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Ecosystem Services in the Context of Agroforestry—Results of a Survey among Agricultural Land Users in the Czech Republic

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Abstract: Agroforestry, the use of trees at the interface between agricultural and forestry systems, is a key component of the multifunctional European landscape, where it provides a whole range of ecosystem services. Its main potential lies in the provision of services including increasing economic yield in agriculture and providing anti-erosion measures. The main objective of this research is to assess the perception of the providing ecosystem services of woody plants growing in agroforestry by farmers as key land users in the Czech Republic. Different aspects influencing farmers' subjective perceptions were identified, especially depending on conventional versus organic farming methods. Respondents' views were mapped using a structured questionnaire, which allowed for independently assessing the importance of windbreaks. Respondents considered regulatory ecosystem services the most important ones, in particular reducing soil erosion and flood risk, or increasing the resilience of the landscape to drought. Respondents perceived the physical obstruction of trees during mechanical tillage and the tenancy relationship with the land as the most significant problem with the introduction of agroforestry systems. The aim of this study is to promote innovative approaches in the national agricultural strategy in agroforestry as one of the tools for climate change adaptation towards sustainable agricultural production.

Keywords: agroforestry; ecosystem services of trees; trees outside forests; windbreaks; forest buffer strips; farmers; agroforestry systems; multifunctionality

Citation: Červená, T.; Jarský, V.; Červený, L.; Palátová, P.; Sloup, R. Ecosystem Services in the Context of Agroforestry—Results of a Survey among Agricultural Land Users in the Czech Republic. *Forests* **2023**, *14*, 30. https://doi.org/10.3390/f14010030

Academic Editors: Syed Ajijur Rahman, Joao C. Azevedo and Peilei Fan

Received: 15 November 2022
Revised: 14 December 2022
Accepted: 19 December 2022
Published: 23 December 2022

1. Introduction

The central objective of agricultural management is to produce sufficient food for the livelihood of the population, but landscape formation and the economical use of environmental components are essential to achieve this goal. Over the last century, conventional farming systems have become established around the world, causing a number of environmental problems associated with the degradation of agricultural ecosystems [1,2] such as biodiversity loss, soil erosion, water and groundwater pollution [3]. A major challenge for agriculture in the coming decades is to produce more food for a growing population while fighting poverty and hunger [4]. The risks associated with climate change make this task even more difficult. Hundreds of thousands of smallholder farmers, especially in developing countries, are switching to farming systems that restore depleted land and increase food crop yields, household food security and incomes [5]. One innovative approach to achieving food security and environmental resilience is evergreen agriculture. Evergreen agriculture is defined as the integration of specific tree species into annual food cropping systems [5]. Under the European Union's Common Agricultural Policy [6], environmentally friendly agricultural practices, such as precision farming, organic farming, agroecology and agroforestry are therefore promoted [4–9]. These agricultural practices ensure a healthier environment for the wider community by reducing the use of fossil fuels, pesticides and other pollutants, maintaining the integrity of the environment and represent an important source of ecosystem services (hereafter ESs) for society [10]. Ecosystem services can be defined as the benefits that human populations derive from functioning ecosystems [7,10–17].

At the international level, many classification schemes for ES are available: The millennium ecosystem assessment [10], the economics of ecosystems and biodiversity [18], and the common international classification of ecosystem services [19,20], all of which deal with the impact of ecosystem quality on ES provision.

Agroforestry systems, due to their high functional potential, are defined as a land use practice in which woody perennials (trees or shrubs) are integrated with crops and/or livestock on the same land unit [21–23]. Agroforestry systems (hereafter AFSs) provide both more biodiversity and greater resilience to sudden weather fluctuations. The main characteristic that distinguishes AFSs from stand-alone agricultural and forestry systems is their greater structural and functional complexity, as well as their emphasis on multi-purpose use of trees [10,19–28].

Woody plants on agricultural land and the ecosystem they deliver are perceived as an important source of ES, providing benefits to society depending on the situation and use. These benefits include biodiversity conservation, carbon sequestration [29], increasing soil fertility through atmospheric nitrogen [30], climate regulation [31,32], soil moisture retention [32–34] and many others [30–37]. Some of these benefits are offered by the woody plants themselves, but most are due to where they grow (i.e., a unified system including the soil and the trees growing on it). Although some of these ESs are difficult to qualify and may even reduce economic benefits to farmers (benefits that can be measured through market transactions), they provide many valuable benefits in the form of positive externalities [21,22,38–40].

AFSs include three main combination systems: silvoarable systems (combining tree cultivation with agricultural crops), silvopastoral systems (combining tree cultivation with livestock grazing) and agrosilvopastoral systems (combining tree cultivation with crops and grazing), as well as buffer strips and forest farming [10,19,41–48]. In temperate regions, the different AFSs include many forms, with the most important traditional form of agroforestry in central Europe being linear plantations with primarily anti-deflation functions (shelterbelts, windbreaks, riparian buffers, alley cropping, hedgerows) [16,35]. These are variously wide strips of linear woody vegetation oriented perpendicular to the prevailing wind direction. Their main role is to increase agricultural yields by providing erosion control measures (wind erosion) [31,34,49].

While the available research shows great potential for AFSs to provide ESs [24,25,50], their practical use is limited by a number of factors. These include the lack of legislation on the use of AFSs, but also a lack of knowledge and understanding of the potential of AFSs for end-users of land [51]. Another limitation is ownership relationships that complicate planting on leased plots [52]. Understanding the importance of ES provision, particularly by farmers who are the key users of the land, and providing them with adequate legislative support, is therefore essential for the successful implementation of AFSs in practice. Current studies [53–55] aimed at assessing the importance of understanding the supply of and demand for Ess show that perceptions of the potential of Ess depend, for example, on the context in which farmers learn about Ess, as well as their level of knowledge of the subject, including cultural attachments, traditional practices and perceptions of the value of the social service [56,57]. For reasons of seeking a better understanding of the need for ES provision and the establishment of sustainable agroforestry systems, according to Langemeyer et al. [58], it is essential to involve stakeholders in the process of ES assessment and landscape greenspace planning. Participatory methods in planning processes could serve to increase the need to consider AFSs in national strategic planning [54,58,59].

Agricultural Landscape in the Czech Republic

The Czech Republic (hereafter CZ) is a landlocked country of 78.866 km^2 located in the middle of the temperate zone of the Northern Hemisphere in central Europe [60]. The current agricultural landscape in the CZ occupies approximately half of its area, of which less than 3/4 is arable land, more than 1/4 is permanent grassland, and a small part is

occupied by vineyards, orchards or hop farms [61]. Farmers therefore significantly co-create the landscape and thus influence the provision and development of ES.

Within the CZ there are differences in terms of agricultural management due to natural, historical and ownership conditions. The total agricultural area was larger before the mid-20th century and consisted mainly of small, diverse fields with trees and shrubs on the edges [62]. However, with the advent of the communist regime in 1948, the landscape changed [63]. The 50-year period saw the nationalization of agricultural land, resulting in the consolidation of field blocks and the removal of vegetation [39,62]. After the collapse of the communist regime in 1989, the land was returned to the owners, who in many cases leased it to agricultural operators who generally farm in a conventional manner [63,64]. This type of farming generally does not support nature conservation objectives and does not tend to re-establish the broken relationship between farmers and the land [62]. In the CZ, almost 73% of agricultural land is rented out [65], which (together with Slovakia—90%) is among the highest in the EU (the EU average is around 50%) [66]. According to data from the agricultural register of the Czech Statistical Office [67], at the end of 2020, a total of 47,160 agricultural entities were active in the CZ, of which 89% are natural persons, but they farm only 27.5% of the total agricultural land. On the other hand, legal entities (cooperatives, limited liability companies, joint stock companies) account for only 11% of the total number of entities, but they manage approximately 69% of the total agricultural land area [65,67].

