Received: 6 December 2021 | Accepted: 11 January 2023

DOI: 10.1002/pan3.10455

PEOPLE AND NATURE
BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

Perception and appreciation of plant biodiversity among experts and laypeople

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Handling Editor: Jennifer Atchison

Abstract

1. Plant biodiversity, which is fundamental for the delivery of ecosystem services, is in decline. Yet, knowledge about how plant biodiversity is perceived and appreciated is scarce.
2. We studied biologists' and laypeople's perception and appreciation for plant communities that differ in plant biodiversity, using ranges of plant biodiversity known to affect ecosystem services. We investigate species richness, species turnover and species evenness. A questionnaire based on photographs displaying artificial plant communities was used.
3. Perceived biodiversity was 12% more often congruent with actual biodiversity for biologists than for laypeople. Species richness was perceived congruently with actual species richness by 77% of all respondents, compared with 27% for species evenness and 29% for species turnover. Appreciation for the displayed communities correlated positively with their actual plant biodiversity, except for species turnover. Appreciation always correlated positively with perceived plant biodiversity and even stronger than with actual plant biodiversity. This was not the case for species richness, for which perceived and actual biodiversity were most often congruent.
4. Our results suggest that plant biodiversity is perceived most accurately when changes in species richness are considered, while changes in species evenness and species turnover are perceived less accurately. The respondents' answers indicate that perceived higher plant biodiversity is appreciated more than perceived lower plant biodiversity, even when perceived and actual plant biodiversity are not congruent.
5. We corroborate findings that people value plant biodiversity per se. But we also find that people largely perceive species evenness and turnover with low accuracy; and that people have low appreciation for these biodiversity dimensions that are lesser known but essential to ecosystem functioning. Our finding that biologists have higher accuracy in perceiving biodiversity suggests that biodiversity literacy is key to increasing people's awareness of changes in plant biodiversity.

KEYWORDS
evenness, plant blindness, species richness, turnover, visual assessment

1 | INTRODUCTION

'The challenges ahead for biodiversity conservation will require a better understanding of one species: our own'—that is how Saunders et al. (2006) expressed the need for comprehension of the human–nature relationship to act on mitigating ongoing changes. This includes how people perceive and appreciate biodiversity, which is the focus of our study.

By enhancing and promoting fundamental ecosystem functions (e.g. primary production, carbon and nutrient cycling, decomposition and more) plant biodiversity is vital to nature and human well-being (Cardinale et al., 2012). A multitude of studies and reviews emphasize that plant biodiversity is an essential part of ecosystems and ecosystem functions and, therefore, also of ecosystem services or beneficial contributions of nature to people (IPBES, 2019). These benefits that people obtain from ecosystems are described in the ecosystem service framework (Díaz et al., 2015), which is evolving towards a more inclusive framework of nature's contributions to people (Ellis et al., 2019). They include supporting services (e.g. soil formation), provisioning services (e.g. food and fibres), regulating services (e.g. water purification and climate regulation) and cultural services (e.g. aesthetic value, religious and spiritual values). Many ecosystem functions connected to these services are in decline due to homogenization and loss of plant biodiversity (Hautier et al., 2018), which in turn lowers the benefits that people can obtain from them. Evidence for the negative impact of biodiversity loss on supporting, regulating and provisioning services is abundant (Cardinale et al., 2012), but the connection to cultural services is less established, due to the relational nature and intangibility of these immaterial goods (Fish et al., 2016). This represents a significant lack of knowledge since this intimate, emotional relation of people to nature could be of high importance to engage the public in the conservation of biodiversity (Novacek, 2008; Tribot et al., 2018).

Plant biodiversity is in human-caused decline, and this decline has consequences for human well-being. Nevertheless, the conservation of plant biodiversity has not received the same attention as, for example, animal conservation (Corlett, 2016). Balding and William (2016) connect this to the phenomenon of 'plant blindness', recently also renamed 'plant awareness disparity' (Parsley, 2020). They summarize it as 'a tendency among humans to neither notice nor value plants in the environment'. This translates to difficulties in perception and a lack of appreciation for plants. Plant blindness was hypothesised to be inherent in the (contemporary, urban) human mindset (Wandersee & Schussler, 2001). Recently, plant blindness was found to be lower in rural communities, especially for people who collect wild plants for subsistence (Stagg & Dillon, 2022). It was also found to decline with early learning and exposure to plants (Jose et al., 2019) and in higher botany education with teaching methods based on variation theory (Sanders et al., 2021). These findings are of importance, as the engagement of society for conservation critically depends on the awareness and the value people assign to organisms (Bonnet et al., 2002; Colléony et al., 2017) and their diversity (Saunders et al., 2006). But knowledge about how people perceive changes in plant biodiversity and how they aesthetically appreciate it is scarce.

In this study, we address the perception and appreciation of plant biodiversity in ranges that have been found to be relevant to ecosystem functioning (e.g. Reich et al. (2012)). We operate in grassland (meadow) vegetation at the community scale, where the majority of evidence on plant diversity effects was gathered (Naeem & Wright, 2003), and which is a scale in which people can experience vascular plant biodiversity. Three different measures of plant biodiversity are the focus of our study: species richness, species evenness and species turnover.

