

## Resilience of traditional knowledge systems:

### The case of agricultural knowledge in home gardens of the Iberian Peninsula

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Victoria Reyes-García<sup>a\*</sup>, Laura Aceituno-Mata<sup>b</sup>, Laura Calvet-Mir<sup>c</sup>,

Teresa Garnatje<sup>d</sup>, Erik Gómez-Baggethun<sup>c</sup>, Juan J. Lastra<sup>e</sup>, Ricardo Ontillera<sup>b</sup>,

Montserrat Parada<sup>f</sup>, Montserrat Rigat<sup>f</sup>, Joan Vallès<sup>f</sup>, Sara Vila<sup>g</sup>,

Manuel Pardo-de-Santayana<sup>b</sup>

<sup>a</sup> ICREA and Environmental Science and Technology Institute, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain

<sup>b</sup> Departamento de Biología (Botánica), Universidad Autónoma de Madrid, C/ Darwin 2. Campus de Cantoblanco, 28049 Madrid, Spain.

<sup>c</sup> Environmental Science and Technology Institute, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain

<sup>d</sup> Institut Botànic de Barcelona (IBB-CSIC-ICUB), Passeig del Migdia s.n., Parc de Montjuïc, 08038 Barcelona, Spain.

<sup>e</sup> Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo. Campus del Cristo, 33071 Oviedo, Spain.

<sup>f</sup> Laboratori de Botànica (Unitat associada CSIC), Facultat de Farmàcia, Universitat de Barcelona, Av. Joan XXIII, s.n., 08028 Barcelona, Spain.

\* Corresponding author:

Victoria Reyes-García

ICREA Professor

Environmental Science and Technology Institute

Universitat Autònoma de Barcelona

08193 Bellaterra, Barcelona, Spain

Tel.: + 34 (93) 586 4985

Fax: + 34 (93) 581 3331

E-mail: [victoria.reyes@uab.cat](mailto:victoria.reyes@uab.cat)

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## **Resilience of traditional knowledge systems:**

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#### **1. Introduction**

Resilience has been defined as a system's ability to absorb change and endure while maintaining its essential structure, function, and feedbacks (Gunderson, 2003) and while remaining flexible in response to social and environmental changes (Redman and Kinzig, 2003). The concept of resilience has been mostly applied to analyze the capacity for renewal of ecological (Holling, 1973) or social-ecological (Folke, 2006) systems in the face of disturbance and change. A basic argument of the resilience approach is that, after each major social or environmental perturbation, the human-environment relation is altered, new knowledge develops, and a new balance is established (Berkes and Folke, 2002; Chapin et al., 2009). Therefore, the resilience of a social-ecological system largely depends on the capacity of the corpus of knowledge to learn by absorbing new information.

It is well acknowledged that in social-ecological systems with some basis of historical and intergenerational continuity in resource use management, people have developed knowledge of resource and ecosystem dynamics and associated management practices, or traditional ecological knowledge (Berkes et al., 2000). From the perspective of social-ecological systems, traditional ecological knowledge has been conceived as an evolving body of knowledge, practices and beliefs that develops over time from long-term observation and monitoring of the system functioning (Berkes et al., 2000), but also from learning with crises and mistakes (Berkes and Turner, 2006; Olsson and Folke, 2001). As other lay and local knowledge systems, traditional ecological knowledge is generally site specific in the sense that it is produced through

26 economic and social interactions with the immediate environment and is dynamic and  
27 mutable (Kloppenburg, 1991). Therefore, traditional ecological knowledge contrasts  
28 with scientific knowledge, an “immutable mobile” (as coined by Latour, cited in  
29 Kloppenburg, 1991) mainly produced with the goal of being universal, transferable,  
30 mobile, and not tied to a singular place. But in contrast with other lay knowledge  
31 systems, the term “traditional ecological knowledge” emphasizes the historical  
32 continuity of such bodies of knowledge, not only their local embeddedness, a  
33 characteristic that seems to contribute to the long-term resilience of social-ecological  
34 systems by providing a pool of information and practices that improves societies’  
35 adaptive capacity to cope with recurrent environmental or social disturbances (Folke,  
36 2004; Gómez-Baggethun et al., 2012; McIntosh et al., 2000).

37         Several researchers have emphasized that traditional knowledge systems should  
38 neither be considered static (Berkes et al., 2000; Gómez-Baggethun and Reyes-García,  
39 2013), nor in isolation from other knowledge systems (Agrawal, 1995; Leonti, 2011;  
40 Leonti and Casu, 2013). Rather, traditional knowledge systems should be understood as  
41 being in constant change, in a dynamic process that encompasses a complex mix of  
42 knowledge replication, loss, addition, and transformation, in a type of process that  
43 anthropologists have noted to involve simultaneously “continuity and change”  
44 (Reenberg, et al., 2008). On the one side, traditional ecological knowledge draws from  
45 historical and intergenerational continuity in resource use management. On the other  
46 side, change in traditional knowledge systems can be triggered by multiple factors that  
47 include -but are not limited to- individuals’ own learning and experimentation, adoption  
48 of new technologies, the production of new knowledge due to adaptation to new social  
49 or ecological conditions or the co-production of knowledge arising from the interactions  
50 with other knowledge systems, such as scientific knowledge.

51           In this research, we offer an exploration of the resilience of a traditional  
52 agricultural knowledge system. Specifically, we assess the ability of the traditional  
53 agricultural knowledge to continue to exist while absorbing changes, that is, its capacity  
54 to simultaneously evolve and persist in response to disturbance and change. After the  
55 presentation of the case study, we analyze the co-existence of agricultural information  
56 derived from two different knowledge systems: i) knowledge and use of landraces  
57 (representative of traditional agricultural knowledge) and ii) knowledge and use of  
58 commercial crop varieties (representative of modern agricultural knowledge). We then  
59 analyze the socio-demographic characteristics associated to the holders of those bodies  
60 of knowledge.

