

# Chapter 3

## Chestnut Production-Related Businesses in the Courel Mountains of Galicia, NW Spain: An Opportunity for Biodiversity Conservation, Ecosystem Restoration, and Rural Development



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**Abstract** Chestnut orchards (*soutos* in the Galician language) constitute the main feature of socio-ecological production landscapes (SEPLs) characteristic to the Northwest Iberian Peninsula. These landscapes display high levels of biodiversity that are shown in the genetic, interspecific, and ecosystem domains. They also produce a variety of ecosystem services, including cultural, regulating, and provisioning ones. Nevertheless, the interrelation between ecological functions, ecosystem services, and businesses in the present day is threatened by the abandonment of traditional management, giving way to a range of transformations that affect both the mountain landscapes and their socio-economic fabric.

The objective of this study is to explore the relationships between socio-economic activities and the capacity of chestnut SEPL to preserve high biodiversity levels in the municipality of Folgoso do Courel (Galicia, NW Spain), an area with a strong tradition in chestnut production systems. To do so, we first analyse the economic structure of the area using official statistics and identifying specific businesses related to the local SEPL. We also use a geographical information system to analyse land cover maps to locate and characterize chestnut production areas. We complete our analysis by interviewing business owners to elicit important elements in the

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business-SEPL relationship. Our results show the strong dependence of chestnut-related businesses on the local SEPL, and how the multifunctional aspects of chestnut production are important assets in the businesses' visions. Also, we identify risks and impacts affecting the socio-ecological production landscape. We conclude that supporting SEPL-related businesses could benefit biodiversity conservation and sustainability in the territorial system.

**Keywords** Traditional chestnut orchard management · Multifunctional agroecosystem management · Mountain areas · Ecosystem services · Conservation of traditional knowledge · Socio-ecological production landscapes

## 1 Introduction

### 1.1 *Agroecosystems, Related Business, and Sustainable Development*

The current global effort to achieve sustainability demands the participation of all sections of society in a variety of initiatives aimed at the integration of biodiversity conservation, climate change mitigation, and adaptation, and the flow of ecosystem services favouring inclusive development. These global imperatives demand both transversal and vertical integration for management of ecosystems and the products and services obtained from them. The Kunming-Montreal Global Biodiversity Framework (GBF) adopted at the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD) in Montreal, Canada, in December 2022 includes maintenance and enhancement of the resilience, integrity, and connectivity of natural and sustainably managed ecosystems among its goals and targets. In rural areas, agroecosystems, forests, and agroforestry systems are essential providers of a variety of nature's contributions to people, securing livelihoods apart from conserving biodiversity and cultural heritage, mitigating climate change, and rendering socio-ecological resilience (Garbach et al. 2014; Barral et al. 2015).

Traditional sweet chestnut (*Castanea sativa* Mill.) orchards, called *soutos*, are a unique distinguishing feature of socio-ecological production landscapes (SEPLs) in Galicia and other neighbouring regions of the NW Iberian Peninsula. Their historical development in the Courel Mountains can be traced back centuries (Pereira-Lorenzo et al. 2019; Fernández-López et al. 2021). At present, their management is based on a combination of traditional and modern practices. They display high levels of biodiversity that are shown in the genetic (their long cultural history induced profuse intraspecific variety), interspecific (being a suitable habitat for many species, including umbrella species like brown bear), and ecosystem (together with other ecosystems, they contribute to the ecological integrity of landscapes) domains. Such biodiversity constitutes the functional basis for producing ecosystem services, including cultural, regulating, and provisioning services. The latter are relevant to

businesses at both the regional and local level: the production of chestnut fruits (up to 3000 kg per hectare annually), mushrooms (up to 200 kg per hectare annually), honey, timber, and livestock, as well as landscape-related tourism. These businesses are highly important, both directly and indirectly, to the integrity of the SEPLs.

Galicia accounts for 66% of Spain's chestnut production area and 90% of production (MAPA 2021). Galicia produced 81,084 tonnes of chestnut with a market value of 20 million EUR in 2020 (Consellería de Medio Rural 2022b). However, only 5.2% of the chestnut area in Galicia is under a regional-level sectoral protection and quality certification institution called Protected Geographical Indication (PGI), which brands the product as *Castaña de Galicia* and is the only quality label for chestnuts in Spain (Consellería de Medio Rural 2021). Certified production was 24.9 tonnes in 2020, 67.7% fresh and 32.3% frozen, and 28.6 tonnes in 2021. This represents a significant decrease in production compared to 2016, when production under PGI amounted to 240 tonnes. Reasons behind this decrease are the economic effects of the COVID-19 pandemic, together with the impact of certain pests and diseases, such as the invasive *Dryocosmus kuriphilus* wasp and the *Gnomoniopsis castanea* fungi (Lombardero et al. 2022; Consellería de Medio Rural 2022a; Aguin et al. 2023). The estimated value of this certified production for 2021 amounted to 233,000 EUR. Regarding the organization of the economic sector, PGI currently accounts for 169 producers, 10 sellers, and 6 processing industries. Most products are locally consumed. Only 3% of total product was exported in 2021, and 51% of shelled chestnuts were utilized in the food industry. Despite its significant production, Galicia imported 1306.7 tonnes of chestnut in 2021 with a value of 2.6 million EUR. Imports have been increasing since 2016 while exports are decreasing, following the trend of production (MAPA 2022).

Researchers have paid attention to *soutos* largely in terms of their production function, ignoring the complexity of eco-agri-food systems (Zhang et al. 2018). Despite the *souto*'s importance in the various dimensions of sustainability, comprehensive knowledge on their multifunctionality and direct and indirect interactions with other ecosystems in SEPLs is lacking. These interactions manifest as (a) the *risks* from ecological degradation to economic activity (e.g. decline in production from forest fires and loss of regulating services keeping pests/pathogens in check and favouring pollinators and beneficial soil organisms); (b) the ecological *impacts* of economic activities (e.g. air, soil, and/or water pollution, overexploitation of natural resources, unsustainable tourism), with obvious effects not only on ecosystem functioning and ecological integrity, but also on business and governance; and (c) new business *opportunities* including those related to ecosystem restoration, enhanced efficiency in the use of natural resources and ecosystem services, or benefits associated with the acknowledgement of good environmental practices or production of ecosystem goods and services through payment schemes (WBCSD 2011; Hanson et al. 2013).

