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Surveys

From famine foods to delicatessen: Interpreting trends in the use of wild edible plants through cultural ecosystem services

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ABSTRACT

The Millennium Ecosystem Assessment found a general decline in the consumption and gathering of wild edible plants, but some studies also observe a localized increase. Using information from interviews (n = 1133) in seven sites in the Iberian Peninsula and one in the Balearic Islands, we 1) identify current trends in the consumption and gathering of wild edible plants (n = 56 plant-uses) and 2) analyze how cultural ecosystem services relate to such trends. Our data show a generalized decrease in the consumption and gathering of wild edible plants, although the trend changes significantly across plant-uses. Specifically, we found that –despite the overall decreasing trend– uses of wild edible plants that simultaneously relate to foods with high cultural appreciation and the recreational function of gathering remain popular. Our results signal that cultural services and values associated to the gathering and consumption of some wild edible plants are important factors explaining divergent trends across plant species. This finding reinforces the notion that cultural ecosystem services are deeply intertwined with other categories of services which can combine in complex, non-linear ways producing a variety of interdependent benefits.

1. Introduction

Wild edible plants are defined as plant species collected in the wild to be consumed as food or drink. Wild edible plants have been an integral part of human diet throughout history and around the world (Behre, 2008; Hummer, 2013; Leonti et al., 2006; Schulp et al., 2014). Although the Millennium Ecosystem Assessment found a general decline in their consumption and gathering (MA, 2005), wild edible plants continue to be consumed in many parts of the world, not only in subsistence-oriented economies but often also in rural and even urban areas in developed countries (Bharucha and Pretty, 2010; Certomà and Tornaghi, 2015; Schulp et al., 2014). Because of their importance to income (Angelsen et al., 2014; Łukasz et al., 2013; Shumsky et al., 2014), nutrition (Mavengahama et al., 2013; Toledo et al., 2003), and food security (Bharucha and Pretty, 2010; Nolan and Pieroni, 2014; Redzic, 2010; Vinceti et al., 2013), wild edible plants are included in all major ecosystem service classifications as a type of provisioning service (see e.g., de Groot et al., 2002; Haines-Young and Potschin, 2013; MA, 2005; TEEB, 2010).

Research suggests that, while wild edible plants were an important provisioning service in Europe until the 20th century (Kangas and Markkanen, 2001; Łukasz et al., 2013), in recent decades their gathering and consumption have decreased both in terms of quantity and diversity (Bharucha and Pretty, 2010; MA, 2005; Tardío et al., 2005). The decrease in this provisioning service is concomitant with urbanization and associated rural exodus, modernization of lifestyles, industrialization of food production, or loss of natural habitats, among others (Abbet et al., 2014; Bharucha and Pretty, 2010; Kalle and Soukand, 2013; Łukasz et al., 2013; Turner and Turner, 2008).

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Decreasing consumption and gathering trends, however, seem not to be affecting all areas and all wild edible plants with the same intensity. For example, a recent research in Cantabria, north of the Iberian Peninsula, found that local people assign a high value to wild fruits, but not so much to wild vegetables, and that the consumption of some wild edibles (i.e., the fruits of *Quercus robux* and *Quercus ilex*) is culturally stigmatized (Menendez-Baceta et al., 2012). The opposite trend is reported for other wild species, like the sprouts of *Asparagus acutifolius* which are increasingly harvested to be sold (Molina et al., 2012), or other wild edible plants that have become local delicatessens and markers of cultural identity (see e.g. Aceituno-Mata, 2010; Kalle and Soukand, 2013). Some researchers have also highlighted the importance of the gathering of wild edible plants as a recreational activity (Kangas and Markkanen, 2001; Schulp et al., 2014). In other words, explanations on divergent trends in the use of wild edible plants in Europe seem to revolve around the cultural services they provide, where cultural services are defined as "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience" (MA, 2005: 894) or as "ecosystems' contributions to the non-material benefits (e.g., capabilities and experiences) that arise from human–ecosystem relationships" (Chan et al., 2012: 9).

The argumentative line of this paper is that cultural ecosystem services and values associated to the consumption and gathering of wild edible plants might help interpreting divergent trends in the use of these plants. Using information from seven sites in the Iberian Peninsula and one in the Balearic Islands, we first identify current trends in the consumption and gathering of wild edible plants and then analyze how different cultural ecosystem services relate to such trends. Our expectation is that the consumption and gathering of species associated to cultural services and values would be more prevalent than the consumption and gathering of species lacking such association.

2. Methods

Data were sampled in seven sites of the Iberian Peninsula and one of the Balearic Islands, a region with a long tradition in the consumption of wild edible species (Leonti et al., 2006; Tardío et al., 2006). Sampling was conducted in two phases. In the first phase, we compiled an inventory of wild edible plants consumed in each area. In the second phase, we conducted a systematic survey on past and present consumption and gathering of selected species. For the purpose of in this work, we define wild edible plants as plant species that are collected in the wild to be consumed as food or drink. Our definition includes native species growing in their natural habitat as well as naturalized species (i.e., species planted in the past, no longer managed but still harvested).

2.1. Site Selection

The site selection was based on several criteria. First, we focused on areas where local people traditionally gathered wild edible plants. Second, we aimed to cover some of the ecological and cultural diversity of Spain, although we are aware of the impossibility of being exhaustive in such criterion. Third, we selected sites where wild plants could be collected near people's homes, e.g. from crop fields, wild areas or hedgerows (González et al., 2011; Stryamets et al., 2012). Fourth, in none of the sites legal restrictions affected the gathering of the selected species. About 50% of one of the sites, Doñana, is protected (Gómez-Baggethun et al., 2010), but survey data were collected in villages with non-protected surroundings. Last, we selected sites where members of the team had either conducted previous ethnobotanical work or had contacts that facilitated the realization of such work.

