Faculty of Biosciences, Fisheries and Economics
Department of Arctic and Marine Biology

Perception and Appreciation of Plant Biodiversity

An assessment of human perception and appreciation of plant biodiversity using photography of artificial plant communities

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BIO- 3950, Master's Thesis in Biology, Northern Populations and Ecosystems

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Eva Breitschopf, artificial plant community, July 2016

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Abstract

Anthropogenically caused global biodiversity declines and other human drivers point to the possibility of local plant diversity changes. The well-studied effects of local plant diversity on ecosystem processes implicate consequences to human well-being in the form of altered ecosystem services (including cultural services).

Public awareness (knowledge and correct perception) about these changes and the valuation (including aesthetic appreciation) condition the importance and hence effort given to conservation, which is necessary in the face of biodiversity changes and their implications.

This study explored the perception and appreciation of local plant species diversity with the use of an online questionnaire on artificial plant communities, displaying differences in α-diversity, β-diversity and evenness. To incorporate possible intrinsic human determinants on the perception and appreciation, the questionnaire was targeted at experts and lay-people in biology in two different countries and assessed more personal features of the respondents.

The results show that the biodiversity category and the profession of the respondent significantly influence the ability to correctly assess the plant diversity displayed in standardized pictures, with α-diversity achieving a high success rate and evenness and β-diversity a low success rate.

Appreciation was positively correlated to α-diversity. Furthermore a stronger correlation of appreciation to the perceived diversity than to the actual diversity was found.

It demonstrates that plant biodiversity is valued per se, even though only species richness can be perceived correctly by the majority. The influence of profession implicates the increasing of knowledge in the public as a sensible target to facilitate conservation of plant species diversity.

Keywords: plant diversity, species richness, evenness, beta-diversity

appreciation, perception, awareness

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Introduction

Biodiversity, the variation of life in all its forms and scales, is changing globally (Millenium Ecosystem Assessment, 2005a). These changes happen in such unprecedented fashion and speed, caused by human interference with ecosystem processes, habitats and the geosphere (Pimm et al., 1995, Sala et al., 2000) that the current geological time period, termed the Anthropocene, is associated with the sixth mass extinction on earth (Barnosky et al., 2011). Present rates of extinctions are about three orders of magnitude higher than the background extinction rate (Pimm et al., 2014)

"The challenges ahead for biodiversity conservation will require a better understanding of one species: our own"- That is how Saunders et al. (2006) termed the need for comprehension of the human-nature relationship to act on mitigating ongoing changes. This includes how people perceive and appreciate biodiversity. This is the focus of this study, concentrated on local plant species diversity.

Despite that vascular land plants, among the eukaryotic organism groups, are the best described (Pimm et al., 2014), information on actual trends in local plant diversity is inconclusive. The estimations based on only the plant species known and scientifically identified, indicate that they are more threatened than birds and as severely threatened as mammals (Brummitt et al., 2015, Corlett, 2016). While the global number of plant species is in decline, regional patterns remain unclear:

Vellend et al. (2013) state no net changes in local scale species richness. They documented that most plots included in their global meta-analysis displayed low levels of change, rarely occurring declines and more often occurring increases of local plant species richness (Vellend et al., 2013). However this study was criticized because of bias in the spatial distribution of the dataset, the predominant use of short time-series and the lack of consideration of appropriate historical baselines (Gonzalez et al., 2016). In the yet unresolved debate about local plant biodiversity change several studies were able to show human impact on local communities. Ellis et al. (2012) e.g. document that the number of species in regional landscapes can increase due to the invasion of exotic species, facilitated anthropogenically. These exotic species have the potential to impact resident biota survival and to change ecosystem processes (Pyšek et al., 2012) but long term effects on global and local plant diversity remain largely unknown (Corlett, 2016) or indicate local plant species richness declines (Vilà et al., 2011). Furthermore native plant species abundance can be reduced when exotic species become dominant (Pyšek et al., 2012), resulting in an homogenisation of the community: a few welladapted species become over abundant and displace the declining species. This represents a broadened loss of biodiversity which is easily overlooked when only species richness is studied (Millenium Ecosystem Assessment, 2005a).

Overall, the evidence for the impact of humans on local plant diversity is not conclusive yet and the available results show high context dependency. Still present studies (e.g: Hautier et al. (2015), Borer et al. (2014), Keeley et al. (2003)) allow the assumption that the human caused global loss of plant biodiversity coupled with other anthropogenic environmental changes translates into local changes of plant diversity. Especially when these scientific findings are used for decision making in society the Precautionary Principal ("Extra precaution is justified when false negatives are worse than false positives." (Persson, 2016)) supports to work on the basis that human actions have an influence on the local plant biodiversity.

Evidence and synopsis from research over the last 30 years indicates that the influence is possibly reciprocal: humans impact biodiversity – biodiversity impacts human well-being (Cardinale et al., 2012, Díaz et al., 2006). This is most often investigated for vascular plants especially in grasslands (Naeem and Wright, 2003). Many ecosystem functions are affected by the loss of plant biodiversity, which in turn alters the ecosystem services people can obtain from them. This can be inferred from for example Reich et al. (2012), who showed that species richness in manipulated grassland communities is positively linked to biomass productivity and that this effect intensifies over time. More direct and indirect effects of species richness on human well-being have been summarized in several reviews (Cardinale et al., 2012, Cardinale et al., 2011, Haines-Young and Potschin, 2010). Despite of many unanswered questions, the authors conclude that there is balanced evidence for a positive effect of biodiversity (mainly meaning species richness) on efficiency of resource extraction, stability of ecosystem functions and productivity, inter alia. Furthermore these effects seem to grow stronger over time and are suspected to translate to effects on ecosystem services, e.g. in crop and fodder yield, pest control and carbon sequestration (Cardinale et al., 2012). Despite the considerable difficulties to extrapolate to real ecosystems induced by the reliance on experiments in random species assemblages the well-investigated effects on ecosystem processes provide theoretical understanding how local plant biodiversity (i.e. species richness) is influencing ecosystem services humans can obtain (Wardle, 2016).

Concluding, there is mounting evidence that plant species diversity influences ecosystem functioning and hence ecosystem services in multiple ways (Mace et al., 2012). Therefore, the existence of a variation of organisms is fundamental for regulating ecosystem services, and can be valued as an ecosystem service itself or a good that humans obtain (Mace et al., 2012).