Nevertheless, the interrelation between ecological functions, ecosystem services, and business is nowadays threatened by the abandonment of traditional management, which has given way to a range of transformations affecting both the mountain landscapes and their socio-economic fabric. These include intensive afforestation

practices, industrial slate quarrying, and wind farming. They have induced irreversible changes not only in land use, but also in the general productive arrangement of the territory from a regenerative to an extractive one, with clear consequences for the sustainability of the whole system. The abandonment of traditional management might also lead to a shift towards a different habitat structure and composition due to natural ecological succession or even, in the case of intensified production systems, to a simplification of the habitat hosting lower biodiversity values.

## 1.2 Objectives

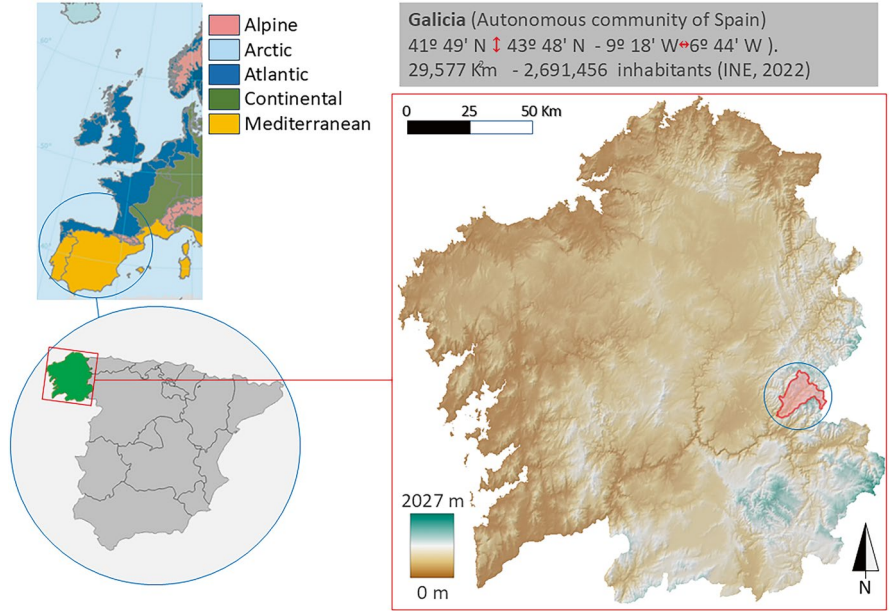
The objective of the present research was to explore the relationships between socio-economic activities and the capacity of a chestnut-dominated SEPL to conserve biodiversity in the Municipality of Folgoso do Courel (Galicia, NW Spain). This study is a component of a wider research programme on socio-ecological characterization of *soutos*-related rural systems in the NW Iberian Peninsula and complements the “CASTEXEN: Location and differentiation of chestnut (*Castanea sativa* Mill.) grafted with traditional cultivars using spatial-temporal analysis of aerial photographs and SSR genotyping” research project, financed by the Campus Terra of the University of Santiago de Compostela (Spain). As such, it is exploratory work aiming for a better understanding of the socio-economic subsystem of the chestnut SEPL.

## 2 Material and Methods

### 2.1 Study Area

Folgoso do Courel is a rural municipality located in the Courel Mountains (Galicia, Spain; see Fig. 3.1 for location, and Fig. 3.2 for basic geographical features). It is characterized by diverse geological substrata shaped in convoluted geomorphology features, recently acknowledged through the designation of the Courel Mountains UNESCO Global Geopark. The area experiences a mix of temperate and Mediterranean climate attributes and is highly rich in biodiversity at the genetic, species, and ecosystem levels. The endangered brown bear (*Ursus arctos*) is an umbrella species. Almost the entire municipality is protected under the European Union “Natura 2000” network, with the exception of a slate quarry area in the south. The population is ageing and decreasing in numbers. Economic activities in the primary sector include livestock and forestry production, which depend largely on local ecosystems (Table 3.1).

The traditional SEPL is a mosaic of traditional agricultural patches, shrublands, and chestnut orchards. Fire risks have increased as a result of abandonment of traditional practices (e.g. tree pruning, forest clearing, and understorey livestock



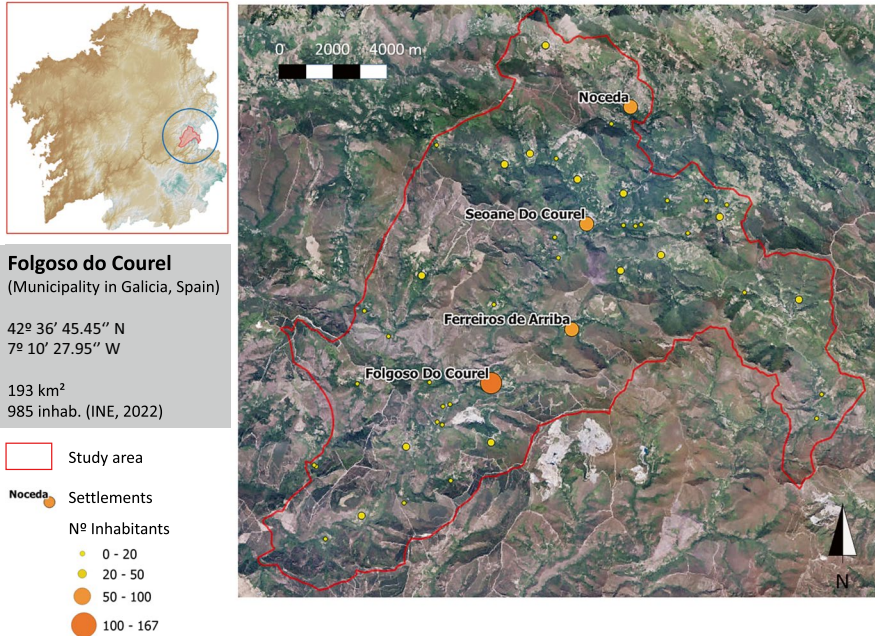
**Fig. 3.1** Study area in Galicia, Spain. (Source: Prepared by authors; Digital terrain model and other GIS data from Centro Nacional de Información Geográfica (2019); Biogeographical map from European Environment Agency (2017); Demographic data from INE (2022))

grazing) and introduction of altogether new ones like intensive afforestation. Pressures from industrial activities include the expansion of slate quarries and planning of future wind farms.

## 2.2 Methodological Approach

A series of steps were taken to explore the connections in Folgoso do Courel between socio-economic activities and the capacity of the chestnut SEPL to conserve biodiversity and provide ecosystem services.