We worked in a total of eight sites; six in mountain regions and two other. The six sites in mountain regions include: *Alta Vall del Ter*, a valley on the southern flanks of the eastern Pyrenees mountain range; *Alt Empordà*, the easternmost region of the north of Catalonia, where the Pyrenees descend through a plain to meet the Mediterranean Sea; *Gorbeialdea*, a mountainous region of southern Biscay in the Basque Country; *Sierra Morena Extremeña*, an area in the low and middle height mountain regions of southern Extremadura; *Sierra Norte de Madrid*, in the Central range that crosses the north of Madrid province, 70 km north of Madrid city; and *east-central Asturias*, an Atlantic valley on the northern slopes of the Cantabrian range. One site was conducted in a plain territory: *Doñana*, marshlands, dunes, and pine forest area in south-western Andalusia touching the Atlantic Ocean. Finally, one site was settled in *eastern Mallorca*, the largest island in the Mediterranean Balearic archipelago, east of the Iberian Peninsula. With the exception of east-central Asturias and Gorbeialdea, which belong to the Euro-Siberian region, all sites are placed in the Mediterranean biogeographical basin (Fig. 1).

2.2. Phase 1: Inventory

In each study area, we started by compiling an inventory of wild edible plants. For *Alta Vall del Ter* (Rigat et al., 2009), *Alt Empordà* (Parada et al., 2011), *Gorbeialdea* (Menendez-Baceta et al., 2012), *Sierra Norte de Madrid* (Aceituno-Mata, 2010), and *east-central Asturias* (San Miguel López, 2004) we used data from previous fieldwork. For *Sierra Morena Extremeña*, *Doñana*, and *eastern Mallorca*, we conducted fieldwork to elaborate the inventory and interviewed people locally recognized as knowledgeable about wild edible plants (Davis and Wagner, 2003). We asked them to list all the wild edible plants in the area and, for each plant listed, to provide all relevant information regarding its gathering and consumption: past and present use, mode of consumption, processing techniques, symbolic attachment, and the like.

Based on Tardío et al. (2006), information regarding edible uses of wild plants was categorized as 1) fruit (when the fresh or dry fruit is eaten, raw or cooked), 2) vegetable (when any of the vegetative parts is consumed, raw or cooked), 3) beverage (when any part of the species is used to prepare liquor or infusions), and 4) seasoning (when any part of the plant is used for food seasoning).

2.3. Phase 2: Survey

Between 2012 and 2013, we conducted a survey. As many wild edible plants have more than one edible use (for example, the fruits of *Rubus ulmifolius* are consumed raw, but they are also used to elaborate liqueurs), we selected only the most popular use. Thus, in our survey we only asked for the most popular use of each wild edible plant (plant-use).

2.3.1. Plant-use Selection

Since we worked in eight areas with marked cultural and ecological differences, we could not use the same survey in all the areas, but rather performed site-specific selections. To ensure comparability, we used the same criteria to select plant-uses in each site. To narrow the selection, we first identified species with a prominent edible use (versus other uses, such as medicinal or ornamental) and not locally gathered for large-scale commercialization, but rather mostly for self-consumption or exchange. In each site-specific survey, we included the four categories of use (fruit, vegetable, beverage, and seasoning). To keep the length of the survey at around 40 min/informant, we limited the survey to seven plant-uses, so –in total– we asked about 56 plant-uses (7 plant-uses * 8 areas = 56; considering the same plant-use in different areas as different observations). The final list of plant-uses is given in Table 1, where we also report the scientific name of the species with taxa authorities, growth form, and voucher number.

2.3.2. Sample Selection

We collected survey data from 1133 informants (between 100 and 180 per site) mostly recruited in villages or small towns. After approaching a person, we first explained our goals and requested consent

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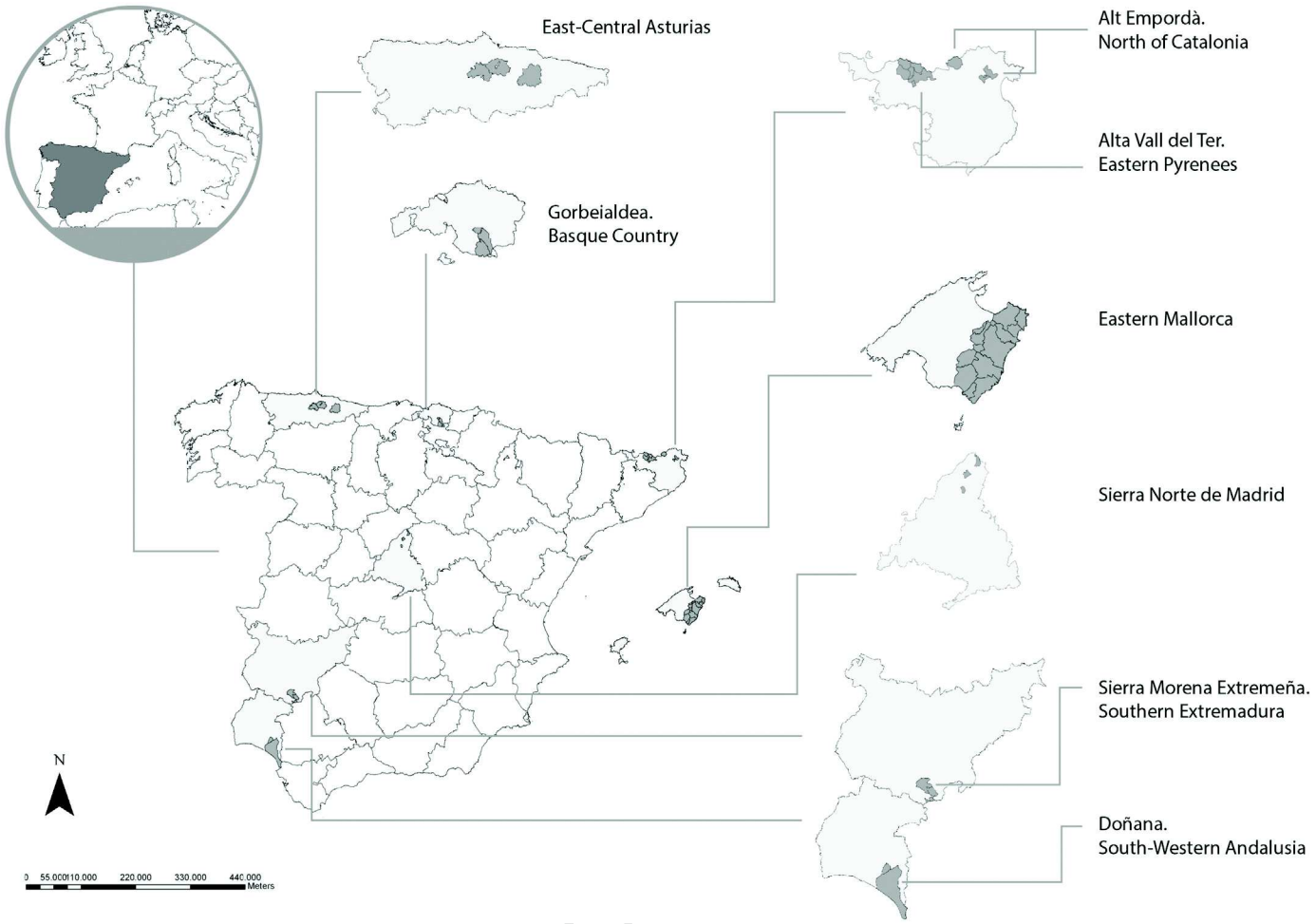

