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REPORT

Factors influencing local ecological knowledge maintenance in Mediterranean watersheds: Insights for environmental policies

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Abstract Local ecological knowledge (LEK) has been found to be one of the main bridges to manage biocultural diversity. We analyzed the factors affecting LEK maintenance and transmission in a Mediterranean watershed. We used a mixed methods approach to evaluate the agricultural LEK in three different dimensions: biological, soil and water management, and forecasting. We found that the main factors for its maintenance were the respondent's time living in the area and the social relationships established among farmers, which involved partner collaboration and farmer information exchanges. Protected areas also played a key role for maintaining the LEK associated with soil and water management. Finally, we found that outmigration and mechanization were the most important indirect drivers of change underlying LEK erosion. We suggest that environmental policies should focus on promoting this experiential knowledge, considering both intergenerational renewal and the gendered aspects of this knowledge.

Keywords Drivers of change · Gender · Protected area · Semi-arid areas · Traditional agriculture · Traditional ecological knowledge

INTRODUCTION

The current and ongoing loss of biological diversity has been increasingly acknowledged to be closely linked to the erosion of cultural diversity (Gorenflo et al. 2012). This issue is derived from social and ecological systems being interlinked and forming complex social–ecological systems that co-evolve over time (Ostrom 2009). New integrative approaches for conservation have been proposed to jointly manage biodiversity and cultural diversity through the management of the links between them and the identification of common drivers of change (Pretty et al. 2009). In this context, knowledge systems acquire high relevance because they are the bases for ecosystems management practices (Berkes 2008).

Local ecological knowledge (LEK)—also referred to as traditional ecological knowledge, indigenous knowledge or ecoliteracy—can provide lessons and insights in addressing the relationships between humans and nature (Berkes 2008). In this study, we use the term LEK, as it is the most inclusive, considering that it is a cumulative body of knowledge, practices, and beliefs developed by stakeholders at the local scale, which is adaptive and largely orally transmitted (Berkes et al. 2000; Brook and McLachlan 2008). Thus, the relevance of these systems of knowledge lies partly in its local and holistic nature and its fuzzy logic functioning (Berkes 2008; Toledo and Barrera-Bassols 2008), which can tackle complex environmental problems. The value of LEK and the need to bridge scientific knowledge and LEK has been indicated as an important aspect for the successful governance and management of social–ecological systems (Berkes 2004; Tengö et al. 2014). However, respect toward the cultural and political aspects of LEK has been described as one of its main challenges (Brook and McLachlan 2008).

Mediterranean traditional land-use systems are a good example of social–ecological systems with a high conservation value and a high cultural diversity (Plieninger et al. 2006), where traditional management practices, such as controlled fire use, water management, or terracing, were part of an intermediate disturbance regime that has proven

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to enhance biodiversity (Blondel et al. 2010). However, Mediterranean systems are currently undergoing intense changes, and, particularly, semi-arid ecosystems are among the most sensitive areas within Mediterranean systems to the effect of drivers of change (EME 2011). These systems are threatened by the increasing adoption of lifestyles disconnected from local ecosystem dynamics (Folke et al. 2011), which have led to a polarization of land-use: the abandonment of land-management practices in some areas and intense use in others (Rescia et al. 2010). Both processes are reducing habitat heterogeneity, landscape multifunctionality and agrobiodiversity (Bugalho et al. 2011; García-Llorente et al. 2012), which are related with a decline of LEK associated to its management (Perrings et al. 2006). Thus, the effect of land-use changes erodes LEK at the same time that it erodes agrobiodiversity and social-ecological resilience (Pretty et al. 2009; Rescia et al. 2010). However, some pockets of this knowledge can be still found in rural and urban communities (Barthel et al. 2010; Gómez-Baggethun et al. 2010; Fernández-Giménez and Fillat Estaque 2012; Oteros-Rozas et al. 2013; Hernández-Morcillo et al. 2014). Unfortunately, few studies have directly analyzed the farmers' knowledge as LEK preservers and the factors underlying knowledge maintenance (Doré et al. 2011). Thus, understanding LEK, which factors underlie its maintenance or erosion and how ultimately these factors affect peoplés ability to adapt and regenerate LEK, is necessary (Gómez-Baggethun and Reyes-García 2013).

We contribute to this line of research by analyzing the state and evolution of LEK in a semi-arid watershed in southeastern Spain. We specifically aimed to (1) identify and explore the factors that contribute to the maintenance of LEK with a particular focus on its generational and gender dimensions, (2) analyze the avenues of transmission and acquisition. Finally, we further discuss the role of environmental policies and protected areas in preserving LEK.

