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Multifunctional Plants: Ecosystem Services and Undervalued Knowledge of Biocultural Diversity in Rural Communities—Local Initiatives for Agroecological Transition in Chile

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Abstract: With the aim of contributing to the understanding of plants' multifunctionality for sustainable agroecosystem management, the first part of this paper addresses the importance of functional biodiversity in the design of agroecological systems, including the local context in the generation of situated knowledge. The second part describes three participatory research experiences with local farmers across three locations in Chile. The first experience reports on the use of *Dasyphyllum diacanthoides* (endemic tree) as fodder. A second experience focuses on the establishment of *Rosa* spp. (invasive species) as an agroforestry system integrated into the landscape. Both experiences were collaborative efforts with farmer communities of the Andean Mountains in southern Chile. The final experience describes the use of different spontaneous aromatic and medicinal plants through biological corridors to encourage beneficial insects as natural controllers. All three research experiences reveal a lack of knowledge, decontextualization, and undervaluation of the biocultural diversity present in some traditional Chilean agroecosystems.

Keywords: participatory research; local ecological knowledge; endogenous potential; socioecological transition

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1. Introduction

By using "Multifunctional Plants", we seek to reveal unknown or often overlooked plants because many have multiple uses or functions within specific agroecosystems. These are plants that are initially known or noted for some particular use (medicinal, aromatic, sustenance, among others) but are more widely underestimated as ecological service providers in the agroecosystem in which they exist [1].

A good example is the denominated non-conventional food (nutritious) plants, which have been widely cultivated in different places over the last decade [2–9]. When we refer to such multifunctional plants, it is not to dismiss their important culinary use, but to emphasize the wide diversity of properties and functions of a species.

From an agroecological perspective, these are plants with spatial complementary functions in agroecosystem design including: ecosystem restoration, soil remediation, and regulation of arthropod populations, among many others, in addition to their food (for humans and animals) and medicinal or aromatic use. Another characteristic refers to their situated or farmer-linked existence, mainly in a socioecological context (environment). Therefore, by multifunctional plants, we refer to certain plant characteristics associated with cultural practices.

The aim of this study is to contribute to and (re)value the knowledge of this multifunctionality of plants present in the agroecological ecosystems in different rural areas (regions) of Chile. In order to do so, we have outlined some key results of initiatives co-developed with local farmer groups across different rural localities.

In the first part, a summary is provided about basic agroecology concepts linked to biodiversity and agroecosystem design. It also evaluates the importance of understanding the local context to gain situated knowledge. The second part details three experiences carried out by GAMA (Group of Agroecology and Environment), jointly executed with farmers, where the exchange of knowledge was shared and appreciated by their own communities. The first experience relates the foraging use of *Dasyphyllum diacanthoides* (endemic medicinal tree). A second experience focuses on the establishment of *Rosa* spp. (invasive species) as an agroforestry system integrated into the landscape. Both experiences were carried out with farmer communities of the Andean Mountains of southern Chile. The third experience describes the use of different spontaneous aromatic and medicinal plants along biological corridors to host beneficial insects as natural controllers.

1.1. Agroecology, Functional Ecology, Biocultural Diversity, and Sociocological Approach

The transdisciplinary science of agroecology [10] broadens the reference frameworks for the complex and situated analysis of case studies as it incorporates other complementary approaches. This work comprises elements from functional ecology centered on the eco-systemic services of biocultural diversity, which are the knowledge of local communities and of socioecology or the interweaving between humans and their environment.

Functional ecology. Functional ecology is based on concepts that have been employed for different purposes. Some of these concepts have already been attributed a more universal meaning, while others are still under construction [11]. Functional ecology provides additional information to other components of diversity that require the inclusion of the value of both taxonomic diversity and functional value. The logic behind this approach is that functional groups with less redundancy should be a key object in conservation efforts due to their unique role in the ecosystem [12].

Functional ecology arises as a nexus between conventional characterizations based on taxonomic (or species) diversity and the diversity of ecological functions and processes in the systems. This provides additional information to identify effective strategies for the conservation of biodiversity in environmental change scenarios. Its analysis focuses on individuals, as the knowledge of functional traits is part of the understanding of interactions between humans and their environment in all dimensions [13]. In this way, functional ecology becomes a key input for the functional restoration of communities and ecosystems as it gives an account of the response of species to environmental conditions.

Both the structure and the processes that take place in a natural system are important for the provision of eco-systemic systems, yet transformed ecosystems can also provide these services as mentioned below. Significant and severe modifications in ecosystems can cause problems mostly in the provision and regulation of services [14]. In addition, a lack of understanding about the relationship between ecological processes and ecosystem services could cause the suggested service classification not to work for decision-making related to resource management and valuation [15] or to the development of suitable socioecological policies [16]. The empirical evidence about the influence of functional diversity on the offer of eco-systemic services shows a direct relationship between the functional traits of different taxonomic groups and the services of ecosystems [17].

Biocultural diversity. Ref. [18] notes that the close relationships between many diversification processes, specifically between biological, genetic, linguistic, cognitive, agricultural, and landscape diversity, form a historically originated biological–cultural complex that is a product of thousands of years of interaction between cultures and their environments or natural surroundings. This process, symbiotic and co-evolutional in nature, emerged due to the ability of the human mind to take advantage of the different singularities of each landscape in the local environment depending on the material and spiritual needs of diverse human groups. Each local culture interacts with its own local ecosystem, and with the combination of landscapes and their corresponding biodiversity, resulting in a complex and broad range of fine and specific interactions.

Biocultural diversity includes what has been denominated "collective cultural heritage" [19] to refer to knowledge, innovations, and practices of indigenous and local peoples that are maintained and formed within socioecological systems. Additionally, biocultural diversity links traditional uses of resources, local economies, and biological diversity at different scales in the context of spiritual values and custom laws that are recognized as part of the collective identity of the inhabitants of a given territory [20].

Conceiving local development from a perspective based on biocultural diversity shows how the relationships between humans and the environments they inhabit are interwoven by cultural and historical relationships that inform about the construction and perception of the resources in a specific space [21]. This perspective presents biodiversity beyond a modern ontology that puts nature at the service of humans, including care and reciprocity views inherited from non-Western cultures [22]. A multidisciplinary approach has developed around biocultural diversity, which seeks to improve the management and sustainability of natural resources and the territories they belong to through the acknowledgement of the inseparability of humans and the environment [23]. Biocultural diversity is a significant advancement in the concepts of biological and cultural diversity because it explicitly recognizes their interdependence and co-creation [24].

