shared utilisation of natural resources (Jones & Lynch, 2002). Specifically for forest socio-ecological systems, norms constitute the formal and informal regulatory structures based on interactions between and among public and private actors regarding the use of forest resources (Giesen & Buttoud, 2014).

Our study focuses on the cognitive (or intellectual) dimension of SC, which means the pool of shared knowledge (Coleman, 1988) and shared meaning and understanding among community members, created through the combination and exchanges of existing (explicit and tacit) knowledge (Nahapiet & Ghoshal, 1998). When referred to forest resource dynamics, we propose that cognitive SC refers to the collective meaning and understanding of human-forest processes based on “mental models”. This is, cognitive SC refers to the community constructs around forest problems and the portfolio of solutions –i.e. management options–, which ultimately shape “shared visions” (Górriz-Mifsud et al., 2016). Mental models regarding how to manage natural resources lead to a set of practices valued by a community as correct or incorrect –i.e. “norms”. In sectors with a multiplicity of spatially dispersed users – as non-wood forest products are–, the field enforcement of such practices is very costly, resulting in information asymmetry on how users behave. In such limited field control contexts, the abundance by “good behaviour” codes remains crucial for natural resource sustainability.

This paper concentrates on the perceptions of local communities regarding mushroom picking regulation, and analyses collective knowledge on the ecological, economic, and social dimensions which underpin the mushroom harvesting governance. This analysis is particularly relevant given the increasing emergence of mushroom picking permit systems (Jones & Lynch, 2002). Methodologically, this study links

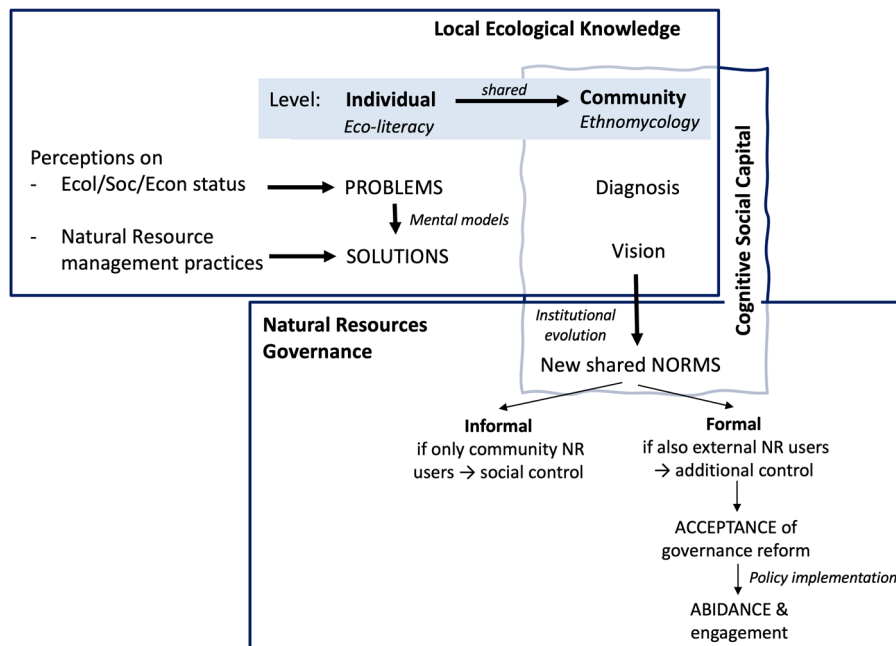
the traditional (T) and local ecological knowledge (LEK) with SC theories by assessing specific knowledge variables. LEK stands for “*people’s knowledge of abundance and distribution of species usually gained from individual’s observations*” after interacting with landscapes over longer periods than are possible in scientific investigations (Pacheco-Cobos et al., 2015). When such wisdom is transmitted and accumulated across generations, we talk about traditional ecological knowledge (TEK) (Berkes, 2000). These LEK variables can be functional in understanding subjacent (myco-)cultural features of local communities and consequently provide support to the forest policy design.

Previous scholars analysed the cognitive aspects of natural resource users from three angles, namely: (i) the TEK held by rural inhabitants and its relation to resilience in a context of global change (Berkes, 2000); (ii) how information regarding the management of natural resources is spread with the consequent adoption of specific mental models (Schlüter & Koch, 2009); and (iii) fuzzy cognitive mapping of mental models on natural resources (Isaac et al., 2009). However, they did not focus on knowledge aggregation and convergence among different natural resource users and decision-makers. Analysing LEK from the cognitive SC perspective is relevant as it spreads through social networks (Jones & Lynch, 2002). Our results, thus, add to the ethnomycology field from a governance perspective.

Two eco-pedagogy concepts helpful for community-level analysis are eco-literacy and eco-mentorship (Pilgrim et al., 2007; Kulnieks & Longboat, 2013). Here we employed two eco-literacy levels: (i) the names of ecosystem components, and (ii) the natural resource management systems and social institutions that govern them (Berkes 1999, in Pilgrim et al., 2007). Folk wisdom on ecology processes around fungi and their multiple uses constitutes the field of ethnomycology (Yamin-Pasternak, 2011). Specifically, macro-fungi picking knowledge has been little explored (Pieroni, 2016) in Spain, with a few descriptive studies (de Román & Boa, 2004) but without analysing the perceptions of picking dynamics, related concerns and derived governance implications.

Fig. 1 illustrates our conceptual framework. Cognitive SC is here conceptualised as the degree of cohesion (or inversely, divergence) of the perceptions –i.e. knowledge–, mental models –i.e. narratives– and positioning –i.e. vision– of community members. Mental models constitute a key tool for interpreting reality when agents count with incomplete information to make decisions or construct their opinion regarding a phenomenon (Denzau & North, 1994). When interpersonal relations contribute to building mental models, individuals often rely on referent agents such as opinion leaders, factual powers, or so-perceived experts. In some cases this might trigger positioning towards specific topics (Schlüter & Koch, 2009).