Species richness, the most common measure of biodiversity and also termed alpha (α)-diversity, is the number of different species present in a given area. It has been the focus of investigations into the relationship between plant biodiversity and ecosystem functioning. Several effects of an increasing number of plant species have been established: for example, increasing productivity (e.g. Reich et al. (2012)), stability (e.g. Tilman et al., 2006) and carbon sequestration (Yang et al., 2019); as well as decreasing risk for invasion and spread of plant disease (Knops et al., 1999). For example, communities consisting of 16 species can yield more than 2.5 times as much biomass as two-species communities (Reich et al., 2012).

A few studies have investigated the perception and appreciation of plant species richness before. For example, Lindemann-Matthies et al. (2010) found that people generally can distinguish between species-poor and species-rich plant communities and Southon et al. (2018) found a strong correlation between perceived and actual species richness. Appreciation of plant communities has been found to increase with actual species richness (Lindemann-Matthies et al., 2010) but also to be unrelated to species richness (Graves et al., 2017; Hoyle et al., 2017, 2018). Perceived species richness was shown to be strongly correlated with actual species richness, vegetation height, evenness and colourfulness (Southon et al., 2018) and to have a strong positive influence on appreciation (Lindemann-Matthies, 2017; Southon et al., 2017).

Species evenness is a biodiversity measure that reflects the relative abundance of species. Equal species abundances give high species evenness. Evenness changes faster in response to anthropogenic influence than species richness (Hillebrand et al., 2008). Changed dominance patterns can lead to altered ecosystem functioning before species are eventually lost from the system (Chapin et al., 2000; Hillebrand et al., 2008). Species evenness effects on ecosystem functions have been shown to have the same direction as species richness effects, with stronger effects in species-rich communities (Lembrechts et al., 2018). For example, the produced biomass in eight species communities is about 1.5 times higher when evenness doubles (Lembrechts et al., 2018). In addition, perception of plant biodiversity is influenced by species evenness. It was shown to influence the perceived number of species, covarying positively (Lindemann-Matthies et al., 2010), and to increase appreciation for plant communities (Graves et al., 2017; Lindemann-Matthies et al., 2010). But how accurately evenness is perceived has, to the best of our knowledge, not been tested before (Table 1).

Species turnover, also termed beta (β)-diversity, is a biodiversity measure that expresses the difference in the composition of species between communities and bridges to larger temporal or spatial scales (Whittaker, 1972). High dissimilarity in species composition between communities, especially in functional traits, promotes ecosystem multifunctionality and, therefore, multiple ecosystem services (Grman et al., 2018; Hautier et al., 2018). To our knowledge, perception and appreciation of plant species turnover have not been addressed before (Table 1).

Effects of changing species richness, species evenness and species turnover on people's perception and appreciation can provide more detailed insights into people's awareness of ongoing changes in plant communities, the basis of ecosystems and their services.

However, both perception and appreciation come with several attached meanings, interpreted differently according to discipline and context. Here in our study, we use the term perception in the sense of the neurophysiological, cognitive process that forms a mental image and interpretation (the percept) of an object or environment (the distal stimulus) in the human mind (Schacter et al., 2012).

In particular, we are interested in how far people's percept of biodiversity is congruent with the distal stimulus of the presented species richness, species evenness and species turnover, to establish insights into awareness about changes in plant biodiversity that matter to ecosystem functioning. For easier reading, we shorten this interpretation by describing perception as *accurate* when the perceived biodiversity is congruent with the actually displayed biodiversity.

We use the term appreciation in the sense of enjoyment, valuing or admiration. In specific, we are interested whether higher species richness, species evenness and species turnover are preferred to lower biodiversity, or, in other words, whether higher biodiversity is visually more attractive to people, in the sense of their personal preference.

Several confounding factors potentially influence the perception and appreciation of plant communities. For instance, features of the observer such as experience and training have been shown to increase sensitivity in a wide range of perceptual tasks in the visual domain (e.g. Lu et al., 2011) among others, the recognition and distinguishing of plants as described above under plant blindness.

Aesthetic appreciation of ecosystems differs between sociodemographic groups (Kaplan & Kaplan, 1989) and nationalities (Lindemann-Matthies, 2017). It is also influenced by factors spanning from evolutionary and biophysical features, over emotions and attention, to influences of cultural and historical background (Jacobsen, 2010). Additionally, people's held values (e.g. whether they are biocentric or anthropocentric) influence which and how much value they assign to ecosystems (Ives & Kendal, 2014). For example, the aesthetic appreciation for a highly managed forest is higher in people who hold anthropocentric values than in people holding biocentric values (Ford et al., 2012). This influence of values also holds in urban meadows: perceived plant species richness is influenced by the perceived naturalness of the community, which in turn is influenced by age, gender and how strongly connected to nature people assess themselves (Hoyle et al., 2019).

To shed further light on the human–plant biodiversity relationship, we aimed to investigate the effects of plant biodiversity, features of the observer and possible interactions among them on the perception and appreciation of plant biodiversity. We aimed to disentangle the role of different dimensions of biodiversity and the role of the observer's experience and knowledge/training. We developed a questionnaire using standardized pictures of artificial plant communities with different levels of species richness, evenness and turnover. To investigate perception, we evaluated to which extent professionals (biologists, assumed to be experienced with and knowledgeable/trained about biodiversity) and laypeople (non-biologists, assumed to have less experience and knowledge/training about biodiversity) accurately perceived the levels of species richness, evenness and turnover displayed in the pictures. To analyse appreciation, we assessed the correlation between displayed biodiversity and the respondents' personal preference for the displayed plant communities. To ensure the relevance of our findings to ecosystem functioning, in particular, in regard to species richness (sensu grassland experiments, for example, Reich et al., 2012), the displayed communities were represented with 2–16 species.