61           Our underlying hypothesis goes as follows. If the traditional agricultural  
62 knowledge system is not able to absorb change, then we should see either a) a  
63 displacement of traditional agricultural knowledge and practices by new knowledge, or  
64 b) the maintenance of the traditional agricultural knowledge, if people are not able or  
65 willing to incorporate new knowledge. In both cases, we would expect to observe a  
66 negative association between the two measures of agricultural knowledge and a  
67 concentration of one or the other type of knowledge in different segments of the  
68 population. If, on the contrary, the traditional agricultural system is capable of  
69 absorbing new information and adapting to change, then we should see that traditional  
70 and modern agricultural knowledge are not necessarily mutually exclusive. Our research  
71 is based on pockets of traditional agricultural knowledge held by gardeners in three  
72 different regions of the Iberian Peninsula.

73

## 74 **2. Home gardens as pockets of social-ecological memory**

75           As mentioned, traditional knowledge is an attribute of societies with historical  
76 and intergenerational continuity in resource use management. Although, by and large,  
77 traditional knowledge systems are mostly found in non-industrial societies, some  
78 traditional knowledge systems remain in rural areas of industrial societies (Aceituno-  
79 Mata, 2010; Beaufoy et al., 1994; Calvet-Mir et al., 2011; Emanuelsson, 2010; Negri,  
80 2003). Barthel et al. (2010) call *pockets of social-ecological memory* those places that  
81 having captured, stored, and transmitted through time the knowledge and experience of  
82 managing a local ecosystem and its services, continue to maintain them alive despite  
83 drastic changes in the surrounding environments (see also Barthel and Isendahl, 2013;  
84 Barthel and Crumley, in press). For example, agricultural landscapes in Europe evolved  
85 through thousands of years of interactions between social and ecological systems, but  
86 changed drastically with the ubiquitous industrialization and mechanization of  
87 agriculture in the last century as well as with societal transformation more broadly  
88 (Emanuelsson, 2010). Despite this general change, some places still preserve locally  
89 evolved experiences of farming with historical continuity in management (Hernández-  
90 Morcillo et al., in press). Such pockets include agricultural systems in parts of Eastern  
91 Europe or in marginal lands such as areas with poor soils or areas in sloping terrains  
92 (Beaufoy et al., 1994; Emanuelsson, 2010; Eyzaguirre and Linares, 2004; Joffre et al.,  
93 1988; Negri, 2003). That is also the case of home gardens in mountain areas of the  
94 Iberian Peninsula.

95           Agriculture in Spain has been subject to deep transformations throughout history  
96 and especially since the 18<sup>th</sup> century (González de Molina and Sevilla-Guzmán, 1993),  
97 but many authors identify the 1960s as the tipping point when agriculture shifts most  
98 radically from a ‘traditional’ to a ‘modern’ (or industrial) agrarian mode of production  
99 based on the use of fossil fuels, chemicals, and machinery (Naredo, 2004). Changes in

100 the long term agricultural tradition in the Iberian Peninsula were motivated by a new  
101 emphasis on exploitation efficiency in terms of physical and monetary yields and  
102 materialized in the simplification of agricultural systems, the introduction of new crops,  
103 and the mechanization of farm activities (Naredo, 2001), all of which have led to  
104 fundamental changes in traditional agricultural knowledge systems (see, e.g. Gómez-  
105 Baggethun et al., 2010). Spain's late entry in the European Union (EU), in 1986, and  
106 the adoption of the Common Agricultural Policy (started in 1957 in other parts of the  
107 EU) settled and reinforced transformations in agriculture and mainly in livestock  
108 activities (Lefebvre et al., 2012). At the landscape level, those changes generally  
109 resulted in the concentration of agricultural activities and the abandonment of traditional  
110 agricultural practices (Naredo, 2004; Beaufoy et al., 2012). At the social level, those  
111 changes generated a developmentalist mindset, which focused in commercial  
112 agriculture, downplayed subsistence agriculture and undervalued traditional knowledge  
113 and practices as old and useless (Entrena-Durán, 1998; Pardo-de-Santayana et al.,  
114 2010). Those changes fully affected the commercial agricultural sector and, to a lesser  
115 extent the agricultural production that remained devoted to self-consumption (Naredo,  
116 2004), such as food production in home gardens, the focus of our study.

117 Our study was conducted in home gardens in three mountain areas of the Iberian  
118 Peninsula: the Catalan Pyrenees, Central Asturias, and Sierra Norte de Madrid (Figure  
119 1). Specific descriptions of each study area can be found in previous work (Aceituno-  
120 Mata, 2010; Calvet-Mir et al., 2011; Reyes-García et al., 2012; Rigat et al., 2011). There  
121 are linguistic and cultural differences between the three areas, but an important  
122 commonality between them is the prevalence of slopes which make intensive and  
123 mechanized agriculture difficult. In the three areas, home gardens are still quite

124 widespread and involve a significant number of people, both when considering their  
125 participation in gardening activities and the consumption of home gardens' products.

126 **FIGURE 1**

127 Home gardens are places of confluence of biological and cultural diversity,  
128 conceived for a small-scale and complementary food production. Previous research  
129 suggests that the studied home gardens provide a myriad of ecosystem services beyond  
130 food production, holding important ecological, socio-cultural and economic values  
131 (Calvet-Mir et al., 2012; Reyes-García et al., 2012). Compared to other agricultural  
132 sectors which have undergone drastic changes since the 1960s (Naredo, 2004), farming  
133 in home gardens continues to involve a high degree of manual labor and traditional  
134 management techniques. Thus, many gardeners in our study areas still use traditional  
135 tools like hoes, billhooks, and sickles; traditional irrigation systems like water canals,  
136 watering cans; and other traditional management practices such as manual weeding and  
137 pest removal. Moreover, home gardens still harbor landraces highly valued for their  
138 taste, smell, and gastronomic characteristics (Aceituno-Mata, 2010; Calvet-Mir et al.,  
139 2011).

