Biological Conservation 256 (2021) 109065

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Policy analysis

Divergent farmer and scientist perceptions of agricultural biodiversity, ecosystem services and decision-making

Bea Maas [a,b,*], Yvonne Fabian [c,d], Sara M. Kross [e], Anett Richter [f,g,h]

[a] University of Vienna, Department of Botany and Biodiversity Research, Division of Conservation Biology, Vegetation Ecology and Landscape Ecology, Vienna, Austria
[b] University of Natural Resources and Life Sciences, Institute of Zoology, Vienna, Austria
[c] University of Göttingen, Department of Crop Sciences, Agroecology, Göttingen, Germany
[d] Federal Department of Economic Affairs, Education and Research EAER, Agroscope, Agroecology and Environment, Reckenholzstrasse 191, Zurich, Switzerland
[e] Columbia University, Department of Ecology, Evolution and Environmental Biology, New York, USA
[f] Thünen - Institute of Biodiversity, Braunschweig, Germany
[g] Helmholtz Centre for Environmental Research (UFZ), Department of Ecosystem Services, Leipzig, Germany
[h] German Centre for Integrative Biodiversity Research (iDiv), Halle-Jena-Leipzig, Leipzig, Germany

ARTICLE INFO

Keywords:
Agri-environment schemes
Conservation actions
Ecosystem services
Implementation gaps
Knowledge exchange
Stakeholder perceptions
Transdisciplinary communication

ABSTRACT

Biodiversity-friendly management is pivotal for sustainable agriculture, but rarely put into practice by farmers despite mounting evidence of the social, environmental, and economic benefits of such practices. We investigated the reasons for this implementation challenge by conducting a transdisciplinary survey to identify differences between perceptions of 208 farmers and 98 environmental scientists from Germany and Austria toward biodiversity, ecosystem services and the decision-making processes shaping agricultural landscapes. Perceptions of biodiversity, agri-environment schemes and conservation measures differed significantly between scientists and farmers. While scientists valued scientific information as more important for agricultural decision-making, farmers valued government and agricultural-sector information sources. We found more "biodiversity-positive" perceptions in female-, organic-, and more highly-educated-farmers, highlighting opportunities for more targeted promotion of conservation schemes. Survey respondents were generally younger than the population averages for both farmers and scientists, and our results therefore provide important insights for the future of biodiversity-friendly farming and related conservation science. Our findings demonstrate the urgent need for enhanced communication platforms and cooperation between scientists and key agricultural stakeholders to establish open dialogues between agricultural research, practice, and policy.

1. Introduction

Agricultural expansion and intensification are major drivers of biodiversity loss and biotic homogenization worldwide (Kehoe et al., 2017). This not only compromises global conservation goals, but also undermines the provisioning of many ecosystem services upon which agricultural communities and general society depend (Bommarco et al., 2013). Government programs that encourage farmers to incorporate biodiversity-friendly farming practices therefore provide a critical opportunity to promote biodiversity conservation and farming practices aligned with global sustainability goals (Kross et al., 2018; Pe'er et al., 2019; Pe'er et al., 2020). However, the implementation of biodiversity-friendly techniques and strategies into farming practices remains a central challenge for conservation and sustainability despite ample scientific evidence of socio-ecological benefits, extensive funding, and infrastructure (Maas et al., 2019; Schneider et al., 2019; Concepción et al., 2020).

In the European Union (EU), a Common Agricultural Policy (CAP) has been enacted to achieve higher sustainability in EU agriculture by providing financial support to farmers through agri-environment schemes (AES). The EU CAP budget for 2021–2027 is 365 billion EUR, a third of the overall EU budget for this period (EC, 2018). AES funds support the design and implementation of agri- environment measures to meet objectives such as the protection or enhancement of

* Corresponding author at: University of Vienna, Department of Botany and Biodiversity Research, Division of Conservation Biology, Vegetation Ecology and Landscape Ecology, Vienna, Austria.

E-mail addresses: bea.maas@univie.ac.at (B. Maas), yvonne.fabian33@agroscope.admin.com (Y. Fabian), saramaekross@gmail.com (S.M. Kross), anett.richter@thuenen.de (A. Richter).

https://doi.org/10.1016/j.biocon.2021.109065
Received 31 July 2020; Received in revised form 1 March 2021; Accepted 5 March 2021
Available online 16 March 2021
0006-3207/

biodiversity, improving landscape/habitat quality, or climate change mitigation (Concepción et al., 2020; Ekroos et al., 2019). AES also seek to strengthen ecosystem resilience - the ability of an ecosystem to absorb various disturbances and reorganize to maintain critical ecological functions and ecosystem services (Sasaki et al., 2015). However, AES have often been criticized for ineffectiveness due their prescriptive nature and design, including inflexible payment conditions, poor targeting, and a low priority put on scientific evidence (Batáry et al., 2015; Pe'er et al., 2017; Arnott et al., 2019; Ekroos et al., 2019; Pe'er et al., 2020).

Increasing participation in AES presents a key challenge for the conservation of agricultural biodiversity and associated ecosystem services (Arnott et al., 2019; Concepción et al., 2020), which are under increasing threat worldwide (Aizen et al., 2019; Sánchez-Bayo and Wyckhuys, 2019). In most countries that support AES-type programs, participation by individual farmers is voluntary (Batáry et al., 2015). Farmer decisions to participate in AES are influenced by financial, social, and administrative factors (Wilson and Hart, 2000; Schroeder et al., 2013), all of which often outweigh ecology-based motivations to participate (Zinngrebe et al., 2017).

In the EU, the uptake and strength of AES vary considerably between regions and countries (Arnott et al., 2019; Pe'er et al., 2020), in part because of information gaps and the lack of transdisciplinary communication and collaboration between science and practice (Bommarco et al., 2013; Fabian et al., 2019). Little is known about how different assessments and perspectives on biodiversity, ecosystem services, and conservation among agricultural stakeholders from science and practice influence AES implementation strategies (Teixeira et al., 2018; Kleijn et al., 2019). Potential mismatches in perceived economic or environmental impact of biodiversity and ecosystem services may explain different behaviours and views with regard to agricultural decision-making (Mills et al., 2017; Fabian et al., 2019; Kleijn et al., 2019). For example, long-term AES participation data indicate that increased farming experience and access to information, as well as individual demographic factors, such as higher education and attitudes toward biodiversity, are associated with conservation-oriented motivations of farmers (Lastra-Bravo et al., 2015; Gatto et al., 2019).

Peer-reviewed publications and scientific conferences are often ineffective for broader science communication (Chavarro et al., 2017; Bertuol-Garcia et al., 2018). Farmers obtain information on agricultural biodiversity and management from different sources (e.g., scientists, national ministries, agricultural societies, NGOs, colleague networks) and through different formats (e.g., verbal communication, scientific- or popular- publications), with each playing varying roles in decision-making processes (Fabian et al., 2019; Villamayor-Tomas et al., 2019). Inevitably, some relevant information is not considered in agricultural decision-making processes because of differences in availability and accessibility (Fabian et al., 2019). Differing perceptions of information sources and formats also seem to play an important role in their uptake (Chavarro et al., 2017; Bertuol-Garcia et al., 2018; Piñeiro et al., 2020). Thus, improved understanding of scientists' and farmers' underlying values and perceptions of biodiversity, ecosystem services and conservation measures is crucial for the design of more effective communication and AES implementation (Wardropper et al., 2020). In this study, we address current debates on the (interconnected) roles of education, environmental conservation schemes, and science communication for the future of biodiversity-friendly, sustainable farming (Carlisle et al., 2019; EC, 2019; Franić and Kovačićek, 2019). To identify key drivers and topics for the assessment of targeted conservation and future implementation trajectories (Kross et al., 2018; Maas et al., 2019), we studied the perceptions of young professional farmers and scientists of agricultural biodiversity and decision-making with regard to demographic factors.