Ref. [25] proposed understanding bioculturality as the interrelation of life in all its manifestations—biological, cultural, and linguistic—which have co-evolved in complex socioecological adaptive systems. Therefore, any action that degrades, disturbs, or affects the comprehensiveness of nature affects humans at the same time, as the human species is not conceived as a discrete component separated from nature. Then, bioculturality consists of exploring appropriate ways of "coexisting with" biodiversity based on the intrinsic value of biodiversity and the need to identify and rethink the relationships between the human community and nature to ensure the conservation of biological diversity [26].

As indicated by [24], the current invisibility of biocultural diversity in economic management and development in rural territories, in addition to the precarity of their inhabitants' conditions of life, invites us to analyze the understanding and treatment of the relationship between biological and cultural diversity and the local economic development with a critical eye.

Socioecological approach. According to [27], socioecology proposes that the existence of humans and their wellbeing depends on their actions but also on other people's actions in a sense of interdependency and correspondence. The more and better relationships are established, the more resilient territories will be, and respect and the fair distribution of costs, benefits, rights, and duties should be pillars in this construction. Beyond the classic property-focused management of territories, the socioecological approach identifies a series of implicit agreements, rules, organizations, and management strategies of the territories that have been hidden or made invisible for most people.

The perspective of socioecological systems allows for a comprehensive review of the role of local communities in the context of their territories, as it promotes the observation of both cultural and environmental elements [28]. The notion of socioecological systems refers to an approach that emphasizes not only the idea of humans in nature but also the leading role of humanity in the great transformations of the biosphere. This perspective conceives a socioecological, economic, and political network and, therefore, focuses on users, governance, and resource use strategies in each ecosystem [29]. Socioecology provides the tools necessary for not canceling stakeholders and experiences that form the landscapes and remnants of a world that is not the subject of the market empire, whether due to its marginality or former devastation [27].

From this perspective, ref. [30] defines socio-ecosystem services as the multidirectional relationships between the elements that compose them and believes that all the components of socio-ecosystems are, at least potentially, beneficiaries and service providers for the others at the same time. Furthermore, the author indicates that humans are not only and necessarily selfish entities destroying nature and voracious consumers of its services, but also, at least potentially (if permitted by the economic–political system), an agent that maintains the basic functions enabling life and biodiversity in the socio-ecosystems they integrate, providing other services in addition to mere regulation.

From this perspective, ref. [30] holds that the economy-driven reductionism and biophysical prejudice of the approach centered on ecosystem factors and elements that provide services to humans while paying little or no attention to the opposite direction is overcome, i.e., the services provided or that could be provided by humans for the maintenance of the basic processes of the ecosystems and the benefits they would bring through this to the other biophysical components of such ecosystems, to which they themselves belong to.

1.2. Agroecology, Biodiversity, and Agroecosystems Design

Agroecology, as observed by [31], promotes principles instead of rules or recipes that must be considered in sustainable agroecosystems design, as well as in the gradual process of the conversion of conventional systems to agroecological production systems.

One of these principles is the promotion of biodiversity—above and under the soil—whose relevance relies on its recurrence, while different species may fulfil the same function. To this end, it is important to understand the different uses, properties, services, and functions of plants present in the agroecosystems used by traditional farmers as a central element of design.

Agroecological management and spatial-temporal arrangement strategies that favor diversity at the field level provide a way to increase productivity, sustainability, and the resilience of agricultural production [31]. The greater the plant diversity of agroecosystems, the greater the capacity of the agroecosystem to absorb plagues and diseases, as well as rainfall and temperature cycle changes, which has been asserted by [32]. Diversified agricultural systems present substantially greater biodiversity, better soil quality, greater water retention capacity, energy efficiency, and increased resilience to climatic change [33].

However, diversity per se does not improve the stability of agroecosystems; it is functional biodiversity that refers to a set of organisms that play key roles in the provision of ecological service (soil fertility, plagues regulation, among others). According to [34], promoting functional biodiversity in agroecosystems is key in a strategy of ecosystem redesign because when the diversity of the functional groups increases, so do processes that are fundamental to the function of the agroecosystem. Greater diversity in cultivation systems also leads to greater diversity in the associated biota [35].

Regarding plant diversity, an organism community in an agroecosystem will be more complex when a greater number of different plants are present. This allows for a greater interaction among arthropods and microorganisms within the biodiversity above and underneath the soil, unleashing ecological processes that provide the agricultural system increased stability. Biodiversity increments enable beneficial interferences among species, improving the agroecosystem sustainability [36].

Complex trophic webs are promoted in these diverse systems, which imply increased connections and interactions among their components and the rise of energy and material flows. The more complex the agroecosystem is structured, the more stable its production can be, and the less vulnerable it can be to undesirable pests and microorganisms [37]. By increasing the functional biodiversity, an important objective in the agroecological conversion process is achieved according to [38], referred to as the "strengthening of agroecological processes of agroecosystems". This allows for the gradual elimination of external inputs while building on the ecological functions of the agroecosystem.

When we refer to biodiversity for the design of an agroecosystem, we must consider at least two central elements: one is that each design must be directly related to the region and the biome to which it belongs [39]. Therefore, the greater the differences between an agroecosystem and the original biome of the region, the further it will be from a stable stage and the greater the need to incorporate supplies that replace the altered biological processes. Hence, the relevance of knowing the local biodiversity and examining the multifunctionality of plants that are offered to us within a determined environment. Secondly, but no less important, we must keep in mind that by agroecosystems biodiversity, we refer to the "biocultural diversity", given that the components of an agroecosystem depend on anthropic action. The multifunctionality of plants is equivalent to the biodiversity expression resulting from the biocultural memory of rural communities.

1.3. Situated Knowledge and Local Resources Valorization

Agroecology bases its performance on complex interactions as a result of the combination of the diverse cultural practices of farmers which are unique for each community (and change) according to their biophysical and sociocultural contexts [40]. Therefore, it is very important to consider the socioecological conditions of the territories and the active participation of their actors [41,42].

Farmers rationally, according to [43], interpret the complexity of their environment to design their agroecological production systems. They convert these field experiences into systematic knowledge arising from a successful practice of productive self-subsistence in agroecological systems. As a result, the management carried out by farmers determines the level of agrobiodiversity present and the complexity of the system [44].

In summary, the assessment of local resources and their associated practices based on knowledge located in specific environments must recognize the effective management of an agroecosystem. In addition, diverse component functions play an essential role in building agroalimentary systems that are truly sustainable [45].