Given that plant biodiversity is under human caused change, also at the local scale, and that these changes have consequences for human well-being, the necessity to act in order to preserve the functioning of local ecosystems and the services they provide becomes clear. Nevertheless the conservation of plant biodiversity has not received the same attention like e.g. animal conservation (Corlett, 2016). Several reasons for that can be developed. Balding and Williams (2016) state it summarizing 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 of plants. Conservation critically depends on the awareness about changes of and the value people assign to organisms (Saunders et al., 2006). Since the conservation of biodiversity, including plants, has been internationally acknowledged as of major importance through the Convention on Biological Diversity (United Nations Environment Programme, 1992) and the formulation of the Aichi Targets (United Nations Environment Programme, 2010), it is necessary to investigate peoples' awareness and valuation of plant biodiversity. This is the area of interest for this study.

Awareness, the knowledge or the perception of a fact (Oxford-English-Dictionary, 2017a), is a prerequisite for people to acknowledge the need for conservation. That means specifically that conservation of plant biodiversity is only considered necessary by the society if the changes are perceived by people. Since conservation is only feasible with the inclusion of the majority of people (Hanski, 2005, Lindemann-Matthies and Bose, 2008) knowledge about peoples' ability to assess plant biodiversity is needed. Realisation of differences in plant biodiversity determines peoples' awareness and therefore the importance they assign to conservation. Therefore perception of plant biodiversity is one main target of the present study.

Furthermore valuation is another determinant of the importance people attach to conservation. According to the Oxford-English-Dictionary (2017b), a value is, among other definitions, the usefulness of something, in other words the benefits people can obtain from something; in the case of plant biodiversity the ecosystem services. Hence peoples' awareness of these ecosystem services and the ability to detect changes in plant biodiversity in ranges that matter to ecosystem processes providing these services are prerequisites to engage in conservation. Hence the investigations of this study will concentrate on the local scale and ranges of plant diversity, in which the above mentioned balance of evidence for biodiversity effects on ecosystem processes and ecosystem services has been acquired.

Ecosystem services, as defined by the Millenium Ecosystem Assessment (2005b), are categorized in provisioning, regulating, supporting and cultural services. Supporting, provisioning and regulating ecosystem services are connected to bio-chemical and physical processes in the ecosystem, such as biomass productivity. This is different for the last category.

Cultural ecosystem services (CES) are defined as "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences" (Millenium Ecosystem Assessment, 2005b) and can be divided in several subcategories (Milcu et al., 2013). CES range from the intrinsic valuation over inspiration, educational, spiritual, recreational and heritage values to the aesthetic appreciation of ecosystems (Milcu et al., 2013) . These values are mostly intangible and therefore subtle and hard to quantify (Milcu et al., 2013, Millenium Ecosystem Assessment, 2005b). Research on CES is in its beginning with an increasing number of projects (Milcu et al., 2013) but remain little studied so far. What determines these services and if biodiversity also has effects on CES, is largely unknown (Lindemann-Matthies et al., 2010).

Aesthetic beauty of ecosystems is one service included in CES and also often used as an argument for conservation of certain iconic species (Stokes, 2007). While aesthetic valuation of biodiversity has been mostly studied on single, mainly animal species (e.g. Stokes (2007)), or theoretically (Kiester, 1996), studies explicitly testing how plant biodiversity influences humans' aesthetic appreciation remain scarce (Graves et al., 2017, Lindemann-Matthies et al., 2010). Furthermore a review of urban biodiversity perception and valuation identified that most studies were undertaken at the ecosystem scale while far fewer studies cover the community scale (Botzat et al., 2016). Nevertheless understanding the links between ecosystem services and biodiversity are crucial in the face of rapid biodiversity loss, also for CES. This study aims to add knowledge on how plant biodiversity delivers CES inform of aesthetic appreciation which adds to the overall valuation of plant diversity.

Biodiversity can be described in several ways, e.g. as species richness (alpha-, beta- gamma-diversity) and evenness, which may impact on how humans perceive and appreciate the biodiversity.

While alpha(α)-diversity describes the number of species at the local level, gamma(γ)-diversity captures the number of species on the regional level (Whittaker, 1972). People are constantly encountering vegetation at the local scale. During a walk in nature or also in urban settings local plant communities are the unit people are confronted with and which can be perceived and appreciated. Furthermore the effects on ecosystem processes have been tested in this also called plot-scale in ranges about $1m^2$ and in α-diversity ranges of 1 to about 30 species (see for example Reich et al. (2012)). Therefore the investigations in this study were chosen to include species richness at the scale of α-diversity.

Beta(β)-diversity expresses the difference in species between local communities and bridges both α- and γ-diversity (Whittaker, 1972). It is a measure of differences in species composition (Koleff et al., 2003) and therefore carries implications for the differences in functioning in local scales. Species turnover, one possible measure to express β-diversity, describes the differences in the identity of the species present. The ability to assess these differences between local communities means to be able to assess the diversity in a larger scale, the regional γ-diversity. Additionally it enables to identify new species, for example exotic species foreign to the region in a temporal turnover. Therefore species turnover was included in the study. Furthermore Legendre et al. (2005) termed it "a key concept for the conservation of biodiversity, and for ecosystem management." Insight into the perception and appreciation of this dimension of plant biodiversity hence are needed.

Evenness, the relative abundance of species, changes faster in response to anthropogenic influence than species richness (Hillebrand et al., 2008). The influence of changed dominance patterns therefore can lead to altered ecosystem functioning before a species is eventually lost from the system (Chapin et al., 2000). Even though there might be no net change in species richness locally, the changes in identity and abundance of the species and their functional traits will potentially change the ecosystem functioning (Vellend et al., 2013) e.g. productivity, stability and the resistance against invasion (Hillebrand et al., 2008). Peoples' ability to realize differences in evenness could greatly increase the awareness of change in their surrounding ecosystems and invoke the urge to conserve before species get lost. Therefore evenness was assessed as well for perception and appreciation.

Investigations on the perception and appreciation must not overlook the human component in the matter. Both are highly influenced by personal features of the observer.

Perception, the comprehension of the environment by identification, classification and interpretation of information acquired through the senses (Schacter et al., 2012), is highly context and person dependent. In perception theory it is usually split into two components: firstly the handling of sensory signals and secondly the mental processing which is individual for every person (Bernstein, 2014).

Experience has been proven to increase sensitivity in perception in a wide range of perceptual tasks including the visual domain (Lu et al., 2011). This process is termed perceptual learning and describes the refinement of perception through training (Lu et al., 2011). Transferred to the perception of plant biodiversity this infers several influential personal features of the beholder. Training in the form of education about biodiversity might influence the ability to perceive differences in all categories (α-, β-diversity, evenness). Like medical personnel's ability to visually identify tumours on x-ray images increases with practice (Sowden et al., 2000), the knowledge about and familiarity with biodiversity obtained by education in biology might increase experts' distinguishing skills in plant diversity over those of non-biologists. Therefore this study was targeted on people with biological education at university level and on people without this kind of education. Additionally age was incorporated as a determinant for perception since experience increases with age. Furthermore the regular encounter of plant communities during time in nature can be a form of experience influencing perception and has been assessed in this study as well.