Our study addresses the following research questions:

1. Perception: (a) To what extent do people accurately perceive an increase in species richness, species evenness and species turnover in ranges relevant to ecosystem functioning? (b) Is perception more accurate among biologists than among non-biologists?
2. Appreciation: (a) Do people appreciate more diverse plant communities more than less diverse communities? (b) Is appreciation mostly linked to how people perceive biodiversity or to actual biodiversity? And finally, (c) Do biologists and non-biologists differ in their appreciation?

2 | MATERIALS AND METHODS

Our study analysed the responses of biologists and non-biologists to an online questionnaire based on pictures of artificial plant communities.

2.1 | Artificial plant communities

Artificial plant communities were arranged to depict changes in the chosen biodiversity categories. Their arrangement was standardized

TABLE 1 Overview of the literature investigating plant biodiversity in relation to appreciation, perception and observer properties: Site judgement indicates positive (+), negative (−) or no effect (0) of the community or biodiversity measure on-site appreciation or perception (p). Biodiversity judgement indicates the effects of observer properties. Non-unidirectional effects of categorical variables are indicated by #.

Reference	Method to acquire people's responses	Systems studied	Measures of communities and biodiversity	Site judgement	Observer properties	Biodiversity judgement
Graves et al. (2017)	Questionnaire on digitally manipulated photographs	Natural woodland meadows (US)	Species richness Species evenness Colour diversity Flower abundance	0 + + +	Psychographic group Local species knowledge Wildflower enthusiasm	0 0 0
Hoyle et al. (2017)	On-site walks Semi-structured interviews	Woodland, Shrubs, Herbaceous vegetation (UK)	Perceived species richness Flower cover	+ +	Educational qualifications	+
Hoyle et al. (2018)	On site questionnaires	Urban annual meadows (UK)	Species richness Colour diversity	0 +	Ethnicity	#
Hoyle et al. (2019)	On-site walks	Woodland, Shrubs, Herbaceous vegetation (UK)	Perceived Naturalness	0 + p	Gender Educational qualifications Nature connectedness	# + +
Lindemann-Matthies (2002)	Education by teachers Pre- and post-education tests	Mixed urban communities along the way to school (Germany)	Species identities	+ p	Age Gender Education	0 0 #
Lindemann-Matthies et al. (2010)	On-site questionnaire	Meadow-like pot arrays (Germany & Switzerland)	Species richness Species evenness	+ +		
Lindemann-Matthies (2017)	On-site questionnaire	Meadow-like pot arrays (Switzerland)	Species richness	+	Nationality Gender Education Environmental expertise Age	# 0 0 + +
Southon et al. (2017)	Photo-elicitation	Perennial meadows (UK)	Species richness Vegetation height	+ +	Eco-centricity Ethnicity-deprivation	# #
Southon et al. (2018)	On site questionnaire	Perennial urban meadows (UK)	Species richness Perceived site diversity Vegetation height Evenness Colourfulness	+ p + + p + p + p	Nature dose Socio-economic status	0 p + p

to eliminate confounding factors other than variation in plant diversity. They were set up in a 30 cm × 30 cm area in a wet sand bed.

'Vases' (holes ca. 2 cm deep) were placed regularly, and fresh plant material was inserted to resemble natural plant individuals.

To standardize the composition of each artificial community, the following rules were applied for all artificial communities: An individual (1) consists of at least 1 inflorescence and 2 leaves, (2) is between 5 and 20 cm in height and (3) is alone in its vase. The community consists of 48 individuals, and each colour must be represented by the same number of species.

2.2 | Species choice and sampling area

Native plants in bloom were sampled from meadows in July and August 2016 from two different areas in the surroundings of Tromsø, Norway (69°39′N, 18°57′E).

The species were chosen by easy access and presence in the sampling area and the colour of their inflorescences (green, red, white, yellow). A species was categorized as green when inflorescences are not produced (cryptogams), inconspicuous (graminoids), or green. Flowering individuals of 26 different species were collected (Table S1). Only fresh and undamaged above-ground parts were used.

2.3 | Biodiversity categories

To display differences in species richness, four communities were created (Figure 1a). The communities contained 16, 8, 4 and 2 species with even abundance. This represents the range of species numbers in which loss of plant species was shown to lower ecosystem functions, for example, reduce productivity (Reich et al., 2012).

Three levels of species evenness were created in eight-species communities (Figure 1b): an even distribution of all species, a 33% and a 50% dominance of one species. This falls into levels of species evenness that can be expected to differ in their effect on ecosystem functions such as productivity (Kirwan et al., 2007; Lembrechts et al., 2018). Since evenness effects on ecosystem functions can be dependent on the dominant species' identity (Orwin et al., 2014), we chose the fern *Gymnocarpium dryopteris*, which is functionally most different from the other species in the communities.

Finally, three different levels of species turnover were created (Figure 1c): total turnover, 50% turnover and no turnover. Each level consisted of three different eight-species communities. This represents dissimilarities that can be expected to cause differences in ecosystem multifunctionality (Hautier et al., 2018). One picture for each community was taken. To display turnover, the three pictures were combined.

2.4 | Photography

All photographs were taken from 80 cm above, under constant light conditions, areal dimensions and photographing variables. This angle ensures that only the features changing with biodiversity differ in the pictures. Although a lower angle is how we perceive communities when walking, in this experimental context it was considered to prevent a clear display of all diversity changes.