140 However, research also suggests that home garden management has not  
141 remained static. Gardeners have responded to environmental, social, and economic  
142 changes in a myriad of ways. Some responses include experimentation with new  
143 technologies and practices. For example, although the overall degree of home garden's  
144 mechanization is low, in most of the studied gardens plowing is no longer done with  
145 mules, but with rotavators. Chemical pest control methods have also made their way  
146 into home gardens. Gardeners also experiment with new crop varieties and as a  
147 consequence seed saving seems increasingly restricted to a smaller number of crops  
148 (Calvet-Mir et al., 2011). Responses to change are also reflected in the household

149 distribution of garden activities. For example, previous work suggests that social  
150 changes affecting patterns of employment in the region have led to changes in the  
151 gendered distribution of home garden tasks (Reyes-García et al., 2010).

152 In sum, agricultural knowledge related to the maintenance of home gardens  
153 presents an ideal case to study the resilience of a traditional agricultural knowledge  
154 system for at least two reasons. First, it presents a clear example of knowledge  
155 developed through historical and intergenerational continuity in resource use  
156 management. And second, it is embedded in a social-ecological system suffering rapid  
157 change.

158

### 159 **3. Methods**

#### 160 3.1. Definitions

161 Since our aim is to analyze the level of co-existence of traditional and modern  
162 agricultural knowledge systems, the definition and operationalization of such  
163 knowledge systems is of paramount importance. We follow researchers who have  
164 analyzed the transformation of the Spanish agricultural sector (González de Molina and  
165 Sevilla-Guzmán, 1993; Naredo, 2004; Carpintero 2005) and differentiate between the  
166 ‘traditional’ and the ‘modern’ (or industrial) agrarian mode of production. By using the  
167 term ‘traditional’ agricultural knowledge, rather than ‘local’, we emphasize historical  
168 and intergenerational continuity in agricultural management. By using the term  
169 ‘modern’ agricultural knowledge, rather than ‘scientific’, we acknowledge that there is a  
170 large scientific agronomic literature, for example in agroecology, emphasizing the  
171 scientific base of many traditional practices (Altieri, 2004; Rist and Dahdouh-Guebas,  
172 2006).



173           From the many aspects that could be considered an integral part of the  
174 agricultural knowledge system, we focus on knowledge and use of landraces  
175 (representative of traditional agricultural knowledge) and knowledge and use of  
176 commercial crop varieties (representative of modern agricultural knowledge). We define  
177 “landraces” as the annual and biennial crops that farmers have reproduced in the area of  
178 study for more than one generation (30 years). For crops with vegetative reproduction  
179 we use the criteria of two generations (60 years) (Calvet-Mir et al., 2011). We focus on  
180 annual and biennial crops excluding perennial trees, because we found that farmers are  
181 often unaware of the origin of trees in their fields. We set up the limit of 30 (or 60)  
182 years, as a minimum amount of time needed both to provide diachronic data to farmers  
183 growing a plant strain and to allow a plant strain to adapt to the local environmental  
184 conditions and management.

185           Traditional knowledge systems are integrated corpus of knowledge, practices,  
186 and beliefs that provide a holistic view of ecosystems (Toledo, 2002). We are aware that  
187 by restricting our analysis to knowledge and use of landraces, we do not capture the  
188 broader complexity of this holistic view. The approach, however, also has advantages.  
189 By focusing on one measurable aspect, we are able to compare the level of landrace  
190 knowledge with the level of commercial varieties knowledge. Furthermore, the  
191 approach allows for testing our ideas in a larger sample than wider or more in-depth  
192 approaches allow. Lastly, the approach also allows for the collection of cross-cultural  
193 comparative data, and therefore for a higher degree of generalization.

194

### 195 3.2. Sample

196           Our sampling strategy proceeded in two steps. We first selected a range of  
197 villages representing key features of the environmental and socioeconomic variability of

198 the study areas. In a second phase, we identified all the active gardens in the selected  
199 villages. For each garden, we requested the voluntary participation of individuals  
200 involved in garden management to answer a survey. As the number of people  
201 undertaking gardening varied from household to household, in some households we  
202 interviewed one person and in other households we interviewed two persons. Our total  
203 sample includes 383 individuals, in 326 households, and 28 villages across the three  
204 study areas.

205

### 206 3.3. Data collection

207 A multidisciplinary team of social and natural scientists collected data during  
208 April 2008-October 2009 using ethnographic tools and a survey.

209 Ethnographic tools: Six researchers lived in one or another of the study sites  
210 participating in local life. The rest of the team, occasionally also collaborated in data  
211 collection. Participant observation allowed the understanding of the different activities  
212 and tasks around gardening by providing ample opportunities -other than during the  
213 formal interviews- to interact with gardeners and to discuss garden's progress and other  
214 issues such as cultural practices and their changes, products grown and their evolution,  
215 destination of these products, and economic implications of home gardening, among  
216 others. We also carried out semi-structured interviews with more than 90 elders (about  
217 30 per study area) regarding traditional management of home gardens and changes on  
218 management techniques over the last decades. We selected people over 65 years of age,  
219 with a long history of living and cultivating a home garden in the study areas.