STUDY AREA

We conducted our study in the Nacimiento watershed, located in the semi-arid region of southeastern Spain (Figs. 1, 2). We analyzed it as a coupled social–ecological system (Ostrom 2009) because local communities are culturally and economically linked to the biophysical system. It comprises ten municipalities, has a territorial extension of 598 km^2, and lies within the borders of the Sierra of Filabres-Baza and the Sierra Nevada Mountain. The relevance of the Nacimiento watershed lies in three main factors: (1) its unique ecological features; (2) its historical management, and (3) its sensitive character to global change. Firstly, the Nacimiento watershed constitutes an ecological edge due to the great variation of altitude in short distances, where Mediterranean mountain, semi-arid areas, agroecosystems, and riparian ecosystems are interspersed. The Sierra Nevada was declared a Unesco Biosphere Reserve in 1986 and a National Park in 1999 because it is a hotspot of vegetation diversity and its cultural heritage related to agricultural management practices (PORN 1994).

Secondly, traditional practices in agriculture have relied on soil and water conservation techniques as in other Mediterranean and semi-arid areas (Altieri and Toledo 2005). The landscape physiognomy has been modeled using agricultural terraces and water transport and storage infrastructures, called *acequias* and *aljibes* (Blondel et al. 2010). These strategies avoid rainfall limitations using snowmelt and have a positive effect on (1) biodiversity maintenance through broad leaf vegetation species, such as chestnuts (*Castanea sativa*), which have a great ecological value and genetic diversity; (2) microclimatic regulation; and (3) hydrological regulation (Pulido-Bosch and Ben Sbih 1995). Broad leaf species create humid spots favoring ecosystems diversity and creating habitats for other species (Espín et al. 2010). When *acequias* have been lined or buried, the vegetation maintained through water infiltration had disappeared (Pulido-Bosch and Ben Sbih 1995). These irrigation systems are governed by water users associations, whose functioning in Spain has been historically documented (Ostrom 1990).

Lastly, the Mediterranean mountain and semi-arid systems are among the most vulnerable ecosystems in the Iberian Peninsula to climate change and land-use change (EME 2011). Regarding the latter, since the 1950s, the integration of local economies into global markets triggered agriculture mechanization and intensification in areas where it was feasible, generally lowlands (Naredo 2004). In geographically disadvantageous areas, the possibilities of younger people finding a job drastically diminished as traditional agriculture was no longer competitive. This entailed the process of depeasantization—i.e., the erosion of an agrarian way of life mostly based on family labor—and a subsequent rural exodus—i.e., outmigration of rural population to urban areas (Sevilla Guzmán 1979). Thus, rural communities are currently composed of an aging population with a lack of generational renewal (see Table S1 in Supplementary Material). Ecologically, this process has led to the lining and burial of the *acequias* to obtain higher water yields (Espín et al. 2010) and a reduction in crop diversity. Consequently, agriculture in the area is now mainly limited to the cultivation of olive and almond trees which are used for family consumption and are a surplus for market exchange (see Table S2 in Supplementary Material).