Mental models lay the foundations for practices seen as (un)proper, i.e. social norms. Our underlying assumption is



**Figure 1.** Conceptual framework. NR: natural resources.

that when socio-economic and/or ecologic changes alter the demand or supply of natural resources, their traditional management may become suboptimal. Hence, the pre-existing normative may be felt insufficient by community members. Thus, the norms could evolve and influence the positioning of the community towards some policy intervention. Brooks (2010) developed a model of institutional evolution, which puts forward that local knowledge about natural resource management leads to behavioural norms (e.g. good practices), which could be incipiently formalised (e.g. voluntary codes of conduct), and eventually become institutionalised as formal rules (e.g. formal permits or prohibitions). The fit between previous informal norms and the formalised institutions likely reflects the reform acceptance.

## Material and methods

### Analytical framework

In this paper the inter-relation between the cognitive dimension of SC with forest governance was analysed at local level because it represents the sphere where citizens have more direct influence in policymaking (Ruppert-Winkel & Winkel, 2011). Our case study deals with the introduction of a picking permit in Catalonia (Spain). Ad-hoc indexes have been developed for three units of analysis: the individual picker, the towns whose municipal territory is affected by that policy instrument (as local communities), and the decision-makers. Wild mushroom picking is conducted seasonally (thus, the experiential knowledge being time-wise restricted), and by dispersed users which

can have self-consumption or commercial purposes (e.g. Lovrić et al., 2021).

Specifically, our study aims at responding to two research questions, setting the ground for our analytical framework (Fig. 2):

Q1) *To what extent is there a convergence of concerns around mushroom picking?*

Q2) *Whether and how do these concerns relate to mushroom picking governance?*

Each question was approached from different angles using complementary analyses. For the first question, we studied the collective knowledge around picking concerns before the permit, both for local pickers and decision-makers (DM) and their justifications. We analysed pickers' perception convergence across towns. Next, we analysed the convergence among the decision-makers, and between them and pickers.

For the second question, we searched which mental models DM ensue to mushroom-related concerns, hence affecting policy design. Moreover, we contrasted whether town-level cohesion correlates with permit uptake, given that solid divergences would indicate the likely existence of opinion subgroups. Finally, we examined whether individual picker variables (namely, perceptions, mushroom literacy, learning source or network size) explain their permit acceptance level.

### Case study description: wild mushroom picking permit in Poblet forest

The protected area of the Poblet forest is located in Catalonia (Northeast Spain), 126 km far from Barcelona city,

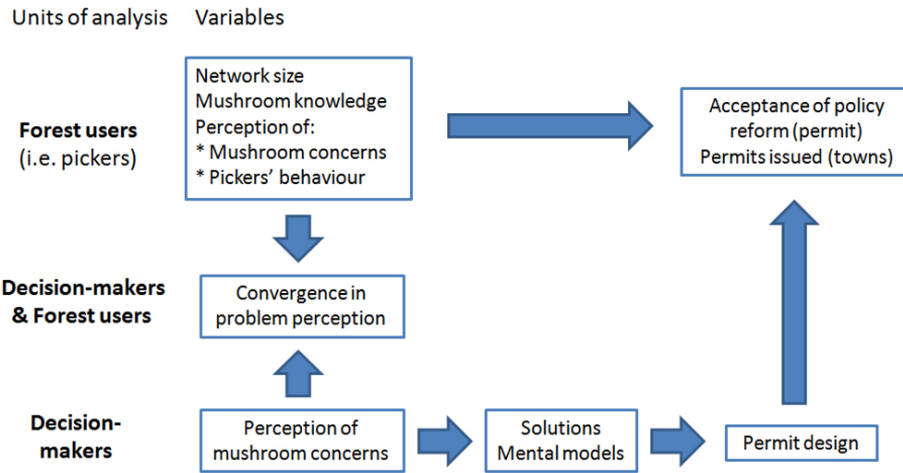


Figure 2. Analytical framework.

and 50 km far from Tarragona city. Spreading over 3,000 hectares, this forest is mainly owned by the Government of Catalonia with some municipal patches. It hosts a wide diversity of Mediterranean forest ecosystems dominated by holm oak (*Quercus ilex* L.) and maritime pine (*Pinus pinaster* Ait.). Declared protected area in 1984, the operational management of Poblet park is conducted by a technical office, while its strategic management relies on a governing body which gathers local stakeholders with provincial and regional decision-makers.

The Article 36.1 of the Spanish Forest Act (BOE, 2003) establishes that the landowner owns non-wood forest products growing on his property, e.g. mushrooms. Hence, the Poblet Governing body decided to pioneer in Catalonia the introduction of the “mushroom picking reserve” concept. Being Catalonia a mycophilic area, with 23% of its citizens declaring to go mushroom picking at least once annually (CEO, 2014), the pressure on the resource has increased in the last decade. This has led to a debate about regulating this

activity and the adequacy of a picking fee to contribute to the management of the forest used by pickers. Yet, managers often worry about pickers’ acceptance of restrictions to a traditional activity in terms of control, practice and fee.

In Poblet area this debate found a positive local ground, which facilitated the establishment of mushroom permits in 2012 (see map in Fig. S1 [suppl]). The permit authorised the daily collection of up to 6 kg per person. Most permits (76%) were acquired by locals (Table 1), who had to pay 1 €/season, whereas the price for outsider pickers was 3 €/day (5% tickets), 10 €/season (9% tickets), 5 €/season to pensioners and youngsters between 14 and 17 years old (5.8% tickets) with gratuities for local and foreign children (<14 years old, 4.2% tickets). The “local” permit category encompasses the inhabitants registered in each of the four municipalities affected by the regulated area: Montblanc, L’Espluga de Francolí, and Vimbodí, in the lowlands; and Prades in the mountains. Climatic conditions precluded the opening of the 2013 permit season, with other seasons showing

Table 1. Target population, permits issued and pickers sampled in the municipalities surrounding Poblet forest. Source of population data: IDESCAT; of permits: Poblet technical office.

Municipality characteristics	Season	Montblanc		L’Espluga de Francolí		Vimbodí i Poblet		Prades	
		Total <sup>[a]</sup>	15-84	Total	15-84	Total	15-84	Total	15-84
Population in 2015		7,283	5,906	3,818	3,087	966	796	623	523
		N <sup>[b]</sup>	15-84	N	15-84	N	15-84	N	15-84
Local permits issued	2012	668	11%	655	21%	178	22%	33	6%
	2014	830	14%	686	22%	198	25%	36	7%
	2015	468	8%	202	7%	76	10%	8	2%
Pickers’ available contacts		470		447		90		3	
		N <sup>[c]</sup>	%	N	%	N	%	N	%
Interview sample		22	2.7%	19	2.8%	10	5.1%	1	2.8%

<sup>[a]</sup> Total and 15-84 years old (active pickers are considered until 84 years old). <sup>[b]</sup> Absolute values and % 15-84 years old population. <sup>[c]</sup> Absolute values and % permits issued in 2014.