220 Ethnographic information helped us to interpret quantitative results in a broader context.

221 Survey: Our survey had two sections. In the first section, we asked about socio-  
222 demographic characteristics of the person answering the survey (age, sex, maximum

223 education level, years gardening, and length of residency in the village). The second  
224 section evaluated gardeners' knowledge of landraces and commercial varieties through  
225 a knowledge test. The test included 36 questions on six different crop varieties  
226 (36=6\*6), of which three were landraces and three were commercial varieties. To  
227 increase variation in responses, we used our ethnographic information to select one well  
228 known, one relatively known, and one rare landrace in each site. We used the same  
229 criteria to select three commercial varieties. For each item we requested gardeners a) to  
230 identify the variety by showing them the seed (or other propagation material such as  
231 bulbs); b) to report whether they were growing this variety at the time of the interview,  
232 c) had grown it in previous years, d) or had it in storage; and e) to answer a question on  
233 the species management, and f) a question on species use. Questions on species  
234 management and use were constructed using ethnographic information collected among  
235 locally recognized experts. Because species and practices vary from one site to another,  
236 the knowledge tests were site-specific, although they all conformed to the same  
237 structure.

238

### 239 3.4. Data analysis

240 We used answers to the 18 questions on landraces to generate a score of  
241 *landrace knowledge* and answers to the 18 questions on commercial varieties to  
242 generate a score of *commercial varieties knowledge*. Specifically, we added a point to  
243 the respective score if the informant a) was able to identify the propagation material by  
244 providing the folk name of the strain, b) was growing it at the time of the interview, c)  
245 had grown the strain during previous years, d) or had the strain in storage, e) knew the  
246 specific management technique of the strain, and f) knew the characteristic use or  
247 preparation for that plant strain (6 questions\*3 landraces=18 points). Answers to

248 questions on landrace folk name, management, and use were considered as correct if  
249 they matched responses from ‘local experts,’ defined here as local inhabitants with  
250 long-term experience with traditional management of home gardens in the area (Davis  
251 and Wagner, 2003) and identified by residents during informal interviews. For  
252 commercial varieties, correct answers were extracted from agronomic literature  
253 (Maroto, 1992).

254 To assess the association between landraces and commercial varieties  
255 knowledge, we used both bivariate and multivariate analysis. We first ran a Spearman  
256 correlation of landraces against commercial varieties knowledge. We then ran a Poisson  
257 multivariate regression with *landrace knowledge* as outcome variable and *commercial*  
258 *varieties knowledge* as explanatory variable while controlling for confounding factors  
259 that research suggests might affect the distribution of traditional ecological knowledge  
260 (i.e., age, sex, years gardening, schooling, and years of residency).

261 To assess trends in the association between those two bodies of knowledge, we  
262 performed a hierarchical cluster analysis classifying interviewees according to their  
263 *landraces* and *commercial varieties* knowledge. We used the Ward's method as  
264 agglomerative technique. Then, we used Kruskal-Wallis and Chi-square tests to  
265 characterize the groups obtained with the hierarchical cluster analysis according to  
266 socio-cultural and demographic variables. For the statistical analysis we used STATA  
267 11.1 for Windows (Stata Corporation, Texas, USA).

268

## 269 **4. Results**

### 270 **4.1. Landraces and commercial varieties knowledge**

271 Table 1 contains definitions and summary statistics of the variables used in the  
272 analyses. The average respondent obtained a similar score in landraces and commercial

273 varieties knowledge, although variation was larger for landraces than for commercial  
274 varieties knowledge. Overall, from a range from 0 to 18, the landraces knowledge score  
275 had a mean of 7.71 (median= 8; mode= 10), and the commercial varieties knowledge  
276 score had a mean of 7.83 (median=8; mode=10).

277 **TABLE 1**

278 The survey sample included people between 17 and 100 years of age, but the  
279 average respondent was 66 years, above retirement age in Spain (65 years). Men  
280 accounted for 68% of survey respondents. About 51% of the interviewees had been or  
281 still were farmers at the moment of the survey. The average informant held a long  
282 experience in gardening (42.6 years), but there were large differences within the sample  
283 (SD=24 years). Twelve percent of people in the sample had no schooling and only 7%  
284 had a university degree. Only about 33% of our respondents conformed to what we  
285 named as “migrant”, a category that included people who was not born in the study site,  
286 but rather who had migrated to it from a city, other rural areas, or other countries (Table  
287 1).

288

289 **4.2. Relation between landraces and commercial varieties knowledge**

290 Bivariate analyses suggest that, overall, landraces and commercial varieties  
291 knowledge correlated in a positive and significant way ( $p < 0.001$ ) although the  
292 correlation coefficient was relatively low ( $r = 0.40$ ). Figure 2 provides a visual  
293 representation of the association between landraces and commercial varieties  
294 knowledge.

295 **FIGURE 2**

296 Multivariate regressions of commercial varieties against landrace knowledge  
297 confirm the intuition of bivariate analysis: commercial varieties knowledge bears a

298 positive and statistically significant association with landrace knowledge (Table 2). That  
299 is, when taking the sample as a whole and after we control for socio-economic  
300 characteristics of the informant, the higher the score of commercial varieties of a  
301 person, the higher his/her landrace knowledge.

302 Other traits presenting a positive association with landrace knowledge include  
303 being a woman, being a farmer, and the number of years the person has been gardening.  
304 Characteristics that present a negative and statistically significant association with  
305 landrace knowledge include higher levels of formal education and age, although for the  
306 variable age the magnitude of the coefficient is very small.

307 TABLE 2

308 Since our three study areas present important socio-cultural differences, we  
309 conducted the same analysis by study area (Table 2). The analysis by study areas  
310 confirms the statistically significant association between commercial varieties and  
311 landrace knowledge. In those analyses, all the variables previously commented maintain  
312 their sign in their association with landrace knowledge, although some loss their  
313 statistical significance. Thus, only two of the control variables included in our analyses  
314 maintain a statistically significant association with landrace knowledge across the three  
315 study areas: years of gardening and age.

316

#### 317 4.3. Characterizing knowledge holders

318 The hierarchical cluster analysis based on answers to the questions on landraces  
319 and commercial varieties knowledge divided the sample in four distinct groups. Results  
320 of the Kruskal-Wallis and Chi-square tests analyzing differences between those groups  
321 suggest that there are statistically significant differences both regarding the landraces

322 and commercial varieties knowledge (the grouping criteria in our cluster analysis) and  
323 also regarding the socio-demographic characteristics of group members.