Fig. 1. Map of the study areas.

to ask some questions. A total of 310 people (21% of the people approached) refused to participate: 50% because of lack of time, 25% because of lack of interest, and 14% because of lack of knowledge. The remaining 11% gave other reasons or simply did not give any clear answer. In each site, the sample was stratified according to criteria that might affect use and consumption of wild edible plants. Specifically, we aimed at having 1) 50% men and 50% women (Grasser et al., 2012; Kangas and Markkanen, 2001), 2) 33% of informants in the each of the three age categories selected (<40; 41–60; and >61) (Cornara et al., 2009), and 3) between 15 and 30% of the population in the agricultural sector, depending on the site (Hadjichambis et al., 2008; Idolo et al., 2010) (Table 2).

2.3.3. Survey Design

Our survey included three sections. In the first section, we asked socio-demographic data (age, sex, occupation). In the second section, we asked about past and present consumption and gathering of the seven selected plant-uses. We started by showing the informant a visual stimulus (a picture, a voucher, or the fresh plant) where the edible part could be easily recognized. We then asked for the local name of the plant. If the person did not recognize the plant, we provided him/her with the local name and asked again if the person knew it. If the informant did not know the species, we moved to the following visual stimulus in the survey. If the person recognized the species, we asked about its uses; again, when informants did not report the selected use, we moved on to the next plant. When informants listed the wild edible use, we asked about present (last 12 months) and past consumption and about the main way of obtaining the species (i.e., gathering, gift, or the market).

In the third section of the survey, we asked informants to tell us their level of agreement on a set of statements related to a selection of predetermined cultural services and values associated with such plant-use, including heritage, place and identity values (e.g., considered a local tradition), health values, perceptional benefits (tasteful), and recreational elements associated with gathering and preparation (e.g., perceived time invested in gathering and preparing it, link to leisure). All statements were evaluated in a scale from 1 (*do not agree*) to 5 (*completely agree*).

2.4. Data Analysis

To assess trends in the consumption of wild edible plants, we aggregated information by site. We first calculated the proportion of informants who recognized each species, irrespectively of whether they knew about their uses, and the proportion of informants who mentioned their edible use. Then, we assessed changes between past and present consumption, calculating the difference between people who reportedly consume the plant now minus the people who reportedly consumed it in the past, divided by the total number of people who consumed the plant in the past. We call this measure *consumption* index. Put it formally

$$\text{Consumption}_s = \frac{\sum_{i=i_1}^{i_N} \text{Sp}_s\text{Eat} - \sum_{i=i_1}^{i_N} \text{EatPast}}{\sum_{i=i_1}^{i_N} \text{EatPast}}$$

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Table 1
Specific uses of wild edible species included in the survey, by study area.