2.5 | Questionnaire

The questionnaire (Table S2) was set up in Quest Back. It was made available in English, German and Norwegian.

For each biodiversity category, the respondents were asked to order the pictures first from highest to lowest diversity; and second in the order of their personal preference.

The pictures were ordered randomly in the questionnaire and marked with letters (A–D for species richness; A–C for species evenness and species turnover). To minimize visual disturbance, the pictures were shown in such a way that only one picture at a time was visible on screen, in the same order for all respondents. Respondents could allocate time to each picture at their own discretion and were able to review previous pictures. The respondents' answers were recorded in ranks.

Respondents were asked to state their profession as precisely as possible. Additionally, they were asked to answer questions about their personal background (age, gender, national background, hours spent in nature per week and care for the environment). These questions were asked to allow for further possible investigation into the dimensions of experience, knowledge and values about nature, expected to differ with profession.

The answers for profession were categorized as *biologist* or *non-biologist*. A respondent was qualified as a biologist if the statement made for profession indicated previous or current enrolment in a bioscience study programme at university level. If the category was unclear, no profession was assigned. National background was categorized as *Norwegian*, *German* and *Other*. Categories for environmental care were *high*, *intermediate* and *none*.

2.6 | Acquisition of respondents

The questionnaire was sent digitally via email invitations and made available on social media during spring 2017. Three target groups were defined: university members (main target group), school members (teachers and pupils older than 16 years) and members of senior residences to broaden the age range. All group categories were contacted in Norway and Germany.

For the acquisition of university members, universities teaching biology were chosen. Staff and students with expertise closest to plant biodiversity were contacted. Within the same university staff and students at the institute of economy were contacted. The decision to sample the institute of economy was informed by the fact that all sampled universities also have an institute of economy, and the assumption that the professional training of economists does not involve biodiversity measures and concepts.

FIGURE 1 Artificial plant communities displaying differences in (a) species richness: 16, 8, 4 and 2 species (left to right), (b) in evenness: even distribution, 33% dominance, 50% dominance (left to right), (c) species turnover: total turnover, 50% turnover and no turnover (left to right). Letters correspond to the order in which the pictures were displayed in the questionnaire. All pictures were displayed in the same size.

For the acquisition of teachers and pupils, teachers were contacted with the kind request to distribute the questionnaire among their pupils. To ensure an equal distribution within the countries, three high schools for each county were sampled at random.

For the acquisition of senior residence members, administrative staff in daycare were contacted with the kind request to distribute and assist with the questionnaire among the members. Also here, three senior residences per county were chosen randomly.

2.7 | Research ethics

We adhered to the guidelines of the Norwegian National Committees for Research Ethics. Consent procedure:

Respondents were, on the front page of the questionnaire, informed about the nature of the questionnaire, the intent and origin of the study, as well as their anonymity. The answers could, by the chosen settings of QuestBack, not be linked to the respondents and, therefore, were anonymous. After the final questions, the participants were presented with a 'send' button to send in their answers to be used in our study. Hence, by not pushing 'send' they could withdraw from the survey at any time without their answers being registered.

2.8 | Statistical analysis

All statistical analysis was performed using the software R 3.5.1 (R Core Team, 2018).

For the analysis of perception of biodiversity, the respondents' rankings were compared to the actual ranking of the displayed biodiversity, and accordingly, for each biodiversity category, a score was assigned. When all pictures within the category were ordered according to the actual biodiversity, *accurate* was assigned; otherwise, the score was assigned to be *diverging*. The influence of biodiversity category and profession on the accuracy of perceived plant biodiversity was predicted using GLM's of the binomial family with a logit link function of R's base package. We tested both additive and interaction terms.

To investigate appreciation, which cannot be assessed as a binary variable and that does not follow a Gaussian distribution, Kendall's rank correlation coefficient tau (τ) was used. To adjust for tied ranks, the tau-b measure was chosen (Agresti, 2012). First, the correlation between the appreciation ranks and the actual biodiversity ranks was assessed. Next, the correlation between the appreciation ranks and the respondents' perceived biodiversity ranks was assessed. Correlations were calculated for each biodiversity category and profession group separately. Confidence intervals for the correlation coefficients were computed by bootstrapping ($B = 1000$) (Efron & Petrosian, 1999). To assess to what extent the profession was confounded with other personal variables, we tested the relationship between profession and categorical personal variables using χ^2 tests and two-sided *t*-tests for continuous personal variables. To obtain insight into the effect of these personal variables, we used GLM models.

3 | RESULTS

A total of 333 target respondents participated in the survey.

3.1 | Personal variables

Of all participants, 151 (45.05%) were categorized as biologists, and 148 (44.44%) were categorized as non-biologists. A few respondents ($n = 34$ (10.21%)) could not be assigned to one of these categories or chose not to state their profession.

Profession and the respondents' personal variables showed confounding (Table 2). We found biologists to be more associated with male, German/Other and older respondents, caring more for the environment and spending more hours in nature.

3.2 | Perception

Across all biodiversity categories, 9.00% of the respondents ($n = 30$, 23 biologists, 6 non-biologists, 1 uncategorized) ordered all pictures congruently to actual biodiversity, whereas 85.59% ($n = 285$) assigned a divergent order in at least one category. For 5.41% of the respondents ($n = 18$), a score over all categories was not available.