The total extent of agroforestry systems in the CZ in 2018 was quantified at approximately 36,000 ha, equivalent to 0.45% of the state's land area and only 0.8% of the agricultural area [68]. The Common Agricultural Policy (CAP) has recognized and supported the establishment of agroforestry systems on agricultural land in both 2007–2013 and 2014–2020 programming periods. In the past, the main support for agroforestry came from CAP measures 2.2.2 and 8.2. Pillar 1, which determined that the basic payment for agroforestry was subject to the same eligibility conditions as for agricultural land. In the framework of both two pillars of the CAP, it can be said that the CAP supported and restricted the planting of trees on EU agricultural land to a certain extent at the same time. Arable land, and thus agroforestry on it, has been determined to be ineligible for direct payments if it contains more than 100 trees/ha. The Strategic Plan of The Common Agricultural Policy (hereinafter "CAP SP") within the European Union, which was approved for the period 2023–2027, is supposed to be the key to anchor, develop and promote agroforestry in the CZ [69]. The new CAP SP contains several policy reforms that support the transition to sustainable agriculture and forestry. Almost a third of the direct payments budget is targeted at supporting eco-schemes—climate and environmental schemes. There is no consensus on which agricultural schemes are actually sustainable [70], however CAP SP considers necessary to support the trend towards (not just maintaining the status quo) more environmentally friendly farming systems and to take advantage of the growing interest in alternative farming methods and integrated production [69]. The main factors influencing the CAP are, as the European Commission points out, the UN Sustainable Development Goals (SDGs) and the Cork 2.0 Declaration [43,71].

The aim of this study is to analyse the perception of the offer of ecosystem services provided by trees growing on agricultural land by farmers as key land users in the Czech Republic. Sociodemographic characteristics of farmers were investigated, as we hypothesized that these may shape the subjective evaluation of ecosystem services of the respondents. Specifically, we focused on whether the perception of ES differs depending on the farming method used by farmers (conventional versus organic). Perception of ESs provided by windbreaks were assessed separately, as they were identified as most common tree formation on agricultural land in the CZ. Furthermore, the reasons for and against the implementation of trees on agricultural land, the presence of which is considered essential for the adoption of AFSs, were collected. The findings identifying and summarizing issues and barriers to the adoption of AFSs by local farmers may contribute to shaping specific approaches, which should be incorporated into policy decision-making and the design of

legislation, subsidies and information systems, to effective support of ES provision in the Czech Republic.

2. Materials and Methods

Farmers' attitudes towards tree planting on farmland and their perceptions of the supply of ES provided by agroforestry were collected in several methodological steps with emphasis on a survey using a structured questionnaire (Supplementary Materials). This was administered online between December 2020 and July 2021.

The study was divided into the following steps:

1. Classification of ES within the AFS;
2. Structured interviews with a pilot sample of stakeholders who framed the real problems of ES provision in agroforestry;
3. Pilot testing of the questionnaire;
4. Launching the online survey and sending out questionnaires;
5. Data processing, analysis and interpretation.

2.1. Step 1. Classification of ES within the AFS

The ecosystem services that have the potential to be delivered in agroforestry systems have been categorized by respondents according to the millennium ecosystem assessment classification scheme, which is currently the most widely accepted and cited classification scheme [10]. These are four basic groups: provisioning, regulating, supporting and cultural ecosystem services, which contain individual services.

2.2. Step 2. Structured Interviews with a Pilot Sample of Stakeholders Who Framed the Real Problems of ES Provision in Agroforestry

Semi-structured interviews with representatives of potential key stakeholders were conducted at the beginning of the ES assessment process. A total of 14 stakeholders were approached in this way, namely: landowners, farmers, foresters, government representatives, representatives of educational institutions and professional foresters. Each stakeholder was asked to recommend other stakeholders who should also be part of the process (i.e., snowball) [72]. The interview included a set of open-ended questions exploring the main motives, socioeconomic impacts, and legislative barriers to AFS implementation. The interviews included questions about the respondents' work/knowledge and experience with agroforestry and an explanation of the concept and perception of the ES offerings provided under AFS. Based on stakeholder input, the analyses separately highlighted windbreaks as one of the forms of tree planting in agricultural landscapes that has historically been most used in the CZ. All other spatial forms of trees (solitaires, flat elements, other linear forms) growing in any AFSs: silvoarable, silvopastoral and agrosilvopastoral systems were evaluated in the opposite group. Based on these interviews, key factors influencing the motivation to introduce an AFS into the landscape were identified. The proposed ESs were assessed, and individual criteria determined based on the stakeholders' own experiences.

As the respondents agreed that farmers are the key players influencing the implementation of AFSs in the Czech Republic, the survey form was subsequently designed to focus only on them.

After evaluating the structured interviews, the final version of the questions was divided into four thematic sections, namely:

- Section 1: respondents' attitudes towards agroforestry;
- Section 2: perception of the importance of tree ecosystem services;
- Section 3: perception of the importance of the ecosystem services provided by windbreaks;
- Section 4: sociodemographic data of respondents.

2.3. Step 3. Pilot Testing of the Questionnaire

The prepared questionnaire was pre-tested on 10 respondents who were then no longer part of the study. These were persons with knowledge of agroforestry issues (organic farmers, agroforesters, farmers). The aim of the pilot collection was to test the logic and clarity of the questions. Based on their findings, several questions were refined.

2.4. Step 4. Launch the Online Survey and Send out the Questionnaires

The questionnaire was distributed to a total of 500 entrepreneurs out of a total of 47.160 agricultural entities operating in the Czech Republic [67], of which 30% were legal entities and 70% were natural persons. To eliminate regional specificities in farming practices, farmers from all 14 regions (NUTS 3 classification) in the CZ were contacted. Farmers were informed in advance by telephone about the distribution of the questionnaire so that the intention could be explained to them in person, thus increasing their willingness to respond. After their consent, they were sent a link to the online questionnaire primarily via email or social media. The questionnaire was distributed using the LimeSurvey platform. This solution was chosen to save time and allow direct contact with respondents without the need for a face-to-face meeting [73] primarily due to concerns about COVID-19 infection and measures resulting from Government Resolution 1375/2020 relating to restrictions on the free movement of persons [74]. Out of a total of 500 farmers, 194 respondents completed the questionnaire in full, i.e., the return rate was 38.8%.

2.5. Step 5. Data Processing, Analysis, and Interpretation

The data were processed in Microsoft Excel and analysed using IBM SPSS Statistics 28 software [75]. Based on the existing theoretical knowledge and the conclusions of the empirical research, the following null hypotheses were established with respect to the objectives of this research work:

1. The respondents' farming method (conventional versus organic farming) does not depend on the sociodemographic characteristics of the respondents.
2. The respondents' farming method (conventional versus organic farming) does not depend on the distance of the respondents' residence from the land they farm.
3. The amount of cultivated agricultural land that respondents own does not depend on concurrent forest ownership.
4. There is no difference between the perception of the importance of ecosystem services provided by windbreaks and other tree forms in agroforestry.
5. There is no correlation between the perceived importance of ecosystem services in agroforestry and the size of land farmed by respondents.

The questionnaire distinguishes between conventional and organic farming. Conventional agriculture means direct focus on the economic component of agriculture, i.e., maximum yield. For this purpose, special varieties (often GMO) are grown, maximum fertilizers (especially mineral) are applied and there is a minimal effort to conserve the environment [76]. Organic farming is a modern form of farming without the use of chemical substances. Organic farmers manage their land without synthetic pesticides, mineral fertilisers, growth promoters or genetically modified organisms. This is to minimise the risk of contaminating the environment and the landscape with these foreign substances [77].

The following statistical methods were used to evaluate the individual statistical hypotheses [78]:

1. The $\chi 2$ test for independence of two or more variables in the contingency table was used to test the dependence of the farming method on the sociodemographic characteristics of the respondents.
2. The Mann–Whitney test was used to test the relationship between the distance of respondents' residence and farming method, since the sample data come from a non-normal distribution and distance is a numerical variable.

3. The $\chi 2$ test for independence of two or more variables in the contingency table was used to test the dependence of the area of privately owned cultivated land on current forest ownership.
4. To test for differences in perceived importance of ecosystem services provided by windbreaks and other forms of trees in agroforestry, a non-parametric Wilcoxon matched-pairs test was used because each respondent rated both importance, i.e., the ratings form pairs, and the data come from a non-normal distribution. The importance of each ecosystem service was rated using a Likert scale from 1 to 5 (1 = low importance, 5 = high importance) [79].
5. The non-parametric Spearman's correlation coefficient was used to test the dependence of the perception of the importance of ecosystem services in agroforestry on the size of the land under cultivation, where this variable can be considered as an ordinal variable. The importance of each ecosystem service was rated using a Likert scale from 1 to 5 (1 = low importance, 5 = high importance) [79].

All tests were performed at a significance level of $\alpha < 0,05$.