324 The first group (Table 3, group A) is the largest (n=164) and includes informants  
325 with the highest levels of both landraces and commercial varieties knowledge. We name  
326 this group ‘hybrid knowledge’ group. Compared with the other two groups, people in  
327 the hybrid knowledge group is older and holds larger experience gardening. This group  
328 is mostly composed by informants who have been (or still are) farmers and who have  
329 spent most of their lives in the study areas. A last marked characteristic of the hybrid  
330 knowledge group is that, compared to the overall mean (Table 1), it concentrates a  
331 larger share of people with no schooling and a lower share of people with university  
332 degrees, although differences in education between groups are only statistically  
333 significant for people having primary education or university degree.

334 INSERT TABLE 3

335 The second group (Table 3, group B) includes informants (n=90) with relatively  
336 high levels of landrace knowledge (7.2) but relatively low levels of commercial  
337 varieties knowledge (4.7). We call this group ‘traditional knowledge’ group. Compared  
338 with informants in the hybrid knowledge group, fewer informants in the traditional  
339 knowledge group have farming experience, and fewer informants have lived most of  
340 their live in the study areas. It is also interesting to notice that the mean score in  
341 landrace knowledge is lower than in the hybrid group.

342 The third group (Table 3, group C) shows the opposite trends in knowledge:  
343 informants in this group show low landrace knowledge (3.6) and high commercial  
344 varieties knowledge (9.8). We call this group ‘modern knowledge’ group, but notice  
345 that the average score in modern knowledge is lower than for the ‘hybrid knowledge’  
346 group. Compared to the other three groups, the average age of informants in the modern

347 knowledge group is the lowest, as it is their gardening experience. This group also holds  
348 the largest share of migrant population from the four groups.

349 Our last group (Table 3, group D) is the smallest in number (n=40). This group  
350 includes informants with low levels of both landraces (1.9) and commercial varieties  
351 (2.7) knowledge. We call this group 'limited knowledge' group. Compared to the hybrid  
352 knowledge and traditional knowledge groups (but not in relation to the modern  
353 knowledge group), informants in the limited knowledge group had lower experience in  
354 gardening. This group is formed by a disproportionate number of men, in relation with  
355 the overall gender distribution of the sample. By the standards of the sampled  
356 population, people in the limited knowledge group also have higher levels of formal  
357 education.

358

## 359 5. Discussion

360 We organize the discussion around results corresponding to the two specific  
361 goals of this article: to analyze the co-existence of traditional and modern agricultural  
362 knowledge and to analyze the socio-demographic characteristics associated to those two  
363 bodies of knowledge. In the last section, we interpret those findings in the light of  
364 resilience theory.

365

### 366 5.1. The relation between landraces and commercial varieties knowledge

367 Our results show a positive association between traditional and modern  
368 agricultural knowledge, specifically landraces and modern varieties knowledge: overall  
369 and by study area those gardeners who are more knowledgeable about landraces are also  
370 more knowledgeable about commercial crop varieties. Several authors have previously  
371 documented similar trends regarding coexistence of traditional and modern agricultural



372 knowledge and practice. For example, a consistent finding has been presented by  
373 Eyssartier et al. (2011) in a case study in Northwestern Patagonia, where local people  
374 maintained traditional practices on vegetable gardens but also adopted greenhouses, as  
375 those improved the conditions for certain crops. Likewise, though in a different domain  
376 of knowledge, Giovannini et al. (2011) document coexistence and complementarity of  
377 individual knowledge of medicinal plants and individual knowledge of pharmaceuticals  
378 among an indigenous population in Oaxaca, Mexico.

379 Our ethnographic information helps contextualize this finding. Gardeners  
380 mentioned that dietary changes and improvement in market accessibility have affected  
381 the composition of their gardens driving them to acquire new commercial varieties and  
382 develop associated knowledge. Before the 1960s, home gardens were essential for  
383 providing staple food for households. As a consequence high-carbohydrate-content  
384 crops like beans and potatoes were the most prevalent and diverse among home  
385 garden's crops (Aceituno-Mata, 2010). Dietary changes have resulted in a decrease in  
386 the volume of staple crops cultivated in gardens as well as in an increase in the diversity  
387 of cultivated vegetable species, including commercial varieties of species such as  
388 cauliflower, broccoli, spinach or radishes. Nevertheless, gardeners reported that they  
389 continue to grow landraces of their preferred staples, even if in a limited extent, as they  
390 prefer their taste in the preparation of traditional dishes. This combination keeps alive  
391 knowledge associated to both landraces and commercial varieties.

392 Gardeners have also acquired knowledge on commercial varieties for other  
393 reasons such as convenience or to complement the harvest provided by landraces. For  
394 example, in the Catalan Pyrenees some gardeners buy seedlings of tomatoes commercial  
395 varieties at the beginning of the planting season. Gardeners argue that those varieties are  
396 not as tasty as landraces, but that they are convenient. Since gardeners do not have the

397 technical equipment (e.g., greenhouses) to start a seed bank during the winter, they  
398 depend on weather conditions to plant their own landraces. In this context, buying  
399 seedlings from commercial varieties comes handily, as those plants would ensure an  
400 early harvest. The incorporation of tomatoes commercial varieties -which, in addition  
401 are often more productive- allows them to have an earlier harvest, without necessarily  
402 renouncing to the tastier –but later- harvest provided by the tomatoes landraces.  
403 Similarly, gardeners in Sierra Norte de Madrid argue that in the past 50 years annual  
404 rainfall has decreased in this mountain area and that summers have become warmer and  
405 drier. The cucumber landrace cultivated in the area is adapted to cold summers but is  
406 very sensible to drought, becoming bitter under water stress. Consequently, in the last  
407 decades gardeners have started to cultivate a new commercial cucumber variety that  
408 does not become bitter under water stress. However, gardeners continue to cultivate the  
409 cucumber landrace, considered tastier. This adaptation strategy ensures a yield of non-  
410 bitter cucumber and, under good weather conditions, a yield of the tastier variety. The  
411 simultaneous use of landraces and commercial varieties fits well with the positive  
412 association found between knowledge of both agricultural systems.