An additive effect of profession and biodiversity category most parsimoniously predicted the accurate ranking by the respondents (Table 3). Both the biodiversity category and the profession were significant predictors (Table 4). Species richness was ordered most accurately while species evenness and species turnover were most often ordered divergently from actual biodiversity (Figure 2).

TABLE 2 Relationship of profession with personal variables. *T*-value for continuous variables (Hours in Nature and Age) and χ^2 for categorical variables, with degrees of freedom [df], the difference of the groups (biologists, non-biologists) means (Δ_{means}) or proportions (Δ_{prop}) and confidence intervals ($CI_{2.5\%}$, $CI_{97.5\%}$) at the 95% level. Confidence intervals, not overlapping zero indicate significant estimates.

	T [df]	Δ_{means}	$CI_{2.5\%}$	$CI_{97.5\%}$
Hours in nature	5.0668 [228,06]	5.3099	3.2449	7.3748
Age	1.9205 [289.25]	3.3341	−0.0828	6.7511
	χ^2 [df]	Δ_{prop}	$CI_{2.5\%}$	$CI_{97.5\%}$
Gender	6.8066 [1]	0.1575	0.2761	0.0389
Country (Ger/Nor)	20.009 [1]	0.2871	0.1619	0.4122
Country (Ger/Oth)	0.0342 [1]	−0.0268	−0.1784	0.1247
Country (Nor/Oth)	11.564 [1]	−0.2287	−0.3680,	−0.0895
Environmental care	21.652 [1]	0.2242	0.1292	0.3192

TABLE 3 Model selection results. For each model, the residuals' degrees of freedom (df), the null deviance and the residuals deviance, the AIC and the difference to the lowest AIC (ΔAIC) are given. The most parsimonious model (accuracy ~ BC + Profession) is indicated by # and bold numbers

Model	Residual df	Null deviance	Residual deviance	AIC	ΔAIC
Biodiversity category (BC)	969	1339.50	1121,69	1127,68	121,81
Profession	874	1210.00	1193,66	1197,66	197,78
BC + profession#	**872**	**1210.00**	**991,88**	**999,88**	**0**
BC × profession	870	1210.00	990,39	1002,38	2,5

None of the covariates influenced the effect of profession: when other personal features were included, biodiversity category and profession remained significant predictors with similar effect sizes (all models and effect sizes found in Table S3).

TABLE 4 Model estimates (probability for accurate order) with 2.5% and 97.5% confidence intervals (CI). Confidence intervals not overlapping zero indicate significant estimates.

	Estimate	CI 2.5%	CI 97.5%
Intercept (species richness, biologist)	0.8454	0.7976	0.8853
Evenness	−0.4833	−0.5681	−0.3922
Species turnover	−0.4662	−0.5526	−0.3746
Profession: non-biologist	−0.1169	−0.1825	−0.0608

3.3 | Appreciation

Both biologists and non-biologists showed a positive correlation of appreciation to the actual biodiversity ranks for both species richness and evenness (Figure 3). The species turnover ranking was not correlated to appreciation for biologists, whereas it was weakly negatively correlated for non-biologists. Overall, the appreciation-actual diversity correlations among biologists were more positive than those among non-biologists.

3.4 | Appreciation and perception

Appreciation was more positively correlated to perceived biodiversity than to actual biodiversity, for both biologists and

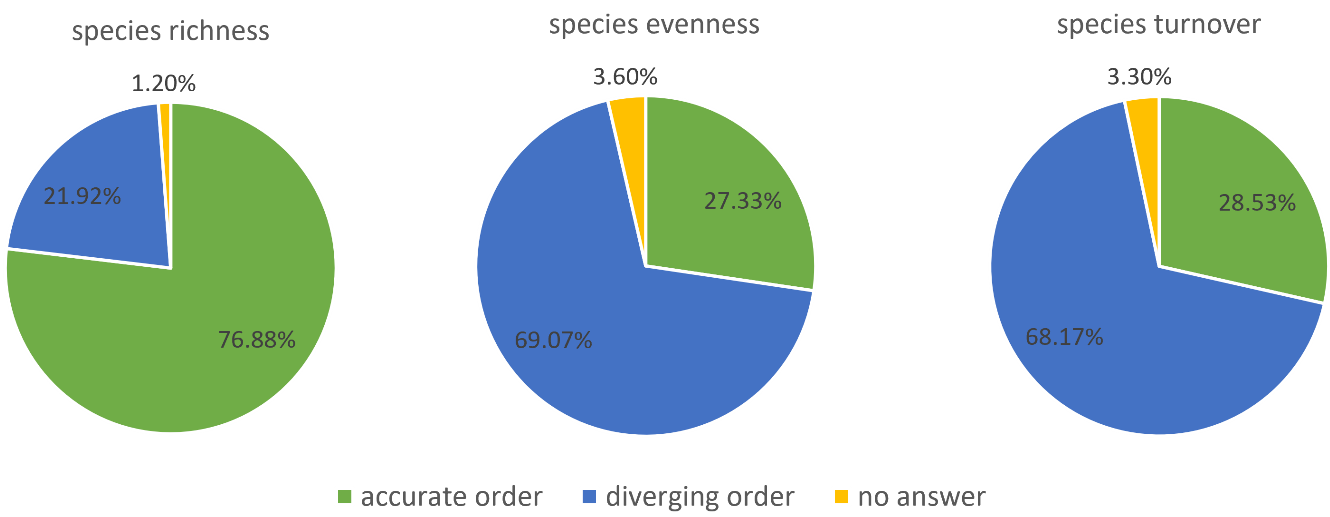

FIGURE 2 Pie charts of the distribution of answers (accurate order, diverging order, no answer) within each of the three biodiversity categories.