3. Results

3.1. Sociodemographic Data of Respondents

The sociodemographic characteristics of the respondents are shown in Table 1. The largest proportion of responses was received from the Central Bohemia and Pilsen CZ regions. In the survey, 75.3% of the respondents were male, 19.6% were female and 5.2% of the surveyed people did not indicate their gender. Overall, 66.5% of the respondents (129 persons) farm in a conventional way, while 33.5% of the farmers surveyed (65 persons) farm in an organic way. In the case of the distribution of respondents by gender and farming mode, it is noticeable that 52.6% of women farm organically, but only 27.4% of men (Table 1). It is therefore not surprising that there are statistically significant differences between men and women in the type of farming they practice ($\chi 2$ test, p-value = 0.007 *, Table 2).

In terms of age categories, the category of the age under 35 dominates (39.2%, Table 1). The age of the respondents does not affect the type of farming chosen ($\chi 2$ test, p-value = 0.637, Table 2).

The surveyed farmers most often live in the smallest municipalities with up to 500 inhabitants (45.4%) or in municipalities with 501 to 1000 inhabitants (22.2%, Table 1). The proportions of organic and conventional farming are very balanced between the size categories of the municipalities, but statistical verification of the differences was not possible due to the large number of underrepresented categories. For the same reason, it was not possible to test for differences in farming methods across regions in the CZ; however, the trend of predominantly conventional farming in all regions in Table 1 makes the Královehradecký region stand out more strongly, where 7 out of 11 respondents farm organically.

Another question looked at the highest level of education attained. Overall, most respondents had a secondary school education with a high school diploma (36.6%), followed by a master's degree (33%). Although the values in Table 1 show a slightly higher proportion of university-educated farmers using organic farming, the use of organic or conventional farming does not depend on the educational level of the respondents ($\chi 2$ test, p-value = 0.130, Table 2).

Statistically significant differences can be observed in the case of the question whether the respondents' field of education is related to the type of farming in which the respondents are engaged ($\chi 2$ test, p-value = 0.029 *, Table 2). Respondents who were educated in agriculture are significantly more likely to be engaged in conventional farming compared to respondents without agricultural education (Table 1). Of those educated in agriculture, 71.3% of respondents farm conventionally. Agricultural education does not lead to the adoption of alternative farming methods, as by default, they are not part of the curriculum.

Table 1. Sociodemographic data of respondents by farming mode.

Sociodemographic Data		In What Mode Do You Mainly Manage?				Total	
		Organic Farming		Conventional Farming			
		n	%	n	%	n	%
Total		65	100.0%	129	100.0%	194	100.0%
Gender	I do not want to state	5	7.7%	5	3.9%	10	5.2%
	Man	40	61.5%	106	82.2%	146	75.3%
	Woman	20	30.8%	18	14.0%	38	19.6%
What age category do you belong to?	up to 35 years	24	36.9%	52	40.3%	76	39.2%
	35–49 years old	27	41.5%	44	34.1%	71	36.6%
	50–64 years old	11	16.9%	29	22.5%	40	20.6%
	over 65 years old	3	4.6%	4	3.1%	7	3.6%
What is the size of your permanent residence?	up to 500 inhabitants	30	46.2%	58	45.0%	88	45.4%
	501–1000 inhabitants	11	16.9%	32	24.8%	43	22.2%
	1001–2000 inhabitants	6	9.2%	15	11.6%	21	10.8%
	2001–5000 inhabitants	6	9.2%	11	8.5%	17	8.8%
	5001–10,000 inhabitants	4	6.2%	7	5.4%	11	5.7%
	10,001–100,000 inhabitants	3	4.6%	3	2.3%	6	3.1%
	100,001–500,000 inhabitants	1	1.5%	1	0.8%	2	1.0%
	over 500,001 inhabitants	4	6.2%	2	1.6%	6	3.1%
In which region do you mainly farm?	Central Bohemia	10	15.4%	28	21.7%	38	19.6%
	Pilsen	10	15.4%	26	20.2%	36	18.6%
	South Bohemia	8	12.3%	18	14.0%	26	13.4%
	Highlands	5	7.7%	8	6.2%	13	6.7%
	Královehradecký	7	10.8%	4	3.1%	11	5.7%
	Ustecký	5	7.7%	5	3.9%	10	5.2%
	Zlín	1	1.5%	9	7.0%	10	5.2%
	South Moravian	5	7.7%	4	3.1%	9	4.6%
	Olomouc	4	6.2%	5	3.9%	9	4.6%
	Moravian-Silesian	4	6.2%	4	3.1%	8	4.1%
	Karlovy Vary	1	1.5%	6	4.7%	7	3.6%
	Liberec	2	3.1%	5	3.9%	7	3.6%
	Pardubice	2	3.1%	5	3.9%	7	3.6%
	Capital City of Prague	1	1.5%	2	1.6%	3	1.5%
Your highest level of education?	Secondary education–teaching certificate	5	7.7%	24	18.6%	29	14.9%

Table 1. *Cont.*

Sociodemographic Data		In What Mode Do You Mainly Manage?				Total	
		Organic Farming		Conventional Farming			
		n	%	n	%	n	%
Your highest level of education?	Secondary school–high school diploma	23	35.4%	48	37.2%	71	36.6%
	Bachelor's degree	10	15.4%	20	15.5%	30	15.5%
	Master's	27	41.5%	37	28.7%	64	33.0%
Is your field of education related to agriculture?	Yes	39	60.0%	97	75.2%	136	70.1%
	No	26	40.0%	32	24.8%	58	29.9%

Table 2. $\chi 2$ test for independence in contingency table.

Sociodemographic Characteristics	Test Criterion	Degrees of Freedom	*p*-Value
Gender	9.906	2	0.007 *
What age category do you belong to?	1.701	3	0.637
What is the size of your permanent residence?		X	
In which region do you mainly farm?		X	
Your highest level of education?	5.648	3	0.130
Is your field of education related to agricultural activities?	4.761	1	0.029 *

Note * statistically significant relationship at $\alpha < 0.05$ significance level.

Table 3 shows the average distances of cultivated land from the respondents' residence. Organic farmers live on average 6.1 kilometres from their cultivated land, while conventional farmers live on average 8.1 kilometres from their fields. Based on the test conducted (Mann–Whitney test, *p*-value = 0.002 *, Table 3), we reject the hypothesis tested. There are statistically significant differences in farming practices depending on the distance of the respondents' residence from their farmed land. Farmers who practice organic farming live closer to their land.

Table 3. Distance of the respondents' residence from their cultivated land.

What is the Average Distance (km) between Your Home and the Farmland You Farm?		In What Mode Do You Mainly Manage?		
		Organic Farming	Conventional Farming	Total
Number of respondents		65	129	194
Average distance		6.1	8.1	7.4
Minimum		0.0	0.0	0.0
Maximum		100.0	150.0	150.0
Directional deviation		14.0	14.5	14.3
Stand. diameter error		1.7	1.3	1.0
Shapiro–Wilk test	Test criterion	0.398	0.412	0.420
	p-value	<0.001 [1,*]	<0.001 [1,*]	<0.001 [1,*]
Mann–Whitney test	Test criterion		320.0	
	p-value		0.002 *	

Note: [1] data from non-normal distribution; * statistically significant relationship at $\alpha < 0.05$ significance level.

3.2. Respondents' Attitudes towards Growing Trees on Agricultural Land

The next part of the questionnaire assessed the respondents' attitudes towards the cultivation of trees on their managed land. A total of 72.7% of respondents stated that they have woody plants on their farmland, but do not grow them purposefully. In terms of the functional form of the arrangement of trees, most respondents (56.2%) prefer a linear type of greenery, followed by flat elements such as game refuges and groves (30.9%). Only 12.9% of respondents prefer solitudes, i.e., individual trees or small group of trees. Respondents prefer deciduous trees (49.5%) or mixed stands (46.9%) on their agricultural land. Only a minimum of respondents prefers coniferous trees.

3.2.1. Reasons for Growing Woody Plants on Cultivated Land

The purpose of monitoring the reasons for the presence of trees on agricultural land was to find out why farmers plant trees on their land and therefore which ES they prefer. Only respondents who have trees on their land (141 persons) answered the question. They were allowed to give more than one answer. The results are shown in Figure 1.