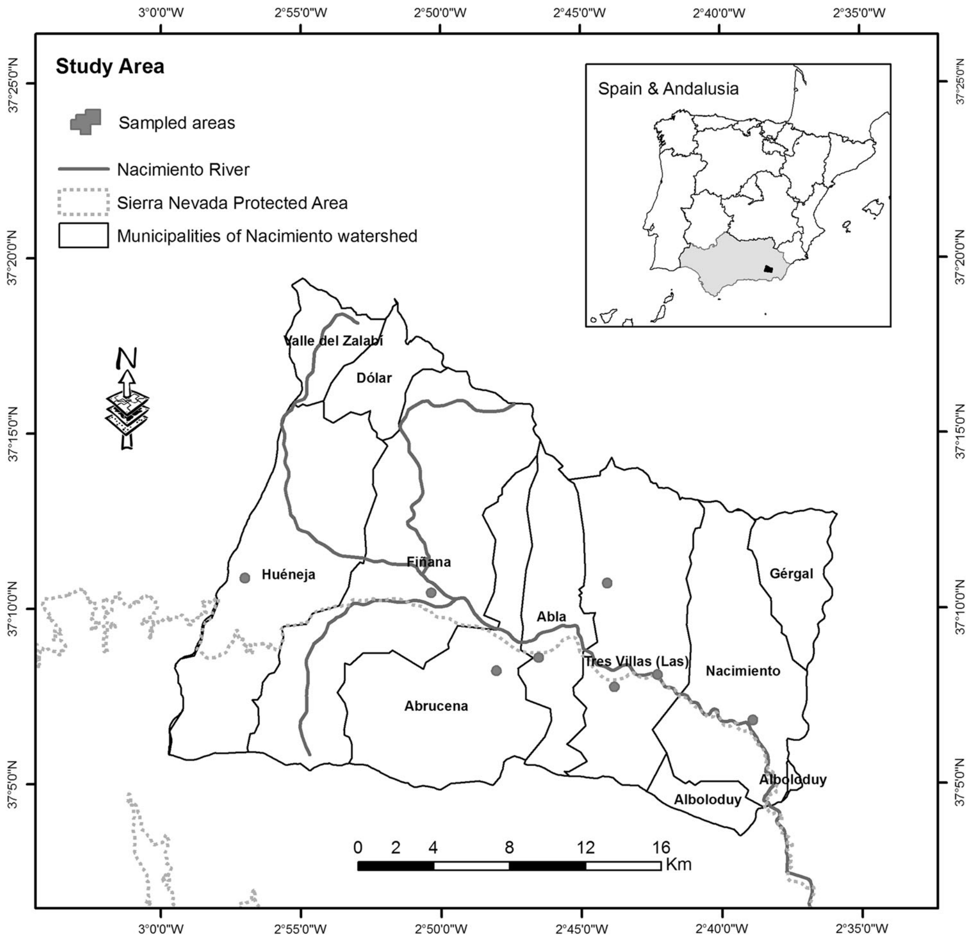

Fig. 1 Location of the Nacimiento watershed in the South-East of Spain, the borders of the protected area, and the sample points where the data were collected

MATERIALS AND METHODS

Research design and data sampling

The data sampling was undertaken between July and October 2010, but we also drew on previous research performed in the area since 2009. We used a mixed methods approach, including participant observation, in-depth interviews, focus groups, and face-to face surveys (Huntington 2000). Although agricultural activities are currently mostly restricted to men, we included women when possible in each phase of the research.

Participant observation facilitated a deeper understanding of the *acequias* system with respect to its complexity and the social structure underlying its management. During the research period, we attended the water distribution meetings (*repartimientos*) of local water users' organizations—i.e., irrigation communities—that occur daily in the area. We also accompanied the *acequias* managers (*acequieros*) in their work distributing water along the *acequias*.

Next, we performed 22 in-depth interviews to two types of key informants. First, we interviewed social scientists and local managers who had investigated the area to facilitate a deeper comprehension of the agriculture and water management system ($N = 7$). Second, we interviewed local agriculture experts ($N = 15$). In both cases, we used the snowball sampling technique to contact more key informants (Huntington 2000). The local experts interviewed were over 50 years old and were often part of irrigation communities. The interviews were organized along three themes: (1) the evolution and management of agriculture; (2) soil and water management; and (3) forecasting techniques. Following Toledo and Barrera-Bassols (2008) and based on the in-depth interviews, we obtained the structural and dynamic components of the LEK related to agriculture. The former refers to the designation, categorization, and classification of the different constituents of ecosystems—i.e., biological, physical or ecogeographic elements. The latter captures the dynamics of nature such as the lunar phases or climatic events that influence productive cycles. See Table S3 in the Supplementary Material.

Fig. 2 Vineyards, olive, and almond orchards are currently the main crops in the agroecosystems of the Nacimiento watershed, and the Sierra Nevada (in the back) provides the main source of water

Drawing on the information obtained in the interviews and participant observation, we designed a questionnaire with the aim of approaching the individual's LEK as previous authors had performed (Gómez-Baggethun et al. 2010; Oteros-Rozas et al. 2013). The questionnaire consisted of a total of 85 questions and was organized into the following sections: (1) socio-demographic information, consisting of 34 questions; (2) knowledge related to the management of different species (*species-LEK*), focusing on olive trees, almond trees, and grape vines and comprising 15 questions; (3) knowledge related to soil and water management techniques (*soil and water-LEK*), comprising 11 questions; (4) knowledge related to atmospheric and forecasting techniques (*forecasting-LEK*), consisting of nine questions; and (5) a final set of six questions dedicated to relationships involving agricultural collaboration, knowledge exchange, and knowledge acquisition and transmission.