**Table 2.** Variables gathered through the interviews to mushroom pickers and decision-makers (DM).

Variable categories	Picker variables	Variable definition	Values
Social profile	Age	Age category of the respondent	18-30 / 31-50 / 51-65 / >65
	Local seniority	Number of years living in one of the four Poblet forest towns, as proxy for temporal trajectory to be acquainted with local myco-ecological processes	Count number [0-[
Ethnomycological variables (when shared, then cognitive social capital variables)	Eco-literacy	Number of mushroom species able to pick in Poblet	Count number [0-[
	Knowledge source	Category of source of knowledge on wild mushrooms picking	Family / friends / course / media / others
	Awareness of legal ownership	Correct answer regarding Poblet forests ownership, and its mushrooms	Binary (yes/no)
	Opportunity cost	Picking also in alternative (non-Poblet) forests	Binary (yes/no)
	Good picking practices	List of characteristic elements of a good picker	Open (text)
	Problem perception prior to permit	Perception of a list Economic, Social and Ecological/Forestry problems (mental model input, Table 3)	Likert-scale (from 0: completely disagree; to 4 completely agree) and "don't know"
Governance variables	Positioning towards solutions	Perception of a list interventions (mental model output, vision). Only posed to DM	
	Permit acceptance	Overall agreement with the current permit system	
	Permit design features	Degree of agreement with different instrument design features: need for a permit, geographical coverage, fee, linked harvesting norms, proceeds to be reinvested	Binary (0: disagree; 1: agree) and "don't know"
Structural SC variables <sup>[1]</sup>	Non-compliers	Acquainted with local pickers gathering in the regulated area without the permit	Binary (yes/no)
	Bonding SC	Network of same town pickers: number of mushroom pickers known within my municipality	Count number [0-[
	Bridging SC	Network of other towns pickers: number of mushroom pickers known in each of the other municipalities	Count number [0-[
	Linking SC	Self-stated proximity to DM (against the list of DM members)	0: don't know; 1: known but never talk; 2: sporadically talk; 3: often talk

<sup>[1]</sup> SC: social capital.

a number of permits somewhat proportional to the productivity. A technical committee advised the permit design and supervised its functioning, elaborating annual reports. In the following we will refer to the governing body and the technical committee as the “decision-makers” (DM).

Poblet park also hosts a network of permanent plots for scientific monitoring of fungal production and diversity (Bonet et al., 2012). These plots are fenced, hence the

impact of picking is not appraised there; instead climate change trends or forestry interventions are measured.

### Data collection and analysis

From a total population of 1750 local pickers who acquired a permit, interviewees were selected among those

recurrently getting the permit (i.e. registered in 2012 and 2014) and left a phone number. After deleting governing body members and non-adults, 1010 contacts were ordered by surname for each municipality, and a systematic random selection was applied. After 258 first-contact phone calls, the rate of acceptance to be interviewed face-to-face was 20%. Only one interview was possible to conduct in Prades; hence its results are only considered for the aggregated analyses (i.e. all four municipalities together). In-depth interviews each were conducted during 2014–2016 to 52 pickers (average 1 h length, confidence interval of 13.5%) and 16 DM members (average 2 h length).

Two questionnaires (one for DM and another for pickers) were drafted combining semi-open and closed questions (Table 2). The interview guideline contained a section regarding familiarity with Poblet forest (forest and mushroom ownership) and the mushroom picking activity there (how to describe a good picker, alternative picking locations), followed by a section on mushroom-related eco-literacy (species able to identify, source of mushroom knowledge), problem perceptions (informal norms), interspersed with questions on permit acceptance (governance) and network connections (structural SC).

Interviewees were confronted with a table of different mushroom-related issues, expressed as statements regarding forest management and mushroom ecology (For), economic (Econ) and social (Soc) concerns, based on previous qualitative research (Górriz-Mifsud et al., 2015). Ecological aspects included mushroom production factors and the harvesting practices which could affect them. Economic concerns referred to rural value chains regarding landowners and commercial pickers (the last were posed only to interviewees who reported knowing some commercial picker). Social concerns included pickers' behavioural factors potentially causing annoyance to other forest users. Interviewed pickers were asked to which degree they considered the statements as a problem at the time of the permit introduction (before 2012) by scoring in a 5-points Likert scale from "totally disagree" to "totally agree". The statement formulation indicated a judgement of what is correct or not, hence representing the interviewee's values. There was also a "don't know" option, and a space for commenting.

Finally, basic structural SC variables were collected as follows:

- (i) picker's network size as number of pickers' known within the same municipality (bonding SC, i.e. strong ties among individuals within the same community -Andriani & Christoforou, 2016) and in neighbouring towns (bridging SC, weak ties connecting individuals of different circles -Andriani & Christoforou, 2016),
- (ii) proximity to the DM (linking SC, representing the connections with powered individuals outside the community -Woolcock, 2001).

The ethnomycological tacit knowledge is mainly experienced-based for pickers, while DM held explicit knowl-

edge (often scientific-based) – *sensu* Polanyi (1958). Consequently, shared problem perception and preferred solutions stem from own experience interacting with the ecosystem and/or from information exchanges with peers. The inter-quartile range (IQR) –i.e. the difference between first and third quartiles– was used as a simple but meaningful indicator for the degree of convergence (or conversely, dispersion) among community members. This indicator is adequate for ordinal variables and is robust to different sample sizes. Null IQR indicates that at least half of the sample shares a score and is interpreted as low dispersion. We also considered that two points of difference of IQR and median between DM and pickers indicates a large discrepancy.