Attention, the focus on which the senses and cognition is concentrated, has high influence on what and how it is perceived (Noë and O'Regan, 2000). The same applies for emotions (Zadra and Clore, 2011). Care incorporates both these features. In the case of plant diversity perception, care about the environment as the attention and emotional connection to e.g. threatened biodiversity, might increase the perceptive abilities. Hence the environmental care of the participant was therefore added to the assessment.

Also aesthetic appreciation is determined by many different factors, spanning from evolutionary and bio-physical features to influences of cultural and historical background, as well as personal variables (Jacobsen, 2010). This is also true for the aesthetic appreciation of ecosystems which differs between socio-demographic groups (Kaplan and Kaplan, 1989). Typical demographic factors like gender and national background were added to the personal features assessed for the perception. Moreover people were targeted in two different countries to account for possible cultural and historical differences.

Previous research on the topic is scarce, especially on the local scale and the few results are partly contradicting. For example Lindemann-Matthies et al. (2010), who worked with grassland communities, found that people generally can distinguish between species poor and species rich plant communities and that the perceived species richness had a strong influence on appreciation. They also stated that appreciation increased with real species richness, while Graves et al. (2017) found that appreciation was unrelated to species richness in their study of forest wildflower communities. Instead they discovered a relation to flower abundance and colour diversity. Both studies examined the effect of species abundance (evenness) and found influences on the perception (Lindemann-Matthies et al., 2010) as well as on the appreciation (Graves et al., 2017, Lindemann-Matthies et al., 2010) of plant biodiversity. A literature search for the perception and/or appreciation of β-diversity yielded no relevant results. Both mentioned studies worked with people possibly affectionate for plants (visitors of botanical gardens (Lindemann-Matthies et al., 2010) and forest visitors in an area where “wildflower viewing and photography is one of the fastest-growing outdoor recreational activities” (Graves et al., 2017)). Both studies performed an assessment of the knowledge of the participants, but this was not explicitly targeted and results remain inconclusive. Concluding there is room to expand the information on the perception and appreciation of local plant biodiversity.

The aim of this study is to explore the perception and appreciation of plant biodiversity at scales that have been shown relevant for ecosystem processes, due to the implication for its valuation as a provider of ecosystem services (including CES) and hence conservation, since human caused global biodiversity decline, climatic changes and emerging evidence is indicative for changes in local plant biodiversity. This is done while accounting for the multiple influencing factors in the variation of biodiversity measures and human personal attributes by the use of an online questionnaire with photographs of artificial plant communities standardized in multiple additional influencing factors (e.g. nr. of individuals and colour diversity).

In order to guide the research and summarize the aims of the study following research questions have been formulated.

1. Perception: Are people able to assess plant biodiversity in different levels and measures? Are there demographic or personal features that influence this ability?

2. Appreciation: Is the aesthetic appreciation influenced by different levels and measures of plant biodiversity? Are there influences of demographic or personal features?

3. Does the perceived plant biodiversity influence appreciation?

Material and Methods

Species choice and sampling area:

Native plants in bloom were sampled, in order to arrange the artificial communities. This was done repeatedly in July and August 2016 in two different areas in the surroundings of Tromsø, Norway (69° 39' N, 18° 57' E). The first sampling area was located centrally on the island of Tromsøya in a birch (*Betula sp.*) forest area close to Lake Prestvannet (69°66' N, 18° 94' E). The second sampling area was located on the mainland close to the delta of the River Tønsvikelva (69° 74' N, 19° 17' E) in a poplar (*Populus sp.*) dominated forest.

The species were chosen by easy access and presence in the sampling area and the colour of their inflorescences (green, red, white, yellow) (Figure 1a). 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 1).

Sampling was performed shortly prior to the arrangement using household scissors. The individuals were only used when they appeared fresh and undamaged. Prior to use, they were kept fresh in a water bucket (Figure 1b, c) sealed with a plastic bag under cool and dark conditions in the University's climate control laboratory.

Figure 1: a) *Plant material shortly after sampling. Individuals of species categorized as yellow, red, white, green (top to bottom).* ***b) c)*** *Plant material (white, red) stored, ready for use.*

Table 1: *List of species used in the set-up of the artificial communities*

	Species	**colour category**	**growth form**
1	*Alchemilla glomerulans*	green	forb
2	*Avenella flexuosa*	green	grass
3	*Deschampsia cespitosa*	green	grass
4	*Dryopteris filix-mas*	green	cryptogam
5	*Equisetum arvense*	green	cryptogam
6	*Gymnocarpium dryopteris*	green	cryptogam
7	*Rumex acetosa*	green	forb
8	*Allium schoenoprasum*	red	forb
9	*Chamerion angustifolium*	red	forb
10	*Epilobium palustre*	red	forb
11	*Geranium sylvaticum*	red	forb
12	*Geum rivale*	red	forb
13	*Silene dioica*	red	forb
14	*Trifolium pratense*	red	forb
15	*Achillea millefolium*	white	forb
16	*Achillea ptarmica*	white	forb
17	*Euphrasia hyperborea*	white	forb
18	*Stellaria nemorum*	white	forb
19	*Trifolium repens*	white	forb
20	*Bistorta vivipara*	white	forb
21	*Crepis paludosa*	yellow	forb
22	*Leontodon autumnalis*	yellow	forb
23	*Ranunculus acris*	yellow	forb
24	*Rhinanthus angustifolius*	yellow	forb
25	*Solidago virgaurea*	yellow	forb
26	*Taraxacum sp.*	yellow	forb

Artificial plant communities

In order to depict different categories and levels of biodiversity artificial plant communities were arranged. They were set up in a 30 cm x 30 cm area in a wet sand bed contained in a planter trough (Figure 2a).

After forming a hole with a pen-shaped planting aid into the sand (hereafter “vase”) (Figure 2 a) plant material was inserted and stabilized with sand to stay up straight in order to resemble a natural plant individual (hereafter “individual”) (Figure 2b).

Figure 2a) *Wet sand bed and holes (vases) made to contain plant material, and* ***b)*** *arranged artificial plant community.*

In order to standardize the composition of each artificial community the following rules were applied for all the biodiversity categories and levels:

1. An “individual” consists of at least 1 inflorescence and 2 leaves.

2. An “individual” should be between 5 and 20 cm in height.

3. An “individual” should be alone in its “vase”.

4. The community consists of 48 “individuals”

5. Each colour must be represented by the same number of species.

Before setting up a community, all plant material was removed from the trough, the sand bed was smoothed and new vases were made.