We pre-tested the questionnaire to check its comprehension. A total of 122 questionnaires were collected in eight different municipalities using a stratified sampling per municipality (see Table S4 in Supplementary Material). This sample size should produce a sampling error of less than ±10%. People were mainly contacted during the water distribution meetings. These meetings gather daily all the farmers in the village who want to irrigate their crops. Using this method, we were assuring to register the variety of farmers in a village. However, to interview people less likely to attend these meetings (mostly women and young farmers), we additionally used the snowball sampling technique, and direct encounters in different village settings. The sampling population was restricted to people over 20 years old. The Supplementary Material (Table S4) illustrates the sampling population characteristics.

Finally, we conducted four focus groups to validate the information gathered through interviews and questionnaires as well as to reach a consensus, avoiding the researchers' biases based on vocabulary, practices, or local traditions. A total of 23 men participated in four focus groups, with ages ranging between 58 and 86 years old.

Data analysis

We coded the answers from the questionnaires as follows: two points if the answer fully matched the consensus responses obtained in the focus groups, 1 if it partially matched the consensus responses, for example, if it entailed some management techniques or agricultural periods but not the whole range considered in the groups, and 0 if it differed completely. Therefore, each of the LEK modules (i.e., *species-LEK*, *soil and water-LEK*, and *forecasting-LEK*) had a different maximum score: 30, 22,

Table 1 Description of variables used in the multivariate regression analysis

Variables	Code	Type	Attributes
Time spent in the area	TIME	Continuous	Ln (TIME)
Total size of the farm (has)	SIZE	Continuous	Ln (SIZE)
Parents farmers	PARENT	Dummy	1, parents were farmers; 0, otherwise
Lives in the area	LIVES	Dummy	1, person living in the watershed; 0, otherwise
Via of knowledge transmission	VIA_PARENTS	Dummy	1, via parents; 0, otherwise
	VIA_FAMILY	Dummy	1, via extended family; 0, otherwise
	VIA_COM	Dummy	1, via community; 0, otherwise
Help in farming tasks	HELP_PARTNER	Dummy	1, partner collaborates; 0, otherwise
	HELP_FAMILY	Dummy	1, family collaborates; 0, otherwise
	HELP_COM	Dummy	1, community collaborates; 0, otherwise
Knowledge and experience exchange	EXCHANGE_PARTNER	Dummy	1, shares with partner; 0, otherwise
	EXCHANGE_FAMILY	Dummy	1, shares with family; 0, otherwise
	EXCHANGE_COM	Dummy	1, shares with community; 0, otherwise
Education	PRIMARY	Nominal	No studies and primary studies
	SECONDARY		Secondary and vocational education
	UNIVERSITY		University studies

and 18 points, respectively. We also created a *Total-LEK* variable by adding the questions of the three modules, with a maximum score of 70 points.

To determine the internal consistency of the three LEK modules of the questionnaire, we performed the Cronbach's α test. We considered an acceptable value of Cronbach's α as an indicator of internal consistency to be greater than or equal to 0.60 (Oteros-Rozas et al. 2013).

To analyze the different variables that influence LEK (either *Total-LEK* or specific LEK modules), we performed an ordinary least squares (OLS) multivariate regression analysis. To perform the full regression model, we used the explanatory variables presented in Table 1. We then used the Akaike information criterion (AIC) to select the best and most parsimonious model among all possible combinations of independent variables. Here, importantly, we only conducted a regression analysis when the Cronbach's α of each LEK module was acceptable according to the Cronbach's α.

We explored other variables that can have an effect on LEK, which work at higher scales than the individual level, such as the role of the protected area. We performed a Spearman's correlation test to explore its association with the maintenance of LEK. We calculated the mean scores of *Total-LEK* and its subcomponents (i.e., specific modules of LEK) per municipality and the percentage of protected surface area.

We used the Kruskal–Wallis and Dunn's multiple comparison post-tests to evaluate the intergenerational differences in LEK. Here, we classified the population into four age groups according to the National Agrarian Census, i.e., younger than 35 years old, between 35 and 54, between 55 and 64, and older than 64 years old. Finally, we used the χ^2 test to analyze the differences in the methods of LEK transmission among the previous four age groups through the different transmission avenues—i.e., through only the father, parents, family, or community or some combinations thereof.

RESULTS

Factors affecting LEK

For the *Total-LEK* set of questions, we obtained a Cronbach's α of 0.79, reflecting a high internal consistency among the three questionnaire modules and the existence of an underlying factor. We then computed the Cronbach's α for each of the three modules—i.e., *species-LEK*, *soil and water-LEK*, and *forecasting-LEK*, obtaining values of 0.73, 0.60, and 0.57, respectively. Because the *forecasting-LEK* module did not meet the threshold of internal consistency, as it was lower than 0.60, it was not considered for multivariate regression analysis.