Scientific name (family; growth form)	Folk name[a]	Herbarium voucher	Part used	Plant-use included in survey (brief explanation of elaboration)
Alt Empordà				
Arbutus unedo L. (Ericaceae; tree)	Cirera d'arboç	BCN29836	Fruit	Fruits (eaten raw)
Cynara cardunculus L. (Asteraceae; perennial herb)	Preó	BCN29860	Inflorescence	Seasoning (to curdle milk)
Foeniculum vulgare Mill. (Apiaceae; perennial herb)	Fonoll	BCN29867	Young shoot	Vegetable (snack)
Juglans regia L. (Juglandaceae; tree)	Nous	BCN29877	Unripe fruit	Beverage (to make alcoholic spirits)
Origanum vulgare L. (Lamiaceae; subshrub)	Orenga	BCN29742	Flowering aerial part	Seasoning
Reichardia picroides (L.) Roth (Asteraceae; perennial herb)	Cosconilla	BCN29933	Young leaf	Vegetable
Rubus ulmifolius Schott (Rosaceae; shrub)	Móra	BCN29938	Fruit	Fruits (raw or cooked in marmalade)
Alta Vall del Ter				
Carlina acanthifolia All. subsp. *cynara* (Pourr. ex Duby) Arcang. (Asteraceae; perennial herb)	Carlina	BCN24738	Inner part of the inflorescence receptacle	Vegetable (snack)
Cynara cardunculus L. (Asteraceae; perennial herb)	Flor d'empresorar	BCN24759	Inflorescence	Seasoning (to curdle milk)
Fragaria vesca L. (Rosaceae; perennial herb)	Maduixa	BCN24889	Fruit	Fruits
Juglans regia L. (Juglandaceae; tree)	Nous	BCN24908	Fruit	Beverage (to make alcoholic spirits)
Origanum vulgare L. (Lamiaceae; subshrub)	Orenga	BCN24939	Flowering aerial part	Seasoning
Rubus ulmifolius Schott (Rosaceae; shrub)	Móra	BCN24978	Fruit	Fruits (raw or cooked in marmalade)
Taraxacum dissectum (Ledeb.) Ledeb. (Asteraceae; perennial herb)	Xicoina	BCN25016	Young leaf	Vegetable
Doñana				
Asparagus acutifolius L. (Asparagaceae; shrub)	Espárrago, espárrago triguero	BCN29976	Young shoot	Vegetable
Chamaerops humilis L. (Arecaceae; palm shrub/tree)	Palmito	BCN23832	Young shoot	Vegetable
Glycycrhiza glabra L. (Fabaceae; perennial herb)	Palodú, palo arazú	BCN47726	Rhizome	Vegetable (chewed as snack)
Mentha pulegium L. (Lamiaceae; shrub)	Poleo	BCN28895	Flower	Beverage
Rubus ulmifolius Schott (Rosaceae; shrub)	Zarzamora, mora	MA729323	Fruit	Fruit
Scolymus hispanicus L. (Asteraceae; perennial herb)	Tagarnina	MA852821	Aerial part	Vegetable
Thymbra capitata (L.) Cav. (Lamiaceae; subshrub)	Tomillo	BCN20616	Flowering shoot	Seasoning
Eastern Mallorca				
Chamaerops humilis L. (Arecaceae; palm shrub/tree)	Garballó	BCN 23832	Apical shoot	Vegetable
Cichorium intybus L. (Asteraceae; perennial herb)	Cama-roja	BCN 29660	Young leaf	Vegetable
Crithmum maritimum L. (Apiaceae; perennial herb)	Fonoll marí	BCN104272	Leaf	Vegetable
Cynara cardunculus L. (Asteraceae; perennial herb)	Card de formatjar	BCN 29860	Inflorescence	Seasoning (to curdle milk)
Foeniculum vulgare Mill. (Apiaceae; perennial herb)	Fonoll	BCN 95541	Shoot	Beverage
Quercus ilex L. (Fagaceae; tree)	Aglà	BCN103497	Fruit	Fruit
Rubus ulmifolius Schott (Rosaceae; shrub)	Móra d'abatzer	BCN 29938	Fruit	Fruit (raw or cooked in marmalade)
East-central Asturias				
Crataegus monogyna Jacq. (Rosaceae; shrub)	Maluca, espinera	ESM141	Fruit	Fruit (as snack)
Fragaria vesca L. (Rosaceae; perennial herb)	Meruétanu, abeyuétanos, freses silvestres	ESM171	Fruit	Fruit
Mespilus germanica L. (Rosaceae; tree)	Carápanu	MP920	Fruit	Fruit (as snack)
Prunus spinosa L. (Rosaceae; shrub)	Andrín	ESM111	Fruit	Beverage
Rubus ulmifolius Schott (Rosaceae; shrub)	Mora	ESM304	Fruit	Fruit (raw or cooked in marmalade)
Rumex acetosa L. (Polygonaceae; perennial herb)	Agrieta, chupes	ESM126	Young shoot and basal leaf	Vegetable (snack)
Vaccinium myrtillus L. (Ericaceae; shrub)	Arándanu	ESM93	Fruit	Fruit
Gorbeialdea				
Fagus sylvatica L. (Fagaceae; tree)	Pago	GM776	Young leaf	Vegetable (chewed as a snack)
Laurus nobilis L. (Lauraceae; tree)	Ereinotza	GM737	Leaf	Seasoning
Prunus spinosa L. (Rosaceae; shrub)	Arranokan	GM723	Fruit	Beverage (to elaborate an alcoholic spirit 'pacharan')
Pyrus cordata Desv. (Rosaceae; tree)	Basomakatz	GM718	Fruit	Fruit (eaten raw as snack)
Rubus ulmifolius Schott (Rosaceae; shrub)	Masusta	GM766	Fruit	Fruit (raw or cooked in marmalade)
Rumex acetosa L. (Polygonaceae; perennial herb)	Bedar garratza	GM668	Young leaf	Vegetable (chewed as a snack)
Urtica dioica L. (Urticaceae; perennial herb)	Asun	GM719	Aerial part	Vegetable (cooked)
Sierra Morena Extremeña				
Asparagus acutifolius L. (Asparagaceae; shrub)	Espárrago, espárrago triguero	BCN29976	Young shoot	Vegetable
Foeniculum vulgare Mill. (Apiaceae; perennial herb)	Hinojo	BCN29867	Young shoot	Vegetable (snack)
Helichrysum stoechas (L.) Moench (Asteraceae; perennial herb/subshrub)	Manzanilla real o grande	BCN29872	Flowering aerial part	Beverage
Rubus ulmifolius Schott (Rosaceae; shrub)	Zarzamora, mora	MA729323	Fruit	Fruit (raw or cooked in marmalade)
Rumex pulcher L. (Polygonaceae; perennial herb)	Romaza, cocina verde	BCN26671	Basal leaf	Vegetable (snack)
Scolymus hispanicus L. (Asteraceae; perennial herb)	Tagarnina	MA852821	Basal leaf pealed	Vegetable
Thymus mastichina (L.) L. (Lamiaceae; subshrub)	Tomillo salsero	BCN34644	Flowering aerial part	Seasoning
Sierra Norte de Madrid				
Armeria arenaria subsp. *segoviensis* (Gand. ex Bernis) Nieto Fel. (Plumbaginaceae; perennial herb)	Patas de cigüeña, majuletas, patas de milano	MA450678	Peduncle of inflorescence	Vegetable (as a snack)
Crataegus monogyna Jacq. (Rosaceae; shrub)	Majoleto, majuelo, espino majulero	MA729324	Fruit	Fruit (snack)
Prunus spinosa L. (Rosaceae; shrub)	Endrino	MA729279	Fruit	Beverage
Rubus ulmifolius Schott (Rosaceae; shrub)	Zarza, zarzamora	MA729323	Fruit	Fruit (raw or cooked in marmalade)

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Table 1 (*continued*)

Scientific name (family; growth form)	Folk name[a]	Herbarium voucher	Part used	Plant-use included in survey (brief explanation of elaboration)
Sierra Norte de Madrid				
Rumex papillaris Boiss. & Reut. (Polygonaceae; perennial herb)	Acedera, azadera	MA852820	Basal leaf	Vegetable
Scolymus hispanicus L. (Asteraceae; perennial herb)	Cardillo	MA852821	Basal leaf	Vegetable
Thymus zygis Loefl. ex L. (Lamiaceae; subshrub)	Tomillo salsero, tomillo	MA784735	Flowering shoot	Seasoning

[a] Folk names are in the following languages: Catalan in Alt Empordà, Alta Vall del Ter and Eastern Mallorca, Spanish in Doñana, Sierra Morena Extremeña and Sierra Norte de Madrid, Asturian in East-central Asturias and Basque in Gorbeialdea.

where Sp_sEat refers to the plant-use consumption now and $Sp_sEatPast$ to the plant-use consumption in the past. A positive number would indicate an increase in the number of consumers over time, a negative number would indicate a decrease, and a number close to zero no changes. The *gathering* index was constructed in a similar way.