Non-parametric statistics were applied using SPSS to assess differences: Mann-Whitney U test between DM and pickers, and Kruskal-Wallis test across municipalities of Montblanc, Espluga and Vimbodí. Besides concerns, DM were asked about their perception of possible "solutions". Spearman correlation was applied for testing DM mental models within the DM group, checking potential linear association between concerns and related measures. To disentangle potential additional explanatory factors, Spearman correlations were run between eco-literacy and social variables (age group, source of mushroom knowledge) as well between pickers' concerns and structural SC variables.

As for governance indicators, we used the number of permits issued per town, and asked pickers about their acceptance of the current permit design. We tested Spearman correlation between such governance and problem perception variables.

## Results

The mycological knowledge was first set out, followed by the mushroom-related problems' perception and convergence. The final section presents the governance variables and its relation to cognitive SC. Excerpts of the pickers' interviews are reported with the initial letter of the town they belong to Montblanc (M), Vimbodí (V), Espluga (E), Prades (P) and DM for DM, followed by the number of interview. Further supporting excerpts can be found in the Annex [suppl].

### Mycological knowledge

#### *Familiarity with wild mushroom picking in Poblet*

Most (90%) of interviewed pickers declared having lived in the Poblet area for over fifteen years. Most of them (80%) report having alternative forests to go mushroom picking beyond Poblet –areas where no permit is required.

**Table 3.** Cognitive aspects of pickers in terms of perceptions regarding mushroom (and forest) related statements. Within each typology of concerns, the table is ordered according to the pickers' IQR from the largest consensus (zero-value) until the largest divergences.

	Type	Statements	Pickers			Decision-makers			DM-pickers difference (U-value)
			Med	IQR	N	Med	IQR	N	
<b>Ecology-Forestry concerns</b>	For1	Forests required forestry interventions	5	0	51	5	0	18	422.5
	For2	Some pickers picked both young and mature mushrooms	5	0	50	5	1	15	314
	For3	Climate change causes more damage than pickers	5	1	49	n.a.	n.a.	n.a.	n.a.
	For4	Some pickers destroyed non-edible species	5	1	52	5	1	16	355
	For5	Some pickers used plastic bags	5	1	51	5	1	18	411.5
	For6	Some pickers used tools that damage the soil	5	1	50	4	1	18	338
	For7	There is high wildfire risk	5	2	52	4	3.50	18	336
	For8	There was risk of mushroom overexploitation	4	4	48	2.5	3	18	296.5
	For9	Wildboars cause more damage than pickers	4	4	52	n.a.	n.a.	n.a.	n.a.
<b>Social concerns</b>	Soc1	Some shouted in the forest	5	0	52	5	2	17	341
	Soc2	Pickers appreciate silence and wild nature	5	0	51	n.a.	n.a.	n.a.	n.a.
	Soc3	Some pickers didn't know that the forest has an owner	5	1	49	n.a.	n.a.	n.a.	n.a.
	Soc4	Some pickers threw trash	5	1	52	5	1	17	423
	Soc5	Foreign pickers cause problems	4	2	47	4	2	18	338
	Soc6	Some pickers are impolite	4	2	45	4	2.25	16	346.5
	Soc7	Locals help to the forest when required	5	4	48	5	3	17	380.5
	Soc8	Controlling pickers in this forest is complicated	4	4	47	4	2.75	18	403
	Soc9	Some parked the car in a wrong manner	4	4	40	n.a.	n.a.	n.a.	n.a.
<b>Economic concerns</b>	Econ1	Commercial pickers didn't ask for permission	5	0	25	5	0	16	192
	Econ2	Commercial pickers didn't gratify landowners	5	0	27	5	0	18	207
	Econ3	Pickers benefited from the forest without contributing	5	1	49	5	1	18	395.5
	Econ4	I trust on marketed mushrooms	5	1	35	n.a.	n.a.	n.a.	n.a.
	Econ5	Forests must be profitable and they aren't	4	2	43	5	0	18	246.5
	Econ6	Mushrooms is an underexploited asset	2	2.75	46	4	2	18	237*
	Econ7	Locals are accomplices of grey market	1	3.5	15	4	2	13	70
	Econ8	There are few income alternatives in this rural area	3	4	43	4	2.75	18	287
	Econ9	Commercials aren't experts	2	4	26	3.50	3.25	12	127

Med: Median. n.a. = not available. \*=significant differences at  $p < 0.05$  level.

All interviewees picked for self-consumption. Commercial picking in Poblet seems to be quite limited, and interviewees reported knowing barely one picker per town selling them. On average, interviewees report knowing 0.4 pickers who did not get the permit (non-compliance).

The mushroom species mentioned as most typically picked are the saffron milk-cap (*Lactarius group deliciosus*), slippery-caps (*Hygrophorus gliocyclus*), and grey knight (*Thricholoma terreum*). Pickers showed a more comprehensive mushroom literacy than DM mem-

bers (i.e. able to recognise 6.8 vs. 5 species on average), which is reasonable given that not all DM live in the area or are pickers themselves. Moreover, older categories of pickers (>50 years) related to more species identification ( $\rho$ : 0.281,  $p=0.044$ ). The Kruskal-Wallis test revealed no significant difference between municipalities regarding eco-literacy,  $p=0.91425$ . Most pickers used some local, yet mycologically inaccurate terms but maintaining the genuine concept, such as “seeds” for spores (referring to the reproductive unit), or “roots” for the mycelium in the soil (referring to the underground network of filaments with growth function), whereas DM tended to use technical mycological terms. Picker’s mushroom literacy is related to having acquired the knowledge through the family ( $\rho=0.287$   $p=0.039$ ), and the proximity to the governing body (DM) ( $\rho$ : 0.287,  $p=0.039$ ).

Only 57% of the respondent pickers knew the land ownership affecting Poblet forest. The main error was assigning it to “the State”, understood by some as Spain and others as the Catalanian Government. Finally, only 22% were acquainted with the legal ownership of mushrooms and hence collecting rights.

### ***Informal norms and their transmission***

Asked about how to define a “good mushroom picker”, interviewees described it as respectful, picking only the species one is sure of, and leaving no trace in the forest. The motivation for behaving as good pickers is justified by their self-interest (i.e. recurrent visit to the same spot) or by deference towards others. Having adequate equipment, orientating oneself in the forest, and knowing diverse mushroom species and locations are pieces of knowledge and skills also considered by many as characterizing “good pickers”. Still, there was some confusion among pickers regarding the convenience of cutting or picking.