Because of the strong correlations between the age of individuals and the time spent in the area (*TIME*) (Spearman's $\rho = 0.716$, $p < 0.001$), between the age classes and *TIME* (Spearman's $\rho = 0.643$, $p < 0.0001$), and between outmigration and *TIME* (Spearman's $\rho = -0.345$, $p < 0.0001$), we used *TIME* as an explanatory variable in the models to avoid colinearity. We also removed 8 observations in the multivariate regression analyses after inspecting the standardized residuals because their distribution was skewed.

Table 2 Results of the multivariate regression analyses for the *total-LEK and* two of the different modules *species-LEK* and *soil and water-LEK*)

Variables	*Total-LEK*		*Species-LEK*		*Soil and water-LEK*	
	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model
TIME	0.296*** (0.095)	0.324*** (0.083)	0.162 (0.103)	0.145 (0.090)	0.404*** (0.093)	0.382*** (0.088)
SIZE	−0.129 (0.088)		−0.202** (0.095)	−0.186** (0.091)	−0.082 (0.086)	
PARENTS	0.204** (0.085)	0.209** (0.084)	0.196** (0.092)	0.190** (0.089)	0.149* (0.083)	0.154* (0.081)
LIVES	0.041 (0.099)		0.011 (0.107)		0.042 (0.098)	0.123 (0.088)
VIA_PARENTS	0.251** (0.125)	0.244** (0.123)	0.084 (0.135)		0.237* (0.122)	
VIA_FAMILY	0.191* (0.098)	0.217** (0.096)	0.138 (0.106)	0.151* (0.090)	0.122 (0.096)	
VIA_COM	0.150 (0.111)	0.173 (0.108)	0.135 (120)		0.122 (0.109)	
HELP_PARTNER	0.222** (0.086)	0.237*** (0.084)	0.150 (0.093)	0.130 (0.089)	0.170** (0.084)	0.189** (0.082)
EXCHANGE_COM	0.169** (0.089)	0.151* (0.082)	0.111 (0.096)		0.216** (0.087)	0.242*** (0.082)
EDUCATION[a]						
PRIMARY	0.140 (0.155)		0.085 (0.167)		0.031 (0.151)	
SECONDARY	0.162 (0.150)		0.153 (0.162)		0.110 (0.146)	
R^2	0.304	0.278	0.185	0.150	0.335	0.293
Adjusted R^2	0.228	0.231	0.097	0.110	0.263	0.260
F	4.041***	5.843***	2.098**	3.799***	4.666***	8.956***
AIC	−371.297	−375.265	−317.890	−325.102	−342.824	−347.904

Significance: * ≤10 %, ** ≤5 %; *** ≤1 %. Numbers in parenthesis are standard deviations (SD)

[a] The category of reference is "university" (see Table 1)

The multivariate regression analyses (both full and reduced models) were significant and were able to explain the dependent variables—i.e., *Total-LEK*; *species-LEK*; and *soil and water-LEK* (Table 2). The variable that was shown to be more important for maintaining *Total-LEK* and also the LEK related to soil and water management (*soil and water-LEK*) was *TIME*. Similarly, sharing information with external people (*EXCHANGE_COM*) and sharing farming responsibilities with a partner (*HELP_PARTNER*) also positively influenced the *Total-LEK* and *soil and water-LEK*. In addition, the parents' dedication variable (*PARENT*) was the only one that had a positive effect on *Total-LEK* and the two modules analyzed—i.e., *species-LEK* and *soil and water-LEK*. Other variables, such as the amount of agricultural surface or vertical transmission, also explained LEK. While the agricultural surface owned by the respondents (*SIZE*) was negatively related to *species-LEK*, vertical transmission (*VIA_PARENTS* and *VIA_FAMILY*) was positively related to *Total-LEK* and *species-LEK* (Table 2).

In addition, we found a positive correlation between the protected area surface and the *soil and water-LEK* (Spearman's $\rho = 0.841$, $p = 0.058$), indicating a relationship between both variables.

Intergenerational LEK transmission and acquisition

We found significant differences in the *Total-LEK*, *species-LEK*, and *soil and water-LEK* among the generations analyzed (Table 3). For each module, the maximum score was obtained by people within the generation born from 1950 to 1959 (55–64 years old). In contrast, the generation of people born in 1976 and later (≤34 years old) obtained the minimum score. We also found significant differences in the avenue of knowledge transmission among the different age ranges (χ^2 test: $\chi^2 = 21.93$; $p = 0.038$) (Fig. 3). In fact, the older generations (≥65 years old) revealed parents as the main important method of knowledge transmission, whereas the reported method of transmission in the younger generations (35–54 and ≤34) primarily showed the father as the exclusive avenue (Fig. 3).