413         In sum, our first finding suggests that gardeners in the sample neither seem to  
414 totally adhere to past management traditions by cultivating only landraces, nor seem to  
415 have completely abandoned them to fully substitute them with commercial varieties.  
416 Remember that the hybrid knowledge group, representing nearly half of the gardeners  
417 (Group A is 43% of the sample), are at the same time those who know more about  
418 landraces and modern varieties, simultaneously suggesting that both types of knowledge  
419 can complement one to each other. Landraces and commercial varieties knowledge  
420 seem to co-exist in a dynamic body of hybrid agricultural knowledge, representing an  
421 example of continuity and change (Reenberg, et al., 2008). It is possible that these

422 characteristics are associated with gardeners' interests and inquisitive nature. Our field  
423 experience suggests that many gardeners experiment with new varieties or technologies  
424 while maintaining the landraces they like and the traditional technologies they are  
425 familiar with. Put it differently, for those who still maintain the activity of gardening,  
426 traditional knowledge persists but not in a frozen form. Rather, it is constantly evolving  
427 in response to changing environmental and socioeconomic conditions by incorporating  
428 new knowledge and adopting an increasingly hybrid character.

429

### 430 5.2. Trends in knowledge holders' groups

431         Despite these overall positive trends in traditional and modern agricultural  
432 knowledge, there are substantial differences in the bodies of knowledge held by  
433 different informants. Our analysis of groups of knowledge holders shows substantial  
434 complexity in the socio-cultural factors that define groups of knowledge holders, and it  
435 seems to contradict overall both the view expressed in standard research on the  
436 diffusion-of-innovation approach and the essentialist view of traditional systems of  
437 knowledge (see Gilles et al., 2013).

438         The literature on diffusion-of-innovations (a theory that seeks to explain how,  
439 why, and at what rate new ideas and technology spread through cultures) has explicitly  
440 analyzed the characteristics of people who adopt modern agricultural practices  
441 (Wejnert, 2002). This line of research is largely based on the assumptions that i) those  
442 who adopt modern agricultural practices will have a comparative economic advantage  
443 over those who do not adopt them (Saltiel et al., 1994) and that ii) adoption and non-  
444 adoption of modern practices are mutually exclusive, implying that everybody will  
445 eventually adopt the new practices on the risk to be out competed by others.  
446 Furthermore, according to Gilles et al. (2013), the idea that a person can adopt some

447 innovations while maintaining a core body of traditional practices is often downplayed  
448 in the specialized literature. The bulk of this literature also suggests that later adopters  
449 of innovations are older, less educated, have less media exposure, more traditional  
450 values and live in more isolated communities than earlier adopters (see Wejnert, 2002  
451 for a review).

452         While the diffusion-of-innovation approach conceives the disappearance of  
453 traditional agricultural practices as a natural consequence of agricultural modernization,  
454 the essentialist approach to traditional knowledge looks for the potential value of these  
455 practices, often assuming that place-based agricultural practices can be self-sustained  
456 and maintained in isolation from new systems of knowledge. This approach emphasizes  
457 the need to understand who conserves traditional knowledge and practices in the face of  
458 modern alternatives. Findings from this line of research indicate that farmers who  
459 cultivate landraces and maintain crop diversity tend to be older, have smaller farms, and  
460 less connection to markets than other farmers. This line of research has also negatively  
461 associated migration, market integration, and off-farm employment with landraces  
462 maintenance (Brush, 2004; Valdivia, 2004).

463         Findings from hierarchical cluster analysis of data provided by our informants  
464 contradict some of the basic assumptions underlying both of these views. According to  
465 our results of groups of knowledge holders, many informants –those in the hybrid  
466 knowledge group, the largest group in our analysis- hold high levels of both landrace  
467 and commercial varieties knowledge. This indicates that, as mentioned before, many of  
468 the informants have acquired substantial amounts of modern agricultural knowledge  
469 while maintaining the bulk of their traditional agricultural knowledge. Furthermore, the  
470 characteristics of the groups of knowledge holders identified do not seem to fit with the  
471 characteristics typically associated to either knowledge innovators or keepers of

472 traditional knowledge. For example, around 30% of the informants in the hybrid and the  
473 traditional knowledge groups are migrants. Despite not being originative from the study  
474 areas, some migrants use landraces and have learned locally-developed garden  
475 management practices. Thus, the group of preservers of landraces is not restricted to old  
476 farmers who have lived their entire lives in the study areas, but it also includes migrant  
477 gardeners who see a diversity of values in those landraces and associated knowledge  
478 beyond merely economic or utilitarian practicalities.

479 In sum, results from our hierarchical cluster analysis challenge the idea that  
480 traditional and modern agricultural knowledge necessarily concentrate on different  
481 segments of the population.

482

### 483 5.3. Interpretation of research findings in the light of resilience theory

484 We started this work highlighting that the resilience of a social-ecological  
485 system depends to a large extent on the capacity of its corpus of knowledge to learn by  
486 absorbing new information in response to change, and by stressing the need to explore  
487 the capacity of traditional knowledge systems to absorb changes and continue to exist.  
488 There are three main caveats to our results. First, we are well aware that the analysis  
489 presented here only partially addresses the resilience of traditional knowledge systems.  
490 That is, we assess the ability of the traditional knowledge system to absorb changes and  
491 continue to exist, but our data do not allow us to test to what point the traditional  
492 knowledge system maintains its essential structure and function. Further research should  
493 address to what extent these traditional knowledge systems maintain or not their identity  
494 and functionality. Second, we are also aware that our measure provides only a reduced  
495 assessment of traditional knowledge systems. Our conclusion is drawn from the fact that  
496 informants seem to combine information from landraces and commercial varieties. But

497 it might well be that innovations such as the use of new varieties are often quickly  
498 adopted because they can be more easily integrated into existing production systems,  
499 but the case might be different when analyzing practices that require deeper  
500 reorganizations of the production systems. Future research should analyze the co-  
501 existence of other aspects of modern and traditional knowledge systems. Third, our data  
502 pictures the situation on a point of time, from which we infer diachronic patterns.