Asked about how such good practices are learned, 80% of interviewed pickers pointed out the family, followed by friends (22%). Interviewed pickers stressed that being exposed since infancy to rural environments imbued them with the norms. Another group explained that good practices can be learned through accompanying wiser pickers, but also through external sources, e.g. internet. Many respondents, moreover, highlighted the self-experience for internalising the code of conduct.

## **Convergence in problem perception**

### ***Problem perception and convergence within pickers***

Table 3 illustrates that social and ecological statements are considered somewhat problematic, whereas econom-

ic aspects are scored differently. A consensus was found regarding the need for forestry interventions (For1), the gathering of both mature and young mushrooms (For2), the noise of some pickers (Soc1), and their preference for silence while roaming in the forest (Soc2).

Regarding the forest-related concerns, virtually all respondents reported a shrinking productivity of mushrooms in the last decades. The mental models explaining such decline diverge considerably, between either caused by pickers –i.e. the largest dispersion falls in the risk of mushroom overexploitation (For8)–, driven by wild boars’ expansion (For9), or induced by climate change (For3) –this last with less dispersion. Climate change affects the mushroom yield in terms of increasingly irregular and meagre precipitations.

Wild boar is spreading along Catalonia (Cahill et al., 2012), but since Poblet is a hunting sanctuary, control measures are tough to take. Wild boars are blamed for turning the ground upside down. Pickers become especially upset because they come across spoilt mushrooms. Apparently, the animals “do not eat the mushrooms but leave them destroyed” (M17). Why wild boars behave in this manner is differently explained across pickers, with some of the opinion that the animal searches for roots or worms and destroys mushrooms as a side-effect. Many interviewees were not able to distinguish wild boar soil damage from that caused by pickers, whereas a few did because “a mushroom picker does not leave saffron-milk caps or dark knights” (M15).

Interviewed pickers supported forest thinning and brush cleaning (For1). Respondents justified them for fire prevention (hence tackling For7, an option value), wild boar control (For9) and easiness to roam (indirect use value). Indeed, a rather high but variable wildfire risk was perceived. Moreover, the past fuelwood use by local families for heating endures in the collective memory of Espluga and Vimbodí; this was referred to contribute keeping a lower forest density and a “clean” understory.

The null IQR confirmed a wide full agreement that some pickers collect both small and mature mushrooms (For2). However, 25% of respondents did not recognise that practice as problematic given that small *Lactarius* are typically used for conserve, which is considered a delicacy in the area. They either did not reflect on the consequence of restricting the spore spread of young exemplars or conceive that such usual practice cannot be damaging. Moreover, others justified picking the youngest by believing that once uncovered from the thick pine needle carpet these small mushrooms will not grow further and become spoilt if not picked (E12, E14, E18).

The use of plastic bags (For5) was conducted by some pickers and was generally considered incorrect, but the reasons diverged. The dominant idea was that spore spread requires porous containers. Yet, some thought that the wicker basket is a fashion (V4, V10, V11) and that the real problem of transporting with plastic bags is “that mush-



rooms become spoilt" (E14, M10, V8), hence not practical for those spending the entire day in the forest.

Respecting the ground was well shared among respondent pickers, who considered that the use of tools damaging the soil constitutes a problem (For6). Regarding the tools, most interviewees referred to the past local practice with hooks. The reason for their use varied: for easier visualisation of mushrooms amidst the large maritime pine needles, or to accessing forest areas with dense or thorny shrubs. Such practice was attributed to both (mainly old) locals and foreigners. In any case, 20% of the interviewees pointed at its reduction as one of the immediate perceived effects of the permit introduction. The use of rakes, instead, is a new practice reported barely and solely for foreigners.

With regard to the social concerns, some interviewees justified shouting (Soc1) to communicate in areas with low phone coverage when going in groups, and especially solitary pickers disliked that behaviour. A high consensus applied for tranquillity as part of the activity (Soc2). Trash is the most disgusting aspect expressed by pickers (Soc4), but a few pointed out an improvement in the last years. Whether this can be attributed to the recently established permit or to generalised civility educational campaigns was unclear to the respondents. The largest divergences were on the wrong parking (Soc9) –which did not seem to be problematic in this area, and local help in forest contingencies (Soc 7). This last question was posed to explore potential community cohesion regarding this specific forest, as possible collaborative caring and identity feeling towards the forest and its components (mushrooms included) versus the non-local pickers. Yet, some interviewees justified that non-locals did not help simply because they were not situated nearby.

Regarding the economic aspects, the most significant cohesion fell on the lack of commercial pickers' request of landowner's picking permission before the permit system (Econ1), followed by the lack of gratification towards the landowner for allowing that activity (Econ2). The largest dispersion in opinions among interviewed pickers fell on the presence of income alternatives (Econ8), and regarding the expertise of commercial pickers (Econ9). Pickers tended to score low the chances of mushrooms as a potential local economic sector (Econ6). Indeed, the scarce entrepreneurship was justified by the uncertain autumn climate in the area that precludes ensuring the inputs to develop businesses more sophisticated than just occasional and opportunistic selling of fresh mushrooms. Besides, interviewees tended to disagree when asking about complicity of locals with the grey market (Econ7). Being some local inhabitants aware of the small informal trade, this scoring was likely indicating that respondents did not perceive illegality in such activity. Still, the applicable Spanish legislation on direct fresh mushroom selling (RD 30/2009 (BOE, 2009)) implies certain requirements (training, labelling) to pickers which are typically unknown and hard to enforce in informal trade channels. Large dispersion

occurred regarding the expectation for forest profitability (Econ5). Only this aspect has been found with a robust positive correlation with pickers' network, both in terms of bonding connections with pickers from the same town (rho: 0.369, p: 0.018) and bridging with the neighbouring towns (rho: 0.411, p: 0.007).

Finally, when analysing across municipalities, neither statistical differences nor clear trends appear (Table S1 [suppl]). Only the cognitive aspect of forest profitability shows significant differences (Econ5,  $p=0.0189$ ). Vimbodí pickers "strongly agree" with the idea that forests should be profitable assets but they are not so far; Montblanc pickers just "agree" with that positioning whereas pickers from Espluga are rather neutral, with a large variability. Yet, this difference alone does not sufficiently justify the stronger permit uptake of Vimbodí in terms of ratio of adult inhabitants.