DISCUSSION

Demographic and technological driving forces affecting the maintenance of LEK

One of the main results that have emerged from our study is the uneven distribution of LEK among the communities studied, and thus, all individuals in a culturally homogeneous community cannot be assumed to reflect the same level of knowledge (Davis and Wagner 2003; Davis and Ruddle 2010). We found that the maintenance of LEK depended on individual and collective factors such as the time spent in the area (*TIME*), the parents' dedication to agriculture (*PARENTS*), the transmission of knowledge

Table 3 Means and SD showing intergenerational differences in *Total-LEK* and its different subcomponents (*species-LEK*, *soil and water-LEK*, and *forecasting-LEK*). Statistical comparisons were made with Kruskal–Wallis tests

Age classes	*N*	*Total-LEK*		*Species-LEK*		*Soil and water-LEK*		*Forecasting-LEK*	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
≤34	6	30.00[a]	12.28	14.00[a]	6.07	8.67[a]	4.59	7.33	3.45
35–54	22	37.00[ab]	8.60	18.00[a]	4.05	12.56[ab]	3.75	6.46	2.98
55–64	35	42.11[b]	8.30	21.37[b]	3.67	13.71[b]	3.79	7.03	3.05
≥65	59	38.81[ab]	9.50	19.42[ab]	5.53	12.49[ab]	2.91	6.90	3.57
χ^2		9.99*		12.68**		7.71*		0.643	

Significance: * ≤10 %, ** ≤5 %

Age classes with different letters were significantly different according to Dunn's multiple comparison test

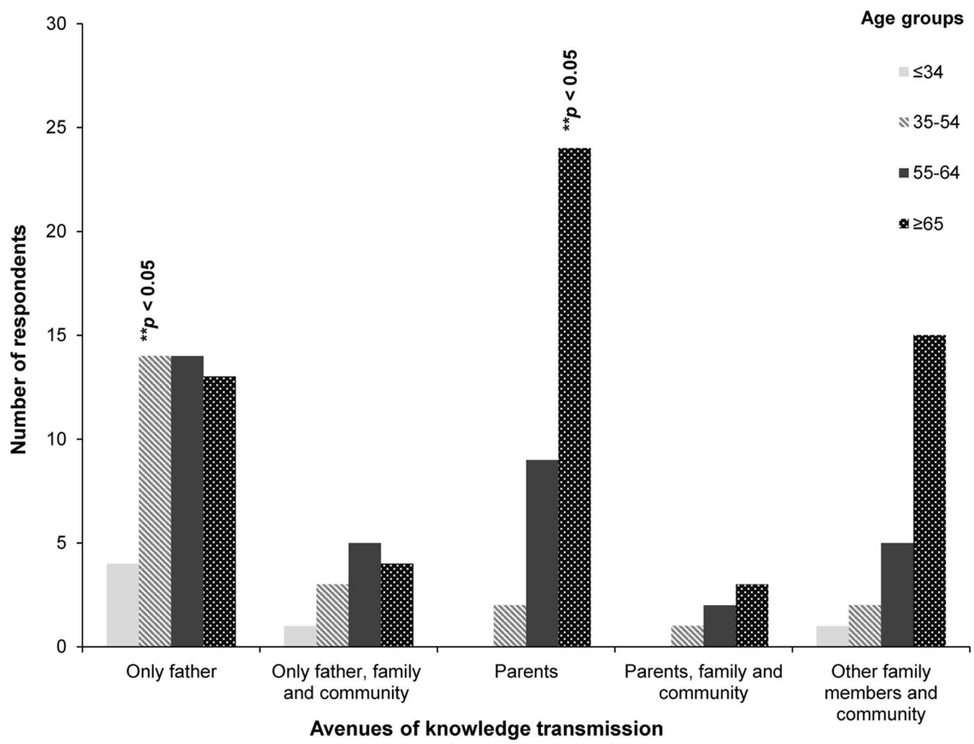

Fig. 3 Relationships between the avenues of knowledge transmission and age groups identified by the National Agrarian Census based on the χ^2 test ($\chi^2 = 21.93$; $p = 0.038$) (**≤5%, positive and statistically significant associations)