503 Our findings, however, advance two important arguments about the potential of  
504 traditional knowledge systems to absorb change, and therefore to contribute to the  
505 overall resilience of a social-ecological system. First, according to resilience theory,  
506 integrating information from several knowledge systems would increase the resilience  
507 of the system by enlarging the range of available responses in the face of different  
508 disturbances or limiting factors (Gómez-Baggethun et al., 2012; Houde, 2007; Plummer  
509 and Armitage, 2007). Moreover, the resilience perspective holds that adaptive  
510 management to deal with complexity and uncertainty in social-ecological systems can  
511 benefit from the combination of diverse types of knowledge (Olsson et al., 2004). For  
512 example, co-management arrangements that allow the integration of different  
513 knowledge systems through collaboration between scientists and resource users can help  
514 build social and ecological resilience, as the complexity that arises from integrating  
515 different knowledge systems offers a chance to find innovate answers to old and new  
516 problems (Plummer and Armitage, 2007; Davidson-Hunt et al., in press). Gardener's  
517 explanations about the combination of landraces and commercial varieties and their  
518 associated knowledge in home gardens provide a good example of how the integration  
519 of information from two knowledge systems is perceived as beneficial by resource  
520 managers.

521           Second, it is important to acknowledge that home gardens are quite distinctive  
522 agricultural systems in industrial Europe. Differently from most other agricultural  
523 systems, home gardens retain an important degree of autonomy and self-organizing  
524 capacity. This autonomy is given by the fact that home gardens are mainly devoted to  
525 household consumption and are often grown in leisure time, which make gardener less  
526 dependent on market dynamics and exogenous knowledge and technologies for  
527 decisions regarding home gardening. Gardeners' knowledge and management  
528 techniques should then be understood in a context in which maximizing productivity  
529 and profit is generally not the ultimate aim, which in turn implies that there are no  
530 economic penalties for failures in experimentation. Previous research claims that  
531 securing traditional knowledge's capacity to regenerate over time requires maintaining  
532 the autonomy and conditions that allow continuing developing, testing, and updating  
533 knowledge in the face of changing environmental and socioeconomic conditions  
534 (Gómez-Baggethun and Reyes-García, 2013).

535

## 536 **6. Conclusion**

537           Much has been written on how traditional knowledge systems may nurture  
538 resilience in ecological or social-ecological systems but far less is known on the  
539 resilience of traditional knowledge systems themselves. Our research on gardeners  
540 suggests that traditional knowledge systems can be dynamic and capable of  
541 incorporating new knowledge while at the same time maintaining the bulk of the  
542 accumulated body of knowledge in a process of continuity and change. Our results  
543 suggest that a) traditional knowledge is not a frozen and static corpus of knowledge and  
544 b) modern and traditional agricultural knowledge are not necessarily mutually  
545 exclusive. Both, the maintenance of some aspects of the traditional knowledge and the

546 incorporation of some aspect of the modern knowledge seem to be core elements of  
547 gardeners' body of agricultural knowledge which is constantly evolving in response to  
548 changing environmental and socioeconomic conditions. Changes in traditional  
549 knowledge can be seen as a part of the general self-organizing process of this  
550 knowledge system.

551         The finding that traditional knowledge systems are dynamic and hybridize with  
552 other knowledge systems and technologies to face changing circumstances dovetails  
553 well with previous research (Agrawal, 1995; Berkes et al., 2000; Dove et al., 2007;  
554 Leonti, 2011; Gómez-Baggethun and Reyes-García, 2013; Leonti and Casu, 2013), but  
555 poses the question of whether the body of knowledge emerging from this dynamic  
556 process can indeed continue to be considered 'traditional'. We argue that this  
557 denomination is still valid in our case study, as our data show persistence of landraces  
558 knowledge and overlap between landraces and commercial varieties expertise. Our  
559 finding, however, should not conceal that under different circumstances hybridization  
560 may indeed led to the loss of traditional knowledge, if this is gradually replaced by  
561 modern knowledge (Gómez-Baggethun et al., in press). Further case studies on the  
562 interactions of traditional knowledge systems with other forms of knowledge, ideally  
563 using a diachronic perspective, could enrich the discussion on the resilience of  
564 traditional knowledge systems.

565



566 **Figure captions**

567 **Figure 1.** Location of the study areas

568 **Figure 2.** Traditional versus modern agricultural knowledge (n=380)

569

570 **Table 1**

571 Definition and summary statistics of variables used in regressions (n=383)

Variable	Definition	n	Mean	SD
Landraces knowledge	Responses to 6 questions on 3 landraces (3*6=18)	383	7.72	4.45
Commercial varieties knowledge	Responses to 6 questions on 3 commercial varieties (3*6=18)	383	7.83	3.85
Age	Age of the person, in years	383	66.1	13.79
Male	Dummy variable that captures the sex of the person interviewed, 1=male, 0=female	383	0.68	0.46
Farmer	Dummy variable that captures whether the person's main occupation is or has been farming.	383	0.51	0.50
Migrant	Dummy variable that captures whether the person comes from another region (=1) or whether she was born and has been resident of the study village for large periods (=0).	383	0.33	0.47
Years gardening	Number of years the person has been gardening	383	42.6	24.92
		N	%	
Schooling	No schooling	45	12.40	
	Primary school	176	48.48	
	Between primary school and university degree	117	32.23	
	University degree	25	6.89	