The experiences have mostly been carried out by GAMA with farmers from rural localities situated in different regions of Chile and in very different biomes. Some of the experiences with farmers were carried out near Calama, Northern Chile, which has a desertic climate characterized by significant thermal oscillations, long drought periods, and very poor and contaminated soils [46]. Another experience was accomplished in the Melipeuco area, Araucania region, Southern Chile, a region characterized by long snowy winters and very low temperatures. Other such experiences were completed in the central zone of Chile characterized by temperate to warm climates.

The experiences selected for this work are focused on what we have called "multifunctional plants". They are framed around major initiatives that pursue agroecological strategy design based on the endogenous potential of the socio-ecosystems (sociocultural and biophysical).

1.4. Multifunctional Plants: Unknown Uses and Ignored Contexts

Most of the time, top-down research approaches do not allow for the knowledge constructed by the local people to be placed in context. An agroecological approach, in turn, involves working with farmers who know their environments best. One can identify more suitable elements at a far more detailed level [47]. The experiences with selected cases are reviewed below.

2. Methodology

This study corresponds to a procedural systematization method that adapts to the context studied [48]. It is also participative [49] as it aims at the generation of information from the initiatives demanded by the local communities involved [50]. Data collection and treatment were participative and collaborative, which allowed for the definition of practices and knowledge socially and territorially rooted in the context of participants.

A qualitative approach was selected as it enabled immersion in the practice identification process, the appraisal of the individual's points of view, and the consideration of this study as an interactive process between researchers and participants [51], in which communication among them is a tangible part of knowledge production.

In addition, this study takes a decolonial perspective as a critical approach and place of enunciation to showcase the situated analysis and the naturalized structural differences that mark researchers as observation subjects [52], thereby giving voice to subaltern speech [53].

Ethnographic field work was conducted in the territories where community inhabitants live through a fluid dialogue with the knowledge of the subjects in such territories. To this end, we participated in the daily life of these families who engaged in in-depth interviews and conversations stretching a long time, as well as their daily tasks inherent to life in the countryside.

The ethnoecology field work was carried out respecting the times and spaces of rural lifestyle [54]. The interview surveys were carried out in a manner harmonized with the different tasks that farmers carried out as part of their routines. There was no determined moment to carry out the interviews, but they were managed based on daily dynamics [47]. That is, they were carried out by accompanying farmers in their daily tasks, which allowed for the verification of what was reported.

The groups that were interviewed in the development of these experiences (in the order in which the results are presented) were as follows: (a) group of peasant farmers belonging to the "neighborhood council" of the community of Huechelepún (5 men and 1 woman); (b) peasant women (4) from the Cherquén area who make up the "Taller Laboral" group; and (c) organic farmers (6 men and 4 women) who make up the Independent Workers Union "Corazón Ogánico de Paine". According to the methodology (1, 26, 28), all groups were considered based on the following criteria: (a) they demanded to solve a problem (local initiative), (b) they formed an organization, and (c) they used agroecological practices.

Considering that endogenous agroecological strategies involve participatory designs, we based our work on the fact that nature and communities co-evolve. In this sense, we operated with five elements applied to all experiences [55]. These elements are as follows: (a) the environment, understood as the biophysical environment in which the members of a group find local material resources for their subsistence; (b) the values involved in the beliefs and worldviews that give a group identity, aimed at articulating their life plans in relation to their environment and appropriate resources; (c) local knowledge, referring to the repertoire of abilities and skills a group uses to appropriate "pieces" of their environment; (d) appropriate technology, focused on productive practices, including the different uses and management of natural resources (collection and exchange); and (e) organization, referring to all forms of collective action aimed at the sustainable management of its resources [50]. In this paper, we focus on some of these elements in each case, namely, local knowledge. The other elements can, however, be identified implicitly.

The participatory agroecological framework basically considered three steps: (a) identification of the problem and definition of a strategy, (b) implementation of a demonstration unit, and (c) assessment and improvement. These steps were iteratively repeated as many times as necessary, including a pedagogical process. At each stage, we held workshops together with all actors involved, and the transition from one stage to the next required approval by all of them. Each case (group) had its own dynamics related to the number of workshops and the number of cycles to be repeated as spiral loops.

More specifically, before starting the demonstrative experience units (also called "assay") in all the cases described here, we collected the herbaceous material (cuttings, plants, seeds) through the following actions performed together with the farmers: (a) we explored the land by making transects, forest inventories, plants collection, and site characterization; (b) in parallel, we applied a semi-structured questionnaire to gather information related to the natural resources involved; and (c) complementarily, we interviewed additional people that the group considered appropriate [47]. In all cases, we referred to the local knowledge of these people.

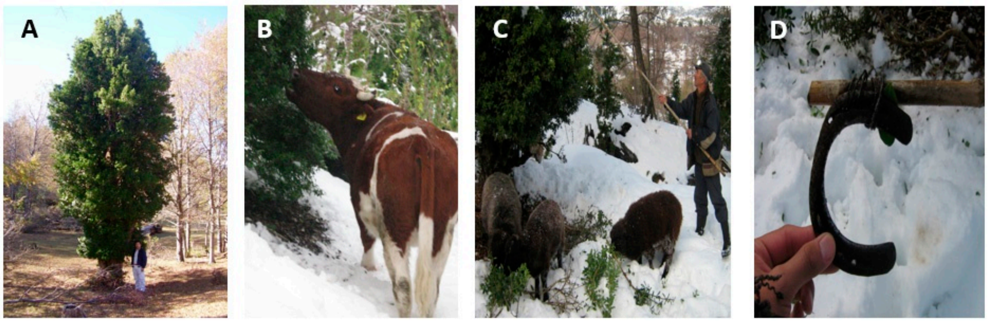
Through this way of working, all the actors can interact with each other and share their knowledge. Democratic decisions can be made while learning in a collaborative way.

3. Results: Experiences of Local Agroecologies

The selected experiences represent our work with rural communities that use plants of different origins (native, endemic, spontaneous, or naturalized) and that constitute (or could potentially constitute) a central element in the agroecosystem management strategy of local actors in their communities.

3.1. Dasyphylum Diacanthoides: The Lesser-Known Fodder of the "White Earthquake"

Dasyphyllum diacanthoides (Less.) Cabrera is an endemic species of Chile, also known as trevo, palo santo, and tayu in Mapudungun, the language of the Mapuche people [56]. It is an evergreen tree with dense foliage and spiny branches. It may reach up to 20 m in height, and its trunk can grow to more than one meter in diameter (Figure 1A). The bark is soft and thin; its color can vary from brown to ash with deep longitudinal grooves [57]. One very interesting phenotypic feature is the presence of a pair of spines, between 0.8 cm and 1.5 cm in length, seen in young branches. The spines disappear at 1.5 m in height; the old branches become glabrous and carry no spines and are located in the upper part of the tree [58].