1. First, we analyzed the economic activities in the area and businesses associated with *soutos*. General features were assessed through official statistics available from the Galician Institute for Statistics (IGE 2023) and the Ministry for Rural Environment (Consellería de Medio Rural 2022b). Specific business orientations were identified through interviews with members of the Regulation Council of the Protected Geographical Indication “Galician Chestnut” (Indicación Xeográfica Protexida Castaña de Galicia; Consellería de Medio Rural 2021). The Protected Geographical Indication (PGI) scheme based on European legislation (Regulation (EU) No 1151/2012 and Commission Regulation (EU) No 409/2010) secures fair returns for the producers and, at the same time, ensures



**Fig. 3.2** Study area: local level. (Source: Prepared by authors; Aerial imagery from Centro Nacional de Información Geográfica (2019); Demographic data from INE (2022))

**Table 3.1** Basic information of the study area

Country	Spain
Province	Lugo
District	O Courel
Municipality	Folgoso do Courel
Size of geographical area—Galicia—(hectare)	2,957,700
Dominant ethnicity(ies), if appropriate	Caucasic
Size of case study/project area (hectare)	19,300
Dominant ethnicity in the project area	Caucasic
Number of direct beneficiaries (people)	985
Number of indirect beneficiaries (people)	2,691,456
Geographic coordinates (latitude, longitude)	42°36'45.45" N 7°10'27.95" W

Source: Prepared by authors, Data from INE (2022)

the intellectual property rights of the territory and of all necessary information about value-addition/end-products for consumers.

2. Then, we used a Geographical Information System (GIS) to precisely locate chestnut production areas and analyze land uses. Also, spatial data of recent forest wildfires was overlaid to quantify the impacts of fires (MITECO 2011; Consellería de Medio Rural 2022a).

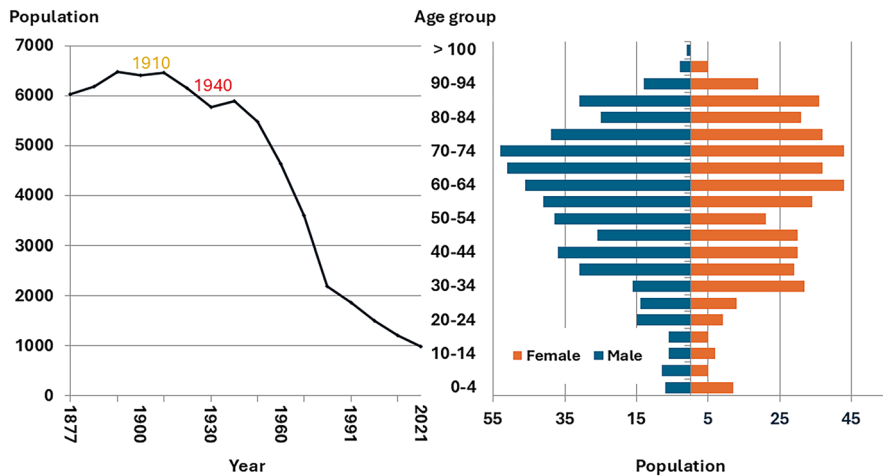
3. Finally, we completed our analysis by interviewing business owners to elicit business-SEPL relationships, problems, and opportunities for *souto*-dependent businesses in the area. In an exploratory approach, we selected local businesses that satisfied the characteristics of (a) being in some way dependent on the local production of chestnut and (b) developing local chestnut-related products. Two businesses that met these characteristics were interviewed. The approach for the interviews was qualitative and employed semi-structured open discussions covering:

- Orientation of production/marketable products
- Relationships with producers/suppliers of raw material (i.e. chestnuts harvested in the *soutos*)
- Customer characteristics and spatial scope and targeting of the products
- Other factors aside from chestnut fruit production and/or use
- Associations and networks, including economic, social, and cultural
- Biodiversity and landscape, and perceived relation with their businesses

### 3 Results

#### 3.1 General Socio-Economic Features

Fologoso do Courel is a municipality with a clear decreasing trend in its population. Figure 3.3 shows the demographic trend from the year 1877. The decline can be traced back to the 1910s, but a clear change in the slope can be identified from 1940.



**Fig. 3.3** Left, population trend in Fologoso do Courel, in total number of inhabitants since 1877, with vertical axis showing population and horizontal axis showing years; Right, population pyramid with values from 1 January 2022, with vertical axis showing age groups and horizontal axis showing number of inhabitants. (Source: Prepared by authors; Data from INE (2022))

The current situation, with 985 inhabitants, shows a population growth rate of  $-22$  (INE 2022), so generational replacement is not warranted.

This demographic situation is also reflected in the occupational structure: 43.2% of the population is retired, 12.6% unemployed, and 7% in other labour situations (e.g. working in non-economic activities or unable to work), and 37% is employed. Around 26% of employed people is engaged in agriculture, 15% in industry, and 53% in the service sector. While statistics show an important shift towards the service sector of the economy, we have to take into account that many retired people are still working in agriculture as a means of supplementing their income.

### **3.2 General Biophysical and Bioeconomic Features**

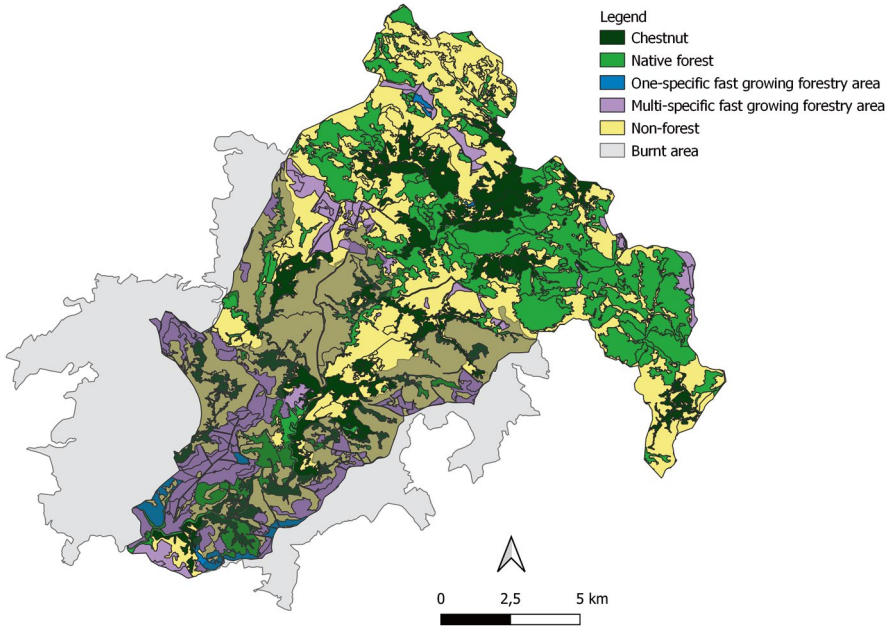
Chestnut forests, including *soutos* in different stages of management (i.e. abandoned, in different stages of abandonment, or fully functional and productive; see Rocés-Díaz et al. 2018), and new plantations span 2756 hectares in Folgoso do Courel (MITECO 2011), implying approximately 14.3% of the municipality area. Other important land cover types are native forests made up of one dominant species (12.1%) or mixed species (12.2%), multi-species fast-growing forest (1.1%), and single-species fast-growing forest (11.8%). Non-forestry areas, usually agricultural land and shrubland, span 48.42% of the total surface.