Biodiversity categories

Three different categories of plant biodiversity were depicted. Artificial plant communities to display differences in α-species richness (hereafter species richness), species evenness and species turnover where made.

Species richness:

Four different communities of species richness were created. The numbers of species present in the artificial communities were 16, 8, 4 and 2 with even numbers of individuals (Table 2). These numbers were chosen to represent levels of species richness that have influence on biomass production (Reich et al., 2012) and therefore on ecosystem functioning. The change from 16 to 2 species in the community was conducted in such a way, that the individuals of the remaining species stayed the same while additional individuals of these species replaced the individuals of the removed species.

Species evenness

Three different levels of species evenness were created in 8-species communities: an even distribution of all species, a 33% dominance of a green species and a 50% dominance of a green species (Table 3).

Species turnover

Three different levels of beta-diversity were created: total turnover of species, 50 % turnover and no turnover. Each level consisted of three different 8-species communities. One picture for each community was taken. To display the turnover the three pictures were combined. To build the artificial communities for these pictures 3 sets of 8 species (8_1, 8_2, 8_3) and 4 sets of 4 species (4_1, 4_2, 4_3, 4_4) were formed (Table 5, Table 6). They were combined to represent the different turnover levels (Table. 4). The species were assigned to the sets at random, only the colours had to be represented equally.

Table 2: *Detailed set-up of the artificial communities depicting differences in species richness.*

col	16 species	Nr	8 species	Nr	4 species	Nr	2 species	Nr
green	*Avenella flexuosa*	3	*Avenella flexuosa*	6				
green	*Equisetum arvense*	3						
green	*Gymnocarpium dryopteris*	3	*Gymnocarpium dryopteris*	6	*Gymnocarpium dryopteris*	12	*Gymnocarpium dryopteris*	24
green	*Rumex acetosa*	3						
red	*Epilobium palustre*	3	*Epilobium palustre*	6				
red	*Geum rivale*	3						
red	*Silene dioica*	3						
red	*Trifolium pratense*	3	*Trifolium pratense*	6	*Trifolium pratense*	12	*Trifolium pratense*	24
white	*Achillea ptarmica*	3						
white	*Bistorta vivipara*	3	*Achillea ptarmica*	6	*Achillea ptarmica*	12		
white	*Euphrasia hyperborea*	3						
white	*Trifolium repens*	3	*Trifolium repens*	6				
yellow	*Rhinanthus angustifolius*	3	*Rhinanthus angustifolius*	6	*Rhinanthus angustifolius*	12		
yellow	*Leontodon autumnalis*	3						
yellow	*Ranunculus acris*	3	*Ranunculus acris*	6				
yellow	*Solidago virgaurea*	3						

Table 3: *Detailed set-up of the artificial plant communities depicting differences in evenness*

	even	**33% dominance**	**50% dominance**
species	**Nr. of ind.**	**Nr. of ind.**	**Nr. ind.**
Gymnocarpium dryopteris	6	16	24
Avenella flexuosa	6	5	4
Epilobium pratense	6	5	3
Trifolium pratense	6	4	4
Achillea ptarmica	6	4	3
Trifolium repens	6	5	3
Rhinanthus angustifolius	6	5	4
Ranunculus acris	6	4	3
Total nr. of individuals	48	48	48

Table 4: *Set-up of the picture sets depicting species turn over. One level consists of 3 pictures, showing 8-species communities. For depicting different species-turnover, 3 sets of 8 (8_{1-3}) and sets of 4 (4_{1-4}) species were grouped.*

	Picture 1	Picture 2	Picture 3
no turnover	8_1	8_1	8_1
50% turnover	4_1+4_2	4_1+4_3	4_1+4_4
100% turnover	8_1	8_2	8_3

Table 5: *Species sets (8_{1-3}) for the set-up of the communities depicting species turn over.*

	8_1	8_2	8_3
green	*Equisetum arvense*	*Avenella flexuosa*	*Alchemilla glomerulans*
green	*Gymnocarpium dryopteris*	*Dryopteris filix-mas*	*Deschampsia cespitosa*
red	*Trifolium pratense*	*Geum rivale*	*Chamerion angustifolium*
red	*Geranium sylvaticum*	*Allium schoenoprasum*	*Silene dioica*
white	*Euphrasia hyperborea*	*Stellaria nemorum*	*Trifolium repens*
white	*Achillea ptarmica*	*Achillea millefolium*	*Bistorta vivipara*
yellow	*Leontodon autumnalis*	*Crepis paludosa*	*Rhinanthus angustifolius*
yellow	*Ranunculus acris*	*Solidago virgaurea*	*Taraxacum sp.*

Table 6: *Species sets ($4_{1\text{-}4}$) for the set-up of the communities depicting species turn over.*

	4_1	**4_2**
green	*Avenella flexuosa*	*Alchemilla glomerulans*
red	*Trifolium pratense*	*Chamerion angustifolium*
white	*Achillea millefolium*	*Stellaria nemorum*
yellow	*Rhinanthus angustifolius*	*Leontodon autumnalis*
	4_3	**4_4**
green	*Equisetum arvense*	*Gymnocarpium dryopteris*
red	*Silene dioica*	*Epilobium palustre*
white	*Trifolium repens*	*Bistorta vivipara*
yellow	*Ranunculus acris*	*Solidago virgaurea*

Photography

All photographs were standardised to show the different communities in constant light conditions, areal dimensions and photographing variables. All communities were photographed from a 90° angle to simulate a view from above, similar to that when walking in a natural habitat.

In order to standardize as many variables influencing the appearance of the picture as possible, the arranged communities were taken into a climate control chamber because of the constant light conditions for the photography.

A tripod was fixated at 1.15 m height and a Canon EOS 500-D Camera with a Tamron 18-270 mm F/3,5 – 6,3 DiII lens was attached to it. The camera settings were kept constant at close up mode and auto focus at the community centre for every picture taken.

The photographs for each biodiversity category are found in Figure 3-5. They are displayed in the order of actual biodiversity levels. They can be found in larger size in the appendix (p. 40 - 46).