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Specie	%OM	% DM	% TA	% CP	% CF	% ADF	% NDF	ME (Mcal/Kg MS)	% EE	% P	% DDM	% DE	DE (Mcal Kg^{-1})
Avena nuda	85.7	87.9	2.2	14.4	2.7	2.8	13.8	3.34	5.89	0.44	86.76	86.00	3.74
Chenopodium album	11.7	20.1	8.4	24.9	N/I	29.0	51.0	2.24	2.28	0.02	66.31	65.88	2.87
Chusquea coleou	31.3	46.4	15.1	12.7	25.3	30.2	50.2	1.62	1.88	0.10	65.36	64.94	2.82
Chusquea quila	26.1	36.4	10.2	13.6	27.4	33.0	52.7	1.75	1.93	0.11	63.23	62.85	2.73
Chusquea uliginosa	33.9	44.2	10.3	12.7	29.9	36.1	55.6	1.52	1.83	0.11	60.75	60.41	2.63
Dasyphyllum diacanthoides	31.7	41.8	10.0	7.2	26.0	35.1	42.2	2.38	2.46	0.13	61.56	61.21	2.66
Juncus sp.	31.3	35.4	4.1	9.3	31.0	37.7	N/I	1.40	0.89	0.12	59.52	59.19	2.57
Medicago sativa	19.9	27.9	8.0	18.9	24.4	29.1	37.0	2.35	3.30	0.30	66.27	65.84	2.86
Morus alba	N/I	29 .0	19.7	18.9	14.9	33.3	40.8	6.95	3.80	0.40	62.94	62.56	2.72
(Heno) poli-específico	78.9	85.4	6.5	7.3	33.9	38.7	62.0	2.17	1.12	0.16	58.79	58.48	2.54
Olea europea	86.0	93.4	7.4	8.9	N/I	29.5	36.2	2.34	2.26	N/I	65.92	65.49	2.85
Trifolium pratense	78.4	86.1	7.6	12.9	27.7	36.6	48.5	2.27	0.96	0.28	60.41	60.07	2.61
Triticum aestivum	80.8	86.1	5.3	3.5	42.7	55.4	82.9	1.46	0.79	0.08	45.71	45.61	1.98
Ulex europaeus	36.5	40.4	3.9	9.6	43.2	53.2	72.0	1.71	1.27	0.08	47.48	47.35	2.06
Zea mays	17.6	22.1	4.6	7.5	27.7	33.3	53.0	2.62	3.00	0.13	62.93	62.55	2.72

Figure 1. (**A**). *Dasyphyllum diacanthoides*; (**B**) cattle browsing; (**C**) farmer cutting a branch; (**D**) craft tool for cutting branches; (**E**) nutritional value of *D. diacanthoides*. Source [59].

Stems and leaves contain triterpenes, lupeol, and peol acetate which have antibacterial properties, to which medicinal properties are attributed. These include their use as febrifuge to eliminate warts, to heal wounds, to alleviate rheumatism and bruises, and to heal liver attacks [60]; it is also used as a diuretic, purgative, and astringent [61]; antiseptic [62]; and antitussive [62–65]. It is also recognized (and recommended) for ornamental use [60,64] and is anecdotally [57] pointed out as being such that "its leaves are attractive to cattle".

Despite being considered a forestry species of economic importance [66]—its timber is used as high-quality firewood, the roots are used for arts and crafts, and apiarists extract a very valuable nectar from its flowers—*D. diacanthoides* does not have a significant commercial value [58]. It has been a scarcely researched species, as there is little information [67] or "insufficient data" to rigorously establish its state of conservation. It is neither part of conservation programs [68] nor found in germplasm banks [69]. According to [70] "a better understanding of their seed biology and propagation methods is needed" and "at nursery level, there are no known studies that have reproduced this species" [58]. As a species of little regenerative potential, *D. diacanthoides* would "in no case [. . .] be considered a species of value in forests when associated with other valuable species" [58].

If in forestry sciences, *D. diacanthoides* has hardly been studied at all. In livestock sciences, it is a perfect mystery species, as there are no records detailing its use as fodder. Although "its foliage is palatable and widely used to feed cattle in winter months" [58], it seems that this species fails to raise interest (of researchers and technicians) as a forage supplement. However, this situation is completely different within rural communities of the Chilean Andean Mountains.

One example is the community of Huechelepún, located in Melipeuco, Araucanía Region, in southern Chile. The locality is affected by extended winter cycles, and its farmers have managed to withstand these conditions by monitoring nature and interacting with it as needed. The economy of these communities is fundamentally based on livestock and timber. The cumulative knowledge of their environment has allowed for them to develop strategies for a sustainable management of their agroecosystems. When the climatic conditions are adverse, with temperatures around −20 °C and 2 m deep snow cover, the naturalized prairies are completely covered by snow during the long winter months, and the population together with their cattle remain isolated. This situation is called "white earthquake" and has forced government authorities to declare it a "catastrophe zone" and, thus, to organize forage delivery operations. They last a few weeks only and are not sufficient to alleviate such a severe situation.

In this context, *D. diacanthoides* plays an important role as a forage complement to feed the community's cattle, thus becoming a determinant element in the survival of their livestock (Figure 1B). In addition to being highly palatable to cattle, *D. diacanthoides* constitutes an important energy and protein source [59], fundamentally during the critical winter months when it is very difficult to access alternative nutritional sources. Compared with the most important forages consumed by cattle in Southern Chile, *D. diacanthoides* shows balanced values in the energy–protein relationship (Figure 1E). Due to the nutritional value of *D. diacanthoides*, farmers have developed a cut-and-carry management strategy that allows them to feed their herd even when the animals cannot graze. Huechelepún farmers choose *D. diacanthoides* which is located at the northern side of any of the slopes—within the Southern Hemisphere, there is higher sunlight exposure on this side of the slope—and use a simple but ingenuous tool to reach the older branches (glabres and without spines) located in the highest part of the tree. To achieve this, they use a colihue cane (Chusquea quila: a type of bamboo that grows in southern Chile) with a horseshoe attached to one end. With this tool they can reach and break the higher branches (Figure 1C,D).

The importance of *D. diacanthoides* for the Huechelepún people has stimulated, in addition, effective and lower-cost-propagation-method assays with seeds and cuttings for reproduction, considering that all sorts of cattle and the native woodlands they feed on are the base of their economy.