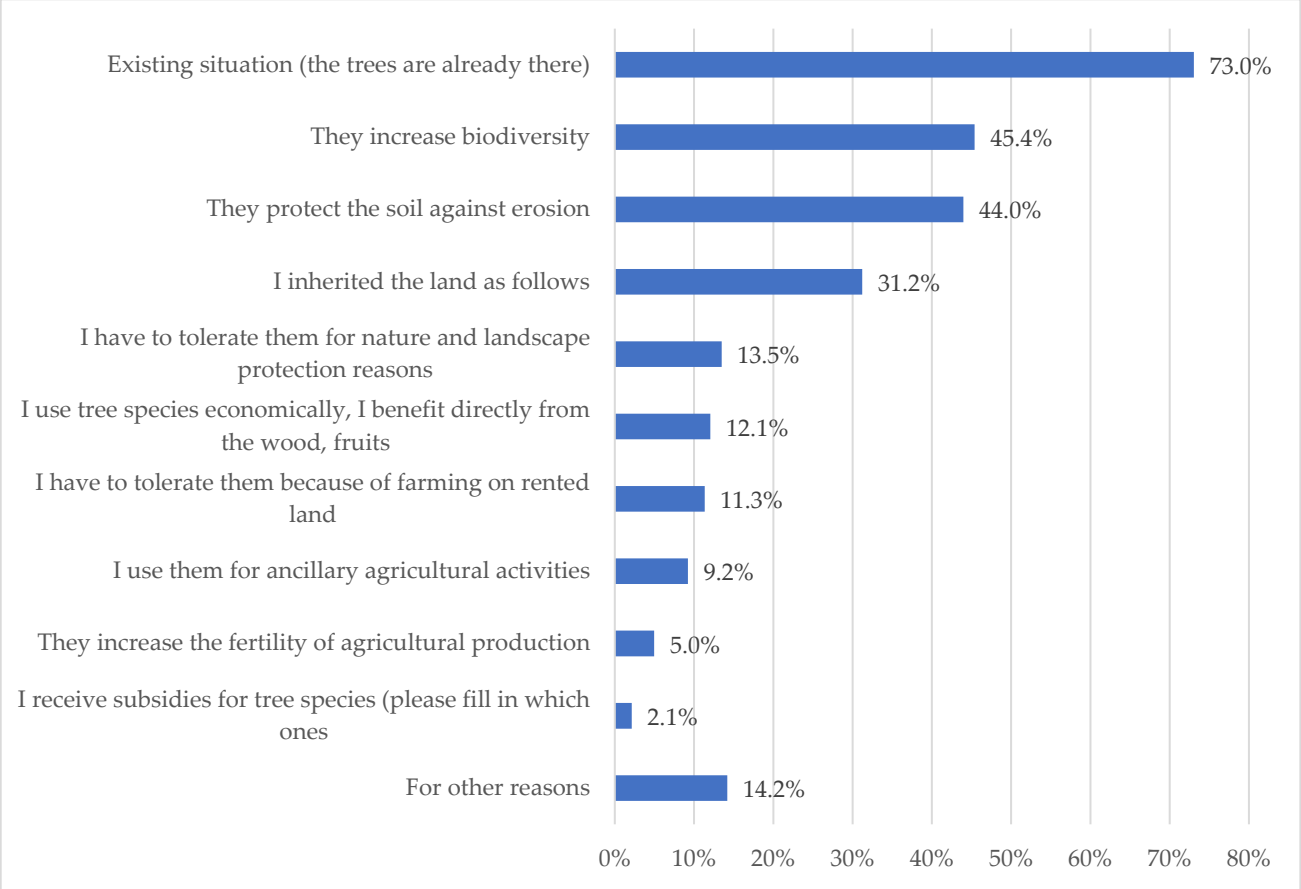


Figure 1. Reasons for growing trees on cultivated land (multiple choice; n = 141).

The most frequent reason for the presence of trees on agricultural land, answered by 72.7% of the respondents, is the fact that they are already growing there (they occurred spontaneously, historically or as a result of someone else's activity). The second most frequently cited reason is the desire to increase biodiversity, and the third reason is to protect the soil from erosion. Other reasons are shade for grazing animals, a source of fruit (for respondents and for domestic and wild animals), and the use of trees as a natural barrier to cattle escaping from the pasture or as a private hedge. Trees are also managed by respondents for beekeeping.

3.2.2. Reasons Not to Grow Woody Plants on Cultivated Land

This question was answered only by respondents who do not grow woody plants on their land (53 persons). The responses are shown in Figure 2. The most frequent reason why respondents do not have trees on their land is foreign ownership of the land (56.6%). Farmers only have rented land under cultivation—they do not arbitrarily decide to plant trees. The second most common reason is the obstacle of cultivating land that would have to be traversed by machinery during farming, which reduces labour efficiency (47.2%). The third most common reason is competition between crops and trees in terms of obtaining resources (water, light) (32.1%). Other reasons included the view that trees simply do not belong in the fields, changes of ownership are taking place, or too small areas of land are being cultivated where it is not worthwhile.

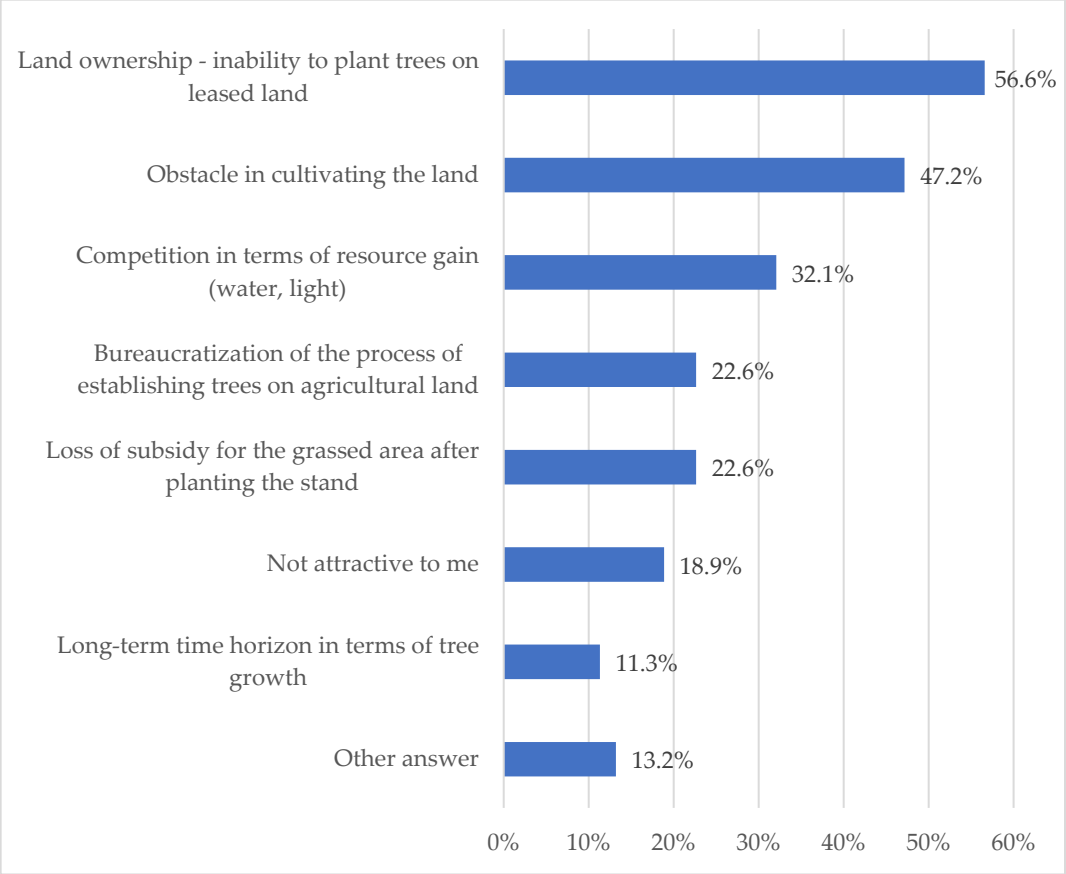


Figure 2. Reasons for not growing trees on cultivated land (multiple choice; n = 53).

3.2.3. The Most Important Problems of Planting Trees on Agricultural Land

The most important problems of tree planting on agricultural land from the farmers' point of view are shown in Figure 3. They were surveyed separately to allow for an evaluation of the list of detected reasons in terms of importance. According to the respondents, these are mainly obstacles to cultivation and the impossibility of planting a tree on rented land. Another important reason is the loss or reduction of entitlement to subsidies, which would occur by reducing the area of land financed. Other responses included the view that if they decide to plant trees, their successors will have a problem cutting down the trees afterwards (nature protection law), i.e., overall, they see the problem as nature protection legislation, and then as unconvincing arguments as to why this should be beneficial to them. Possible damage to trees because of livestock grazing was also mentioned.