Figure 3*: Artificial plant communities displaying differences in species richness: 16, 8, 4, and 2 species (left to right). The letters correspond with the order the pictures were displayed in the questionnaire.*

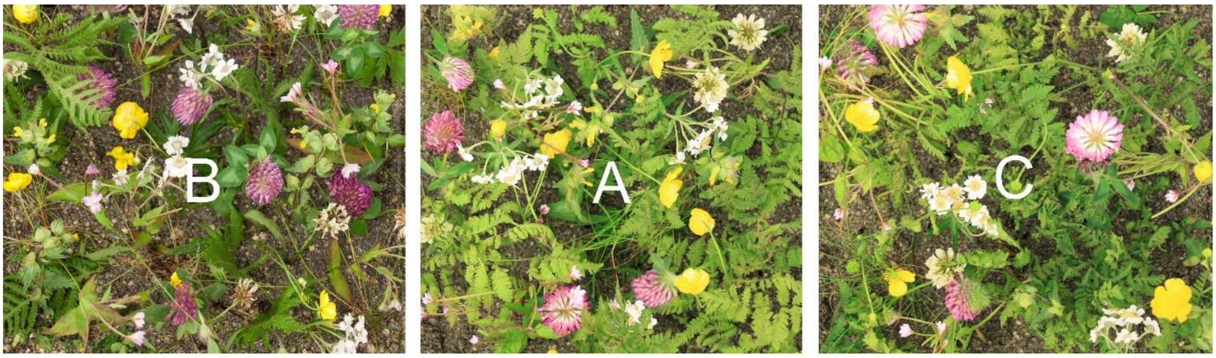

Figure 4: *Artificial plant communities displaying differences in evenness, ordered (left to right): even distribution, 33% dominance, 50% dominance. The letters correspond with the order the pictures were displayed in the questionnaire.*

Figure 5: *Artificial plant communities displaying differences in species turnover): total turnover, 50% turnover, no turnover (left to right). The letters correspond with the order the pictures were displayed in the questionnaire.*

Questionnaire

The questionnaire was set up in Quest Back (www.questback.com) under a sub account of UiT, The Arctic University of Norway, with access to QUEST BACK ESSENTIALS. The questions were made available in English, German and Norwegian. The complete questionnaire is attached in the appendix (p. 39-48).

For each biodiversity category the participants were asked to order the pictures first from the highest to the lowest diversity and second in the order of their personal preference. The same phrasing (Table 7) was used for all biodiversity categories, first species richness, second species evenness and third species turnover.

The pictures/picture-sets were marked with letters (A-C/D) and ordered randomly. In order to minimize visual disturbance the pictures were shown in such a way, that only one picture at the time was visible on the screen.

Table 7: *Question text for assessing the respondents' perception and appreciation of the different biodiversity categories*

	Question text
perception	"Please order the pictures [...] from the highest to the lowest diversity. The picture with the highest diversity on the top and the one with the lowest on the bottom."
appreciation	"Please order the pictures [...] according to your personal preference. The picture you like best at the top and the picture you like least at the bottom."

The respondents' answers are given in ranks for each picture. The ranks correspond with the position the respondent assigned to each picture, when ordering them from highest to lowest biodiversity or personal appreciation.

After the questions concerning the pictures, participants were asked to answer question about the personal background (Table 8).

The answers for profession were categorized in *biologist* or *non-biologist.* A respondent was qualified as biologist, if the statement made for profession indicated previous or current enrolment in a bio-science study program at university level. If the category was unclear NA was assigned. National background was categorized in *Norwegian*, *German* and *Other*. Categories for environmental care were *high*, *intermediate* and *none*.

Table 8: *questions targeted at the personal features of the respondent.*

Feature	**Question text**
Age	*"How old are you?"*
Gender	*"Please select: -I am female -I am male"*
Environmental care	*"Please select what applies most to you :* *- I care a lot about the environment.* *- I care intermediately about the environment.* *- I do not care about the environment. "*
Hours in nature	*"How many hours per week do you spend in nature approximately (when circumstances are good)?"*
National background	*"Please enter the country you grew up in or you feel most belonging to."*
Profession	*"What is your profession? Please write in the box below. (As precisely as possible, e.g. "Master Student, Plant Ecology")"*

Acquisition of respondents

The questionnaire was sent out digitally via e-mail invitations, a built-in feature of Quest Back. Three target groups were defined: university members, school members (teachers and pupils older than 16) and members of senior residences. All groups were contacted in Norway and Germany.

For the acquisition of university members universities teaching biology were chosen. In Germany the ten largest and in Norway all biology teaching universities were contacted. Within the chosen universities, first the webpages of the biological institutes were searched for e-mail addresses of staff and students with expertise closest to plant biodiversity. Within the same university the webpages of the institute of economy was searched for e-mail addresses of staff and students.

For acquisition of teachers and pupils webpages of schools in both countries were searched for e-mail addresses of teachers. In order to ensure an equal distribution within the countries, for each county (Fylke (19) in Norway, Bundesland (16) in Germany) three high schools (NO: videregående skole; DE: Gymnasium) for each county were sampled. Teachers were contacted with the kind request to distribute the questionnaire among their pupils.

For acquisition of senior residence members the same procedure as for schools was performed. Administrative staff in day-care were contacted with the kind request to distribute and assist with the questionnaire among the members.

Furthermore the questionnaire was made available via Facebook to international students of UiT.

The respondents were informed about the intent and origin of the study as well as about the confidentiality with which their data was handled. The answers could not be tracked back to the respondents and therefore were anonymous. Contact information was provided and any questions or concerns were answered via e-mail immediately.

Statistical Analysis

All statistical analysis was performed using the software R 3.4.0 (R Core Team, 2017). The personal variables were checked for confounding using χ^2 -tests and ANOVA to test the assumption of independence required for Generalized Linear Models (GLM).

For the analysis of the perception of biodiversity the respondents' ranks were compared to the correct order of the pictures and accordingly, for each biodiversity category (species richness, species evenness, species turnover) separate, a score was assigned. When all pictures (within one biodiversity category) where at the correct position, *correct* was assigned, otherwise the score was assigned to be *wrong*. GLMs of the binomial family with a logit link function were used to predict the influence of the personal variables on the ability to perceive biodiversity correctly. Also the influence of the biodiversity category was analysed using GLMs.

For the analysis of the appreciation, Kendall's rank correlation coefficient tau-b (τ) was used. The correlation between the appreciation ranks and the actual biodiversity ranks as well as to the perceived ranks was assessed. This was performed for each biodiversity category separate. Groups clustered by the personal variables were compared to each other.

Results

The acquisition of e-mail addresses yielded 1778 addresses (1197 in universities, 108 in senior residences, 443 in schools).

A total of 334 participations were obtained (164 from universities, 8 from senior residences, 103 from schools, and 59 from Facebook).

<u>*Personal variables*</u>

Age ranged from 6 to 79 years. One response of a 6-year old participant was excluded from further analysis. So the age spanned from 16 to 79 years with mean of 38.07 years and a median of 36 years. See the age distribution in Figure 6.