Based on the methodology described in the previous sections, we organized workshops with the Huechelepún families. They had decided to work on trevo (*D. diacanthoides*) cuttings propagation after having explored the native forest looking for the best trees, and several weeks on different farms complemented with dialogues among farmers. The criteria to choose trees was proposed by both researchers and farmers based on spine presence and parent plants exposition. In subsequent workshops, we decided when and how the cuttings should be reproduced. Finally, an on-farm experiment was carried out under their local socioecological conditions. This is very relevant in order to test viability and sustainability because it is rather usual to accomplish this kind of assays under controlled variables inside high-technology greenhouses and using expensive supplies instead.

Thus, the benefit sought was to have plants for the establishment of agroforestry systems that integrate livestock with cultivated plants of trevo. In this manner, the farmers can replicate their landscapes with plants obtained by themselves at low costs while contributing to the conservation of an endemic tree species. The experiences developed by all the actors (farmers, researchers, technicians) under the given environmental conditions using endogenous resources showed a successful reproduction using semi-lignified cuttings. The best results were identified using the stakes from mother plants without spines and facing north. This shows that the variables indicated by the farmers (spine presence and parent plant exposition) were relevant in the design of the assays [71]. These results regarding the feasibility of propagating *D. diacanthoides* by semi-lignified cuttings coincide with investigations carried out in other native species in Chile, such as those of the genus Nothofagus [72] as well as for endemic species such as *Berberidopsis corallina* Hook. f. [73], *Eucryphia glutinosa* (Poepp. and Endl.) Baill. [74], and *Guindilia trinervis* Gillies ex Hook. et Arn. [75].

D. diacanthoides is one of two arboreous species of Asteraceas of South America [76] and represents one of the taxa of the Miocene paleoflora [77]. These are two good reasons to continue researching this species.

The experience described above highlights the relevance of this kind of work. On the one hand, it is the importance of the knowledge of local peoples, and on the other hand, it is the native-endemic nature of *D. diacanthoides*, with its economic importance due to both its medicinal and forage properties.

3.2. *Rosa spp.: Agroecological Cultivation of an Invasive Plant*

Rosehip has its origins in Eastern Europe [78] and was introduced to America during the Spanish conquest [79]. In Chile, rosehip is geographically distributed from the provinces Colchagua to Aysén (34° S to 45° S) growing in forest clearings and in open areas [80]. Three species of rosehip have been described: *Rosa canina* L., *Rosa rubiginosa* L., and *Rosa moschata* Herm.; according to [81], they are considered new native species.

Rosehip is a shrub (spontaneous and wild growing) that can reach 1 m to 2 m in height. Its stems are thin, are flexible, and carry many curved spines. The annual leaves have serrated edges, smooth obverse, and hairy reverse. The flowers have five pink petals, either single or grouped into two or three. Its fruit is an ovoid achene, orange red or bright scarlet in color, and 1 cm in length with some bristles; the fruit houses numerous seeds [82,83] (Figure 2A).

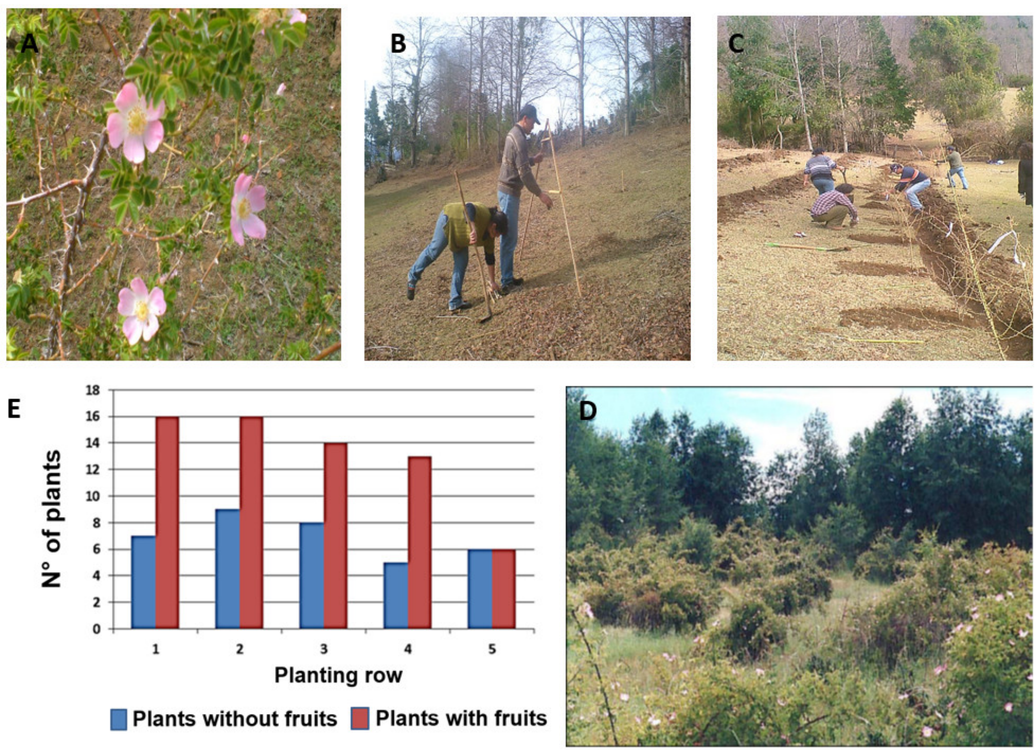

Figure 2. (**A**). *Rosa* spp. plants; (**B**) local people using "Nivel A" tool; (**C**) *Rosa* spp. planting; (**D**) spontaneous development of *Rosa* spp.; (**E**) cultivated *Rosa* spp. development (Based on [50]).

Rosehip is known worldwide for its diverse properties and the multiple uses of its fruits and seeds [84]. Its fruits are used as raw ingredients for juice, marmalades, tea, soup, jelly, and liquor bases [85,86], and oil is extracted from the seeds for cosmetic use [87–90]. The production of biogas from waste rosehips is less known (*Rosa canina* L.) [91]. Originally, however, rosehip was introduced for a mere ornamental use.

Properties worth mentioning are health benefits, such as in chemotherapeutic complements [92], in dermatology as a stimulator, and for the reconstruction and elimination of stretch marks [85]. In natural medicine, rosehip stimulates organism resistance to fight colds and flu symptoms; it is used for the improvement of digestion, in the treatment against depression, in the dissolution of stones, and for the cleaning of kidneys and the bladder [93–95]; in nutrition, it is used for its vitamin A qualities [96–98] as well as vitamin C [85,86,99,100]; because it contains vitamin F, it is used for its essential oils [101], its sugars, and its antioxidant properties [101–104].