We also calculated a *market origin* index as the difference between a) the number of informants who obtain the plant-use from the market now divided by the total number of informants who consume it now, minus b) the number of informants who obtained the plant-use from the market in the past divided by the total number of people who consumed it in the past. High values indicate an increase in the proportion of people depending on the market to obtain the plant-use.

$$\text{MarketOrigin}_s = \frac{\sum_{i=i_1}^{i_N} Sp_sBuy}{\sum_{i=i}^{i_N} Sp_sEat} - \frac{\sum_{i=i_1}^{i_N} Sp_sBuyPast}{\sum_{i=i_1}^{i_N} Sp_sEatPast}$$

To analyze trends while simultaneously considering consumption and gathering, we performed a hierarchical cluster analysis with Ward agglomerative technique (Kaufman and Rousseeuw, 1990). The procedure clusters items (plant-uses in our case) according to the calculated distance between pairs of observations regarding some selected criteria (here *consumption* and *gathering* indices). Distances between objects are represented in a dendrogram where objects are joined together in a hierarchical fashion from the most similar to the most different regarding the *consumption* and *gathering* indices. We interpret the different clusters as representing the different trends in consumption and gathering of wild edible plants.

In our last step, we explored relations between the clusters and people's evaluations of the cultural services provided by plant-uses in each cluster. For each plant-use, we first calculated the percentage of people who partially (=4) or totally (=5) agree with each statement in our questionnaire. We then used a Kruskal–Wallis test to examine whether such percentages varied across the different clusters. To detect differences between clusters, we ran multiple comparisons using a post hoc Dunn test (Dunn, 1964). For all the calculations we used the full sample. For the statistical analysis we used STATA 11.1 for Windows (Stata Corporation, Texas, USA).

Table 2
Sample description, by study area.

Study area	N	% women	% per age group			% agriculture
			<40	41–60	>61	
Alt Empordà	101	48	38	27	36	15
Alta Vall del Ter	100	51	18	36	46	22
Doñana	150	53	28	35	37	44
Eastern Mallorca	152	45	38	30	32	6
East-central Asturias	150	42	7	31	63	33
Gorbeialdea	150	49	35	35	30	22
Sierra Morena Extremeña	150	48	26	33	41	31
Sierra Norte de Madrid	180	52	30	42	28	11
Total	1133	48	28	34	38	21

3. Results

3.1. Knowledge, Consumption and Gathering of Wild Edible Plants

Overall, 50 out of the 56 species in our surveys were recognized by at least half of the people interviewed (see Supplementary material). A remarkable exception is *Rumex acetosa* in Gorbeialdea, recognized only by 28% of the informants. While the recognition of the selected species was rather generalized, we found variation between sites, with higher levels of recognition in Doñana, Alta Vall del Ter, and Sierra Morena Extremeña. Less people identified the selected plants as edible; thus, only 40 out of the 56 species in the survey were recognized as edible by at least half of the informants. Remarkable cases are *Fagus sylvatica*, *Crataegus monogyna* and *Urtica dioica* in Gorbeialdea, which were recognized by 93%, 87% and 99% of the informants, but only 7%, 13% and 31% identified them as edible.

The analysis of the consumption index (potentially ranging between 1 and −1) suggests an overwhelming general decrease in the consumption of wild edible plants. From all the plant-uses in the survey, only one, the vegetable use of *A. acutifolius* in Sierra Morena Extremeña, has experienced an increase in consumption. The consumption of all the other plant-uses in all the other sites has decreased, including the consumption of the same species in Doñana. Overall, 14 plant-uses had a decrease in consumption index higher than 0.75, and 32 had a decrease in consumption index higher than 0.50.

Our analysis further suggests that, from a given plant-use, trends in consumption vary from one area to another. Thus, the consumption of the fruits of *R. ulmifolius*, a plant-use included in all the surveys, varies from −0.15 in Eastern Mallorca to −0.70 in Doñana. It is also worth noticing that overall trends are dissimilar between sites. For example, while four or five of the seven plant-uses in the surveys in Alt Empordà, Alta Vall de Ter, and Doñana had a consumption index >−0.5, the seven plant-uses included in the survey in Gorbeialdea and five of the plant-uses included in the survey in Sierra Norte de Madrid had a consumption index <−0.75.

The decrease in gathering appears even more pronounced than the decrease in consumption. None of the plants in our surveys experienced an increase in gathering related to the particular use selected and only four had a gathering index >−0.25 (indicating a very low decrease). The three plant-uses with values in the gathering index close to zero (*Origanum vulgare*, *R. ulmifolius*, and *A. acutifolius*) also have very low decrease in consumption. Furthermore, of the 56 plant-uses in our survey, 38 (68% of the total) had a gathering index ≤−0.50.

Despite the general decreasing trend in gathering, we found differences between sites. In Gorbeialdea and eastern Mallorca all the plant-uses but one have gathering indices ≤−0.50. Similarly, in east-central Asturias, four out of the seven plant-uses included in the survey had a gathering index ≤−0.75.

3.2. Trends in the Use of Wild Edible Species

Based on the visual inspection of the dendrogram resulting from cluster analysis, we classified plant-uses into three clusters. The first cluster (Table 3, Group A) is the smallest (n = 11, ≈20% of the total) and includes species for which the selected uses have experienced a

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Table 3
Characterization of groups resulting from the hierarchical cluster analysis.

Variables	Total	Group A	Group B	Group C	Kruskal–Wallis	
		Popular (n = 11)	Gradually abandoned (n = 29)	Mostly abandoned (n = 16)	χ^2	p-Value
Mean of variables used to create cluster						
Consumption index[a]	−0.53	−0.12	−0.52	−0.84	45.51	.0001
Gathering index[a]	−0.62	−0.35	−0.58	−0.87	36.98	.0001
Values of independent variables across clusters						
Current status						
Recognize[a,b]	82.30	95.42	86.91	64.90	20.80	.0001
Edible[a,b]	72.27	91.53	77.23	50.04	18.78	.0001
Market index[a]	0.08	0.15	0.07	0.04	9.50	.009
Cultural heritage[b]						
The use is traditional in this area	58.15	71.93	61.11	43.31	8.19	0.02
It is good for health	45.44	63.59	49.88	24.94	15.46	0.0004
It tastes good	44.90	59.39	50.71	24.41	15.71	0.0004
It is only eaten in times of famine	15.06	11.54	16.17	15.45	1.13	0.57
Recreation[b]						
I gather it for leisure	20.18	31.09	21.92	9.54	8.17	0.02
Gathering is time consuming	12.25	9.45	16.98	5.62	4.92	0.08
Preparing is time consuming	8.67	4.08	13.02	4.08	3.14	0.21