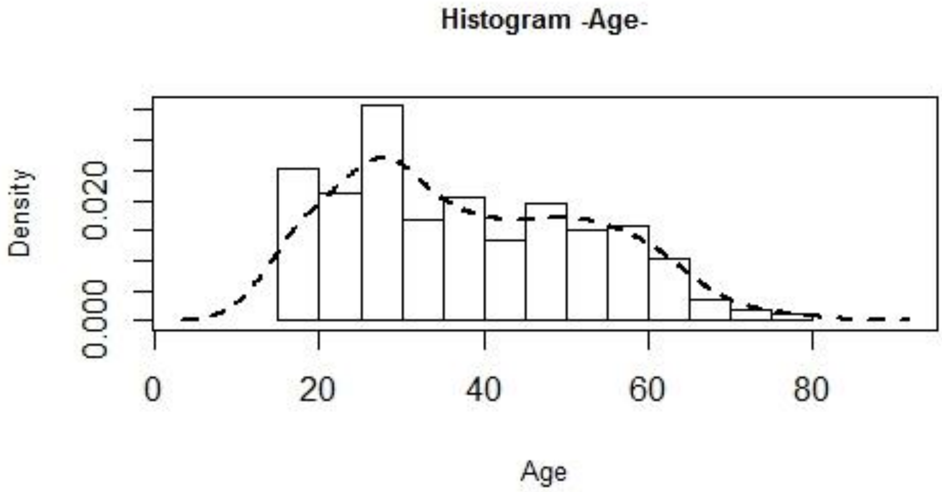

***Figure 6**: Histogram of age, the distribution of age in the sample (n=331)*

Nearly half of the participants (50.75%, n=169) were female and 48.64% (n=163) male and one chose not to state the gender.

In total 31 different national backgrounds were reported. German background was stated by 39.64 % (n=132) of the participants, 45.64% (n=153) stated Norwegian background while 12.31% (n= 41) belonged to another nationality and 7 participants (2.40 %) chose to not state the nationality.

A total of 151 (45.05%) participants were categorized as *biologist*, and 148 (44.44%) were categorized as *non-biologist*. A few respondents (10.21%, (n=34)) could not be assigned to one of these categories ore chose to not state their profession. An overview of the demographic distribution is given in Table 9.

Table 9: *Respondents Overview: shown are those respondents for whom all information was available.*

total sample size: n=333 all personal data available n=295				
		Gender (NA=1)		
Country (NA=7)	**Profession** (NA=34)	**female**	**male**	
Germany	Biologist Non-Biologist	31 21	45 23	
total		**52**	**68**	**120**
Norway	Biologist Non-Biologist	21 56	26 33	
total		**77**	**59**	**136**
Other	Biologist Non-Biologist	13 10	13 3	
total		**23**	**16**	**39**
summed total		**152**	**143**	**295**

No participant stated she/he would "not care about the environment". The majority, 79.88% (266) of the participants stated high environmental care, 65 (19.52%) intermediate environmental care, 2 (0.6%) chose to not answer this question.

The hours the respondents stated to spend in nature per week ranged from 1 to 27 hours, with a mean of 14.34 hours and a median of 17. See the distribution of 'Hours in Nature' in Figure 7.

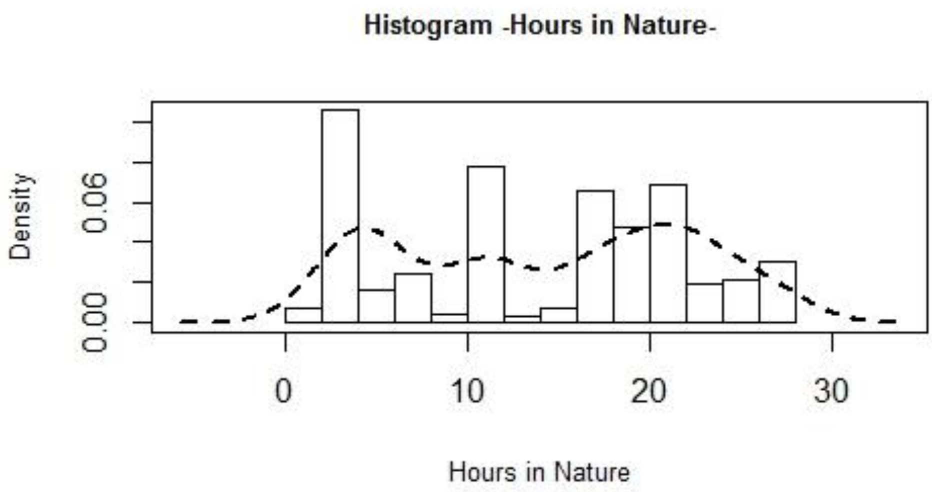

Figure 7: *Histogram 'Hours in Nature', the distribution of the number of hours respondents stated to spend in nature in the sample (n=328)*

The analysis of independence between the respondents' personal variables showed confounding of gender (χ^2=6.81, df =1, p = 0.0091), country (χ^2=25.81, df = 2, p < 0.0001) and environmental care (χ^2= 21.65, df=1, p < 0.0001) with profession. Also age indicated a dependence on the respondents' profession ($F_{(1, 296)}$ = 3.695, p = 0.0555). Only the hours spent in nature were independent from the respondent's profession ($F_{(1, 293)}$ = 0.007, p = 0.9329). Consequently the profession accounts for most information of the other personal variables. Therefore the analysis of the influence of personal variables was concentrated on profession.

Perception

The distribution of the assigned ranks to the pictures per biodiversity category when asked to order in decreasing biodiversity are found in the appendix (p.49 - 50, Table A1, A2, A3)

The order respondents assigned to the pictures when asked to order from high to low biodiversity was compared to their correct order within the 3 categories of biodiversity. For species richness 256 respondents (76.88%) ordered the pictures correctly, 73 respondents (21.92%) assigned a wrong order and 4 respondents (1.2%) did not answer this question. Analysing the answers for evenness showed that 91 respondents (27.33%) assigned a correct order, 230 respondents (69.07%) ordered the pictures wrongly and 12 respondents (3.6%) chose to not answer this question. For species turnover 95 respondents (28.53%) ordered the pictures correctly while 227 respondents (68.17%) assigned a wrong order; 11 (3.3%) gave no answer. Over all biodiversity categories 30 respondents (9.01%, 23 biologists, 6 non-biologists, 1 uncategorized) were able to order all pictures correctly, 285 (85.59%) did not assign all pictures correctly, for 18 (5.41%) a score over all categories was not available.

χ^2-tests on the distribution of correct answers between the biodiversity categories revealed significant differences between them. Significantly more respondents achieved a correct score for species richness than for both evenness (χ^2 = 157.75, df =1, p < 0.0001) and species turnover (χ^2 = 150.91, df =1, p < 0.0001). Correct answers were not differently distributed for evenness and species turnover (χ^2 = 0.0556, df = 1, p = 0.8136).