Based on all these properties, rosehips have always been very attractive. Specifically, indigenous and local women belonging to different regions of Araucanía have developed initiatives related to environmental care with a gender approach, supported by a social economy model.

Considered an atypical forest product of a high commercial value [105] of which Chile is the largest exporter, harvesting rosehips fruits for eventual sale is not without controversy, as they are obtained from invasive and naturalized plants that compete with other native plants and invade livestock pastures, thus diminishing their nutritional value (Figure 2D). The situation is contradictory because, on the one hand, harvesting is promoted to exploit the commercial value of this product and, on the other hand, plant removal is encouraged to minimize the degradation of native forests and to improve areas dedicated to livestock farming.

Because of the economic importance of rosehip for many rural and indigenous families in Southern Chile, private and government initiatives have fostered its cultivation via a strategy that intends to reconcile both positions. With the establishment of the crop, the pressure on native forests is reduced by the controlled production of rosehip in places where other types of crops are not viable. However, most of the rosehip crops are cultivated as conventional monoculture.

In the context of self-management initiatives for the Mapuche territorial exchange (among others regarding rosehip) with communities in the municipality of Melipeuco [106], we carried out an agroecological cultivation of rosehip with women (who own their land) in the Cherquén area. The initiatives in the territory were aimed to establish a cooperative marketing of rosehip by involvement of the various collectors in the territory.

This enterprise faces many challenges, including the volatility of the market price, the ignorance around actual sale conditions, and the low level of cooperation among farmers for commercial endeavors. In addition, it lacks large collective efforts aimed at their appreciation and valuation as a typical commercial product [107]. In addition, during the fruit harvest, the workforce is informal and without specialization, and the work is carried out under adverse conditions due to the thorns of the fruit, difficulties of access due to the scale of growth, and extensive days under the summer sun.

As indicated in the methodology, our agroecological approach was implemented with five elements. Thus, in this particular case, we worked together with four women who lived in a particular place of Cherquén. In the participatory workshops performed, the women decided to establish a rosehip demonstrative unit, including its design and the farm where rosehip was to be cultivated. Supported by their families and with some information given by us, they arranged the activities and the schedules. This specific experimental unit was designed with five rows (100 m) separated by 3 m between them to cultivate oat and clover as forage (Figure 2C).

Our objective in the agroecological design for the rosehip crop establishment was to gather relevant information about the conditions of the associative purchase of organizations in the first phase (price, volume, sanitary requirements, margin, among others) as well as aspects related to the perception of the harvesting work carried out by women [50]. Finally, based on the knowledge that farmers have of their environment (place of collection, type of plants, aspects of the fruit), the specimens obtained were transplanted in contour lines (Figure 2B shows a farmer using a Nivel A to create contour lines) to avoid soil erosion and in a suitable plantation framework for management (fertilizer, pruning, harvesting) under agroecological techniques and the free movement of livestock. The results showed a good adaptation of plants to the site, maintaining the features of the fruit (color, shape, diameter, length); therefore, rosehip could be considered in the design of controlled production systems.

As we noted previously, "the use of branches as plant material to reproduce rosehip, the use of guano (manure) as fertilizer and integrating the system into the landscape via contour lines, clearly showed that the practices developed by women and their families allowed us to establish a culture of rosehip outside conventional industry logic putting pressure on monoculture, the related use of synthetic fertilizers and more complex propagation systems that have proven to be unnecessary for the requirements of rosehip production" [50]. Figure 2E shows that there were more plants (by row) with fruits than those without fruits (except in one row). Therefore, the design established, including its agroecological management, was considered well done and suited for further, more in-depth and long-term research.

3.3. Aromatic and Medicinal Plants as Hosts of Natural Friends

Across Chile's central region Edafo, climatic conditions prevail which are very favorable for the crop establishment of various aromatic and medicinal plants, although such conditions, depending on the species, are found throughout the country [108]. According to [109], there are limited producers of cultivated medicinal and aromatic herbs, and most are organic.

There are also initiatives by farmers that cultivate the numerous varieties of medicinal and aromatic herbs that lead to the development of viable productive alternatives [110] that, through the know-how of local people [111], create independent and/or associative ventures [112]. Most of these initiatives are monocultures that may be annual, biannual, or perennial. The purpose of these "ventures" is to market them for their edible, culinary, or medicinal use. Examples are Romero (rosemary, *Rosmarinus officinalis*), Caléndula (common marigold, *Calendula officinalis*), Melisa (lemon balm, *Melissa officinalis*), Salvia (common sage, *Salvia officinalis*), Albahaca (basil, *Ocimum basilicum*), Manzanilla (chamomile, *Matricaria chamomilla*), Matico (orange-ball-tree, *Buddleja globosa*), Cedrón (lemon verbena, *Lippia citriodora*), and Sanddorn (sea-buckthorn, *Hippophae rhamnoides*) [109].

However, aromatic and medicinal plants can also be used as accompanying plants that are useful to attract beneficial insects/natural enemies ("natural friends"), utilized as manure (as compost or green manure), and used to repel insects considered pests. They can be included in predial designs as cover crops and beneficial plants established in strips, interspersed, and mixed rows or edges. However, these properties, which provide a very important ecosystem service, are often unknown, so their application is rare.

Regarding the field work carried out by GAMA with local people and organic farmers from Maipo Valley (Metropolitan Región, Central Chile), different aromatic and medicinal plants have been used with this "double" purpose (pest management and crops) [113].

In our visit to the farms, we observed the presence of syrphidae in *Calendula officinalis*, coccinellid egg poses *in Achillea millefolium*, and aphids in *Ruta graveolens*. In the case of *C. officinalis* and *R. graveolens,* the farmers also cultivate them to sell because of their medicinal properties.

Based on this observation, farmers proposed to delve deeper into this aspect. Thus, following the methodological approach described previously. In the first stage of the framework, we carried out workshops to prioritize the issues that they needed to develop. One of them was on how to manage pests in a biological way [114]. The second step to be agreed was to perform a farm prospection that they knew about (or had been given information about) to make inventories with plants that could have a potential as insect hosts. Complementarily, we surveyed farmers and local people about the properties and uses of these plants and cross-checked them with the relevant literature.

After the prospection, they observed how various insects are housed on different plants that contribute to maintaining the arthropod population balance (and with it helping to minimize the plaguicide use). Field trails were carried out on 14 different species of aromatic and medicinal plants. These findings gave hope to the farmers because they could sell their organic products at the agroecological local market whilst needing to go forward with their transition into overcoming inputs substitution.