[a] See definitions in the Supplementary material.
[b] Cells represent the percentage of informants who partially (=4) or totally (=5) agree with each of the statements.

small decrease in consumption (average consumption index = −0.12) and a relatively low decrease in gathering (average gathering index = −0.35), at least in relation to the other groups (Fig. 2). Plant-uses in this group include the fruits of *Fragaria vesca* and *R. ulmifolius* (one occurrence), the use for seasoning of *O. vulgare*, *Mentha pulegium*, *Thymbra capitata*, *Thymus mastichina* and *Thymus zygis*, the use for beverages of *Juglans regia* and the vegetable use of *A. acutifolius*. Because overall they continue to be widely used plants, we name this group 'popular' plant-uses.

The second cluster (Table 3, Group B) includes 29 plant-uses (≈52% of the total) with intermediate values. In contrast with 'popular' plant-uses, we found a steeper decrease in the consumption and gathering of plant-uses in this group (−0.52 and −0.58). Plant-uses in this group include the fruits of *R. ulmifolius* (seven occurrences), *Prunus spinosa* (two occurrences), *F. vesca*, *Arbutus unedo*, *Q. ilex*, and *Mespilus germanica*; the vegetable use of *Taraxacum dissectum*, *Chamaerops humilis*, *Cichorium intybus*, *Crithmum maritimum*, *U. dioica*, *F. sylvatica*, and *Scolymus hispanicus*; the use for seasoning of *Laurus nobilis* and *Foeniculum vulgare*; and the use for beverage of *J. regia*. We call this group 'gradually abandoned' uses.

Finally, the third cluster (Table 3, group C), composed by 16 plant-uses (≈28%), experience the strongest decrease in consumption (−0.79) and gathering (−0.86). Plant-uses in this group are varied and include the fruits of *C. monogyna* and *Pyrus cordata* and the use as vegetable of *Reichardia picroides*. However, many of the plant-uses in this group refer to vegetable uses, mainly consumed as snacks while in the field (*F. vulgare*, *Carlina acanthifolia*, *Vaccinium myrtillus*, *R. acetosa*, *Armeria arenaria*). We call this group 'mostly abandoned' plant-uses.

3.3. Cultural Services and Wild Edible Species Use

We next explore cultural services and values associated with the three clusters identified. The percentage of informants who recognized species was significantly different among the three clusters, using Kruskal–Wallis, $\chi^2 = 20.8$, $p < .0001$ (Table 3). A post hoc Dunn test showed that the percentage of people who recognized species in the mostly abandoned cluster (65%) differed significantly ($p < .001$) from those who recognized species in the gradually abandoned (87%) and popular (95%) clusters (Fig. 3). Results are similar for the variable that capture the percentage of informants recognizing the species in each cluster as edible ($\chi^2 = 18.78$, $p < .0001$ for the Kruskal–Wallis test), with statistically significant differences between the cluster of mostly abandoned plant-uses (in which 50% identified species as edible) and the clusters of gradually abandoned (77.2%) and popular (91.5%) plant-uses ($p < .001$ for both comparisons). We also found differences in the three clusters regarding the number of informants who report to buy such species now versus the past ($\chi^2 = 9.50$, $p < .009$ for the Kruskal–Wallis test). Statistically significant differences were found between the cluster of popular plant-uses (which had an average market index of 0.14) and the clusters of gradually (0.07; $p = .07$) and mostly abandoned (0.4; $p = .002$) plant-uses (Table 3).

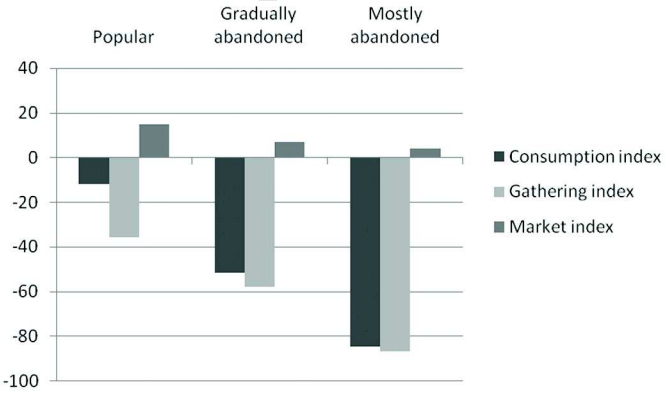

Fig. 2. Consumption and gathering indexes, by group.

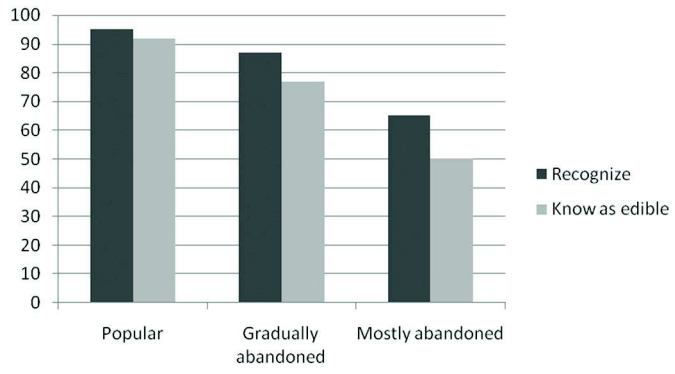

Fig. 3. Proportion of informants who know and identify as edible plants in the three groups.

Results from Kruskal–Wallis test show that the percentage of informants who agree with statements indicating cultural appreciation was significantly different among the three clusters ($p < .05$) for all the variables, except for agreement with the statement that such plant-uses were only consumed in times of famine, variable for which we did not find statistically significant differences among clusters ($p = .57$). A series of multiple comparisons using post hoc Dunn tests showed that the differences regarding the perceptions of plant-uses as traditional, healthy and tasty were statistically significant when comparing mostly abandoned plant-uses with both gradually abandoned and popular plant-uses ($p < .05$ or lower for all comparisons).