We conducted a survey with farmers and environmental scientists in Germany and Austria, the two countries in the EU with the highest per-ha contributions to the Common Agricultural Policy's AES (Batáry et al., 2015). Our survey was designed to test four hypotheses: (**H1**) Farmer perceptions differ depending on their education level and gender (Kross et al., 2018); (**H2**) organic farmers, compared to conventional or dual-approach farmers, are more likely to have positive perceptions of biodiversity and environmental conservation schemes (Kross et al., 2018); (**H3**) farmers perceive scientific publications or presentations as having low importance for agricultural decision making, compared to more public information sources (Fabian et al., 2019); and, (**H4**) in contrast to scientists, farmers value ecosystem services that are more closely related to agricultural management and production more (Kleijn et al., 2019).

2. Methods

2.1. Survey instrument and questions

Our transdisciplinary survey instrument integrated data and approaches from the fields of agroecology, ecology, conservation, communication and social sciences. Three topics were defined for the creation of a web-based survey: (i) Assessment of the perceived "importance" of biodiversity and ecosystem services (distinguishing between production-oriented and ecosystem resilience-oriented assessment of ecosystem services); (ii) assessment of the perceived "effectiveness" of AES and conservation measures, and (iii) assessment of the perceived "importance" of different information sources and modes of information transfer for agricultural decision-making processes. For each topic, a coherent group of questions (scale) consisting of different sub-questions (items) was defined, based on existing literature and a pilot survey with agricultural scientists and farmers to define the final set of scales and items. The quality of the final survey was checked by testing item reliability and correlation before the survey was distributed.

We chose to focus on Germany and Austria for four reasons. First, as part of the EU CAP, both countries are subject to the linked requirements for food production, community development and sustainable agriculture (Batáry et al., 2015). Second, over 40% of both countries' land is dedicated to agriculture, allowing us to target a large population of farmers. Germany is, due to its large land surface area (348,672 km^2), among the leading EU countries for overall organic farming area (EC, 2020). While Austria, with a much smaller land surface area (82,445 km^2), leads the EU in proportion of arable land using organic farming. Third, both countries belong to the German-speaking region of Central Europe, allowing us to target a large population of farmers in a single-language survey. Finally, we (BM YF and AR) have access to nation-wide networks of scientists and farmers in both countries through longstanding working groups, and were therefore able to reach farmers across all agriculturally relevant areas in both countries (Fig. A1) within applicable privacy and data protection policies of the EU.

For the dissemination of the survey, we approached 81 representatives of national and international networks of environmental scientists and farmers in Austria and Germany. Between April and July 2018 (before the main harvesting season starting in August), 72 of these contacts distributed the survey through their networks via email. Details on the survey design and distribution are provided in Online Panel A1. The invited participants took part in the survey via the online platform SurveyMonkey. The survey consisted of 13 online pages, including a cover page, 11 pages for individual scales and items and a final page. Each survey scale contained 4 to 10 items to which the participants assigned perceived importance along a Likert scale (not important; less important; neutral; important; very important). Participants were instructed to use neutral for "no tendency" or "it depends" views and to not provide an answer if they did not wish to answer or did not know what to answer. We collected demographic data from each respondent on occupation, age, gender, and education level. Each question and the final survey page allowed the respondents to provide comments.

To account for uncertainty and potential bias in this convenience sampling method, we applied some precautions and controls before the data analyses: (i) distributing the survey via 72 networks to achieve higher levels of diversity and sample size in our survey, representing the largest available sample of both scientists and farmer perceptions on agricultural biodiversity available to date; (ii) controlling spatial representativeness through spatial analyses of 132 provided respondent postcodes, showing a broad spatial distribution of participants mostly from agricultural areas in both countries (Table A1); and, (iii) controlling demographic representativeness by comparing our survey sample to EU-census data of farmers (Table A1) and scientists (Table A2), showing a high level of representativeness for gender and a higher representation of younger age groups compared to the overall populations, presumably through the web-based survey approach. In addition, sampling bias was avoided through (iv) the participants' self-identification with occupational groups of farmers and scientists, (v) increased sample size and diversity through repeated survey distributions over the four-month survey period, allowing single IP-addresses only once per survey and indicating that participants should complete the survey only once; (vi) a feasibility and impact assessment (Table A3); (vii) reliability analyses of item-total correlation corrected for item overlap and scale reliability for each item and scale (Table A4); and, (vii) cross-validation of randomly selected halves of the data set, revealing no significant differences to our selected approach.

2.2. Data analyses

We received 208 responses from farmers and 98 responses from scientists. All data was analysed in R version 3.4.3 (R Core Team, 2017). We tested item reliability and correlation with Cronbach's Alpha for internal validity (Table A4). The Cronbach alpha was near or above 0.70 for most scales, representing a good level of fit (e.g., Cortina, 1993). We tested for collinearity of socio-demographic variables with Chi^2-tests and selected uncorrelated final variables (i.e., age was highly correlated to education level and therefore not analysed separately). We used visual examination of explanatory demographic variables to confirm normality of residuals and homoscedasticity of variances. We analysed responses of all farmers (n = 208) and scientists (n = 98) with respect to socio-demographic variables. Responses to the question on participants' highest completed educational level were grouped into 'higher education' beyond school level (apprenticeship, college, university studies or