Once the prospecting task was performed, and following a couple of workshops, one of the initiatives approved by all participants (e.g., farmers, researchers, technicians) was to establish a "microassay" of biological corridors. Even though the design involved the whole orchard, in this paper, the results presented focus on the relation between olive (*Olea europaea*) and its main pest (see below) as well as the potential use of some medicinal and aromatic plants as hosts of natural enemies. One of the reasons was that there was very little organic olive production in the region, and the farmers thought that it could be an interesting initiative for the future.

A biological corridor was established in three different places (sector A, B, and C; Figure 3B) in the diversified orchard. Each sector corresponded to the limit between the sections in which the farm was divided in relation to crop rotations. One of these corridors is shown in Figure 3C. The aromatic and medicinal plants used in each corridor and their location inside the corridor were discussed and agreed on between farmers and researchers through workshops on the farm, followed by implementation, monitoring, and evaluation carried out collaboratively. Specifically, farmers, technicians, students, and researchers worked together, supported by specialists. The entomologists helped us to monitor and evaluate the insects during the trial (from winter to summer) using different tools (adhesive traps, aspirator, entomological umbrella).

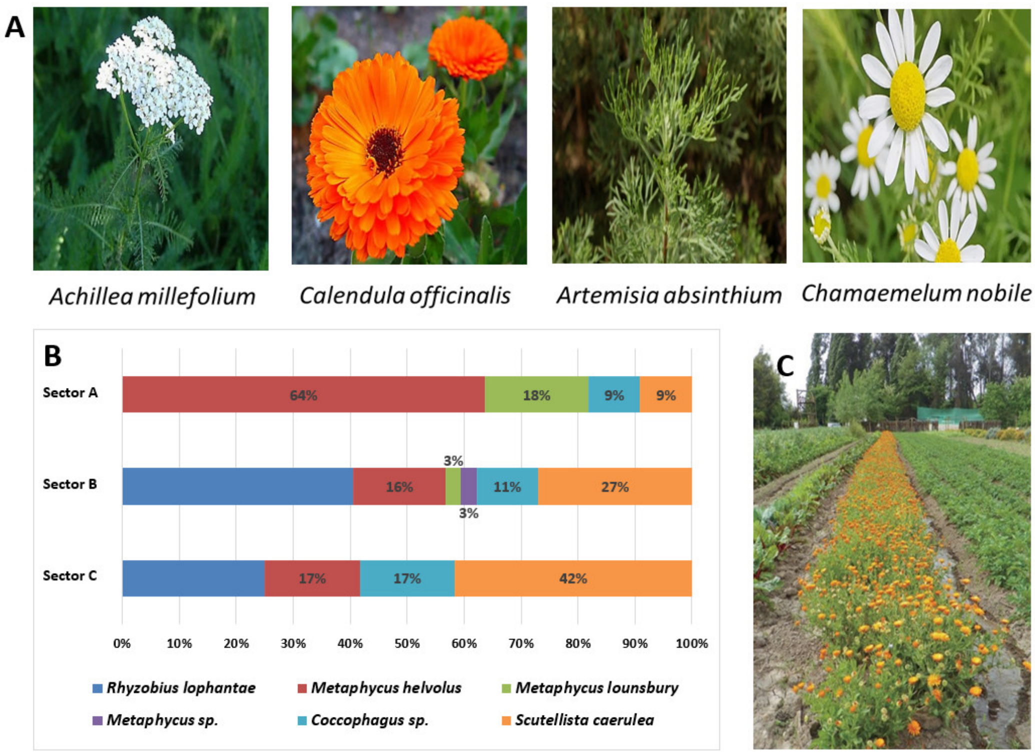

Figure 3. (**A**) Some Asteraceas most visited by insects; (**B**) presence of beneficial insects in different sections of the farm; (**C**) biological corridor with aromatic and medicinal plants; Source [113].

The results showed that with the establishment of biological corridors in different sectors of the farm, it was possible to keep some of the insect populations below the threshold of economic damage.

The species that best created a habitat to accommodate natural friends for the olive tree were *Calendula officinalis*, *Borago officinalis*, *Achillea millefolium*, *Linun usitatissimum*, *Chamaemelum nobile*, *Origanum vulgare*, *Artemisa abrotanum*, and *Symphytum officinale.* Of these, Asteraceas were the most visited (Figure 3A). The asteraceous plants used in this study have secondary metabolites that may have relevant effects in the control of local insect pests, forming part of the "ideal" biotope for the reproduction, permanence, and survival of natural enemies in the refuge found in medicinal plants [115].

For Chile, 17 pests associated with the olive tree have been identified [116]. Among these, *Saissetia oleae* (Hemiptera: Coccidae) is one of the two most harmful, causing damage to foliage and fruits [117]. Associated with the excretion of honeydew by this insect, it produces infections by the fungal complex known as "fumagina" (sooty mold), which reduces the photosynthetic ability of the leaves, with negative consequences for flowering and productivity.

In the nymphal stage, these scale insects are controlled by oils and detergents. The use of insecticides is justified in situations of high infestation [118]. The biological control of *S. olea* started at the beginning of the 20th century [119], being substantially reduced mainly due to the action of *Metaphycus helvolus*, *M. lounsbury*, and then *Scutellista cyanea* [120]. At present, no type of biological control is used for *S. olea*, and the use of host plants for its natural enemies is not being promoted.

This is the reason why we considered our results highly positive. Figure 3B shows a total of six "natural friends" or arthropod species found in plants mentioned above: *Coccophagus* sp., *Metaphycus helvolus*, *Metaphycus lounsbury*, *Metaphycus* sp., *Rhyzobius lophanthae*, and *Scutellista caerulea*. Depending on the sector where the biological corridor was established on the farm, its presence fluctuated percentage wise.

The location of the plants in the corridor and the establishment of it in different sections of the farm allowed for a stratification (plant height) and an abundance of colors that induced a greater work for the pest insects. This contributes to a longer search period to find the ideal host crop. For example, the greater presence of *Metaphycus helvolus* (64% in Figure 3B) in corridor A could be explained by its proximity to the olive grove (*Olea europaea*) and by it being more distant from the daily activities of the farm.

These results confirm the suitability of incorporating aromatic and medicinal types in the design of biodiverse farms, taking advantage of their complementary value and avoiding the productive hyperspecialization of agricultural systems. The next challenge will be to amplify and scale-up this design to many more farmers who practice agroecological approaches.

4. Discussion

This work analyzed three experiences with different farmer groups in three territories, which have as a common element the invisibility and undervaluation of their knowledge and, especially, their meanings.