Regarding the recreation function, the percentage of informants who gather wild plants as a hobby was significantly different among the three clusters ($\chi^2 = 8.17$, $p < .02$, Table 3), with statistically significant differences between the cluster of mostly abandoned plant-uses (9.54) and the clusters of gradually abandoned (21.91%) and popular (31.09%) plant-uses. We also found statistically significant differences between clusters regarding the percentage of informants who agree with the statement that gathering the selected species is time consuming ($\chi^2 = 4.92$, $p < .08$, Table 3), but not in the percentage of informants who agree with the statement that preparing the selected species is time consuming. Regarding gathering time, the Dunn test suggests that differences are statistically significant only when comparing plant-uses in the gradually abandoned (16.98) and mostly abandoned clusters (5.62), with popular plant-uses somewhere in between (9.45%).

4. Discussion

We start the discussion by acknowledging some limitations of this study. A first important limitation relates to sample selection biases. To select informants, we used a convenience sample by soliciting participation from people in public places, e.g., parks, bars, and grocery stores. Convenient sampling precludes us from drawing conclusions about the larger population (Babbie, 2009). Furthermore, about 21% of the people approached declined to participate. Given that some of these people argued that they lacked knowledge on wild edible plants, our findings might indeed underrepresent the real magnitude of the decreasing trend in the use of wild edible plants. We argue, however, that this was the only ethical way to conduct the survey, and that –given that much research on wild edible plants– is largely conducted with local experts, this first approach to capture a larger part of the population provides valuable insights for the purposes of our research.

Two additional caveats relate to our survey. First, our questions only gather people's perceptions. Whether wild edibles were actually consumed in the past with the frequency reported by informants is an open question. However, given the lack of other empirical data, it is the best estimation we can have. Second, many of the variables measured are intertwined, even if we attempted to measure them independently. For example, we found that a large proportion of informants were not able to identify or recognize as edible species with 'mostly abandoned' uses. The finding is not surprising, as gathering is clearly related to the abilities to identify and recognize wild plants as edible (Pilgrim et al., 2008). While such abilities might be less clearly related to consumption (wild edible plants can also be obtained by means not requiring identification abilities such as gifts or the market), the possibility that those variables are closely interrelated remains high.

Keeping those caveats in mind, we now discuss the main findings of this work. First, we found an overall, generalized decrease in the consumption and gathering of wild edible plants. In fact, we only find an increase in the consumption of one of the plant-uses analyzed: the consumption of *Asparagus* in Sierra Morena Extremeña, a plant-use that is a strong marker of cultural identity and place attachment (Acosta-Naranjo and Díaz-Diego, 2008). We found no instance of increase in gathering of any wild edible plant.

Several authors have argued that such general trend is concomitant with urbanization and modernization of lifestyles (González et al., 2011; Hadjichambis et al., 2008; Seeland and Staniszewski, 2007; Tardío et al., 2005). Even in rural areas, as the sites studied here, most people nowadays rely on foods obtained through the market (Abbet et al., 2014; Kalle and Soukand, 2013; Łukasz et al., 2013), which imply that the general decrease in the consumption and gathering of wild edible species relates to the overall drop in the provisioning services they use to provide. In such context, the question that remains, however, is 'why the consumption and gathering of *some* wild edible plants (about 20%) remains relatively popular?'

The analysis of the uneven trends in the consumption and gathering of wild edible plants helps us answer such question. Data presented in Fig. 4 suggest that plant-uses in the 'popular' and 'gradually abandoned' clusters are relatively similar in most criteria except two: the market index and the gathering time. These two cluster together contrast sharply with the cluster of 'mostly abandoned' plant-uses. We first discuss the differences between the first two clusters and then the differences between those two and the last one.

We found two main differences between the first two clusters. First, 'popular' plant-uses have the highest average market index, suggesting an increased dependency on the market for obtaining the species. Plant-uses in this cluster include the use for seasoning of *O. vulgare* and *T. zygis*, now easily available in the market. Moreover, some plants in this cluster, like *A. acutifolius*, are sold by gatherers in informal local markets. Second, more informants reported gathering of species with uses falling in the 'gradually abandoned' cluster as time consuming. 'Popular' plant-uses included several fruits and plants for seasoning, whereas 'gradually abandoned' plant-uses included many species used as vegetables, which require long preparations. For example, although our ethnographic information suggests that *S. hispanicus*, a wild vegetable present in three of the study areas, is highly valued, it systematically fell within the category of 'gradually abandoned'. The preparation of such vegetable requires peeling the thorny leaves, a time consuming process that might discourage some gatherers. Thus, the two factors that seem to explain why some plant-uses remain relatively 'popular' while others are being 'gradually abandoned' relate to the increasing availability of some plants in formal and informal markets and to required time investment for gathering.

Those factors alone, however, do not explain the difference between species in those two clusters and 'mostly abandoned' plant-uses. For example, many of the 'mostly abandoned' plant-uses are snack foods, and therefore did not require long gathering and preparation times. Then, what explains that some uses remain relatively popular, while some others are being 'mostly abandoned'? Some researchers have argued that the decrease in the consumption of wild foods relates to the fact that they are perceived as food of the poor, a safety net, or a reserve food in case of famine (e.g. Hedge et al., 1996; Łukasz et al., 2013; Pouta et al., 2006; Senaratne et al., 2003). This, however, does not seem to be the case in our sites, as –on average– only 15% of informants agreed that wild edible plants are only eaten in times of famine, the percentage being similar across the three clusters.