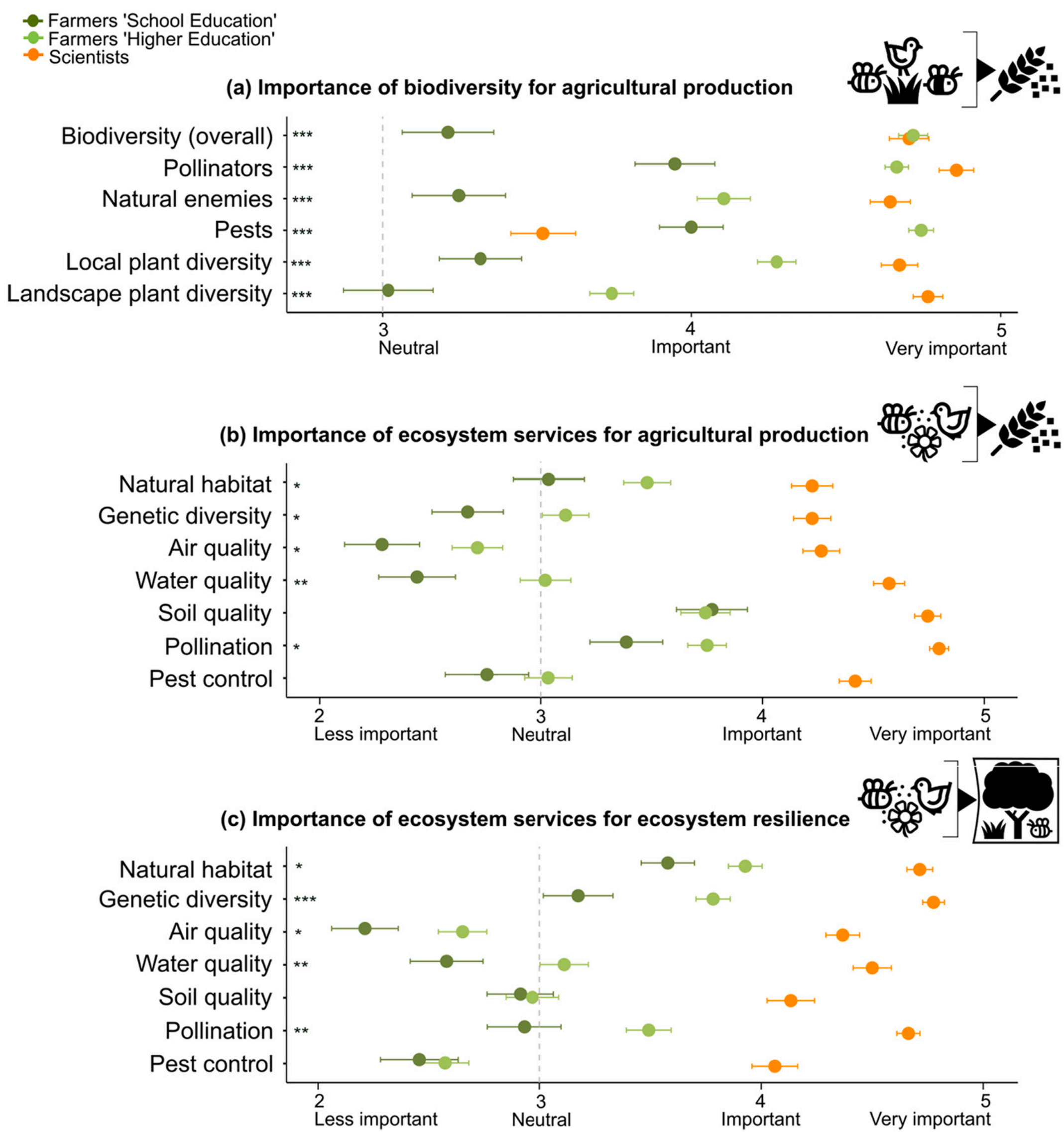

Fig. 1. Opinions of farmers and scientists toward the (a) importance of biodiversity, and (b) ecosystem services for agricultural productivity or (c) ecosystem resilience. Lines show ±1 standard error of the mean response. Significance levels from ANOVA's with Scheffé multiple comparison tests (*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$) are provided for differences related to farmer education level (Table S5). Only the range of the Likert scale in which responses were provided is shown, and the neutral response level is indicated by a dashed line.

PhD) and 'school education' (compulsory school, secondary school or high school). There were no significant differences in educational level, age, or gender between Germany and Austria, and therefore, differences at country level were not further investigated.

To analyse differences in farmer perceptions compared to scientists, we used ANOVA models with Scheffé's multiple comparison tests (Sullivan and Artino, 2013). Scheffé tests not only allow for comparison across groups with multiple categories but are also conservative since they reduce the likelihood of a Type-I error. The ANOVA models included a two-way comparison of the demographic variables for occupation (farmer, scientist), farmer education (school education, higher education), farmer gender (female, male), and farming approach (conventional, dual, organic). Results are presented as means (±1 standard error) based on Likert scale values (1 = not important, 2 = less important, 3 = neutral, 4 = important, 5 = very important).

3. Results

3.1. Differences within farmer perceptions

3.1.1. Education level

Farmers who completed higher education levels (n = 151) attributed much greater importance to biodiversity and associated ecosystem services than farmers who completed school-education levels (n = 57; H1, Fig. 1, Table A5). While both groups generally perceived biodiversity as important for agricultural production, there was a significant difference between the groups (school = 3.21 ± 0.15, higher = 4.72 ± 0.05, $P < 0.001$; Fig. 1a). Farmers with higher-education generally considered ecosystem services as more important for both agricultural production and ecosystem resilience than farmers with school-education (Fig. 1b, c).

Both groups of farmers generally agreed on the importance of "AES and other agri-environmental measures" for conservation of agricultural biodiversity (Fig. 2a, all $P > 0.1$), except fallows, which farmers with higher education levels perceived as significantly more important (school = 2.84 ± 0.15, higher = 3.42 ± 0.09, $P = 0.001$). However, farmers with higher-education levels also considered conservation measures as more important compared to farmers with school-education (Fig. 2b, $P < 0.05$ for all).

3.1.2. Organic, conventional and dual farming

Farmers who practiced conventional, dual, or organic management (n = 85, 59, and 65 respectively) also differed significantly in their opinions on the different topics and items related to biodiversity and associated ecosystem services (H2; Table 1). Organic farmers attributed the highest importance to most classifications, while dual approach farmers attributed intermediate importance, and conventional farmers lowest importance. All three groups perceived biodiversity as important for agricultural production, while organic farmers tended to perceive ecosystem services as important for agricultural production, and conventional farmers perceived them as 'less important'.

3.1.3. Gender differences

Biodiversity and associated ecosystem services were generally considered important by both female (n = 82) and male farmers (n = 126; H1, Table A6), with female farmers often showing a stronger tendency to classify items as important. In particular, significant differences exist in the perceived importance for agricultural production of natural enemies providing pest control (female = 4.11 ± 0.13, male = 3.71 ± 0.10, $P = 0.014$), and plant diversity at the landscape level (female = 4.05 ± 0.11, male = 3.21 ± 0.07, $P < 0.001$). Compared to male farmers, female farmers considered natural habitat as more important for agricultural production and ecosystem resilience (all $P < 0.001$). Compared to female farmers, male farmers assigned higher rankings to the importance of soil quality for agricultural production ($P < 0.001$), and to the effectiveness of AES ($P = 0.04$).

3.2. Differences between farmers and scientists

Perceptions of farmers and scientists were significantly different for all questions (H4; $P < 0.05$; Figs. 1 to 3, Table A5), except for their opinion on the importance of hunting and regulation as effective conservation measures (H2; farmers = 3.44 ± 0.07, scientists = 3.32 ± 0.09, $P = 0.314$).

Biodiversity and ecosystem services were generally considered of higher importance for agricultural production and ecosystem resilience

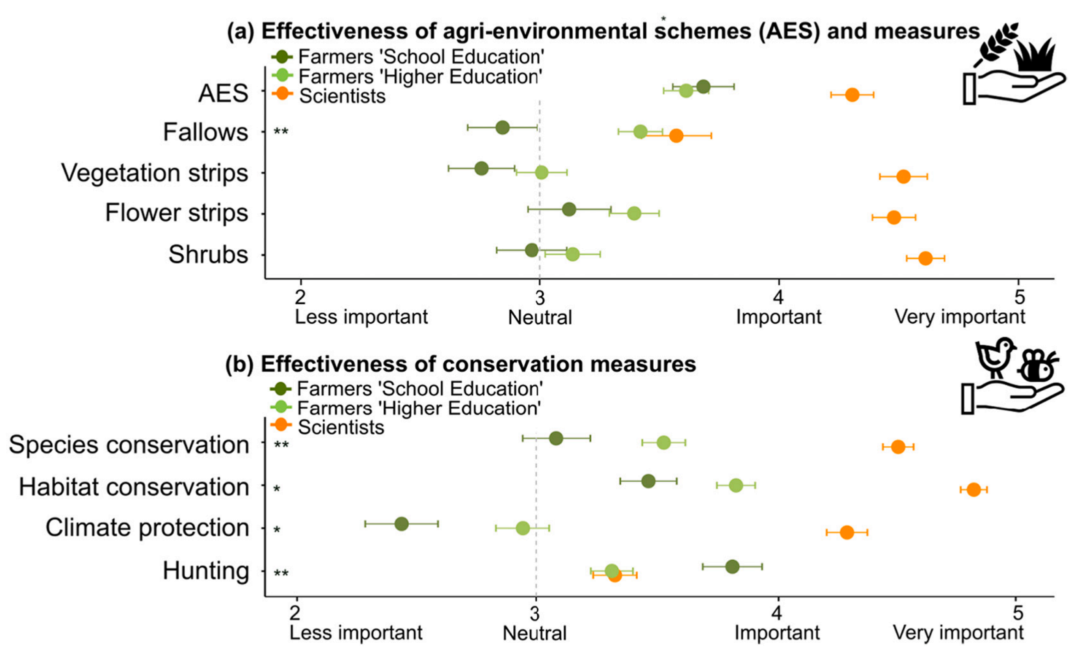

Fig. 2. Opinions of farmers and scientists toward the efficacy of (a) agri-environmental schemes and (b) conservation measures. Lines show ±1 standard error of the mean response. Significance levels from ANOVA's with Scheffé multiple comparison tests (*$P < 0.1$; **$P < 0.05$) are provided for differences related to farmer education level (Table S5). Only the range of the Likert scale in which responses were provided is shown, and the neutral response level is indicated by a dashed line.