For example, organic farmers from Valle del Maipo refer to beneficial insects or natural enemies as natural friends. For them, arthropods that are hosts in the multifunctional plants identified in their environment are considered organisms that help them handle populations of insects that damage their cultures. In this line, for rural women from the Cherquén town, rosehip (exotic) is not an invasive plant but a plant that is part of the environment and complements their domestic economy. In both rural communities, warmongering language is absent, as they built other meanings for their relationship with the environment. These interactions gradually shape the landscape, resulting in the conservation of a significant number of species that give structure to local ecology. This explains the fact that these constructions change their functions rather than disappearing over time [121].

As indicated by [122], most exotic plants can coexist with the diversity of native plants, as they are responsible for important wanted and unwanted economic impacts.

The phenomenon of biological invasions has always been an action area for diverse social stakeholders with different interests and implications. In this light, it should be noted that despite the term "natural enemy" (arthropods) being predominant, it is possible to find in the literature the denomination of natural allies for these species [123].

The use of rosehip by the women of Cherquén shows the importance of the participation of women in different development areas, as well as their specific capacities or contributions to understand and promote territorial dynamics. As pointed out by [124], from a gender studies perspective, the visibility of the work and role of women is necessary, as the territory is a fundamental factor in the understanding of their identity and political representations in the general context of society. We agree with [124] that the knowledge and strategies developed by rural women in their environments should be acknowledged. In this way, it would not be necessary to repeat the same interventions with already structured dynamics and networks but rather to systematize the reality lived by women farmers in order to escalate them to larger territorial levels.

These local knowledges, as expressed by [125], not only refer to the diverse practices linked to agriculture but also transcend other dimensions of their work in the territory, for example, the strengthening of their local identity, their relationships with nature, and the importance of sharing to tackle difficulties and survive.

The management of the trevo tree established by the mountain's agropastoral community is probably the clearest case of what [27] denominates territory management strategies that have been hidden or made invisible for most people due to cancelling, which also translates as the statement that farmers are destructive toward native forests in conservation language.

The trevo tree, which some communities denominate as palo santo, is certainly not a sacred tree for the Mapuche culture. It also does not have significance to farmers, whose economy is mainly based on livestock production.

The dynamic relationships between communities and their environment, which create changing landscapes, could cause this species to change its connotation in future. For example, the Mapuche families of the Tirúa communes (Biobío region) mention eucalyptus as significant trees together with their sacred trees, as noticed by [126], to reclaim trees through political actions with discourses linked to the spiritual sphere.

Similar to the trevo tree's is the case of the oak tree (*Nothofagus obliqua*), whose dialogue with humans is not emphasized in the scientific literature. According to [121], the presence of oak trees (similar to trevo trees) is felt in the local cultures of this territory. It permeates the materiality of daily life in the form of firewood, a construction material for houses or everyday objects. These are species that have had a structuring role in the relationship humans have established with their environment. Not only have humans but also cultures have noticed the strategic role of such species in the conservation, reproduction, and perpetuation of local ecosystems.

Studies conducted with rural mountain communities from the Araucanía region reported results coincident with this study in terms of the presence of diverse knowledges and practices that are safeguarded by Mapuche and non-Mapuche farmers. Far from static, this knowledge is under permanent adaptation through assimilation and hybridization processes [127]. A second common aspect is related to the development of adaptation practices and strategies with a community approach on the local scale through diagnosis tailored to the reality of a community and interventions applied participatively and pedagogically [128]. This confirms that in-depth ethnobotanical documentation contributes to the objectives in the life plan and development strategies of communities [129].

Lastly, we agree with [24] on the rural territorial advancement of recognizing and valuing the interconnection between biodiversity and culture, as this interconnection generates initiatives that consider the promotion of local products based on biocultural diversity for the well-being of communities. Biocultural diversity is a crucial conceptual evolution as it expressly recognizes their interdependence and co-creation, which contributes to the support of the people's claims for self-determination and autonomous decision-making about their territories and identities, the forms they adopt, and how they are created, negotiated and advanced, reflecting their attitudes, values, and desires for the future in terms of the continuity of their relationships with the territory.

5. Conclusions

In the previous sections, we reviewed some of the experiences conceived by the Agroecology and Environment Group (GAMA), aiming to uncover and exchange the knowledge of plant species that we call "Multifunctional Plants".

Such experiences were the result of collaborative work with various communities and groups of farmers tailored to suit their specific needs and requirements. To achieve our goals, we used participatory technics to promote multi-actor participation in each territory. We shared experience of life and exchanged knowledge and advice among all: farmers, local agents, technicians, researchers, students.

As we have briefly described, the execution of these initiatives involved a methodological articulation that included field work, the establishment of tests, laboratory analysis, and a slow dialogue over time between the different actors in the context of participant-led research. The most important element of this interdisciplinary strategy was the commitment of all the people involved, and more specifically, the local people, because we ultimately worked to meet their needs.

This methodological pluralism adjusted to the diversity of contexts in which these plants develop allowed us to approach their multifunctionality as a complementary form of inquiry, integrating farmers' concepts, based on detailed and precise observations of their environment because of their permanent interaction.

The agroecological perspective in our approach to the singularities of each initiative allowed us to develop each of the actions we carried out with a different lens. In addition, regarding plant resources, we observed and shared situated knowledge typical of the place and often unknown or less appreciated by conventional scientific methodologies.

A good example of this is the lack of knowledge of some researchers and technicians about the use and forage value of *D. diacanthoides*. For the Huechelepún people, who are marginalized and have to live under climatic adversity, this tree constitutes an important source of energy and protein for them. As we have highlighted, Huechelepún farmers have been feeding their cattle with this plant for many years. However, the properties of the plant have not yet been valued by conventional sciences and have even gone unnoticed by the professionals involved in the territory. The situation is similar with regard to the rational use of *Rosa* spp. by the women of Cherquén. Despite being an invasive species, agroecological criteria applied in the context of family economy allow for the commercial use of *Rosa* spp. to be made compatible with the conservation of native tree species that make up the local landscape.

An agroecological approach that enhances local knowledge has allowed us to investigate the multiple uses, properties, ecological functions, and ecosystem services of the plant species discussed in this paper. Rural communities and farmers evaluated the approach and took their own decisions on how to use knowledge in a certain context, incorporating the plant species into the design of their agroecosystems coupled to their territories.

The purpose of this research is to contribute to the knowledge and (re)valuation of the multifunctionality of little-known and undervalued plants. In this way, we can increase the repertoire of agroecological strategies in the design and management of agroecosystems based on biodiversity and assuming that it is the investigated subject who must define the purpose and objectives of the research—the "what", "what for", as well as the "how".

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