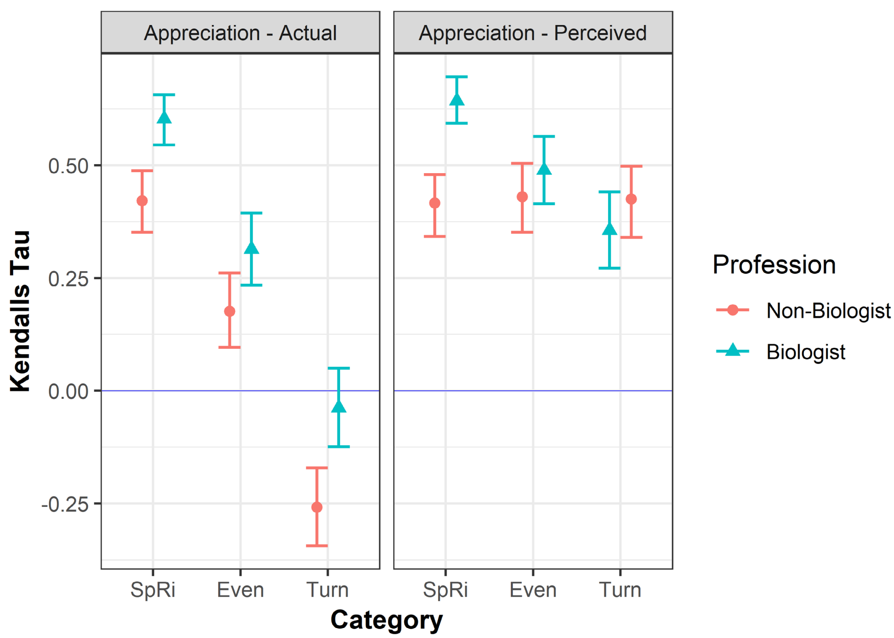

FIGURE 3 Kendall's tau-b correlation coefficients with confidence intervals (95%-level) of appreciation ranks to actual biodiversity ranks (left) and perceived biodiversity ranks (right); for Species Richness (SpRi) Evenness (Even) and Species Turnover (Turn); for biologists (green triangle) and non-biologists (red dot).

non-biologists, in all biodiversity categories but species richness (Figure 3). The correlation coefficients for appreciation to perceived biodiversity differed between professions for species richness, where biologists had a more positive correlation, but not for evenness and turnover.

4 | DISCUSSION

In our study, we show that accuracy in the perception of plant biodiversity is highly dependent on the biodiversity category in question. We found that respondents in general perceived species richness accurately, whereas species evenness and turnover were perceived less accurately. Additionally, we found biologists to perceive plant biodiversity more accurately than non-biologists. Appreciation of plant biodiversity always correlated positively with perceived biodiversity and is stronger than with actual biodiversity, except for species richness. In this category, perceived and actual biodiversities were most often congruent.

These findings suggest that changes in plant biodiversity other than species richness are more difficult to perceive; and that people appreciate what they perceive as high plant biodiversity even when actual plant biodiversity is low.

In the following, we first discuss the posed research questions and then elaborate on the implications of our findings.

4.1.1 | (1a) To what extent do people accurately perceive an increase in species richness, species evenness and species turnover?

Our results confirm previous studies that people perceive changes in species richness accurately (Lindemann-Matthies et al., 2010; Southon et al., 2018). We found pronounced differences in people's perception between biodiversity categories that matter for ecosystem functioning. Although people might not perceive, for example, an increase in productivity directly, our results suggest people perceive changes in species richness which were found to be related to changes in productivity (Reich et al., 2012). Several studies found that people use clues like, for example, colour diversity, evenness, vegetation height or perceived naturalness (Graves et al., 2017; Hoyle et al., 2019; Southon et al., 2017, 2018) for species richness. These features were controlled for and kept constant in our artificial communities. This suggests that people did not need other obvious cues to distinguish levels of species richness.

Both evenness and turnover were perceived less accurately. These biodiversity measures are not easily evaluated, even for trained plant ecologists (Damgaard, 2014). Therefore, a low accuracy is expected in these biodiversity categories when assessing digitalized displays of artificial plant communities. Since these biodiversity categories are lesser known, potentially even among biologists, these perceptual difficulties point towards the importance of knowledge/training. Consequently, pictures displaying those categories might have been evaluated in terms of the more familiar category species richness, which did not vary in the evenness displays and, therefore, could not be successful in this case. The species turnover displays translate to a total species richness of 8, 16 and 24 species in the three-picture sets. Lindemann-Matthies et al. (2010) found that the ability to distinguish species richness levels decreased with increasing numbers of species. As the number of species in their study exceeded 16, the perceived species richness diverged further from the actual species richness. The authors connect this to the effect of large numbers, which cannot be discriminated as exactly and quickly as lower numbers (Moyer & Landauer, 1967). Hence, the low accuracy in perceiving species turnover might also be due to higher species numbers and higher complexity of the picture sets. The scale dependence of the perception of evenness and turnover presents an interesting field for further investigation, especially because it can be experienced in several scales simultaneously.

4.1.2 | (1b) Is perception more accurate among biologists than among non-biologists?