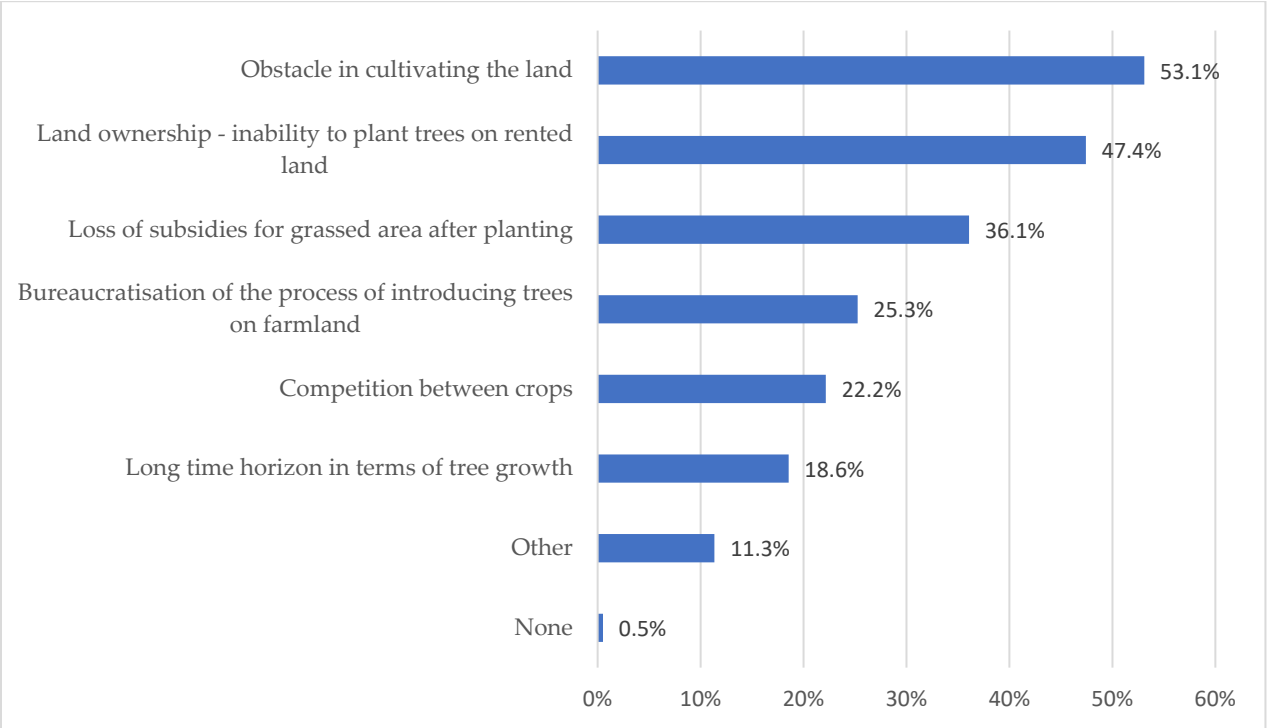


Figure 3. The most important problems of planting trees on agricultural land (multiple answers; n = 194).

3.2.4. Knowledge of the Content of the Agroforestry Concept

More than half of the farmers surveyed (52.1%) had never heard of the term agroforestry. Only respondents who were familiar with the term (93 persons) went on to answer open-ended questions. The answers to the question of what respondents specifically understood by agroforestry showed that the term agroforestry was not sufficiently familiar to many respondents. Although there was a consensus that it was a combination of farming and planting trees around fields, some farmers defined agroforestry as tree planting only, while other farmers spoke, for example, of fast-growing trees only, of coniferous planting in combination with conventional farming, of a combination of separate forest and farmland management by one entity, or agroforestry was seen as a new term for conventional forestry—land management where the "crop" is trees.

Selected respondents who had heard of the concept of agroforestry were also asked to indicate whether they would be willing to plant trees on agricultural land, and if so, on what kind of land—leased or privately owned. The results are shown in Figure 4. If respondents would plant trees, it would only be on their own land (53.8%). Overall, 38.7% of respondents are not interested in planting. Only 12.9% of respondents already farm in this system, and the same proportion of respondents would establish it on leased land.

3.2.5. Motivation to Grow Trees in the Context of Long-Term Sustainability of Management and Experience of Forest Ownership

Another aspect identified was the potential motivation of farmers to grow trees with the aim of long-term sustainability of farming, which would be ensured by the ES provided by the trees. Just under 73% of respondents plan to farm for the long term, while 59.8% of them want to pass the farm on to the next generation. Only 18.6% of respondents see the farm as an investment (36 persons). Responses also included the motivation to farm to try to change and develop the landscape. The main reason for continuing and sustaining farming is tradition—caring for the heritage acquired and passed on—has historically been a very strong motivation for good stewardship.

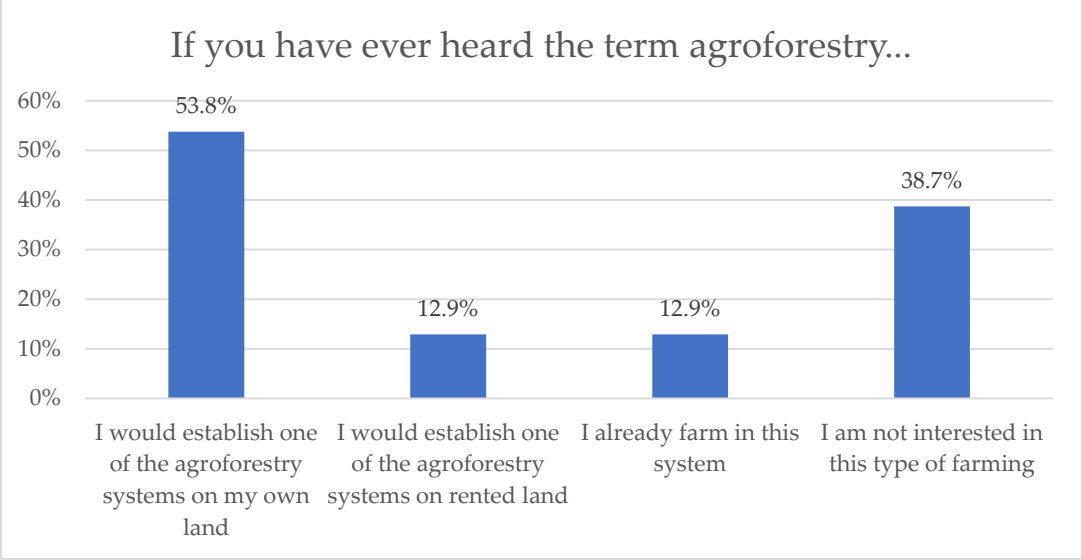


Figure 4. Willingness to establish agroforestry systems (multiple choice; n = 93).

More than half (54.6%) of the respondents are also forest owners. The most common reason why respondents own a forest is that the forest was part of their heritage (66%). The forest was also often an integral part of the farmland that respondents bought. It was asked whether forest ownership was related to the total amount of directly owned farmland. From a historical perspective, there is an assumption that farmers who acquired their fields as part of their inheritance always received a portion of forest in addition to their land, while farmers who rent their land no longer own forest in addition to their land because they are not interested in forest management. The results of the values are shown in Figure 5. Based on the test conducted ($\chi 2$ test, p-value = 0.023 *), we reject the tested hypothesis. Farmers who own forest have higher shares of privately owned land than farmers who do not own forest. The assumption of a historical relationship between agriculture and forestry is confirmed.

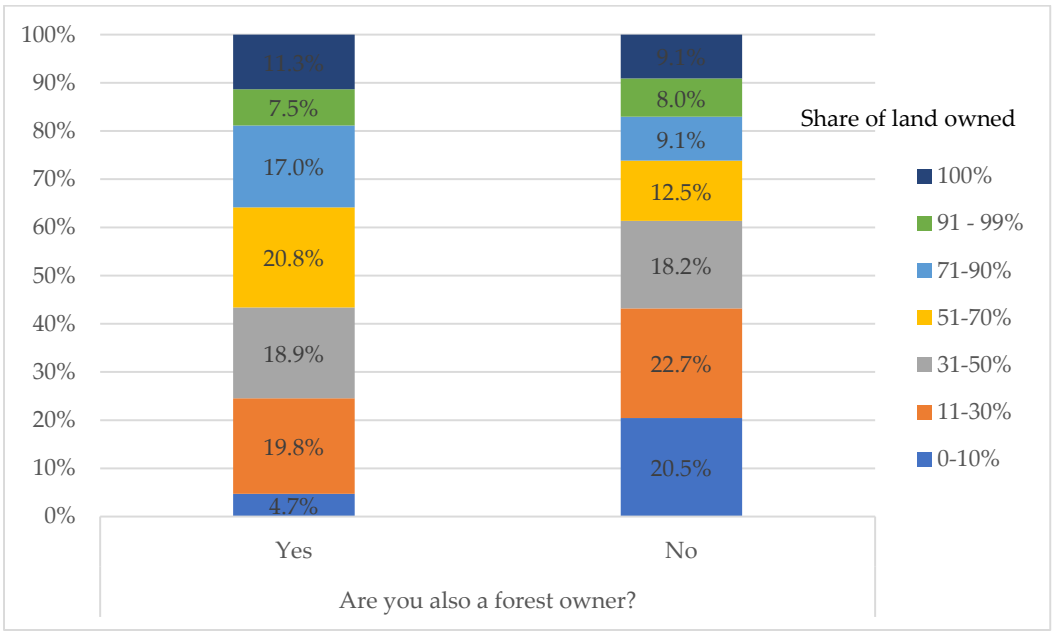


Figure 5. Percentage of land in private ownership by forest ownership.