Analysis of land surface affected by forest fires in 2022 (See “Burnt area” overlaid with other land cover classes in Fig. 3.4) showed that most of the burnt forested areas correspond to exotic single-species (67%) or multi-species (84%) fast-growing forest stands, while native forests showed relatively low impacts in one dominant species stands (9%) or multi-species mixed (13.2%), with chestnut forests affected at a rate of 25.5% (Percentages are the proportion of the total of each land cover type prior to the wildfire.)

### **3.3 Specific Examples of Local Businesses and Business Structure**

#### **3.3.1 Protected Geographical Indication**

The interviews with members of the Regulation Council of the Protected Geographical Indication “Galician Chestnut” (see Sect. 2.2) allowed for identification of the main typologies of actors and their relationships. This information was a valuable contribution to the development of a basic representation of the chestnut SEPL focused on the socio-economic subsystem (see details in discussion and Fig. 3.6).



**Fig. 3.4** Chestnut forest distribution in the study area (in dark green). Grey shadow shows the area affected by forest fires in 2022. (Source: Prepared by authors; Land cover data from MITECO (2011); Wildfire data from Consellería de Medio Rural (2022a))

### 3.3.2 Study Case 1: Diversified Food Processing Business

The first interviewee is native from Courel who started a trading business. Together with his wife in 2008, he founded a business based on the elaboration of different food products in the nearby municipality of Quiroga. Product diversification became necessary due to constraints related to the COVID-19 crisis that make it difficult to make a living just from chestnut production. The business uses chestnut fruit as raw material for an estimated 40% of their products, producing jams, syrups, compotes, or just preserved fruits. Habitual customers are consumers reached directly or through markets at local fairs or, especially when customers are already familiar with products, through the Internet. Initially, the family planned to sell raw chestnut fruits but later started making valued-added products when they realized that the margin of profit increases by 400% with value addition. The interviewee identified the low prices of chestnuts paid by intermediaries to producers and the ageing population as the most important factors driving abandonment of chestnut-based activity in the area.

Nevertheless, the interviewee emphasized the importance of plant and fruit variety. From the economic point of view, price levels and their evolution are also dependent on quality, which is directly related to the fruit varieties and their

**Fig. 3.5** Products made from chestnuts (cookies and jams) and honey from *soutos* in Courel. (Photo by authors)



diversity. He named important varieties like *branca*, *verdea*, *pareda*, and *presa*. The reasons for this importance include differences in seasonality and the possibility of a continuous supply if an adequate varietal diversity is found in the *soutos*, as well as suitability to different uses depending on the characteristics of the varieties.

The business's link with the territory was prominent, as not only do they have their own *soutos* as well as individual trees for chestnut production, but also use mushrooms, blackberries, and blueberries growing wild in the *soutos* for preparations. In the past, they also produced honey (Fig. 3.5). The interviewee spoke with strong conviction about the relationship between the quality of their products and the place of origin:

The chestnut fruits (...) of the Courel area are the best in the world (...) Starting from this, evidently you must value what you have: chestnuts from very nice varieties, a spectacular place, an incredible tradition and culture around the chestnut. Then, you must sell that.

For this business, the connection to the *souto* is multi-level and acknowledges cultural elements as important, especially the landscape and traditional knowledge. Regarding the latter, the interviewee recognized that much traditional knowledge on management (e.g. planting, pruning or selecting trees, and caring for the whole *souto*) has already been lost. As he stated:

(...) the *souto* is lost when the elder people are gone.

This aspect of multifunctionality was also underscored in comments on the impacts of recent wildfires, that in addition to highlighting the protective function of *soutos* (as they are less flammable than fast-growing species), warned about the proliferation of fast-growing species around settlements:

In the Courel (...) area, all villages are surrounded by *soutos* (...) the recent wildfires confirmed that villages are surrounded by chestnut trees for a reason – not only because they produce fruit – if a wildfire occurs, chestnut trees don't burn (...) if you surround a village with fuel, in the end it will burnout.

During the last few years (especially in the last decade), chestnuts have suffered impacts from plagues (e.g. the chestnut gall wasp, *Dryocosmus kuriphyllus*), diseases (e.g. those caused by fungi *Phytophthora cinnamomi* and *Cryphonectria parasitica*), and droughts in summer that together caused a major decrease in production. As these impacts, together with the ageing population, are generalized in the area, it was difficult for the business to find local product sellers that could compensate for the decreased production in their own *soutos*. Consequently, they had to adapt their level of production to the lack of chestnut fruit.

### 3.3.3 Study Case 2: Chestnut-Specialized Food-Processing Business

The second example is a business in Folgoso do Courel, founded by two women. They started making chestnut products when they observed a demand for chestnut-related products at local cultural events but a lack of supply. They started producing chestnut cakes, but soon extended their production to chestnut cookies and preserved fruits. The products were bought by individuals as well as restaurants. They noted the importance of coordinating with other producers through informal networks (e.g. sharing resources in packaging and attending markets). They have received some special requests. In particular, last Christmas they produced 5000 biscuit bags for a big company from Madrid that were integrated in gift boxes planned for local products from areas impacted by wildfires.

Nowadays, they feel rather pessimistic about the continuity of the business as a result of ageing and the increasing frequency of summer droughts, pests, and diseases. Government agencies do assess damages and propose solutions, but the formalities required to take advantage of these are too complicated. These problems led them to drastically reduce/abandon their *soutos* and buy around 1000 kg of dried chestnut fruits/chestnut flour from nearby *soutos* to meet their needs.