572

573 **Table 2**

574 Relation between traditional and modern agricultural knowledge (n=383).

	<i>Total</i>	<i>Asturias</i>	<i>Catalan Pyrenees</i>	<i>Sierra Norte de Madrid</i>
Commercial varieties knowledge	0.037 (0.007)***	0.021 (0.011)**	0.077 (0.016)***	0.023 (0.012)**
Age	-0.006 (0.002)**	-0.019 (0.009)**	-0.006 (0.003)*	-0.005 (0.003)*
Male	-0.137 (0.038)***	-0.011 (0.062)	-0.142 (0.070)**	-0.125 (0.025)***
Farmer	0.130 (0.064)**	0.183 (0.046)***	0.200 (0.080)**	0.021 (0.117)
Years gardening	0.008 (0.002)***	0.019 (0.005)***	0.007 (0.002)***	0.008 (0.004)**
Migrant	-0.085 (0.053)	0.034 (0.028)	-0.072 (0.098)	-0.136 (0.050)***
Schooling (reference category no education)				
Primary school	-0.068 (0.061)	0.153 (0.128)	0.029 (0.118)	-0.121 (0.089)
Between primary and university	-0.227 (0.083)***	0.087 (0.192)	-0.123 (0.139)	-0.275 (0.170)
University	-0.377 (0.178)**	0.000 (0.000)	-0.047 (0.180)	-0.824 (0.588)
n	383	58	196	129

575 Note: For definition of variables see Table 1. Cells report regression coefficients with robust standard errors in  
576 parenthesis. \* p<0.10; \*\* p<0.05, \*\*\* p<0.01. Regressions contain a set of dummy variables for the village of  
577 data collection and a constant (not shown).

578 **Table 3**

579

580 Characterization of respondents resulting from the hierarchical cluster analysis.

581

Variables	$\chi^2$	<i>p</i> -value	Group	Group	Group	Group	
			A	B	C	D	
			Hybrid knowledge	Traditional knowledge	Modern knowledge	Limited knowledge	
Landrace knowledge (average)	299.9	0.0001	11.7	7.2	3.6	1.9	
Commercial varieties knowledge (average)	243.3	0.0001	10.2	4.7	9.8	2.7	
Age (average)	12.4	0.006	66.2	65.6	58.8	64.6	
Years gardening (average)	57.9	0.0001	50.7	45.5	25.2	36.4	
Male (%)	13.6	0.004	63.4	62.2	68.7	89.7	
Farmer (%)	31.9	0.0001	67.1	44.4	35.0	34.7	
Migrant (%)	10.0	0.02	27.4	31.1	47.5	34.7	
Schooling (%)	No schooling	5.2	0.16	14.8	7.7	10.2	6.3
	Primary school	10.0	0.02	48.7	62.2	38.8	41.8
	Between primary and university	2.0	0.57	30.8	24.4	34.7	31.6
	University	16.9	0.001	5.6	5.5	16.3	20.2
	n			164	90	80	49

582

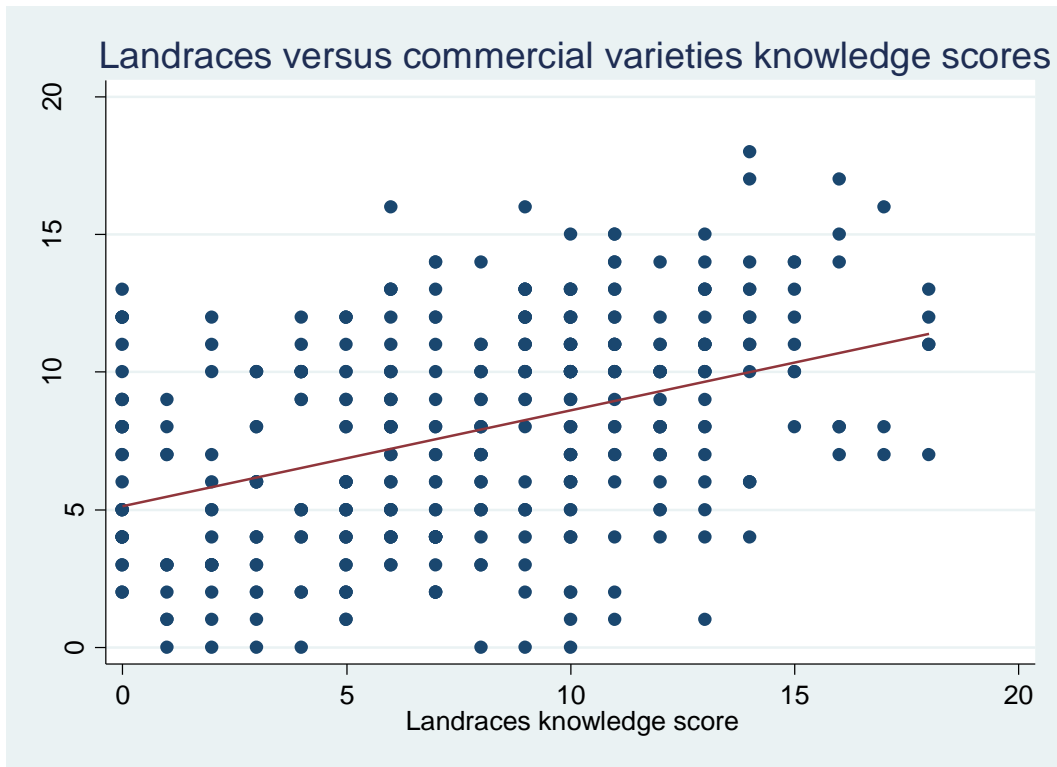
583

584 **Figure 1**



585

586 **Figure 2**



587

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