3.3. Perception of the Importance of Ecosystem Services in Agroforestry with Emphasis on Windbreaks

Respondents were asked to subjectively rate the importance of individual ecosystem services that trees growing on agricultural land are able to provide. Windbreaks were distinguished separately from other spatially and functionally different forms of tree planting. The millennium ecosystem assessment [10] classification scheme was used to classify ecosystem services. Four basic categories of ecosystem services were identified—provisioning, regulating, supporting and cultural.

Respondents rated the importance of each ecosystem service on a Likert scale from 1 to 5 (1 = low importance, 5 = high importance). The average results are shown in Table 4.

Table 4. Perceived importance of windbreaks and other forms of trees on agricultural land.

The Importance of Trees and windbreaks in Agricultural Landscapes	Importance of Tree Species of Different Forms	The Importance of Windbreaks	Wilcoxon Matched Pairs Test	
			Test Criterion	*p*-Value
Provisioning services	3.0	2.6	−6.116	<0.001 *
Groundwater recharge, provision of drinking water	3.8	3.2	−6.164	<0.001 *
Increase production of pastures, crops, livestock	2.9	3.0	−1.621	0.105
Source of firewood	2.9	2.4	−4.978	<0.001 *
Source of wood and fibre for the timber industry	2.2	2.0	−1.563	0.118
Source of medicines in the form of herbs, herbal supplements	2.7	2.4	−4.763	<0.001 *
Food source, e.g., fruits, nuts, mushrooms	3.3	2.7	−6.944	<0.001 *
Regulating services	3.9	3.7	−2.536	0.011 *
Ability to purify surface water	3.7	3.3	−5.026	<0.001 *
Ability to reduce surface runoff	4.2	3.8	−5.690	<0.001 *
Soil erosion reduction	4.3	4.2	−1.483	0.138
Reducing flood risk or increasing the resilience of the landscape to drought	4.1	4.0	−1.288	0.198
Reduction of pests and diseases in crops and livestock	3.0	3.0	−0.169	0,865
Water retention in the landscape	4.2	3.9	−4.569	<0.001 *
Ability to provide odour screen, dust capture, noise protection	3.6	3.9	−3.843	<0.001 *
Support services	4.2	3.8	−5.733	<0.001 *
Providing shelter for different species of animals	4.3	3.9	−4.739	<0.001 *
Maintaining the genetic diversity of the landscape	4.1	3.7	−4.850	<0.001 *
Cultural services	3.5	3.2	−4.916	<0.001 *
Creating landscapes, providing scenery and scenic landscapes	4.0	3.6	−5.589	<0.001 *
They represent traditional features of the historical landscape (legends, fairy tales, traditions, customs	3.4	3.2	−2.307	0.021 *
Leisure activities (sports, hunting, hiking, etc.)	3.2	2.9	−3.585	<0.001 *

* statistically significant differences at the $\alpha < 5\%$ significance level.

Reducing soil erosion and providing space and shelter for different species were considered the most important ESs across all forms of tree arrangement (mean rating for both services 4.3). In the case of self-rated windbreaks, reducing soil erosion (mean 4.2) and

reducing flood risk or increasing landscape resilience to drought (mean 4.0) were perceived as most important.

The average importance rating by basic ES category is ranked the same for all forms of tree planting on agricultural land. For windbreaks and other forms of tree planting, support services are rated as most important, followed by regulating services. Cultural services appear to be the less important, and provisioning services the least important (Figure 6).

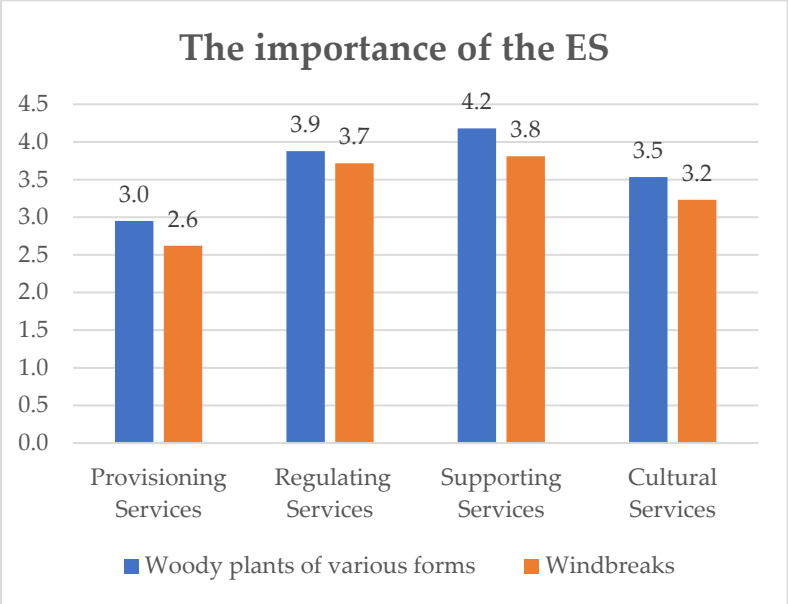


Figure 6. Comparison of the importance of different ES categories for windbreaks and other forms of tree planting on agricultural land.

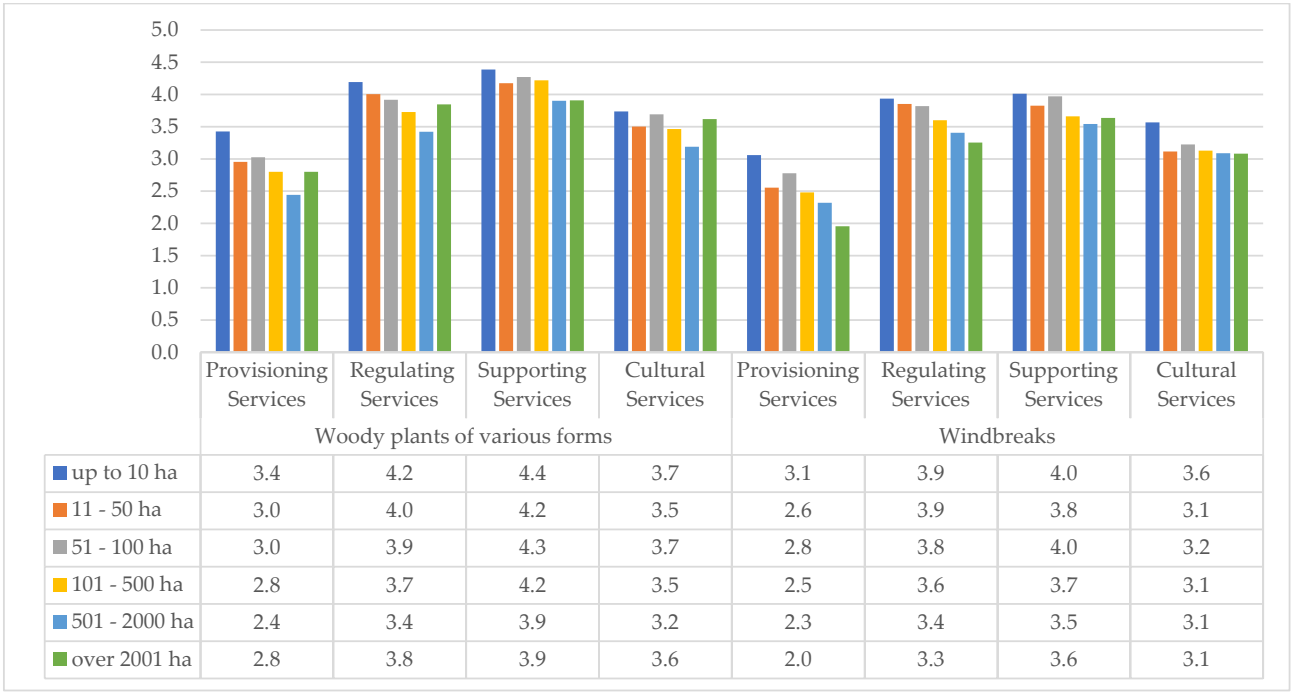
Ratings of the perceived importance of ES provided by windbreaks and other forms of woody plants differed statistically significantly (Wilcoxon paired test) for almost all ESs, except increased production of pasture, crops, and livestock (p-value = 0.105); Source of wood and fibre for the timber industry (p-value = 0.118); reduction of soil erosion (p-value = 0.138); reduction of flood risk or increase in landscape resilience to drought (0.198); reduction of pests and diseases of crops and livestock (p-value = 0.865) (Table 4).