Table 1
Opinions of conventional, dual and organic farmers on the (1) importance of biodiversity and ecosystem services, (2) effectiveness of agri-environmental and conservation measures, and (3) importance of information sources or mediums for agricultural production, ecosystem resilience, and decision-making. Responses are arranged according to the three topics, related scales, and individual items which were assessed based on Likert-scale values (1 = not important; 3 = neutral, 5 = very important). Dark green colour indicates mean ranks above 4; light green colour indicates mean ranks above 3, and no colour indicates mean ranks below 3. Mean values (±1 standard error) from an ANOVA with Scheffé multiple comparison tests are shown with letters indicating a significant difference between the means on the basis of $P < 0.05$.

Question group	Perceived importance of following items	Conventional (n = 85)	Dual (n = 59)	Organic (n = 65)
(1) Biodiversity & ecosystem services	Biodiversity (overall)	4.05 (0.13) A	4.27 (0.14) AB	4.68 (0.07) B
	Pollinators	4.28 (0.08) A	4.53 (0.10) AB	4.66 (0.06) B
1.1: Importance of biodiversity for agricultural production	Natural enemies	3.19 (0.12) A	4.10 (0.13) B	4.55 (0.09) C
	Pests	4.47 (0.07)	4.46 (0.11)	4.71 (0.06)
	Local plant diversity	3.68 (0.09) A	3.98 (0.14) A	4.48 (0.08) B
	Landscape plant diversity	3.11 (0.08) A	3.49 (0.14) B	4.17 (0.11) C
1.2: Importance of ecosystem services for agricultural production	Natural habitat	2.69 (0.09) A	3.37 (0.14) B	3.91 (0.15) C
	Genetic diversity	3.64 (0.10)	3.59 (0.14)	3.66 (0.17)
	Air quality	2.53 (0.10) A	3.02 (0.15) AB	3.40 (0.19) B
	Water quality	3.05 (0.14) A	3.41 (0.15) AB	3.60 (0.17) B
	Soil quality	2.66 (0.12) A	3.02 (0.18) A	3.72 (0.17) B
	Pollination	2.79 (0.13) A	3.58 (0.16) B	3.91 (0.14) B
	Pest control	2.72 (0.14) A	2.86 (0.15) A	3.46 (0.15) B
1.3: Importance of ecosystem services for ecosystem resilience and stability	Natural habitat	2.18 (0.13) A	2.54 (0.18) A	3.18 (0.18) B
	Genetic diversity	2.55 (0.15) A	2.81 (0.18) AB	3.31 (0.17) B
	Air quality	4.09 (0.09) B	3.10 (0.23) A	3.89 (0.15) B
	Water quality	3.34 (0.13) A	3.69 (0.14) AB	4.02 (0.12) B
	Soil quality	2.01 (0.12) A	3.36 (0.13) B	3.83 (0.14) B
	Pollination	3.39 (0.09) A	3.98 (0.12) B	4.28 (0.10) B
	Pest control	3.26 (0.12) A	3.56 (0.12) A	4.14 (0.10) B
(2) AES & conservation measures	AES	2.20 (0.12) A	2.37 (0.17) A	3.11 (0.17) B
	Fallows (abandoned grassland)	2.68 (0.13) A	2.93 (0.17) AB	3.37 (0.18) B
2.1: Effectiveness of AES and agri-environmental measures	Vegetation strips	3.05 (0.12) AB	2.53 (0.19) A	3.22 (0.19) B
	Flower strips	2.94 (0.14) A	3.27 (0.17) A	3.92 (0.12) B
	Shrubs	1.64 (0.09) A	2.27 (0.13) B	3.97 (0.11) C
2.2: Effectiveness of conservation measures	Species conservation	2.81 (0.10) A	3.36 (0.15) B	4.20 (0.10) C
	Habitat conservation	3.15 (0.08) A	3.61 (0.13) B	4.57 (0.06) C
	Climate protection	2.51 (0.12) A	2.68 (0.14) A	3.26 (0.21) B
	Hunting	3.66 (0.10) B	3.68 (0.11) B	2.94 (0.16) A
(3) Information sources & transfer	National Ministry	4.65 (0.07) B	4.22 (0.13) A	4.48 (0.10) AB
	Land Use Ministry	4.86 (0.05) C	4.20 (0.11) A	4.32 (0.10) B
3.1: Importance of provided information by different sources for agricultural decision-making	Agricultural Chamber	4.84 (0.05) B	4.08 (0.11) A	4.26 (0.08) A
	Agricultural Consultancy	4.05 (0.08) A	4.15 (0.09) A	4.75 (0.06) B
	Agricultural Societies	3.35 (0.12) A	3.54 (0.14) A	4.25 (0.07) B
	Agricultural NGO's	2.74 (0.15) A	3.32 (0.17) A	3.57 (0.10) B
	Conservation NGO's	2.45 (0.11) A	2.64 (0.13) A	3.65 (0.12) B
	Colleagues	2.95 (0.16)	2.58 (0.19)	3.05 (0.13)
	Science	2.69 (0.13) A	3.15 (0.15) A	3.89 (0.12) B
	Scientific publications	2.52 (0.14) A	2.76 (0.14) AB	3.23 (0.17) B
3.2: Impact of different information mediums for agricultural decision-making	Verbal communication	4.75 (0.06) B	4.44 (0.12) AB	4.31 (0.12) A
	Popular/public presentations	3.08 (0.12)	2.85 (0.18)	2.66 (0.17)
	Popular articles	3.36 (0.15)	3.19 (0.13)	3.52 (0.12)
	Scientific presentations	2.46 (0.13) A	2.63 (0.17) A	3.18 (0.15) B
	Scientific articles	2.15 (0.10) A	2.37 (0.15) A	3.02 (0.15) B

by scientists than by farmers (Fig. 1, Table A6), with a few interesting exceptions. Compared to scientists, farmers assigned greater importance to the occurrence of pests for agricultural production (farmers = 4.54 ± 0.05, scientists = 3.52 ± 0.11, $P < 0.001$), but much lower importance of biological pest control for agricultural production and ecosystem resilience (farmers < 3, scientists > 4, $P < 0.001$).

The role of pollinators on farms was assessed as important by both groups (farmers = 4.47 ± 0.05, scientists = 4.86 ± 0.06, $P < 0.001$), with 93% of farmers and 98% of scientists describing pollinators as 'important' or 'very important'. Farmers assessed genetic diversity, air quality, water quality, and pest control at much lower levels of importance to agricultural production (farmers mean ≤ 2.99) than scientists did (scientists mean ≥ 4.22; all $P < 0.001$).