through other family member (*VIA_FAMILY*), and the exchange of information with other members of the community (*EXCHANGE_COM*) (Table 2) and that it varied among generations (Table 3). Although the person who ranked higher in the LEK study pertained to the oldest generation, overall, the oldest generation did not show the highest levels of knowledge (Table 3). This observation can be explained by various factors. The first is the intense processes of outmigration that has occurred since the last century in the area, reaching its maximum during the 1950s and 1960s (Sánchez-Picón et al. 2011). In fact, the time spent in the area (which was negatively correlated with the outmigration process) was the most important factor explaining the maintenance of LEK (Table 2). Currently, this process continues to occur in the Iberian mountains, where the population density has decreased from 2000 (EEA 2010) due to the practical impossibility of finding a job and becoming established in the rural context. Second, farming is no longer the main economic source (see Table S2 in the Supplementary Material), and it has become an activity sustained mainly by older people, who had returned to their hometowns after retirement from jobs in cities. Thus, we found that currently, people over 65 years old were dedicated to farming but did not hold much agricultural LEK. Therefore, we can conclude that LEK tends to be maintained when people live and grow up in the same area (Pilgrim et al. 2007).

The demographic driver of change has a huge effect on the de-structuring of the social community and the embedded knowledge system for two main reasons: (1) the lack of contact with the local management practices and (2) the rupture of the transmission system. Both aspects interfere with two key attributes of LEK: (1) its development through direct experience and (2) its transmission between or among generations (Davis and Ruddle 2010). When the intra- and intergenerational web of relationships breaks down, younger people have difficulty making sense of their observations in the environment (Davidson-Hunt and Berkes 2003).

We also found that the cultivation of larger areas was negatively related to the maintenance of LEK with respect to the management of different crop species (*LEK-species*) (Table 2). This observation could be explained through the processes of land consolidation that occurred in the upper areas of the watershed, resulting in a higher level of mechanization compared with the steeper and smaller areas where mechanization is not worthwhile.

Consequently, the maintenance of LEK at the local scale primarily depends on the underlying driving forces operating at a broader scale, i.e., the demographic tendencies in rural mountain communities and technological implementation in response to market forces, which are the common denominators in several case studies around the world (Blanckaert et al. 2007; Gómez-Baggethun et al. 2010). These factors have been found to affect not only LEK maintenance but also the capacity of people to generate, transform, and transmit knowledge, which, as recently highlighted by Gómez-Baggethun and Reyes-García (2013), is even more important than the loss of the knowledge itself.

The gender implications of the driving forces in maintaining LEK

Both the mechanization and the demographic processes have been found to have a very marked gender dimension. Although frequently overlooked, both households and communities have been described as being gendered units, and as such, the distribution of LEK among its components and their contributions to biodiversity conservation varies (Pfeiffer and Butz 2005). In this study, we found that gender is a key factor to LEK maintenance and transmission. First, one of the variables that affected LEK was the partner contribution to agricultural activities (Table 2), which in this case were mainly associated with women, as identified by the interviewed men in the quantitative phase, and who outweighed women in the sample (Supplementary Material, Table S4). Second, we observed that the contribution of women in knowledge transmission decreased in the younger generations, which in fact hold less LEK (Fig. 3).

The role of women in both LEK maintenance and transmission has drastically changed due to the "masculinization" process that has taken place in rural communities in Europe (Camarero and Sampedro 2008), which is defined by women leaving agriculture to a greater extent than men. On the one hand, the outmigration process in rural societies has different consequences for men and women. Women have left the rural areas through acquisition of higher formative qualifications as a mean to break with the agrarian context (Camarero and Sampedro 2008). Data from the recent diagnosis of gender equality in rural areas in Spain (MARM 2011) set a ratio of 124 men per 100 women in the most acute cases with the worst scenario between the ages of 35 and 49 years. On the other hand, the mechanization processes in agriculture have led to a redistribution of tasks between men and women in some cases, with the women becoming simply assistants of male farmers (Brandth 2002). From our qualitative results, we can conclude that since the disappearance of certain crops—i.e., cereals or fruit trees—and the eradication of subsistence agriculture as the main livelihood source, women have greatly reduced their agricultural activities and sometimes remained collaborators during the harvest time (mainly for olives and almonds) (Iniesta-Arandia et al. 2014).

Because, in this study and others, gender has been found to be an important factor to account for sustainable agricultural management practices and associated biodiversity in Spain (Reyes-García et al. 2010) and in other systems (Pfeiffer and Butz 2005), there is an urgent need to address the gender dimensions of rural development and conservation policy agendas (Deda and Rubian 2004). Neglecting the gendered nature of LEK can lead to a rapid erosion of certain management practices due to a lack of awareness of its existence. A sound management of ecosystems and biodiversity should consider gender as a cross-cutting issue and target women's needs and priorities through women involvement and empowerment, i.e., recognizing their active role as users, transmitters, and preservers of LEK (Deda and Rubian 2004).