Figure 6 shows a slightly higher importance for other forms of tree planting compared to windbreaks in all categories. When testing for statistically significant differences between windbreaks and other forms of tree planting within the ES categories (Wilcoxon paired test), statistically significant differences were found in all four ES categories (provisioning services p-value <0.001 *, regulatory services p-value = 0.011 *, support services p-value <0.001 * and cultural services p-value <0.001 *) (Table 4).

Windbreaks are generally rated as less important for providing ecosystem services than other forms of tree planting on agricultural land.

3.4. The Influence of the Size of the Cultivated Area on the Evaluation of the Importance of ES in Agroforestry

It was investigated whether the perceived importance of ecosystem services was related to the size of the area managed by the respondents. Figure 7 shows that landowners with up to 10 ha of land perceive the importance of ES more than those with larger land areas, for all ES categories and for all forms of tree species growing on agricultural land.



	Woody plants of various forms				Windbreaks			
	Provisioning Services	Regulating Services	Supporting Services	Cultural Services	Provisioning Services	Regulating Services	Supporting Services	Cultural Services
up to 10 ha	3.4	4.2	4.4	3.7	3.1	3.9	4.0	3.6
11 - 50 ha	3.0	4.0	4.2	3.5	2.6	3.9	3.8	3.1
51 - 100 ha	3.0	3.9	4.3	3.7	2.8	3.8	4.0	3.2
101 - 500 ha	2.8	3.7	4.2	3.5	2.5	3.6	3.7	3.1
501 - 2000 ha	2.4	3.4	3.9	3.2	2.3	3.4	3.5	3.1
over 2001 ha	2.8	3.8	3.9	3.6	2.0	3.3	3.6	3.1

Figure 7. Average rating of the importance of ES in relation to the size of the cultivated land.

The results of the statistical analysis in Table 5 show that there is a statistically significant relationship between the perceived importance of the ES and the size of the cultivated land. Respondents' perception of the importance of almost all ecosystem services decreases as the size of the land managed by the farmer increases, both for windbreaks and other tree forms (the only exception is the category of cultural services for other tree forms, where no statistically significant difference was found (Spearman's correlation coefficient, *p*-value = 0.071, all other *p*-values < 0.05 *) (Table 5)).

Table 5. Spearman's correlation coefficient—ES rating by land size.

		Correlation Coefficient	*p*-Value
Woody plants of various forms	Provisioning services	−0.348	<0.001 *
	Regulatory services	−0.321	<0.001 *
	Support services	−0.171	0.017 *
	Cultural services	−0.130	0.071
Windbreaks	Provisioning services	−0.283	<0.001 *
	Regulatory services	−0.287	<0.001 *
	Support services	−0.167	0.020 *
	Cultural services	−0.158	0.028 *

Note * statistically significant difference at α < 5% significance level.

4. Discussion

Agroforestry as a concept of the use of land and landscape is undergoing constant evolution. The total area of agroforestry in the EU is about 15.4 million ha, corresponding to about 3.6% of its territorial area and 8.8% of agricultural land use, using the Lucas Land Use and Land Cover (LUCAS) database [80]. The basic idea of agroforestry is that the combination of trees and crops in a spatial or temporal arrangement leads to greater structural and functional complexity in comparison to traditional monoculture production [43], which is conditioned by the fulfilment of multiple ESs and multipurpose trees. Agroforestry has traditionally been an important element of the European landscape, but many of these systems have disappeared as a result of economic and social changes (land abandonment and agricultural intensification [63,64]). Promoting agroforestry at European level requires a better understanding of stakeholder perceptions [81]. The actual adoption of an AFS requires the identification of problems and a debate between the farmers, landowners, agricultural advisors, landscape engineers, technicians, environmental experts and representatives of government interests. A participatory discussion is an appropriate method to identify views and find common solutions, promoting a "shift" in the approach to ES evaluation from interdisciplinary to applied transdisciplinary socioecological sciences [82]. Moreover, this approach supports the growing trend of collaboration between scientists and non-scientific stakeholders in the field of sustainability. The results of the questionnaire survey yielded several interesting and stimulating results.

The sociodemographic characteristics of the farmers and their attitudes towards the issue were identified. The most preferred form of tree planting on farmland in the CZ is linear vegetation elements (56.2%). Farmers also prefer deciduous (49.5%) or mixed stands (46.9%). The most common reason for the presence of trees on farmland, according to the respondents, is that trees were already there before their arrival, followed by biodiversity enhancement and erosion control. This shows that farmers are not very interested in actively growing and planting trees on their land, they just leave it as it is. Historically, trees have been planted as landmarks on property boundaries, along roads, or have taken hold spontaneously on unmanaged stony or waterlogged areas. These areas are still passed over unnoticed by farmers today, even though they are aware that trees can perform some ecosystem functions.

Currently, agroforestry is not widespread in the CZ compared to other EU countries. This finding can be interpreted mainly by the historical development in the Czech lands, when land consolidation and agricultural intensification led to the removal of trees from agricultural land [62]. Research shows that land ownership is an obstacle to the adoption of innovative practices and the willingness and ability of farmers to adopt conservation measures on agricultural land [34,43,83,84]. The majority of farmers (73%) in the CZ currently farm on rented land [65]. The issue of investing time and money in rented land was the most frequently cited barrier to adopting any measures by respondents (56.6%). Planting trees can also mean tying up land for future use (mature trees are legally protected against felling) [51]. By contrast, in third-world countries, tree planting represents rights to agricultural land that are transferred to future generations [85]. It is therefore essential to also involve landowners in the process of implementing agroforestry systems. Awareness of farmers and landowners on the issue should be raised and conditions created for easier communication between them. Due to the large fragmentation of land holdings in the CZ [86,87], the implementation of AFS could require the consent of a larger number of landowners. It is crucial for the farmer, as the final implementer of the measures, that economic support measures are simple and can be considered as an alternative source of income. Before farmers decide to invest in an AFS, they should see examples that these practices are profitable and provide many other benefits.

Farmers also perceive tree planting on farmland as a physical obstacle to cultivation (47.2%). In particular, trees on arable land hinder mechanised cultivation and farmers deliberately remove or damage them with agricultural machinery [34]. Despite the trees representing a difficulty for the movement of farm machinery, and the size of farm machin-

ery may not be adapted to the width of the intercrops, it is necessary to design such a spatial layout that allows farmers to grow woody plants on arable land without damage. The shape and size of the field block, as well as the use of seeding and agronomic practices, are some of the economic aspects of AFS. Planting trees on fertile land is perceived by farmers as reducing yields from the land, and trees would only be planted on the edges of land, roads or boundaries where farming is difficult or impossible [51]. Current farmers often see AFS as difficult to manage, unproductive and unprofitable [88]. It is undoubtedly more difficult to establish an agroforestry system than to continue with conventional farming, but AFS can be adapted to a large extent to the possibilities and needs of the farmer and his land. The stated negatives stem rather from passive behaviour, insufficient knowledge of the issue and unwillingness to change anything.

To motivate farmers to establish more complex agroforestry systems compared to conventional farming, it is first necessary to thoroughly inform them about their purpose and raise their awareness of the benefits they provide [3]. Interestingly, more than half of the respondents had not encountered the term agroforestry at all (52.1%) or defined the term incorrectly. Lack of knowledge leads to incorrect assumptions. Alternative farming practices require the adoption and acquisition of new knowledge and skills that can be built in partnership with other knowledge systems [89]. Many farmers would be willing to consider AFS if they had more knowledge about its layout, profitability, benefits and practical know-how [51]. To promote agroforestry, it is advisable to include communication tools to share knowledge about agroforestry such as seminars, workshops, training programs and educational articles [3].