A clear influence of the respondent's profession on accuracy was found. Independent of the biodiversity category, the biologists among the participants had an 11.69% higher probability to order the pictures congruently with the actual biodiversity. Hence, it can be concluded that experience and knowledge in the form of professional training in biology at university level are connected to increased accuracy in the perception of local plant biodiversity. This is further supported by the fact that 23 of the 30 respondents who achieved all accurate scores were categorized as biologists. Biological knowledge is the main explanation for the increased accuracy in perceiving biodiversity since experience increases sensibility in visual perception (Lu et al., 2011). It can be assumed that having learned the concepts and definitions of biodiversity is connected to an increased ability to assess differences in local plant biodiversity, which can be linked to perceptual learning. Educational qualifications alone cannot explain the increased accuracy since the majority of our non-biologists are in, or have been in, higher education (sampled at universities). Nevertheless, it presents an interesting candidate for further investigation since, for example, Hoyle et al. (2019) found a positive effect of educational level of visitors in urban green spaces on the perceived biodiversity.

Additionally, other factors connected with being a biologist, for example, being familiar with looking at plants from above, and variables indicated by the confounding with profession, might be causal to the elevated accuracy in perceiving plant biodiversity. Further investigations are needed to disentangle the role of, for example, care for the environment for which Southon et al. (2018) found an effect on perception, but hours spent in nature and age are also candidates for further inquiries.

4.1.3 | (2a) Do people appreciate more diverse plant communities more than less diverse communities?

Appreciation for diversity differed between biodiversity categories. We found species richness to be the strongest correlated category. Higher species richness was preferred to lower species richness. This is consistent with the results of Lindemann-Matthies et al. (2010) and Southon et al. (2018) who found that appreciation increases with increasing species richness. Colour diversity has been shown to increase appreciation (Graves et al., 2017; Hoyle et al., 2018). Therefore, we tested appreciation of species richness with stable colour diversity except for the community with the lowest species richness, and we can strengthen previous arguments that high species richness is attractive to people, even without additional cues. We can confirm the positive effect of evenness found by Graves et al., 2017 with the positive correlation that we found between evenness and appreciation, but not their finding that species richness has no effect on people's appreciation. Although significantly weaker than the species richness-appreciation correlation, our results indicate a substantial influence of the relative distribution of species in plant communities on people's preferences: even distributions were preferred to communities dominated by one species. Appreciation of species richness found by Southon et al. (2018) was associated with evenness. In our study, we disentangled the role of evenness and richness in people's perception and found that, independent of species richness, changes in evenness matter.

The effect of species turnover on appreciation was none or a weakly negative influence. The difference in the results for species richness could indicate that appreciation of plant biodiversity is scale-dependent, or it can be explained by the higher complexity in the communities displayed in the species turnover picture sets. Complexity has been found to influence aesthetic preferences for objects (Jacobsen, 2010). The relationship seems to be an inversed U-shape with a dislike for very low complexity (due to boredom) and very high complexity (due to incomprehensibility) (Akalin et al., 2009; Hekkert & Wieringen, 1990).

Our results here stand in contrast to the results shown by Lindemann-Matthies et al. (2010), who displayed a linear increase in appreciation for species richness up to 60 species. However, this was performed in nonchanging spatial dimensions, while in our study the displayed area in the pictures/picture sets changed. Therefore, these results are not strictly comparable and more research into the scale dependence is needed.

4.1.4 | (2b) Is appreciation mostly linked to perceived biodiversity or actual biodiversity?

The correlations between appreciation ranks and perceived biodiversity ranks were considerably stronger positive than actual biodiversity ranks for evenness and species turnover (the two less accurately perceived categories), but not for species richness. This means that the plant communities were valued when plant biodiversity was perceived as high, even when the actual plant biodiversity was low. High biodiversity was, therefore, valued per se: respondents liked what they thought is more diverse, and vice versa. This is especially evident in species turnover, where the correlation to actual diversity is not present or was weakly negative, but the correlation to perceived diversity is strongly positive.

Although influencing factors such as colour and flower diversity (Graves et al., 2017) were kept constant in the present study, other undiscovered factors might explain the remaining variance in appreciation for the plant communities. For example, the presence of a specific species might increase or decrease the aesthetic appreciation through, for example, inflorescence size, colour, symmetry and complexity (Hůla & Flegr, 2016). Lindemann-Matthies et al. (2010) found such an effect for 15 of their 65 used species. The only species in common with the present study was *Trifolium pratense* for which they found a positive effect on appreciation. It was present in all of our artificial communities and, therefore, cannot be tested for its influence. But its high abundance in low-diversity communities, which were appreciated less than more diverse communities with lower abundance of *Trifolium pratense*, indicates that the effect of this species does not exceed the effect of biodiversity on appreciation.

4.1.5 | (2c) Do biologists and non-biologists differ in their appreciation of species richness?

Biologists' appreciation was more positively correlated to actual species richness and evenness, as well as to perceived species richness. This finding is in contrast to the results of Graves et al. (2017) on appreciation of plant biodiversity, which were 'remarkably constant across the psychographic groups' and for which previous knowledge of the flora of the sampling area had no significant impact.

4.1 | Implications

The results presented here indicate that people perceive changes differently depending on the dimension of plant biodiversity. Most people perceived species richness accurately. However, accuracy in the perception of plant species along with their abundances, core to the biodiversity dimensions of evenness and turnover, was low. This points to a possible 'plant biodiversity blindness' that has only been overcome for species richness due to the prominence of the term and the resulting attention to the variation it implies (Sanders et al., 2021).