GLM analysis affirmed biodiversity category as a significant predictor for the correctness. While comparing different models, the one with the lowest Akaike Information Criterion (AIC) was chosen. It included an additive effect of biodiversity category, profession and hours in nature. An overview of the assessed models can be found in the appendix (p. 50, Table A4)

For the chosen model (Table 10) the effects of both biodiversity category and profession (Figure 8 a,b) were highly significant. The probability of achieving a correct score decreased from 0.8199 for species richness ($p < 0.0001$) to 0.3240 ($p < 0.0001$) for evenness and to 0.3406 ($p < 0.0001$) for species turn over. Furthermore the probability decreased by 12.62 % when the respondent was a non-biologist ($p < 0.0001$): for species richness to 0.6937, for evenness to 0.1925 and for species turnover to 0.2044. Hours in Nature (Figure 8c) had no significant effect at the significance level of 0.05.

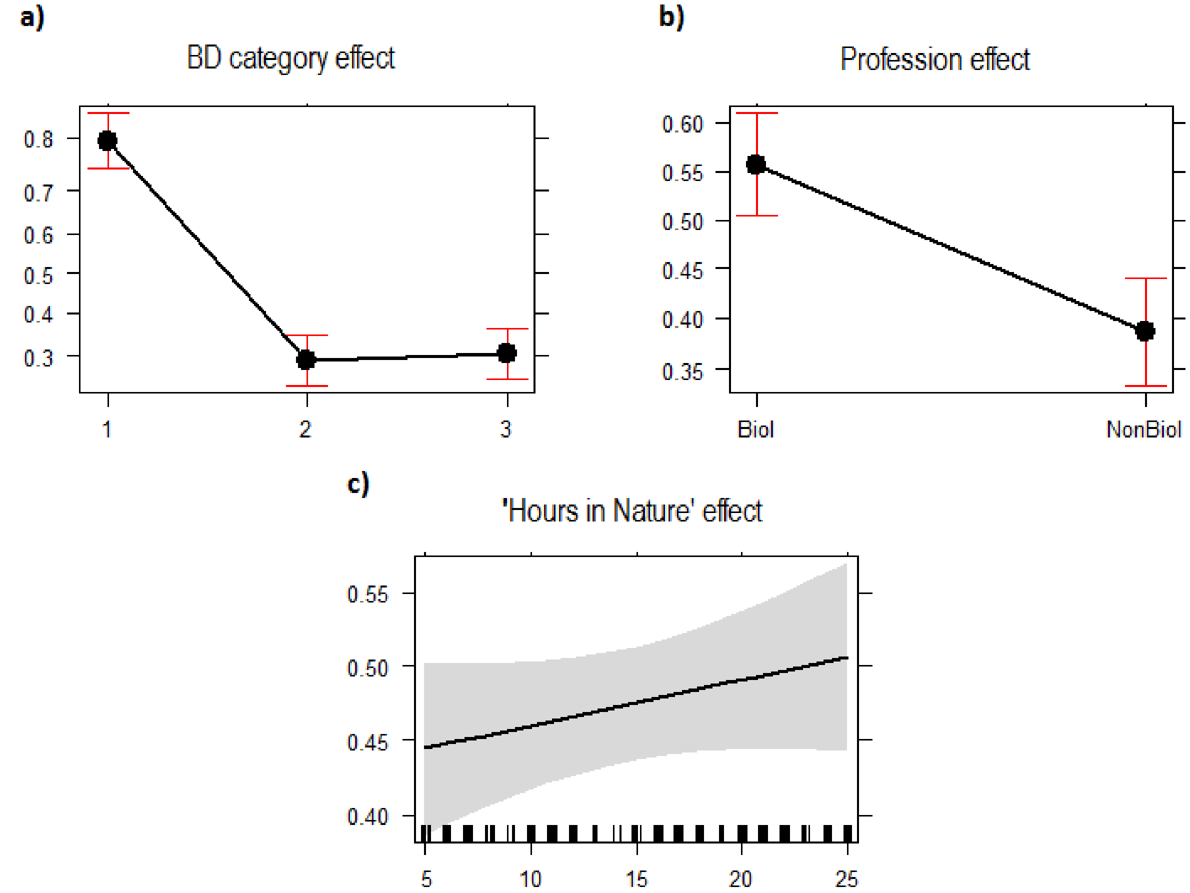

Figure 8a): *Effect of Biodiversity category (1= species richness, 2 =evenness, 3= turnover),* ***b)*** *Profession and* ***c)*** *Hours in Nature on the probability to achieve correct scores*

Table 10*: Model estimates, standard errors in probability and p-values for the best model (correctness ~ BC + Profession + Hours in Nature). Significance is notated with *. The estimates in logit scale can be found in the appendix (p.50, Table A5)*

	Estimate	**Std. Error**	**p**
Species richness (Intercept)	0.8199	0.0345	< 0.0001***
evenness	-0.4959	0.0416	< 0.0001***
species turnover	-0.4793	0.0425	< 0.0001***
Profession: Nonbiologist	-0.1262	0.0341	< 0.0001***
Hours in Nature	0.0009	0.0015	0.01251

Appreciation

The distribution of the assigned ranks to the pictures (separate for each biodiversity category) when asked to order in decreasing personal preference are found in the appendix (p. 51, Table A6, A7, A8)

The correlation between the actual biodiversity rank and the appreciation rank was assessed with Kendall's rank correlation coefficient tau-b, for each biodiversity category separately. For species richness a significant positive correlation with appreciation was found ($\tau = 0.495$, $p < 0.0001$). For evenness the correlation was weaker and also positive ($\tau = 0.216$, $p < 0.0001$). For species turnover the appreciation ranking showed a weak negative correlation to the actual ranking ($\tau = -0.152$, $p < 0.0001$).

Analysing the rank correlation for profession groups separately revealed following patterns: Both biologists and non-biologists expressed a positive correlation of appreciation to the actual biodiversity rank for both species richness ($\tau_{biologists} = 0.603$, $p < 0.0001$, $\tau_{nonbiologists} = 0.421$, $p < 0.0001$) and evenness ($\tau_{biologists} = 0.314$, $p < 0.0001$, $\tau_{nonbiologists} = 0.176$, $p < 0.0001$). Species turnover ranking was not significantly correlated to appreciation for the biologists ($\tau = -0.0377$, $p = 0.3712$), whereas it was significantly negatively correlated for the non-biologists ($\tau = -0.258$, $p < 0.0001$).