Most respondents want to manage agricultural land for the long term in the future (73%), while 59.8% of them want to pass the farm on to the next generation. Only 18.6% of respondents consider farming as an investment. More than half of the respondents are also forest owners (54.6%). It was found that those farmers who own a forest have a higher proportion of farmland in their ownership than those who do not own a forest. This confirms the assumption that agriculture, forestry and land ownership have a strong historical tradition in the Czech Republic. It can be assumed that the introduction of agroforestry systems could be easier through farmers with a higher proportion of their own land and experience in forestry, a situation that is particularly true for smaller farms.

Specifically, in terms of assessing the perceived supply of each ES tree species on agricultural land, respondents considered reducing soil erosion, providing cover for different species and reducing flood risk or increasing landscape resilience to drought to be the most important. Overall, the categories of regulatory and support services were identified as most important. Provisioning services were rated as least important. This view differs, for example, in Mediterranean regions where farmers report that the main benefit of agroforestry is to increase production, while farmers in northern Europe place emphasis on the environment [23]. The detected lack of emphasis on cultural ESs is also indicated by a similar assessment of ecosystem services in forestry, where cultural services were rated as least important [55]. Ecosystem services with specific impacts on natural processes and animals are generally perceived as more important compared to cultural services, which are difficult to quantify.

Another interesting finding was that when comparing the ES of windbreaks and other forms of tree arrangements growing on agricultural land, windbreaks always received a lower weighting, even though it was defined by stakeholders at the outset as the most common AFS in the CZ, and in terms of shape was ranked as the most preferred by respondents.

It is necessary to deepen and refine the awareness of our farmers and landowners about ecosystem services and landscape management practices to optimize the use of all landscape components. This is confirmed by the finding that the importance of individual ecosystem services from the perspective of farmers decreases statistically significantly with the size of the land they farm. It is likely that this view is the result of farming intensification and the loss of experience with an AFS [90]. Based on stakeholder interviews, there is

also a need to raise consumer awareness to favour agroforestry products despite higher prices, which would provide an incentive for farmers on a supply and demand basis [91]. Another tool for promoting AFS is to ensure a good image and information campaign, where there is a need to increase knowledge of the ES throughout society and to emphasise local solutions [51,88,91].

Establishing the objective geographic spread of agroforestry in Europe is essential for the development of supportive policies [80]. The spread of agroforestry practices is mainly known in southern European countries [92]. These are countries where farmers value the economic benefits (Dehesa in Spain and Montado in Portugal) [35]. Agroforestry is currently not widespread in central, northern and eastern Europe [92]. Its use is oriented to areas where the productive form of farming is limited by the nature of the soil, which cannot be cultivated with modern machinery, or where production is severely limited by drought (Mediterranean areas) or low temperatures (boreal and alpine areas). Overall, agroforestry is only practiced where it allows farmers to obtain economic returns from land that would otherwise be unproductive, suitable at most for forestry use [93]. Efforts should be made to introduce AFSs in northern European countries and to maintain existing systems in southern Europe.

The focus is shifting from the landscape level of agroforestry to the policy level, and much effort is being devoted to the environmental domain in particular, aiming to close the gap between agricultural, forestry and other sectoral policies [28]. Agroforestry in the EU takes place in the context of global strategic policies as described in the UN [94], the millennium development goals and the FAO [95]. In addition to these specific objectives, AFSs can help address a large number of initiatives at a European level, such as the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) [96], the European Landscape Convention [97], the European Climate Change Programme (ECCP) and Natura 2000 [51] and the Common Agricultural Policy (CAP). To promote agroforestry at the international level, the International Union for Agroforestry (IUAF) platform is dedicated to sharing agroforestry practices and research. In addition, the European Agroforestry Federation (EURAF) is active in Europe and promotes the use of trees on farms. Currently, agroforestry courses are organised within the Czech Republic to promote agroforestry. In addition, the Czech Republic has an agroforestry association (CSAL), which is a member of the European Forestry Federation (EURAF).

In the Czech Republic, there is no legislative anchor for the economic form of agroforestry on agricultural or forestry land. In order for this forestry–agriculture measure to be adopted, farmers and landowners (implementers of the measure) must be convinced that the benefits of AFS, and therefore their presence in the landscape, outweigh the costs of providing them [43]. Some farmers would adopt these agroforestry practices if there were economically viable, simple and targeted support measures. The issue of ES provision is an area of public interest that cannot be addressed by market functioning without public support. Agroforestry practices have been overlooked by previous CAP schemes, resulting in billions of trees being destroyed across Europe [98]. Recently, incentives for establishing AF plots have been introduced, but conflicts between pillar 1 and pillar 2 rules have prevented European farmers to establish or maintain agroforestry systems [98]. The subsidies that can currently be used are mainly for independent tree planting. However, none of these titles is primarily intended to support agroforestry. A new subsidy title should be announced in 2023 as part of the new CAP strategic plan. The 2023–2027 strategic plan will provide new mandatory and optional measures to encourage changes in land management that will contribute to a sustainable economy. Specifically, this will include a contribution to the establishment and maintenance of agroforestry systems [99]. This intervention will support the establishment of two types of agroforestry systems, namely silvoarable and silvopastoral, which will be registered by farmers in the land registry system of the Czech Republic (LPIS). Here, 100 trees per hectare will have to be planted, with more than 50% of the forest trees used, and no species may be represented in the planting area by more than 40% [90]. The new farm to fork strategy is also a new opportunity for support [6],

the European Green Deal [100], Biodiversity Strategy for 2030 [101] and the New Forestry Strategy for 2030 [102], in which the EU has committed to plant three billion trees by 2030 beyond current levels [103]. Czech legislation, which regulates only agricultural and forestry activities separately, should also respond to these European strategies.

5. Conclusions

A sustainable economy and the relationship between agroforestry and farmers' demand for ESs contribute to many of the Sustainable Development Goals set by the UN. Perceiving and assessing the supply of the different ecosystem services provided by trees growing in AFSs by farmers, as end-users of land in the CZ, allows the identification of problems and constraints, the solutions to which can then be incorporated into policy decision-making and the design of legislative, subsidy and information systems. Landowners were identified as an equally important group for the implementation of agroforestry in the CZ. Understanding farmers' and landowners' attitudes towards agroforestry, including socioeconomic aspects, is essential for development and sustainable management in the landscape. To enable an effective transition to more environmentally friendly farming systems, farmers and landowners need to be thoroughly informed about current environmental issues and alternative farming options and their environmental and economic benefits.

This study should help in promoting innovative approaches for a new national agricultural policy strategy to support supply and demand of individual ESs in agroforestry as one of the tools for climate change adaptation towards sustainable agricultural production.

A follow-up to this study will be to conduct a survey of supply and demand for ES in agroforestry among stakeholder groups such as farmers, technicians, legislators, etc. In addition, more EU stakeholders will be involved to get a more complete picture of country comparisons.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/f14010030/s1, QUESTIONNAIRE.

Author Contributions: Conceptualization, T.Č. and L.Č.; Formal analysis, T.Č. and R.S.; Funding acquisition, V.J; Investigation, T.Č.; Methodology, T.Č. and P.P.; Project administration, T.Č. and R.S.; Resources, T.Č. and L.Č.; Supervision, V.J.; Validation, T.Č. and L.Č.; Visualization, T.Č.; Writing—original draft, T.Č. and L.Č.; Writing—review and editing, T.Č., V.J. and P.P. All authors have read and agreed to the published version of the manuscript.

Funding: The research was funded by the CZ National Agency of Agricultural Research (NAZV) grant number QK21020371.

Data Availability Statement: Not applicable.

Acknowledgments: The authors wish to thank all the stakeholders who took part in this research and made it possible.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

AF	Agroforestry
AFS	Agroforestry system
CAP	Common Agricultural Policy
CAP SP	The Strategic Plan of The Common Agricultural Policy
CSAL	Czech Association for Agroforestry
CZ	Czech Republic
ECCP	European Climate Change Programme
ES	Ecosystem service
EU	European Union

EURAF	The European Agroforestry Federation
FAO	Food and Agriculture Organization of the United Nations
IUAF	International Union for Agroforestry
LUCAS	Lucas. Land Use and Land Cover
MEA	Milleninum ecosystem assessment
PEBLDS	Pan-European Biological and Landscape Diversity Strategy
SDGs	Sustainable Development Goals
TEEB	The Economics of Ecosystems and Biodiversity

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