### ***DM concerns on mushroom picking***

To avoid repetitions, we present here only a few aspects and DM justifications that complement those given by pickers. Table 3 shows that DM coincide in the need of forestry interventions (For1) for drought adaptation and positive effects on *Lactarius* spp. productivity. Large dispersion occurs with the risks of wildfire (For7) –perceived as high, but not at the top– and of mushroom overexploitation (For8), which does not seem to justify the permit introduction.

Most forest-related and social concerns are reflected in the picking norms they approved. DM were also rather worried about the economic aspects of mushroom picking (Econ1 to Econ8  $\geq 4$ ). While they did not seem willing to promote commercial picking, they found in mushrooms a resource that could contribute to the forest economic sustainability. We put forward that this sensibility towards the economic concerns is rooted in their awareness of the park budgetary restrictions and their related challenges.

### ***Cognitive convergence between pickers and DM***

Table 3 shows that the largest convergence between pickers and DMs concentrates in the need of forestry interventions in Poblet forest. Interviewees also coincided in the two commercial picker-related statements. The Whitney-Mann test indicates significant statistical differences regarding the consideration of mushrooms as an infra-utilised resource, where DM perceived a potential for promoting the area through e.g. mycotourism.

A few other aspects were not statistically significant different, but still showed large divergence between DM and pickers. Decision-makers completely agreed (i.e. high convergence) with need of forests to be profitable, while pickers assigned it less relevance with larger diver-

**Table 4.** Mental models: correlation analysis between Decision-Makers' statements on problems and policy interventions (solutions) related to mushroom picking. "Don't know" observations were deleted.

Problems	Solutions	Spearman Rho coeff.	N
There was a high wildfire risk	This forest required forestry interventions	0.532*	18
Forest must be profitable and they weren't	Raised funds must be reinvested in the forest	0.514*	18
There was a mushroom overexploitation risk	The access to the forest should be limited	-0.344	18
	Landowners must conduct mycosilvicultural practices	0.452	17
Mushrooms were an underused asset in this area	There were few income alternatives in these rural areas	0.742***	18
Pickers benefited from a forest product without contributing to its maintenance	Landowners should be allowed to put a price for pickers in their forests	0.194	18
Foreign pickers caused problems	Local pickers must be positively discriminated	0.278	18
	Foreign pickers must contribute to the forest	0.261	18
Local pickers must be positively discriminated	Foreign pickers must contribute to the forest	0.716**	18
Some pickers picked both small and mature mushrooms	Picking small mushrooms must be forbidden	0.029	14
Some pickers use rakes and other tools which damage the ground	Stirring up the mycelium must be forbidden	0.392	18
	Only a knife must be used	0.242	18
Some pickers used plastic bags	Only wicker basket must be allowed	-0.331	18
Some pickers throw trash	Throwing trash must be forbidden	0.568*	17
Commercial picking must be regulated	Commercial pickers must gratify the forest owner	0.576*	15

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

gence. Besides, DM median perception considered economic aspects related to the current informal market as problematic in contrast with pickers. DM differed three points from local pickers regarding finding neighbours as grey market accomplices, and 1.5 points in questioning commercial pickers' expertise, which poses a sanitary problem. In both cases large divergences occurred within DM, but they were even larger among interviewed pickers.

Finally, the perception of mushroom overexploitation differed 1.5 points between DMs and pickers –the last more concerned; nevertheless, the opinions of both groups fluctuated considerably.

These differences show that pickers assigned more weight to ecological challenges and DM to economic opportunities. Such diverse diagnoses could ground a conflicting permit design; yet, these aspects were not incompatible to each other. There were more aspects (77%) of convergence than disagreement, mainly related to the improvement of social aspects and most ecological practices. Instead, outsider pickers were the most affected by the permit. Interviewees tended to blame them for most poor behaviour (Soc5), which may be behind the DM introducing a positive discrimination towards locals.

## Mushroom picking permit governance

### *DM mental models to design the permit*

Table 4 illustrates the level of congruence between problem perception and policy intervention statements. Further correlation analysis can be found in Table S2 [suppl].

A statistically significant trend was found between DM members perceiving a high fire risk with those requiring the execution of forestry interventions. The economic-related statements and the positive permit price discrimination to locals would implicitly contend that the costs of forest tendering were to be born mainly by foreign pickers. The support for an increased forest profitability linked to the preference for earmarking permit revenues to forestry. This goes in line with the logics of Payments for Ecosystem Services, where beneficiaries of a forest ecosystem service financially contribute to its targeted forest management (Wunder, 2005). Finally, the perception of mushrooms as an asset related to perceiving few income opportunities in Poblet municipalities.

Regarding pickers' behaviour and consequent policy reaction, we found that DM's perception of pickers throwing trash correlated with the claim for forbidding such

**Table 5.** Pickers' acceptance (percentage on N=52) to the mushroom picking permit system (overall and by municipality).

Permit design aspects	Average	Montblanc	Espluga	Vimbodí
Requirement of a mushroom harvest permit	96%	95%	100%	90%
At local level (vs. entire Catalonia)	64%	52%	75%	60%
Involving a permit fee	96%	95%	100%	90%
Proceeds to be reinvested in forestry	100%	100%	100%	100%
Permit linked to harvesting norms	96%	100%	93%	90%
Degree of agreement with the current permit system	87%	85%	89%	85%

behaviour. However, similar statements did not hold such legal reaction (e.g. use of plastic bags, rakes, picking small mushrooms), where the behaviour was detected but not problematized, or a prohibition was rather considered disproportionate for the impact caused.

Contrary to expected, a few potential mental models did not show statistically significant correlations. DM's perception of overexploitation did not necessarily lead to the preference for limiting pickers' access or to oblige landowners to change practices towards mycosylviculture (ergo, increasing fungal production). Moreover, no linear relation was found between the lack of pickers' contribution to the forest and the landowners' permission to establish a picking fee. A plausible reason for the mismatches might be the coercive formulation of the policy interventions in the interview, while the overall consideration of the permit was rather as an awareness-raising than sanctioning tool.