In any case, they highlighted their dependence on chestnuts from *soutos*, as opposed to industrially produced ones:

We don't buy industrially-produced chestnut fruits, ours are all produced (...) in *soutos* [and we see it as interesting that] we keep doing like that. Could you imagine bringing in industrialized chestnuts?

As in the former case, the values linked to the *soutos* are perceived as multiple. While economic activity is apparently driven mostly by instrumental values—those

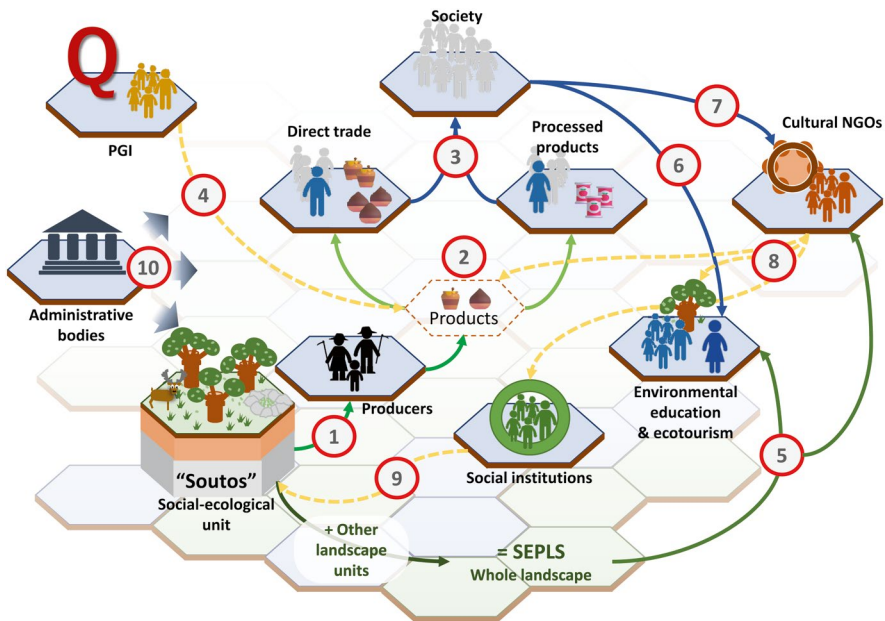
related to the obtainment of direct benefits from the chestnut forest ecosystem—it is apparent that relational values—those reflecting a symbolic dimension and a sense of identity in the relationships with nature—were also behind the motivation to develop their business. In addition to the interest in preserving the diversity of chestnut varieties and the use of chestnuts produced in *soutos*, there is also a clear interest in the preservation of related cultural traditions and landscapes. This was especially evident when asked about the importance of *soutos* in the local landscape:

[*Soutos* integration in the landscape is] vital. Because it is culture, it is tradition, and it is landscape. Imagine taking out the *soutos* [from the landscape]. And here many are decaying. But here all the villages have their *soutos*.

Also, they considered their activities' contribution to biodiversity and landscape conservation through the culture of *soutos* to be very important.

### 4 Discussion

Integration of the information gathered from interviews and field observations led us to a graphic outline of the socio-economic subsystem of the chestnut SEPL (Fig. 3.6).



**Fig. 3.6** Synthetic scheme for the integration of business activities in the SEPL, each line-patterned hexagon symbolizing an interacting element in the socio-economic sub-system. See text for details. (Source: Prepared by authors)

The starting point in the figure are the *soutos* as the socio-ecological units in the SEPL system. Their management allows producers to obtain products like chestnut and honey (1), and also to benefit from other provisioning (e.g. wood), regulating (e.g. protection against fire), and cultural (e.g. traditional knowledge) ecosystem services. These products are integrated in the market through direct trade, or as raw material for value-added products (2). Different profiles of final customers access the outcoming products by buying them at the local, regional, and even national level (3). The intervention of the Protected Geographical Indication (PGI) organization enhances the value of products and credibility of producers as well, and supports coordination between producers, processors, and other actors in the chestnut sector (4). On the other hand, *soutos* are an indivisible part of the aesthetic and cultural values of the whole landscape that are reflected in both local environmental education/eco-tourism businesses and cultural NGOs that preserve traditional knowledge (5) and promote activities with a diverse demand from society (6, 7). Specifically, activities by cultural NGOs sustain important linkages with environmental education, promotion of local products, and visibility of social institutions (8), that in turn provide essential support for the *soutos* (9). Finally, administrative bodies (10) have the responsibility to directly support all stakeholders and the functions and integrity of the SEPL.

Nevertheless, relationships between economic activity and ecosystems in the study area cannot be simplified into linear or direct relationships. This should be expected, as socio-ecological systems are by definition complex adaptive systems (Levin et al. 2013; Preiser et al. 2018) often exhibiting surprising or unexpected effects. As mentioned, interrelationships between economic activities and biodiversity may be represented by *risks*, *impacts*, and *opportunities*.

For instance, *soutos*-related businesses suffer from *risks*, both of a biophysical (e.g. pests, diseases, and wildfires) and economic (e.g. uncertainties in prices and availability of suppliers) nature. Wildfires heavily affected the area in 2022 (see Sect. 3.2 and Fig. 3.7) with immediate, destructive effects. While wildfires are not a

**Fig. 3.7** Post-fire image of a *souto* in the Vilar settlement, affected by the 2022 wildfires. (Photo credit: Orlando Gregorio Álvarez-Álvarez, neighbour; reproduced with permission)



new phenomenon, their underlying causes and spatial patterns vary in space and time (Bowman et al. 2011). Due to climate change (Lindner et al. 2010; Sousa-Silva et al. 2018) and the increasing connectivity and extension of vegetation with high fuel load capacity (Castellnou and Miralles 2009; Moreira et al. 2020), wildfires are becoming progressively more relevant today. There has been an increase in the occurrence, extent, and severity of forest fires. At a finer scale, vulnerability may depend on landscape pattern (Calviño-Cancela et al. 2017), with mosaic areas being less vulnerable than extensive areas of fast-growing afforested species or some types of shrubland. The results of our land cover analysis provide support for this difference in vulnerability (see Fig. 3.4 and related text). Thus, landscapes including well-managed chestnut *soutos* offer the *opportunity* for *fire-smart* management (Pais et al. 2020).