The relevance of LEK in a changing semi-arid environment and the role of environmental policies in promoting LEK

Our results and those from other studies (Gómez-Baggethun et al. 2010; Carvalho and Frazão-Moreira 2011;

Gómez-Baggethun et al. 2012) continue to confirm that existing bodies of LEK remain in rural areas of industrialized countries, often concurrently with protected areas. In fact, LEK and its associated practices have been pivotal for the design and maintenance of these landscapes. The importance of traditional soil and water conservation techniques for semi-arid and Mediterranean environments has been repeatedly highlighted by different authors (Blondel et al. 2010). Techniques such as terracing and the use of water ditches have effectively prevented soil erosion and promoted biodiversity. However, LEK in industrialized countries has been argued to be between the rock of development and the hard place of the dominant conservation paradigm (Gómez-Baggethun et al. 2010). On the one hand, the mechanization process to obtain more productive crops as a result of the expansion of agribusiness has entailed the intensification of land-use systems and the abandonment of traditional multifunctional land-uses (EEA 2010; Fischer et al. 2012). On the other hand, most of the current conservation policies seek to preserve only the ecological system and those species embedded within it (Martín-López et al. 2011). A common result of this conservation vs. development model is the break of historical links between ecosystems and social systems and thus between ecological functioning and the functional characteristics of LEK within their specific cultural context. In this sense, a new conservation paradigm should emerge in relation to rural communities of industrialized Mediterranean countries in which the ultimate goal should be to promote biocultural diversity. Folke et al. (2011) recognized that such a new paradigm should account for the multiple services that ecosystems provide to society in order to design broader management strategies that promote the fit between ecosystems and local institutions. Both aspects are relevant in the Mediterranean rural landscapes because, on the one hand, a diverse flow of ecosystem services is enhanced by maintaining traditional management practices (Bugalho et al. 2011; García-Llorente et al. 2012) and, on the other hand, local communities have adaptively managed ecosystems during centuries through the creation of institutional arrangements that fit ecosystem dynamics, such as those at work in the irrigation communities. Precisely, Martín-López et al. (2012) found that LEK was bundled with regulating services related to water and soil management, suggesting that the experiential knowledge is strongly interconnected with the ecosystems functioning. Additionally, we found that the surface of protected area was positively correlated with the preservation of the LEK associated with soil and water management. Therefore, it seems that preserving LEK should be a key tool for preserving rural Mediterranean social–ecological systems. However, warnings against preserving LEK as a compilation of static practices should be made as the current context of global change may require new approaches. Thus, some management practices that could be fitted to other social or ecological contexts may no longer be adequate. On the other hand, it should be noted that LEK does evolve not only from ecosystem dynamics, but also from maintaining social memory (Davidson-Hunt and Berkes 2003), and our results point to the importance of maintaining a social fabric to facilitate the adaptation of LEK to current contexts.

Currently, there has been a debate on environmental and agricultural policies (i.e., EU Biodiversity Strategy and Common Agricultural Policy), which has discussed how traditional management practices and their embedded knowledge system should be preserved while at the same time ensuring they are financially attractive. Similar to Fischer et al. (2012), we consider that the real challenge of environmental policies is recognizing the interlinking processes between nature and people. Thus, it is necessary that protected areas (1) recognize the real value of LEK as one of the key factors for coupling nature and society, (2) strengthen local organizations where experiential knowledge should be exchanged among community members, such as irrigation communities, and (3) foster new initiatives co-created by protected area managers and local people to empower local communities in actions addressed to protect biodiversity and cultural diversity. Therefore, the role of protected areas should focus not only on protecting biodiversity but also on preserving LEK through the promotion of those institutions and cultural factors that favor biodiversity conservation while empowering local communities. Steps in this direction have been taken in the Nacimiento watershed as the Sierra Nevada National Park has promoted actions for restoring old high-mountain *acequias* and compiling the experiential knowledge related to water management (Espín et al. 2010). In addition, in the Sierra Nevada National Park, there are local water organizations that work to conserve LEK and traditional management practices, although they are composed of an aging community without generational renewal. Consequently, engaging the young population and providing opportunities for their active participation is a key task to be tackled in Mediterranean rural landscapes. New approaches in protected area management can emerge as a key strategy to preserve biocultural diversity related to LEK in the rural landscapes of industrialized Mediterranean countries if they focus on those social processes that contribute to the maintenance of this type of knowledge, its related traditional management practices, and the cultural factors that support biodiversity conservation.

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