### *Acceptance of the policy reform*

Most interviewed pickers agreed with the current design of the permit system (Table 5), which is largely consistent across municipalities. However, the geographical coverage of the permit was sometimes questioned; this is, near 35% pickers would like a picking permit also covering other Catalanian forests.

The permit requirement was felt positively by many "*in order to know who's entering the forest*" (E19). Having a picking fee is largely supported, but 27% respondents specified that "*if its price is symbolic, as it's now*". The positive side of a payment was justified as a dissuasive mechanism, as awareness-raising tool about the mushroom value, and for covering the permit costs. Moreover, a few note that with the current prices the aim was fungal conservation rather than fund-raising. Yet, most interviewed pickers were neither aware of the actual amount of money raised nor the use of the proceeds.

As for DM, they reported a satisfaction level of 77% (normalised average between satisfied and very satisfied). Indeed, the Park director stated that they were expecting around 500 permits, which was by far exceeded.

### *Pickers' uptake of permits*

Table 1 reveals the experience of three mushroom seasons of permit implementation. A rather stable gradient in permits emerges according to town size: Vimbodí issues permits for a larger ratio of adult inhabitants than Espluga, and this more than Montblanc in turn.

No significant differences regarding the problem perceptions of the interviewed pickers were detected across municipalities that could help explaining the differential permit uptake.

## Discussion

### **Ethnomycology: perceptions and related mental models**

Most interviewed pickers are well rooted in the forest area under analysis. Having alternative forests nearby where mushroom harvesting is not restricted, the permit introduction could constitute a trigger to divert the picking activity towards easier areas. Yet, through the interviews no complaints against the permit were detected, and most local pickers acquired the permit. This suggests that the permit does not imply a substantial opportunity cost for them.

Concerning picking norms, interestingly the scientific literature has found no impact differences between cutting or picking mushrooms (Egli et al., 2006), but this information seems not to have percolated to them yet. The transmission of good picking practices occurs through pickers being imbued within wiser close network interactions – acting as eco-mentors (Kulnieks & Longboat, 2013). Given that interviewees were non-commercial pickers, this confirms Pilgrim et al. (2007) that in non-resource dependent communities TEK is spread mainly through network relations. Such vertical (i.e. across generations) and horizontal (i.e. across peers) knowledge transmission trajectories fit with those found for truffle pickers in northern Italy (Pieroni, 2016).

Regarding our first research question, the lack of significant inter-municipality differences on the potential mush-

room-related social, economic and economic concerns may reflect two aspects, namely: a possible sample bias (given that all interviewees were “legal”), or the likely unique “community of practice” (Poe et al., 2013) regarding mushroom picking across the three towns. Consequently, a single hermeneutical community would challenge the validity of the administrative town boundary for studying the community knowledge. In contrast, non-locals could be interpreted as another group of users with fuzzier boundaries, often newer in the practice and with less attachment to a specific forest. Reticence toward non-locals can stem from the uncertainty regarding the length of pickers’ learning process (Jones & Lynch, 2002). Complementarily, DM’s concern statements ground on the scientific experiments conducted in Poblet regarding mushroom productivity in pine plots (Bonet et al., 2012) and on climate change effects on *Q. ilex* plots (Barbeta et al., 2015). These results are reported to DM regularly.

Mushroom overexploitation is differently perceived by pickers and DM. Overexploitation of the fungal resource originated by an unsustainable open-access management has been reported in some Asian countries (see Pandit & Thapa, 2003). Poblet pickers, instead, seem to put forward that a set of norms are applied by locals in order to avoid a tragedy of the commons, but perceive foreign pickers not following them – aligned with Brooks’ (2010) model. Lacking sound data on such effect, the precautionary principle would suggest regulating mushroom harvesting based on an intuitive overexploitation. This would fit well with the Catalan Forest Act (DOGC, 1988), which contemplates the conservation of forest resources as one of the reasons for regulating non-wood forest products (Article 19). Yet, the lower concern by DM may justify the quite generous daily harvesting quota.

Regarding the picking fee, it could be argued that the convergence about the missing contribution from pickers to forest tending is prioritised versus the grey market divergences. Indeed, the commercial picking was left out of permit focus, which follows pickers’ priorities. The need for forest tending covering thinning and shrub reduction is linked to reduced wildfire risk (Regos et al., 2016), whose consideration as a problem is similar both for pickers and DM.

### **Intertwining forest governance with Cognitive Social Capital**

Along the paper the cognitive SC aspects of mushroom picking governance have been analysed. The ecological knowledge and socio-economic perceptions stem mainly from family transmission, but also from standardised knowledge and media (Pieroni, 2016). Moreover, proximity to DM also provided more advanced eco-literacy indicators, which shows the relevance of social networks. Such proximity could be interpreted either as a spurious

relation, or as a proxy for the interviewee being (e.g. professionally) close to local natural resources management (and thus interacting with those DM, while simultaneously familiar with several mushroom species), or rather that the ethnomycological knowledge may be transferred (in two-ways probably) between local pickers and the local DM members to whom they interact.

With respect to our second research question, we found a rather cognitively cohesive community of pickers, where half of the knowledge statements hold one or less points of dispersion (Table 3). The robustness of these findings indicates the strong cultural significance of mushroom picking within these communities (Garibay-Orijel et al., 2007). Such local knowledge constitutes a valuable capital which could be used for monitoring and further reinforced in synergy with new technologies (citizens’ science, see Pacheco-Cobos et al., 2015). Yet, some justifications (regarding immature mushroom picking, the use of basket and hooks) shows that the so-considered proper picking practices do not always fit with the “official” good practices stipulated by the permit –and indeed those are aspects which are distant between the DM and the pickers. This analysis then helps to uncover the specific logics of social practices, which set the basis for modifying them from somewhat “external” governance initiatives –this is, it is only a coincidence that some DM are simultaneously pickers themselves in the targeted area.