On the other hand, the *risks* of pests and diseases often cause fragmentation of chestnut orchards apart from decline in economic yields. Specifically, for the recently arrived exotic pest *Dryocosmus kuriphyllus*, access to programmes by the regional administration aimed at biological control using the exotic parasitoid *Torymus sinensis* (Nieves-Aldrey et al. 2019) can be hindered by administrative barriers and lack of communication, as reported by the local population. Additionally, the use of an exotic species for biological control should be monitored to avoid impacts on local biodiversity (Gil-Tapetado et al. 2023). At longer temporal scales, the capacity of the SEPL for the conservation of a high genetic diversity in chestnut trees could be a crucial opportunity, noting the observed differences in susceptibility to *Dryocosmus kuriphilus* by chestnut tree genotypes (Lombardero et al. 2022; Castedo-Dorado et al. 2023). As mentioned, such genetic diversity also has economic importance for the diversification of fruit-related products.

However, as interviewees stated, economic benefits from chestnuts have dramatically declined because of the combined/synergistic effects of climate change, demographic change, pest/pathogen infestation, and habitat homogenization from deagrarianization over the last few decades (López-Iglesias 2006; López-Iglesias et al. 2013). Courel is one of the areas in Europe suffering the greatest *impacts* from loss of utilized agricultural area (UAA) (Murua et al. 2013). These factors combined put at *risk* the continuity of the local supply of chestnut fruit. Abandonment of traditional activities can be, from the socio-economic point of view, associated with the demographic decline, a continuous process since the beginning of the last century that accelerated from the 1940 and 1950s. Causes for these demographic dynamics are multiple, and some of them correlate with the socio-ecological transitions associated with social, institutional, and technological changes (Guzmán-Casado et al. 2018; González de Molina et al. 2019). Nevertheless, two demographic components should be noted: (i) decline in numbers is, in itself, due mainly to successive waves of migration of younger people from rural areas to cities (Dubert et al. 2019), in a great extent associated with the deagrarianization process (Pérez-Fra et al. 2006), and (ii) the ageing population is consequence of both the absence of the migrated young population and increased lifespan. This begs policy interventions to maintain *soutos* and the *soutos*-based economy to create new social and

economic *opportunities*. The ageing population, in fact, allows for conservation of traditional knowledge but not its practice, more so for labour intensive practices, in youth outmigration scenarios; also, it challenges the capacity of rural areas to provide social services. In any case, deagrarianization and associated abandonment can have important direct and indirect *impacts* on *soutos*-related businesses through interactions with other ecosystems and economic activities in the landscape. As previously mentioned, one possible outcome is the progressive substitution of *soutos* with fast-growing forest plantations or natural vegetation arising from ecological succession. The aforementioned changes are likely to increase wildfire vulnerability and thus may negatively *impact* ecological (Deus et al. 2018) as well as social systems (Martínez-Cabrera et al. 2020). Nonetheless, natural succession in abandoned orchards (see e.g. Díaz-Varela et al. 2011; Rocés-Díaz et al. 2018) could be an *opportunity* for enhancement of biodiversity including umbrella species such as the brown bear (*Ursus arctos*) (Pérez-Girón et al. 2022).

Lastly, it is important to note that sustainable economic sectors and activities, such as the ones that are the focus of this study, have a strong potential to contribute to a knowledge transmission process based on the co-production of knowledge involving different sectors of society (Ruckelshaus et al. 2015; Posner et al. 2016). The activities themselves could help to reveal the importance of biodiversity and ecosystem services for society, facilitate the development of a common language, and generate actions aimed at the production of specific results in the preservation and maintenance of ecosystems.

## 5 Conclusions

The persistence of economic activities related to *soutos* presents multifaceted opportunities for the communities and ecosystems of the Courel mountains. Businesses created around the processing of chestnut fruits and other products such as honey, berries, or mushrooms are closely linked to the continuity of the *soutos*, not only in their productive aspect but also as part of the natural capital and cultural heritage of the area. Consequently, economic activities related to the management of *soutos* and their related socio-ecological production landscapes play an important role in nature's contributions to people, including important flows of provisioning, regulating, and cultural ecosystem services. Their supply is dependent on ecological integrity and ecosystem functioning, which is also reflected in the concurrence of relational and intrinsic values in the perspectives and views of local actors. On the other hand, the maintenance of these forms of interaction between society and nature has a strong potential to preserve biodiversity at the genetic, species, and ecosystem levels, with direct and indirect linkages to more intrinsic values of landscape and nature. This constitutes the basis for the extension of the described multifunctional character to other economic activities dependent on the mountain landscapes where the *soutos* are an essential element. These include environmental

education, agri-tourism, and eco-tourism, for which institutional initiatives related to rural development could provide essential support. Also, institutional level responses, such as the recently approved Strategic Program for Chestnut at the regional level and the existing classification of *soutos* as “*Castanea sativa* woods,” an Annex I habitat type (code 9260) in the European Union’s Habitat Directive, could be potentially useful to strengthen the *soutos*, provided they are appropriately implemented.

Nevertheless, the future of *soutos* as a multifunctional element with high capacity for biodiversity conservation may be hindered by risks and impacts of a bio-physical and socio-economic nature, showing a complex interlinkage between causes and effects and elements and connections in the socio-ecological system. The involvement of different actors, institutions, and administration directly or indirectly related to the SEPL will be necessary for the co-production of knowledge and the development of pluralistic, holistic views for integrated ways of management and restoration of the socio-ecological chestnut production landscapes.