AES and conservation measures, with regard to their effectiveness, were also perceived as more important by scientists than by farmers (Fig. 2, Table A7). Compared to farmers, scientists perceived as more important agri-environmental schemes such as shrubs, vegetation strips, and flower strips (farmers mean ≤ 3.32, scientists mean ≥ 4.48; all $P < 0.001$), and conservation measures such as climate protection, species and habitat conservation (farmers mean ≤ 3.72, scientists mean ≥ 4.29; all $P < 0.001$). The only exception in this section was in perceptions of the efficacy of regulation and hunting measures (farmers = 3.44 ± 0.07, scientists = 3.32 ± 0.09, $P = 0.314$), although this question had the most 'neutral' answers in our data (neutral responses farmers = 36%; scientists = 55%).

3.3. Information sources and mediums

Farmers, regardless of education level, agreed that information provided by national and land-use ministries, as well as verbal

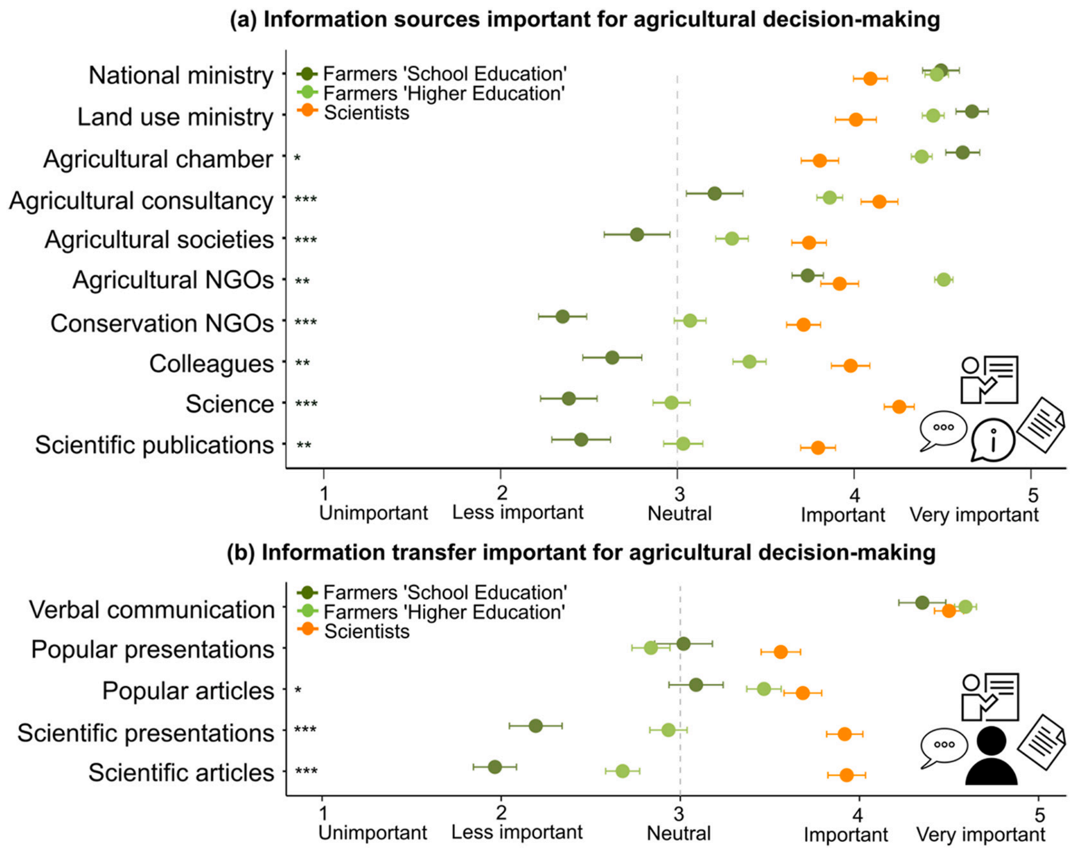

Fig. 3. Opinions of farmers and scientists toward the (a) importance of different information sources and (b) mediums of information transfer for agricultural decision-making. Lines show ±1 standard error of the mean response. Significance levels from ANOVA's with Scheffé multiple comparison tests (*$P < 0.1$; **$P < 0.05$; ***$P < 0.01$) are provided for differences related to farmer education level (Table S5). Only the range of the Likert scale in which responses were provided is shown, and the neutral response level is indicated by a dashed line.

communication and public presentation of agriculturally-relevant information are important for agricultural decision-making processes, but their opinions regarding other information sources and mediums differed significantly (H3; Fig. 3). Farmers assessed 'science and research' and 'scientific articles' to be of low importance (Fig. 3), and farmers who had school-level education ranked these information sources lower (2.63 ± 0.17 and 1.96 ± 0.12, respectively) than farmers with higher-level education (3.41 ± 0.09 and 2.68 ± 0.09, respectively; $P < 0.001$). Scientists, on the other hand, ranked the same modes of communication as important (3.98 ± 0.11 and 3.93 ± 0.10, respectively). Farmers and scientists differed significantly in their assessment of information sources and mediums relevant for agricultural decision making (Fig. 3), with the exception of their agreement on the importance of verbal communication for agricultural decision making (H3; farmers = 4.53 ± 0.06, scientists = 4.50 ± 0.08, $P = 0.793$), which was considered important by 84% of the farmers and 88% of the scientists.

4. Discussion

Biodiversity-friendly management options are rarely put into practice, despite ample scientific evidence of their efficacy and available infrastructural support (M'Gonigle et al., 2015; Kleijn et al., 2019). Our results show that farmers and environmental scientists have divergent views on these matters; illustrating crucial limitations toward sustainable farming progress if knowledge and communication gaps are not identified and addressed (Pe'er et al., 2020; Batáry et al., 2015; Kleijn et al., 2019; Schneider et al., 2019) (Fig. 4).

Our results demonstrate that professional views vary considerably regarding the importance of biodiversity and ecosystem services, agri-environmental schemes and conservation measures, as well as information transfer in agricultural decision-making processes. These findings coincide with previous findings that decisions are often influenced by professional context (Kross et al., 2018; Kleijn et al., 2019), but also reveal novel insights for the central challenge of better integrating research, farming, and policy practice (Teixeira et al., 2018). A large part of the implementation challenges for conservation and management measures in agricultural landscapes can be traced back to the design of practices, which often lack ecological incentives and cross-disciplinary approaches (Batáry et al., 2015; Pe'er et al., 2017). Our results suggest that evidence-based support for practices oriented toward biodiversity conservation should not be seen in a static sense, as a situation determined by one or several influencing factors, but rather as a process marked by interaction (Wilson and Hart, 2000; Siebert et al., 2006).

We show that both farmers and scientists hold mostly positive attitudes toward the value of biodiversity and AES for agricultural productivity. However, key differences were observed between the two groups, for example, farmers attribute significantly less importance to most ecosystem services than scientists. In line with previous studies, farmers perceived ecosystem services that are traditionally related to agricultural management and production such as soil quality (Kleijn et al., 2019), and pollination (M'Gonigle et al., 2015) as more important than other services (Zhang et al., 2018). This shows that accumulated scientific knowledge about the multiple benefits of biodiversity-friendly farm management is neither well communicated (McAfee et al., 2019; Kidd et al., 2019), nor effectively implemented in agricultural decision-making (Gillson et al., 2019; Kleijn et al., 2019; Maas et al., 2019; Pe'er et al., 2020). Perception differences related to gender, education and applied practices of farmers have been shown to drive different interests in the environment and related behaviours (Kross et al., 2018;

Fig. 4. Agricultural landscapes and biodiversity are linked to various ecosystem services and management measures that farmers and scientists view from different perspectives. For example, scientists are more likely to view biodiversity and ecosystem services as more important for agriculture (top image), compared to farmers who are more likely to view pests as more important for agriculture production (bottom image).