The rather homogenous cognitive indicators among pickers align with the permit acceptance, yet they do not explain different municipal ratio of permit acquisition. Through this methodology the perceptions of local pickers who did not acquired a permit –who either picked illegally, or stopped picking in the regulated area, and/or went picking somewhere else– were not captured. Owing to the low, symbolic permit cost, the park technical office understood that the number of undetected pickers is likely to be negligible. Hence, it could be interpreted that either the municipalities may have different percentage of (illegal) pickers, or that the permit-related behaviour responds to non-cognitive factors. Given that in a sister study (Górriz-Mifsud et al., 2017) correlation was found between permit uptake and the municipal-level structural social capital of pickers, this may indicate that the connections with DM and with pickers of other municipalities behave as a better predictor than the cognitive variables.

Our results show that individual forest users (i.e. pickers) make their harvest decisions (permit acquisition, harvest modes) without complete information (e.g. on mushroom ecology, other pickers’ behaviour), hence showing a bounded rationality which is mediated by community norms (Ostrom, 2011). This is, limited information available to most natural resource users represents an uncertainty context in which pickers need to make harvesting decisions (how much to pick, where, when, what exactly), which in turn offers the possibility for pickers to misbehave –opportunistic behaviour, presenting then a social dilemma. Is in this situation

where community norms (e.g. good practices based on local knowledge) intervene, unofficially punishing those not following them, and aligning informally most pickers towards certain desirable behavioural approach. What is the role of the government with regard to social norms is difficult owing to its very definition - as “*a rule governing an individual’s behaviour that third parties other than state agents diffusely enforce by means of social sanctions*” (Ellickson, 2001). Kinzig et al. (2013) suggest governmental support of the social norms considered as beneficial, through e.g. campaigns, recognition. Interviews showed that pickers base their behaviour on their constructed reality, and hence on their local mushroom ecological knowledge but also on the integration with other community members. We can derive then that cognitive SC influences mushroom governance. Policy makers are then advised to take into account existing networks of local wisdom in view of reducing ecological illiteracy of forest users (Hahn et al., 2006) while simultaneously strengthening key networks. For example, a local steward picker award or public speeches within mushroom fairs could help to consolidate their network position as “example-to-follow” or eco-mentor. To increase credibility, the selection of those eco-mentors could take into account the contrasted ecological knowledge of the candidates, this is, local TEK aligned with available scientific grounds. In this line, Serra et al. (2017) tested the mycological walks in Portugal to engage local pickers in community building and forest governance.

Beyond the environmental concerns, in our case study most of the policy instrument design underpins pre-existing social norms. Indeed, the sharp differentiation between local and foreign pickers’ behaviours jointly with the perception of local pickers’ capabilities (namely, their social sanctioning not affecting the foreigners), urges the need of formal rules (the state intervention) for tackling forest users beyond the community. Such policy intervention demonstrates the demand for the institutionalisation of traditional rights, as put forward by Brooks (2010). This paper then contributes to the ethnomycology field by providing a methodological framework to proof how the traditional and local knowledge on mushrooms sets the basis for subsequent picking norms, ultimately shaping its governance system –e.g. Hussain & Sher (2023) suggest several governance reforms in Pakistan mushroom picking system based on the revealed TEK.

## Study limitations

Our sample of pickers was based on those who obtained the permit. Having left aside the non-compliers entails potential local pickers with cognitive SC differing from the abovementioned findings. Identifying the non-compliers remains difficult, yet future research focusing on that population could test whether those share similar ethnomycological background and related social norms, as they

clearly are not aligned with the introduced governance reform. In addition, the limited number of observations suggest caution in the interpretation of our results. The strong convergence indicators (IQR  $\leq 1$ , Table 5 ratios) of some findings however clearly indicate robust trends. Yet, this invites future research employing larger samples and/or additional case studies to contrast these figures.

## Conclusions

The management of open access resources poses challenges regarding their related community of users. We search evidence that the ecological knowledge shared in rural communities shapes their usage norms for natural resources. Our proposed methodology to assess cognitive SC combines IQR indexes for community cohesion, pairwise comparisons across social groups, and correlations for mental models.

Our study reveals that cognitive SC reflects how local mental models relate to social norms. The mental models of DM link problem perceptions and the portfolio of solutions, which result relevant for the policy design. These perceptions are partly shared by the pickers’ community: the perceived dissimilar behaviour between local and foreign pickers, the need for forest tending –mainly addressing the wildfire risk–, and the problem of trash left in the forest. However, pickers and DM partially differ regarding the economic aspects of the governance reform. At the aggregated level, this pool of knowledge sets the basis for the norms that the new permit system underpins, and hence its design and large acceptance.

The cognitive aspects do not seem to explain the differential permit engagement in each town. Hence, it could be interpreted that in terms of ethnomycology, related values and perceptions, local pickers constitute a single community, whereas the actual behaviour responds rather to smaller circles.

At the individual level, yet, no cognitive factors relate to the permit acceptance. However, we find evidence of knowledge spread factors: mushroom literacy (number of species identified) relates to learning from the family and being proximal to the DM. Pickers’ network plays a role insofar as the bonding (intra-municipality connections), bridging (inter-municipality) and linking social capital (proximity to DM) positively affects the demand for profitable forest management.

We therefore highlight the relevance of the networks of forest users in Socio-Ecological System governance reforms, and suggest investing in eco-literacy programs with community-level influence (e.g. eco-mentorship) for improving the acceptance of institutional changes. Complementarily, supporting mycological studies would be beneficial to confirm or contrast current pickers’ perceptions on what is ecologically challenging or not (e.g. picking young exemplars).

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## Authors' contributions

**Conceptualization:** E. Gorriz-Mifsud, L. Secco, E. Pisani, J. A. Bonet

**Data curation:** E. Gorriz-Mifsud

**Formal analysis:** E. Gorriz-Mifsud, R. Da Re

**Funding acquisition:** E. Gorriz-Mifsud, L. Secco, E. Pisani

**Investigation:** E. Gorriz-Mifsud

**Methodology:** E. Gorriz-Mifsud, R. Da Re, L. Secco, E. Pisani

**Project administration:** E. Gorriz-Mifsud, L. Secco

**Resources:** not applicable

**Software:** not applicable

**Supervision:** E. Gorriz-Mifsud, L. Secco

**Validation:** not applicable

**Visualization:** E. Gorriz-Mifsud

**Writing – original draft:** E. Gorriz-Mifsud

**Writing – review & editing:** E. Gorriz-Mifsud, L. Secco, E. Pisani, J. A. Bonet, R. Da Re

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