## References

- Aguín O, Rial C, Piñón P, Sainz MJ, Mansilla JP, Salinero, C (2023) First Report of *Gnomoniopsis smithogilvyi* Causing Chestnut Brown Rot on Nuts and Burrs of Sweet Chestnut in Spain. *Plant Disease* 107(1):218
- Barral MP, Benayas JMR, Meli P, Maceira NO (2015) Quantifying the impacts of ecological restoration on biodiversity and ecosystem services in agroecosystems: A global meta-analysis. *Agric Ecosyst Environ* 202:223–231
- Bowman DMJS, Balch J, Artaxo P, Bond WJ, Cochrane MA, D’Antonio CM, DeFries R, Johnston FH, Keeley JE, Krawchuk MA, Kull CA, Mack M, Moritz MA, Pyne S, Roos CI, Scott AC, Sodhi NS, Swetnam TW (2011) The human dimension of fire regimes on Earth. *Journal of Biogeography* 38(12):2223–2236
- Calviño-Cancela M, Chas-Amil ML, García-Martínez ED, Touza J (2017) Interacting effects of topography, vegetation, human activities and wildland-urban interfaces on wildfire ignition risk. *For. Ecol. Manag.* 397:10–17
- Castedo-Dorado F, Álvarez-Álvarez P, Cuenca Valera B, Lombardero MJ (2023) Local-scale dispersal patterns and susceptibility to *Dryocosmus kuriphilus* in different *Castanea* species and hybrid clones: Insights from a field trial. *New Forests* 54(1):9–28
- Castellnou M, Miralles M (2009) The changing face of wildfires. *Crisis Response* 5(4):56–57
- Centro Nacional de Información Geográfica (2019) Centro de Descargas, Madrid, viewed 25 February 2023. Retrieved from <http://centrodedescargas.cnig.es/CentroDescargas/index.jsp>
- Commission Regulation (EU) No 409/2010, of 11 May 2010, entering a name in the register of protected designations of origin and protected geographical indications (*Castaña de Galicia* (PGI))
- Consellería de Medio Rural (2021) *IXP Castaña de Galicia*, Galician Ministry for Rural Areas, Xunta de Galicia, Santiago de Compostela, viewed 25 February 2023. Retrieved from <https://mediorural.xunta.gal/es/temas/alimentacion/productos-gallegos-de-calidad/productos-origen-vegetal/castana-galicia>
- Consellería de Medio Rural (2022a) Perimeter of wildfire impacting Courel Mountain Areas, Dirección Xeral de Defensa do Monte, Galician Ministry for Rural Areas, Xunta de Galicia, Santiago de Compostela, unpublished data

- Consellería de Medio Rural (2022b) Programa Estratéxico do Castiñeiro, Grupo de investigación G4 Plus, Universidade de Vigo-Dirección Xeral de Planificación e Ordenación Forestal, Galician Ministry for Rural Areas, Xunta de Galicia, Santiago de Compostela
- Deus E, Silva JS, Castro-Díez P, Lomba A, Ortiz ML, Vicente J (2018) Current and future conflicts between eucalypt plantations and high biodiversity areas in the Iberian Peninsula. *J. Nat. Conserv.* 45:107–117
- Díaz-Varela RA, Álvarez-Álvarez P, Díaz-Varela E, Calvo-Iglesias S (2011) Prediction of stand quality characteristics in sweet chestnut forests in NW Spain by combining terrain attributes, spectral textural features and landscape metrics. *For. Ecol. Manag* 261(11):1962–1972
- Dubert I, Cernadas XMA, Castelao OR, Romero HM, Villares R, García FG, Caramés AP, Pardo AL, Vázquez RS, Borge JH, Táboas DL, Fernández MF (2019) A morte de Galicia, Edicións Xerais, Santiago de Compostela
- European Environment Agency (2017) Biogeographical Regions in Europe, Copenhagen, viewed 25 February 2023. Retrieved from <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2>
- Fernández-López J, Fernández-Cruz J, Míguez-Soto B (2021) The demographic history of *Castanea sativa* Mill. in southwest Europe: A natural population structure modified by translocations. *Mol. Ecol.* 30:3930–3947
- Garbach K, Milder JC, Montenegro M, Karp DS, DeClerck FAJ (2014) Biodiversity and ecosystem services in agroecosystems. *Encyclopedia of agriculture and food systems* 2:21–40
- Gil-Tapetado D, López-Estrada EK, Jiménez Ruiz Y, Cabrero-Sañudo FJ, Gómez JF, Durán Montes P, Rey del Castillo C, Rodríguez-Rojo MP, Polidori C, Nieves-Aldrey JL (2023) *Torymus sinensis* against the invasive chestnut gall wasp: Evaluating the physiological host range and hybridization risks of a classical biological control agent. *Biological Control* 180:105187
- González de Molina M, Soto Fernández D, Guzmán-Casado G, Infante-Amate J, Aguilera Fernández E, Vila Traver J, García Ruiz R (Eds.) (2019) *Historia de la agricultura española desde una perspectiva biofísica, 1900-2010*, Gobierno de España, Ministerio de Agricultura, Pesca y Alimentación, Madrid
- Guzmán-Casado GI, Aguilera E, García-Ruiz R, Torremocha E, Soto-Fernández D, Infante-Amate J, González de Molina M (2018) The agrarian metabolism as a tool for assessing agrarian sustainability, and its application to Spanish agriculture (1960-2008). *Ecol. Soc.* 23(1):2
- Hanson C, Finisdore J, Ranganathan J, Iceland C (2013) *The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change, Version 2.0*, World Resources Institute, Washington, DC
- IGE (2023) Instituto Galego de Estatística (Galician Institute for Statistics), viewed 02 February 2023. Retrieved from [www.ige.gal](http://www.ige.gal)
- INE (2022) *Instituto Nacional de Estadística (Spanish Statistical Office) – Nomenclátor, Nomenclátor: Población del Padrón Continuo por unidad poblacional*, viewed 02 February 2023. Retrieved from <http://bit.ly/2WToH7L>
- Levin S, Xepapadeas T, Crépin AS, Norberg J, Zeeuw A, Folke C, Hughes T, Arrow K, Barrett S, Daily G, Ehrlich P, Kautsky N, Mäler KG, Polasky S, Troell M, Vincent JR, Walker B (2013) Social-ecological systems as complex adaptive systems: Modeling and policy implications. *Environ Dev Econ* 18(2):111–132
- Lindner M, Maroschek M, Netherer S, Kremer A, Barbati A, Garcia-Gonzalo J, Seidl R, Delzon S, Corona P, Kolström M, Lexer MJ, Marchetti M (2010) Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. *For. Ecol. Manag.* 259(4):698–709
- Lombardero MJ, Ayres MP, Álvarez-Álvarez P, Castedo-Dorado F (2022) Defensive patterns of chestnut genotypes (*Castanea* spp.) against the gall wasp, *Dryocosmus kuriphilus*. *Front. for. glob. change* 5:1046606
- López-Iglesias E (2006) Axuste agrario e despoboamento rural en Galiza: análise das tendencias recentes e reflexións cara o futuro. In: Foro Rural Galego (ed) *Congreso Técnico-Científico sobre Desagrariación e Sostibilidade Rural na Euro-Rexión Galicia-Norte de Portugal*, Fondo Rural Galego, Lugo, pp 89–100