Wardropper et al., 2020; Nowak-Olejnik et al., 2020), and should be addressed more specifically in communication and funding strategies. For example, in order to achieve the EU CAP objectives to 'preserve landscapes and biodiversity', more "biodiversity-positive" stakeholders could be promoted more strongly. Support should also include the identification and involvement of stakeholders in cross-disciplinary research and decision-making processes, to allow enhanced co-production and uptake of information (Wilson and Hart, 2000; Pe'er et al., 2020).

In comparison to farmers, scientists in our study showed very positive, almost idealistic views regarding the efficacy of agri-environmental schemes and conservation measures. Farmers and scientists show significant differences in their perception of all conservation measures, except for the perceived effectiveness of fallows (abandoned grasslands) and regulated hunting (Table A7). The less distinct view on the effectiveness of fallows could result from regional differences in their long-standing management and implementation (Concepción et al., 2020; Ustaoglu and Collier, 2018) that make them more difficult to assess in comparison to other measures with more unique or clear designs. However, perceptions among farmers toward the effectiveness of fallows differ greatly with regard to different education level, gender and farming practice. In the case of hunting, farmer and scientists perspectives do not significantly differ, but we refrain from a closer interpretation of the results due to the high inter-relatedness of this item in the scale (Table A4). The deviations in farmer and scientist perceptions of hunting as a conservation measure indicate strongly differentiated and diverging views, and thus valuable information for future research to address these topics with a more nuanced survey approach. Many complex conservation issues such as the climate and biodiversity crises cannot be addressed in isolation (Gardner et al., 2020), which presents a central challenge to their effective communication to broad audiences and their implementation into the practice of other disciplines such as agriculture. Ultimately, targeting communication strategies to different key audiences will be crucial to secure meaningful and long-term engagement of multiple stakeholders (Arnott et al., 2019; Reed et al., 2019).

The design of this study utilizes a transdisciplinary approach to assess different professional perspectives on the conservation and management of biodiversity in agricultural landscapes. Our survey is based on a conceptual framework addressing biodiversity and conservation concepts and approaches. These concepts are familiar to both agroecological research and agricultural practice and policy, and are part of current debates on agricultural sustainability (Carlisle et al., 2019; EC, 2019; Franić and Kovačićek, 2019). Our results demonstrate divergent perspectives of scientists and farmers on several key concepts of sustainable agriculture, suggesting multiple avenues for future pathways to increase the uptake of AES by farmers, and to improve communication between scientists and farmers (Schneider et al., 2019). Our results – demonstrating that education-level, farming practice, and gender drive the perceptions of farmers – provide valuable information for developing more targeted support programs and funding schemes (EC, 2019; Franić and Kovačićek, 2019). On the other hand, the almost idealistic views of scientists participating in our survey indicate a need for more integrative and transdisciplinary research to better align the expectations and direction of science with the perspectives and opportunities of farming practice (Schneider et al., 2019). Promoting cross-disciplinary approaches that integrate methods, knowledge and concepts from different disciplines in agricultural science, practice and policy will be key to coordinating varying views and perspectives on conservation research, and making them more accessible for applications in sustainable agricultural practice (Evely et al., 2010; Schneider et al., 2019).

Our finding that farmers find traditional scientific communication sources (e.g., papers such as this one) to be of low importance for agricultural decision making indicates an alarming information gap affecting the implementation of scientific evidence into practice (Maas et al., 2019). The low perceived importance of scientific evidence should be taken very seriously by both scientists and policy makers in the mode and accessibility of their methods for communicating information (Chavarro et al., 2017; Bertuol-Garcia et al., 2018). These results also confirm the need for direct avenues for policy makers to enhance collaboration with, and between, scientists and farmers (Geertsema et al., 2016). The investigation of socio-demographic factors in relation to the perceptions of farmers suggests that the identification of target groups and topics may be beneficial for optimized biodiversity-friendly agricultural management (Concepción et al., 2020). Farmers' assessments differed greatly depending on education level, gender, and farming practice. These findings are in line with previous studies from the US, showing that female and organic farmers would be more likely to positively assess biodiversity and environmental conservation schemes than male, conventional or dual approach farmers (e.g., Kross et al., 2018). Moreover, these results provide a more nuanced insight into drivers of stakeholder perceptions and motivations to participate in AES (Prokopy et al., 2019; Piñeiro et al., 2020), opening new avenues for the combined consideration of extrinsic and intrinsic motivations, such as economic incentives and socio-demographic factors (Zinngrebe et al., 2017). To improve communication and implementation of conservation science evidence in an agricultural context, a better understanding of relevant target groups, their individual differences, needs and perceptions is urgently needed from other areas.

From a motivation perspective, education is regarded as a key driver affecting positive attitudes and farmer participation in environmentally friendly schemes globally (Schneider et al., 2014; Gholamrezai and Sepahvand, 2017; Issa and Hamm, 2017). Our findings on perspectives depending on farmer education levels coincide with studies that found strong support for biodiversity promotion measures, especially among younger generations. For example, young age combined with fair payments and higher education is critical for effectively promoting farmer participation in agri-environmental schemes in the EU (Lastra-Bravo et al., 2015), as well as in other areas in which such vital measures and cross-country cooperation do not yet exist (Donald and Evans, 2006; Saura et al., 2019). Next to, and increasingly in combination with, economic motivations (Zinngrebe et al., 2017; Lastra-Bravo et al., 2015; Gatto et al., 2019), farmers' perceptions of biodiversity and ecosystem services are key drivers for the promotion of more sustainable, resilient and biodiversity-friendly farming (Teixeira et al., 2018). Agricultural policy-makers in and beyond the EU can enhance biodiversity-friendly farming by considering the divergence of professional perspectives in the design and application of decision-support tools, as well as related communication and cooperation strategies (Grass et al., 2020; Concepción et al., 2020). Our results emphasize the generally more positive and supportive views of young and female farmers and scientists toward agricultural biodiversity, highlighting the need for better outreach and education targeting these important social groups to promote sustainable farming and ecologically-skilled workforces (Carlisle et al., 2019). Promoting young generations in the agricultural sector is well in line with current European Commission programs that explicitly support young and female farmers (EC, 2019; Franić and Kovačićek, 2019) and scientists (Fatourou et al., 2019).

To enhance the effectiveness of agri-environment schemes and related conservation measures with regard to diverging professional perspectives on agricultural biodiversity, ecosystem services and decision making, we recommend four key actions to the agricultural science and policy sector: First, to foster and establish collaboration initiatives and communication platforms to provide more accessible information on "*What works best in agricultural management*", enhance dialogues between policy, science and practice representatives, and assist support units that regularly advise farmers. Second, to consider differences between stakeholder groups in the design and application of policy instruments and decision support tools, which should be regularly evaluated to contribute to more targeted research and practice. Third, to actively identify and promote target groups that can provide added value for the more efficient implementation of common science-practice objectives, for example through specific motivations. Fourth, enhanced cross-disciplinary research and decision-making is needed, through the active involvement of farmers as equal counterparts (Siebert et al., 2006; Evely et al., 2010; De Snoo et al., 2013), to allow enhanced co-production and uptake of information. To achieve the multiple and interlinked goals of biodiversity conservation, food security, resource management, and local development (Kremen and Merenlender, 2018), cross-disciplinary partnerships and political commitment at the highest level are required (Schneider et al., 2019). Understanding the perceptions of different actors in this environment presents an important piece of the puzzle, which should be followed by courageous actions to counteract the ongoing degradation and decline of agricultural biodiversity and associated ecosystem services globally.