The shown limitations of the majority of respondents to distinguish evenness differences and an increasing dominance of one species implies that biodiversity aspects beneficial for ecosystem functions have low recognition. Altered abundance of species shows transformations in the ecosystem before species get lost (Hillebrand et al., 2008). Therefore, our results suggest that possible 'early warnings', which could trigger people's awareness of plant biodiversity declines first-hand, can be largely overlooked.

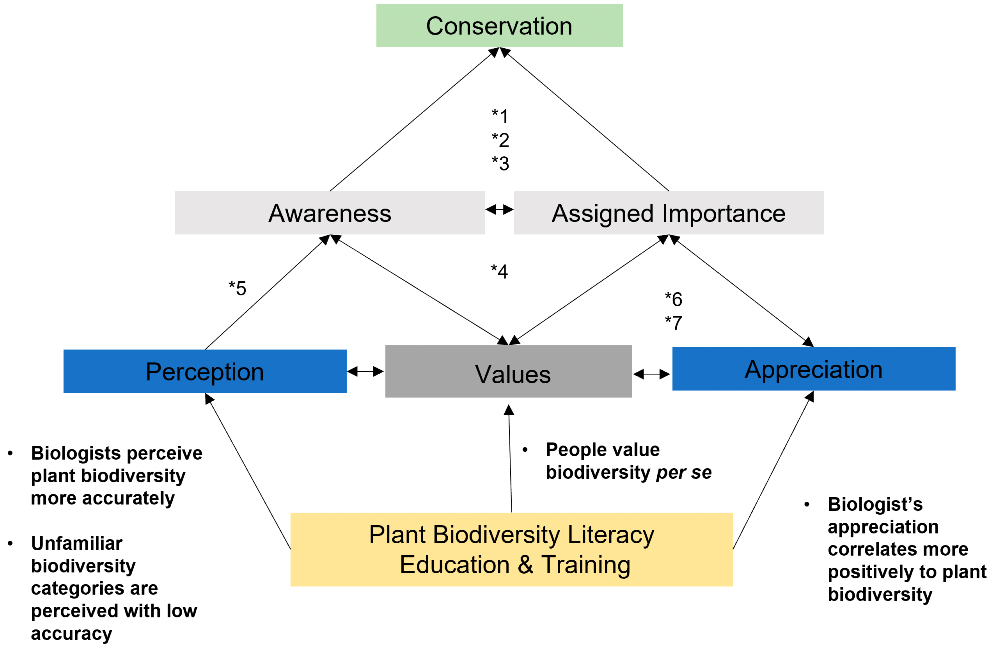

FIGURE 4 Infographic on the contribution of the article in a larger context. The bullet points indicate our findings. * refer to cited articles that investigate the indicated connection: *1 Balding and Wiliams (2016) *2 Colléony et al. (2017) *3 Saunders et al. (2006) *4 Stagg and Dillion (2022) *5 Sanders et al. (2021) *6 Ford et al. (2012) *7 Ives and Kendal (2014).

Also, the revealed difficulty to perceive changes in species turnover implies a low awareness about changes among communities. We showed that people generally struggle to recognize a homogenization of communities, which could imply that a loss of ecosystems' multifunctionality goes unnoticed.

Finally, our study indicates an approach to increase people's awareness about plant biodiversity losses. Professional training in biology was linked to an increased accuracy in perceiving changes in local plant biodiversity. Hence, fostering literacy in biodiversity, especially in less familiar biodiversity dimensions, can be considered efficient for increasing perception skills. Additionally, our study indicates that the valuation of local plant communities can be hampered by a misperception of their biodiversity, also supposed by Lindemann-Matthies et al. (2010).

Our finding that biology knowledge increases the perception skills for biodiversity, in turn increasing appreciation for diverse communities, makes us confident to recommend education and training as a key instrument to enhance public engagement in the conservation of plant biodiversity. Knowledge about biodiversity's role for ecosystem functions and services might further enhance the value people assign to and, thus, their appreciation for biodiversity. This in turn could lead to increased participation in the conservation of biodiversity. Including biodiversity and plants early in the curriculum can help society act on the biodiversity crisis.

Figure 4 provides an overview of this studies' contribution in a larger context.

AUTHOR CONTRIBUTIONS

The study was conceptualized and designed by both authors. Eva Breitschopf has acquired, analysed and interpreted the data. She also drafted, wrote and revised the manuscript. Kari Anne Bråthen contributed substantially to the analysis and interpretation of the data. She also critically revised the manuscript.

ACKNOWLEDGEMENTS

This study was supported and financed by UiT—The Arctic University of Norway. Many thanks to all participants. We are grateful to the Climate Laboratory Holt (UiT&NIBIO) for the provided workspace. We would like to thank Mari Bergset and Vera Hausner for valuable insights in the development phase. This article relies in parts on the corresponding author's Master's thesis. We would like to thank the reviewers for their insightful comments that improved the presentation of our research.

CONFLICT OF INTEREST STATEMENT

We have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The dataset for this study is available at the Zenodo repository under https://doi.org/10.5281/zenodo.7551468.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1: Supporting Information: list of species that were used (Table S1), the questionnaire (Table S2), fullsize pictures (Figure S1–10) and additional model ananlysis (Table S3).

How to cite this article: Breitschopf, E., & Bråthen, K. A. (2023). Perception and appreciation of plant biodiversity among experts and laypeople. *People and Nature*, *5*, 826–838. https://doi.org/10.1002/pan3.10455