- López-Iglesias E, Sineiro-García F, Lorenzana-Fernández R (2013) Processes of farmland abandonment: land use change and structural adjustment in Galicia (Spain). In: Ortiz-Miranda D, Moragues-Faus A, Arnalte-Alegre E (eds) *Agriculture in Mediterranean Europe: between old and new paradigms*. Emerald Group Publishing Limited, Bingley, pp 91–120
- MAPA (2021) *Ministerio de Agricultura, Pesca e Alimentación - Anuario de Estadística 2021*, Ministry of Agriculture, Fisheries and Food, Madrid, viewed 25 February 2023. Retrieved from <https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/2021/default.aspx>
- MAPA (2022) *Ministerio de Agricultura, Pesca e Alimentación - Análisis y prospectiva-Informe interactivo de comercio exterior*, Ministry of Agriculture, Fisheries and Food, Madrid, viewed 25 February 2023. Retrieved from <https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/powerbi-comex.aspx>
- Martínez-Cabrera H, Rodríguez G, Ballesteros H (2020) Degradation of social institutions and land use: unfolding feedback mechanisms between afforestation with fast-growing species and living conditions in rural areas. *Revista Galega de Economía* 29(2):1–18
- MITECO (2011) *Ministerio para la transición ecológica y el reto demográfico-Cuarto Inventario Forestal Nacional: Galicia*. Ministry for Ecological Transition and Demographic Challenge, Madrid, viewed 25 February 2023. Retrieved from [https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/inventario-forestal-nacional/cuarto\\_inventario.aspx](https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/inventario-forestal-nacional/cuarto_inventario.aspx)
- Moreira F, Ascoli D, Safford H, Adams MA, Moreno JM, Pereira JMC, Cattry FX, Armesto J, Bond W, González ME, Curt T, Koutsias N, McCaw L, Price O, Pausas JG, Rigolot E, Stephens S, Tavsanoglu C, Vallejo VR, Van Wilgen BW, Xanthopoulos G, Fernandes PM (2020) Wildfire management in Mediterranean-type regions: Paradigm change needed. *Environ. Res. Lett.* 15(1):011001
- Murua JR, Astorkiza I, Eguía B (2013) Conflicts between Agricultural Policy and Sustainable Land Use: The Case of Northern Spain. *Panoeconomicus* 3:397–414
- Nieves-Aldrey JL, Gil-Tapetado D, Gavira O, Boyero JR, Polidori C, Lombardero MJ, Blanco D, Rey del Castillo C, Rodríguez Rojo P, Vela JM, Wong E (2019) *Torymus sinensis* Kamijo a biocontrol agent against the invasive chestnut gall wasp *Dryocosmus kuriphilus* Yasumatsu in Spain: its natural dispersal from France and the first data on establishment after experimental releases. *Forest Systems* 28(1):e001
- Pais S, Aquilué N, Campos J, Sil Á, Marcos B, Martínez-Freiría F, Domínguez J, Brotons L, Honrado JP, Regos A (2020) Mountain farmland protection and fire-smart management jointly reduce fire hazard and enhance biodiversity and carbon sequestration. *Ecosyst. Serv.* 44:101143
- Pereira-Lorenzo S, Ramos-Cabrera AM, Barreneche T, Mattioni C, Villani F, Díaz-Hernández B, Martín LM, Robles-Loma A, Cáceres Y, Martín A (2019) Instant domestication process of European chestnut cultivars. *Ann. Appl. Biol.* 174:74–85
- Pérez-Fra M, García-Arias AI, Docio Rodríguez F (2006) Efectos territoriales de la reestructuración de la ganadería bovina de la Cornisa Cantábrica. In: Arnalte Alegre E (ed) *Políticas agrarias y ajuste estructural en la agricultura española*, Ministerio de Agricultura, Pesca y Alimentación, Madrid, pp 327–350
- Pérez-Girón JC, Díaz-Varela ER, Álvarez-Álvarez P, Hernández Palacios O, Ballesteros F, López-Bao JV (2022) Linking landscape structure and vegetation productivity with nut consumption by the Cantabrian brown bear during hyperphagia. *Sci. Total Environ.* 813:152610
- Posner SM, McKenzie E, Ricketts TH (2016) Policy impacts of ecosystem services knowledge. *Proc. Natl. Acad. Sci. U.S.A.* 113:1760–1765
- Preiser R, Biggs R, De Vos A, Folke C (2018) Social-ecological systems as complex adaptive systems: Organizing principles for advancing research methods and approaches. *Ecol. Soc.* 23(4):46
- Regulation (EU) No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs

- Roces-Díaz JV, Díaz-Varela ER, Barrio-Anta M, Álvarez-Álvarez P (2018) Sweet chestnut agroforestry systems in North-western Spain: Classification, spatial distribution and an ecosystem services assessment. *For Syst* 27(1):03
- Ruckelshaus M, McKenzie E, Tallis H, Guerry A, Daily G, Kareiva P, Polasky S, Ricketts T, Bhagabati N, Wood SA, Bernhardt J (2015) Notes from the field: Lessons learned from using ecosystem service approaches to inform real-world decisions. *Ecol Econ* 115:11–21.
- Sousa-Silva R, Verbist B, Lomba Á, Valent P, Suškevičs M, Picard O, Hoogstra-Klein MA, Cosofret VC, Bouriaud L, Ponette Q, Verheyen K, Muys B (2018) Adapting forest management to climate change in Europe: Linking perceptions to adaptive responses. *For Policy Econ* 90:22–30
- WBCSD (2011) Guide to Corporate Ecosystem Valuation. World Business Council on Sustainable Development, Geneva, viewed 17 February 2023. Retrieved from <https://www.wbcsd.org/contentwbc/download/573/6341>
- Zhang W, Gowdy J, Bassi A, Santamaria M, Declerck F, Adegboyega A, Andersson G, Augustyn AM, Bawden R, Bell A, Darnhofer I, Dearing J, Dyke J, Failler P, Galetto L, Hernández C, Johnson P, Jones S, Kleppel G, Komarek AM, Latawiec A, Mateus R, McVittie A, Ortega E, Phelps D, Ringler C, Sangha KK, Schaafsma M, Scherr S, Hossain MS, Thorn JPR, Tyack N, Vaessen T, Viglizzo E, Walker D, Willemsen L, Wood SLR (2018) Systems thinking: an approach for understanding ‘eco-agri-food systems’. In: TEEB (ed) TEEB for Agriculture & Food: Scientific and Economic Foundations, UN Environment, Geneva, pp 17–55

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