5. Conclusions

In view of the global biodiversity and climate crisis, and the associated role of land use practices (Kehoe et al., 2017), better understanding the perceptions of professionals from agricultural science and practice is highly needed for the development of more effective solutions. Our survey of scientists and farmers on increasingly threatened agricultural biodiversity, related conservation measures and agricultural decision-making processes, demonstrates the generally high appreciation of these topics in Germany and Austria, the two EU countries with the highest per-ha contributions to agri-environmental schemes. However, lower educated-, male-, and conventional- farmers perceived environmentally-friendly or scientifically-based agricultural management and decision-making as less important compared to scientists, and highly educated-, female-, and organic- farmers. This highlights key opportunities for more targeted collaboration and communication measures to advance the conservation of agricultural biodiversity. Our study encourages the promotion of cross-disciplinary approaches and more direct communication in agricultural decision-making processes. Open dialogues, educational platforms, decision-support tools and programs for skilled future professionals will bridge information and communication gaps and advance the implementation of more sustainable agricultural management to the benefit of biodiversity, ecosystem functions and human well-being alike.

Data accessibility

Most of the data of this study at the journal level are available within the paper and it's Supporting information. The entire dataset that supports the findings of this study is archived in a permanent open access data repository of the University of Vienna (permanent link: http://phaidra.univie.ac.at/o:1165458). Extended data are available on request from the authors.

Ethics review process

The results of this study are based on an anonymous questionnaire which is subject to the most recent data protection guidelines in the study areas (University of Vienna in Austria and Helmholtz Centre for Environmental Research in Germany). Particular attention was paid to gender differences. The survey was coordinated by BM and AR.

CRediT authorship contribution statement

All authors have made a substantial contribution to the article, including study design (BM, YF, AR), data collection (BM, AR), data analysis (BM, YF), writing and revising the manuscript (BM, YF, SK, AR).

Declaration of competing interest

We have no conflicts of interest to declare.
We further declare that:

- The work is all original research carried out by the authors and all funding sources are fully acknowledged in the manuscript.
- All authors agree with the contents of the manuscript and its submission to the journal.
- No part of the work has been published or is considered for publication in any form elsewhere.
- All appropriate ethics and other approvals were obtained for this work. All provided survey data is anonymous and subject to data protection and no ethical issues are applicable to this manuscript.

Acknowledgements

This research was funded by the Austrian Science Fund (FWF) [grant number P 27602]. For the purpose of open access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission. The online survey via Survey Monkey was privately funded by the corresponding author. We thank the editor and two anonymous reviewers for providing comments on previous versions of this manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2021.109065.

References

Aizen, M.A., Aguiar, S., Biesmeijer, J.C., Garibaldi, L.A., Inouye, D.W., Jung, C., Pauw, A., 2019. Global agricultural productivity is threatened by increasing pollinator dependence without a parallel increase in crop diversification. Glob. Chang. Biol. 25 (10), 3516–3527.

Arnott, D., Chadwick, D., Harris, I., Koj, A., Jones, D.L., 2019. What can management option uptake tell us about ecosystem services delivery through agri-environment schemes? Land Use Policy 81, 194–208.

Batáry, P., Dicks, L.V., Kleijn, D., Sutherland, W.J., 2015. The role of agri-environment schemes in conservation and environmental management. Conserv. Biol. 29, 1006–1016.

Bertuol-Garcia, D., Morsello, C., El-Hani, C.N., Pardini, R., 2018. A conceptual framework for understanding the perspectives on the causes of the science–practice gap in ecology and conservation. Biol. Rev. 93 (2), 1032–1055.

Bommarco, R., Kleijn, D., Potts, S.G., 2013. Ecological intensification: harnessing ecosystem services for food security. Trends Ecol. Evol. 28, 230–238.

Carlisle, L., Montenegro de Wit, M., DeLonge, M.S., Iles, A., Calo, A., Getz, C., Knox, R., 2019. Transitioning to sustainable agriculture requires growing and sustaining an ecologically skilled workforce. Front. Sustain. Food Syst. 3, 96 (1–8).

Chavarro, D., Tang, P., Ràfols, I., 2017. Why researchers publish in non-mainstream journals: training, knowledge bridging, and gap filling. Res. Policy 46, 1666–1680.

Concepción, E.D., Aneva, I., Jay, M., Lukanov, S., Marsden, K., Moreno, G., Schraml, A., 2020. Optimizing biodiversity gain of European agriculture through regional targeting and adaptive management of conservation tools. Biol. Conserv. 241, 108384.

Cortina, J.M., 1993. What is coefficient alpha? An examination of theory and applications. J. Appl. Psychol. 78 (1), 98–104.

De Snoo, G.R., Herzon, I., Staats, H., Burton, R.J., Schindler, S., van Dijk, J., Schwarz, G., 2013. Toward effective nature conservation on farmland: making farmers matter. Conserv. Lett. 6 (1), 66–72.

Donald, P.F., Evans, A.D., 2006. Habitat connectivity and matrix restoration: the wider implications of agri-environment schemes. J. Appl. Ecol. 43 (2), 209–218.

EC (European Commission), 2018. EU Budget: the Common Agricultural Policy beyond 2020. Available at: https://ec.europa.eu/commission/presscorner/detail/en/MEMO_18_3974.

EC (European Commission), 2019. 1 billion for Europe's next generation of farmers. Available at: https://ec.europa.eu/info/news/euro1-billion-europes-next-generation-farmers-2019-may-10_en.

EC (European Commission). Eurostat regional yearbook 2020 Edition. Luxembourg: Publications Office of the European Union, 2020. https://doi.org/10.2785/764915.

Ekroos, J., Tiainen, J., Seimola, T., Herzon, I., 2019. Weak effects of farming practices corresponding to agricultural greening measures on farmland bird diversity in boreal landscapes. Landsc. Ecol. 34 (2), 389–402.

Evely, A.C., Fazey, I., Lambin, X., Lambert, E., Allen, S., Pinard, M., 2010. Defining and evaluating the impact of cross-disciplinary conservation research. Environ. Conserv. 442–450.

Fabian, Y., Bollmann, K., Brang, P., Heiri, C., Olschewski, R., Rigling, A., Holderegger, R., 2019. How to close the science-practice gap in nature conservation? Information sources used by practitioners. Biol. Conserv. 235, 93–101.

Fatourou, P., Papageorgiou, Y., Petousi, V., 2019. Women are needed in STEM: European policies and incentives. Commun. ACM 62, 52.

Franić, R., Kovačićek, T., 2019. The Professional Status of Rural Women in the EU. EU Policy Department for Citizens' Rights and Constitutional Affairs. https://doi.org/10.2861/212719. Available at: https://op.europa.eu/en/publication-detail/-/publication/dd3d08da-90ac-11e9-9369-01aa75ed71a1/language-en/format-PDF.

Gardner, C.J., Struebig, M.J., Davies, Z.G., 2020. Conservation must capitalise on climate's moment. Nat. Commun. 11 (1), 1–2.

Gatto, P., Mozzato, D., Defrancesco, E., 2019. Analysing the role of factors affecting farmers' decisions to continue with agri-environmental schemes from a temporal perspective. Environ. Sci. Pol. 92, 237–244.

Geertsema, W., Rossing, W.A., Landis, D.A., Bianchi, F.J., Van Rijn, P.C., Schaminée, J. H., Van Der Werf, W., 2016. Actionable knowledge for ecological intensification of agriculture. Front. Ecol. Environ. 14, 209–216.

Gholamrezai, S., Sepahvand, F., 2017. Farmers' participation in water user association in western Iran. J. Water Land Dev. 35, 49–56.

Gillson, L., Biggs, H., Smit, I.P., Virah-Sawmy, M., Rogers, K., 2019. Finding common ground between adaptive management and evidence-based approaches to biodiversity conservation. Trends Ecol. Evol. 34 (1), 31–44.