Our analysis unravels that, indeed, the cultural ecosystem services and values associated with different wild edible species can be a critical factor in explaining different trends in their consumption and gathering. For example, in contrast with plant-uses in the 'popular' and 'gradually abandoned' groups, less informants agreed with statements regarding cultural appreciation (e.g., being traditional in the area, healthy, or tasty) when such statements referred to 'mostly abandoned' plant-uses. Similarly, the gathering and consumption of 'popular' and 'gradually abandoned' plant-uses are more frequently identified as leisure activities than the gathering and consumption of 'mostly abandoned' plant uses. Moreover, when all explanations provided are taken together, non-use values, such as those associated with cultural identity and heritage values seem to be –at least– as important as cultural services more frequently accounted for in the literature on

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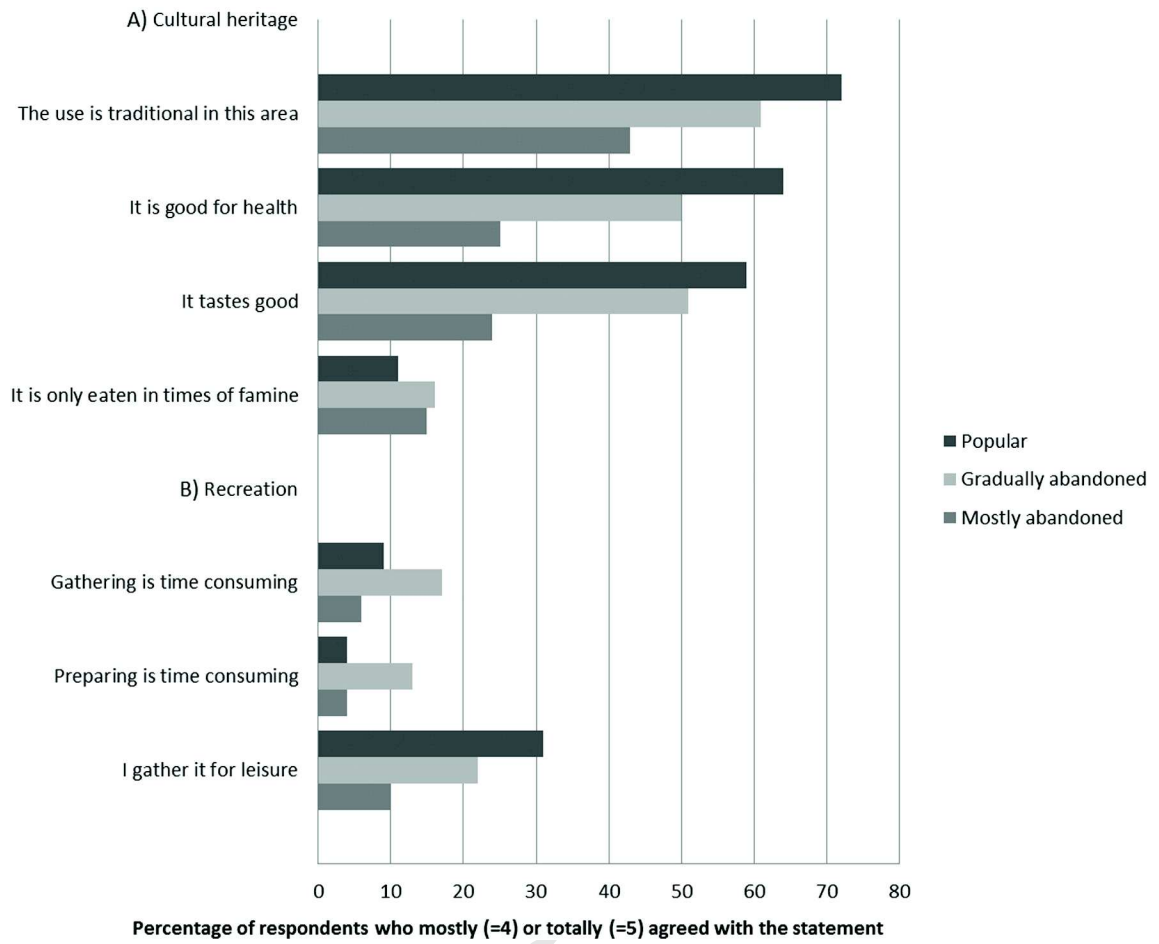

Fig. 4. Percentage of informants who mostly or totally agree with statements regarding A) cultural heritage and B) recreation values of wild edible plants.

cultural ecosystem services and wild edible plants, such as recreation (Schulp et al., 2014).

The interpretation that the association with cultural ecosystem services relates to different trends in the consumption and gathering of wild edible plants matches well with previous research findings and with our own ethnographic information. Previous research has highlighted that the gathering and consumption of wild edible plants play a significant role in maintaining local culture, identity (Pardo-de-Santayana and Gómez-Pellón, 2002; Schunko and Vogl, 2010; Seeland and Staniszewski, 2007), and spirituality (Hummer, 2013). Similarly, in some of our sites, we observed that some uses of wild edibles seem to be maintained due to a revival of traditions linked to their cultural construction as "typical" foods. This is the case of species used to elaborate liqueurs, as the use of walnut in a traditional Catalan beverage (*ratafia*) or the fruits of *P. spinosa* macerated in alcohol in Basque Country (*patxaran*). The finding also meshes with previous research highlighting that wild edible plants have remained more important in countries in which wild food is important in the traditional cuisine, versus countries where traditional cuisine is dominantly based on agricultural products (Schulp et al., 2014). Thus, identitarian-gastronomic traditions seem to help maintaining alive the gathering and consumption of some wild edible plants (see also Leonti et al., 2006; Pieroni and Price, 2006).

5. Conclusion

Our data show a generalized decrease in the consumption and gathering of wild edible plants in all study sites. However, we also found that the assessed trend is uneven and changes significantly across plant-uses. Specifically, we found that –despite the overall decreasing trend– uses of wild edible plants that simultaneously relate to foods with high cultural appreciation and the recreational function of gathering remains popular. While the overall decrease in the consumption of wild edibles might be concomitant with forces related to urban, industrial, and post-industrial lifestyles in which wild edible plants have lost their historically important role as provisioning services (Abbet et al., 2014; Bharucha and Pretty, 2010; Kalle and Soukand, 2013; Łukasz et al., 2013; Turner and Turner, 2008), cultural services and values associated to the gathering and consumption of some wild edible plants seem to explain divergent trends across species. In sum, even if wild edible plants are a provisioning ecosystem service, in our study sites (and, we may dare to say, in other sites with modern food production and supply systems) their role as a provisioning service is nowadays marginal or negligible, and in most cases no longer accounts for continuity in their use. It is primarily through their bundling with cultural ecosystem services and non-use values that the persistence in the consumption and gathering of some wild edible plants can be explained. Our finding reinforces the notion that ecosystem services tend to combine in complex and non-linear ways and, more specifically, that cultural ecosystem services are deeply bundled with the other categories of ecosystem services (Gould et al., 2014; Gould et al., 2015; Milcu et al., 2013), often producing a wide range of interdependent benefits.

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