Grass, I., Kubitza, C., Krishna, V.V., Corre, M.D., Mußhoff, O., Pütz, P., Brinkmann, N., 2020. Trade-offs between multifunctionality and profit in tropical smallholder landscapes. Nat. Commun. 11, 1–13.

Issa, I., Hamm, U., 2017. Adoption of organic farming as an opportunity for Syrian farmers of fresh fruit and vegetables: an application of the theory of planned behaviour and structural equation modelling. Sustainability 9, 2024.

Kehoe, L., Romero-Muñoz, A., Polaina, E., Estes, L., Kreft, H., Kuemmerle, T., 2017. Biodiversity at risk under future cropland expansion and intensification. Nat. Ecol. Evol. 1, 1129–1135.

Kidd, L.R., Bekessy, S.A., Garrard, G.E., 2019. Neither hope nor fear: empirical evidence should drive biodiversity conservation strategies. Trends Ecol. Evol. 34 (4), 278–282.

Kleijn, D., Bommarco, R., Fijen, T.P., Garibaldi, L.A., Potts, S.G., van der Putten, W.H., 2019. Ecological intensification: bridging the gap between science and practice. Trends Ecol. Evol. 34 (2), 154–166.

Kremen, C., Merenlender, A.M., 2018. Landscapes that work for biodiversity and people. Science 362, 6412.

Kross, S.M., Ingram, K.P., Long, R.F., Niles, M.T., 2018. Farmer perceptions and behaviors related to wildlife and on-farm conservation actions. Conserv. Lett. 11 (1), e12364.

Lastra-Bravo, X.B., Hubbard, C., Garrod, G., Tolón-Becerra, A., 2015. What drives farmers' participation in EU agri-environmental schemes? Results from a qualitative meta-analysis. Environ. Sci. Pol. 54, 1–9.

Maas, B., Toomey, A., Loyola, R., 2019. Exploring and expanding the spaces between research and implementation in conservation science. Biol. Conserv. 240, 108290.

McAfee, D., Doubleday, Z.A., Geiger, N., Connell, S.D., 2019. Everyone loves a success story: optimism inspires conservation engagement. BioScience 69 (4), 274–281.

M'Gonigle, L.K., Ponisio, L.C., Cutler, K., Kremen, C., 2015. Habitat restoration promotes pollinator persistence and colonization in intensively managed agriculture. Ecol. Appl. 25 (6), 1557–1565.

Mills, J., Gaskell, P., Ingram, J., Dwyer, J., Reed, M., Short, C., 2017. Engaging farmers in environmental management through a better understanding of behaviour. Agric. Hum. Values 34 (2), 283–299.

Nowak-Olejnik, A., Mocior, E., Hibner, J., Tokarczyk, N., 2020. Human perceptions of cultural ecosystem services of semi-natural grasslands: the influence of plant communities. Ecosyst. Serv. 46, 101208.

Pe'er, G., Zinngrebe, Y., Hauck, J., Schindler, S., Dittrich, A., Zingg, S., Schmidt, J., 2017. Adding some green to the greening: improving the EU's Ecological Focus Areas for biodiversity and farmers. Conserv. Lett. 10 (5), 517–530.

Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., Hansjürgens, B., 2019. A greener path for the EU Common Agricultural Policy. Science 365 (6452), 449–451.

Pe'er, G., Bonn, A., Bruelheide, H., Dieker, P., Eisenhauer, N., Feindt, P.H., Marquard, E., 2020. Action needed for the EU Common Agricultural Policy to address sustainability challenges. People Nat. 2 (2), 305–316.

Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A.M., Kinengyere, A., Torero, M., 2020. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nat. Sustain. 3 (10), 809–820.

Prokopy, L.S., Floress, K., Arbuckle, J.G., Church, S.P., Eanes, F.R., Gao, Y., Singh, A.S., 2019. Adoption of agricultural conservation practices in the United States: evidence from 35 years of quantitative literature. J. Soil Water Conserv. 74 (5), 520–534.

R Core Team, 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Reed, J., Barlow, J., Carmenta, R., van Vianen, J., Sunderland, T., 2019. Engaging multiple stakeholders to reconcile climate, conservation and development objectives in tropical landscapes. Biol. Conserv. 238, 108229.

Sánchez-Bayo, F., Wyckhuys, K.A., 2019. Worldwide decline of the entomofauna: a review of its drivers. Biol. Conserv. 232, 8–27.

Sasaki, T., Furukawa, T., Iwasaki, Y., Seto, M., Mori, A.S., 2015. Perspectives for ecosystem management based on ecosystem resilience and ecological thresholds against multiple and stochastic disturbances. Ecol. Indic. 57, 395–408.

Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A., Dubois, G., 2019. Global trends in protected area connectivity from 2010 to 2018. Biol. Conserv. 238, 108183.

Schneider, M.K., Lüscher, G., Jeanneret, P., Arndorfer, M., Ammari, Y., Bailey, D., Eiter, S., 2014. Gains to species diversity in organically farmed fields are not propagated at the farm level. Nat. Commun. 5 (1), 1–9.

Schneider, F., Kläy, A., Zimmermann, A.B., Buser, T., Ingalls, M., Messerli, P., 2019. How can science support the 2030 Agenda for Sustainable Development? Four tasks to tackle the normative dimension of sustainability. Sustain. Sci. 14 (6), 1593–1604.

Schroeder, L. A., Isselstein, J., Chaplin, S., & Peel, S. (2013). Agri-environment schemes: Farmers' acceptance and perception of potential 'Payment by Results' in grassland—A case study in England. Land Use Policy, 32, 134-144. https://doi.org/10.1016/j.landusepol.2012.10.009.

Siebert, R., Toogood, M., Knierim, A., 2006. Factors affecting European farmers' participation in biodiversity policies. Sociol. Rural. 46 (4), 318–340.

Sullivan, G.M., Artino, A.R., 2013. Analyzing and interpreting data from Likert-type scales. J. Grad. Med. Educ. 5 (4), 541–542.

Teixeira, H.M., Vermue, A.J., Cardoso, I.M., Claros, M.P., Bianchi, F.J., 2018. Farmers show complex and contrasting perceptions on ecosystem services and their management. Ecosyst. Serv. 33, 44–58.

Ustaoglu, E., Collier, M.J., 2018. Farmland abandonment in Europe: an overview of drivers, consequences, and assessment of the sustainability implications. Environ. Rev. 26 (4), 396–416.

Villamayor-Tomas, S., Sagebiel, J., Olschewski, R., 2019. Bringing the neighbors in: a choice experiment on the influence of coordination and social norms on farmers' willingness to accept agro-environmental schemes across Europe. Land Use Policy 84, 200–215.

Wardropper, C.B., Mase, A.S., Qiu, J., Kohl, P., Booth, E.G., Rissman, A.R., 2020. Ecological worldview, agricultural or natural resource-based activities, and geography affect perceived importance of ecosystem services. Landsc. Urban Plan. 197, 103768.

Wilson, G.A., Hart, K., 2000. Financial imperative or conservation concern? EU farmers' motivations for participation in voluntary agri-environmental schemes. Environ. Plan. A Econ. Space 32 (12), 2161–2185.

Zhang, H., Potts, S.G., Breeze, T., Bailey, A., 2018. European farmers' incentives to promote natural pest control service in arable fields. Land Use Policy 78, 682–690.

Zinngrebe, Y., Pe'er, G., Schueler, S., Schmitt, J., Schmidt, J., Lakner, S., 2017. The EU's ecological focus areas–how experts explain farmers' choices in Germany. Land Use Policy 65, 93–108.