Appreciation and Perception

Comparison of the rank correlation coefficients of appreciation and perception, which were obtained in closely similar datasets, reveals that appreciation showed a stronger correlation to the perceived biodiversity ranks ($\tau_{species\ richness} = 0.506$, $p <0.0001$; $\tau_{evenness}= 0.451$, $p <0.0001$ $\tau_{turnover} = 0.388$, $p <0.0001$) than to the actual ranking for each biodiversity category ($\tau_{species\ richness} = 0.495$, $p <0.0001$; $\tau_{evenness}= 0.216$, $p <0.0001$ $\tau_{turnover} = - 0.152$, $p <0.0001$)

Also within profession groups the correlation between the appreciation ranks and the perceived biodiversity ranks were always positive and mostly stronger than the correlation to the actual biodiversity ranks. For species richness this difference was minor for both biologists ($\tau_{appr\text{-}actual} = 0.603$, $p < 0.0001$; $\tau_{appr\text{-}perc.}= 0.643$, $p < 0.0001$) and non-biologists ($\tau_{appr\text{-}actual} = 0.416$, $p < 0.0001$, $\tau_{appr\text{-}perc.}= 0{,}421$, $p < 0.0001$). For evenness and species turnover this difference was more pronounced for both groups and greater for non-biologists. In evenness the biologists showed a correlation coefficient to actual diversity of $\tau_{appr\text{-}actual} = 0.314$ ($p <0.0001$) and to perceived diversity of $\tau_{appr\text{-}perc.} = 0.489$ ($p <0.0001$), while the non-biologists' correlation coefficient increased from $\tau_{appr\text{-}actual} = 0.176$ to $\tau_{appr\text{-}perc} = 0.43$ ($p < 0.0001$).

The rank correlation coefficient for species turnover increased for biologists ($\tau_{appr\text{-}actual}$ = -0.0377, p = 0.37118; $\tau_{appr\text{-}perc}$ = 0.356, p < 0.0001) as well as for non-biologists ($\tau_{appr\text{-}actual}$= -0.258, p < 0.0001; $\tau appr_{\text{-}perc}$ = 0.425, p < 0.0001). For an overview all correlation coefficients for the appreciation ranks to the perceived and actual biodiversity ranks are listed in Table A9 and A10 found in the appendix (p. 52).

Discussion

Even though not necessarily representative for the global population the present study gives insights to human perception and appreciation of plant biodiversity. The abstract and standardized method to assess human stands towards plant biodiversity allowed to give answers to the developed research questions.

<u>1. Perception:</u> *Are people able to assess plant biodiversity in different levels and measures? Are there demographic or personal features that influence this ability?*

The analysis of the questionnaire revealed pronounced differences between the tested biodiversity categories.

Species richness displayed a high success rate when respondents were asked to order the pictures form high to low diversity. A percentage close to 80% of participants with a correct order of the pictures, is indicative for the ability of most respondents to correctly assess species richness in the tested range of 2 to 16 species. This conclusion is consistent with the findings of Lindemann-Matthies et al. (2010), who found that people in general were able to distinguish species-rich and species-poor plant communities. GLM analysis affirmed a strong effect of the biodiversity category on the probability to order all pictures (within one category) correctly. Compared to species richness this probability decreased by almost 50% for both other categories (-49.59%, SD= 4.16 for evenness, -47.93% SD=4.25 for turnover). Thereof can be concluded that the participants were much better at assessing species richness than species evenness and species turnover in local plant communities.

For evenness a substantially lower success rate was found. Not even a third (27.33%), of the respondents were able to assign a correct order to the pictures displaying differences of evenness in constant species richness. The probability for the participants to order the pictures correctly dropped from more than 80 % in species richness to only 32.40% in evenness. This pronounced difference might be due to the prominence of species richness which is the most used measure of biodiversity and easiest to assess (Purvis and Hector, 2000). The pictures displaying evenness probably were evaluated in species richness terms, due to a lack of awareness about other biodiversity measures, an approach that cannot be successful for ordering in terms of evenness. Furthermore the measurement of species abundance is not easily feasible even for trained plant ecologists (Damgaard, 2014). Several methods for measuring plant abundance (e.g. visual cover estimates, point intercept frequency, image analysis) have been and are still developed to increase accuracy of this measurement with different outcomes

(Damgaard, 2014). Therefore a low success rate is coherent when assessing digitalized displays of artificial plant communities.

Also species turn over yielded a success rate close to 30%. Less than a third of the respondents (28.53%) were able to order the picture sets correctly. GLM analysis showed a similar drop of probability for ordering the pictures correctly compared to species richness like for evenness. That reveals difficulties in the assessment of β-diversity. Beta-diversity, like species evenness achieves less attention and is more difficult to assess than species richness (Purvis and Hector, 2000) and the same reasoning as for evenness can be applied: the respondents might have evaluated the pictures displaying species turnover in species richness terms. In this case both measures are correlated. It would translate to species richness of 8, 16 and 24 species. Since the respondents were able to distinguish species richness in lower numbers, this low success rate might be due to higher species numbers. Also Lindemann-Matthies et al. (2010) found that the ability to distinguish species richness levels decreased with the increasing of the number of species. As the number of species in their study exceeded 16 the perceived species richness diverged further from the true species richness (Lindemann-Matthies et al., 2010). This can be interpreted as coherent with the results of this study, since when assessing the pictures of species richness in lower species numbers the large majority of participants was able to sort the pictures in decreasing biodiversity order, while the majority could not do that in higher species ranges displayed in the turnover pictures. Lindemann-Matthies et al. (2010) connect this to the effect of large numbers in mental scaling, which cannot be discriminated as exactly and fast as lower numbers (Moyer and Landauer, 1967). It must be considered that the results for the assessment of the species turnover pictures might not be fully comparable to the other categories, due to the smaller size of the pictures displaying a single plant community in species turnover compared to those in species richness and evenness. Still when considered independently the low success rate in this category implicates limitations in the ability to perceive the composition of local plant communities

Besides the significant differences between the biodiversity categories, a clear influence of the respondent's profession was found. Independent from the category biologists had a 12.62 % (SD = 3.41) higher probability to order the pictures correctly than the non-biologists among the participants. Hence it can be concluded that education in biology increases the ability to perceive local plant biodiversity correctly. This is further supported by the fact that 23 of the 30 participants that achieved correct scores in all diversity categories were categorized as biologists. The biological knowledge is the major explanation for the advantage in perceiving biodiversity correctly, since experience increases sensibility for visual perception (Lu et al., 2011). It can be assumed that having learned the concepts and definitions of biodiversity included in the education on university level, increased the ability to assess differences in local plant biodiversity, which can be linked to perceptual learning.

But also other factors inclusive of being a biologist (indicated by the confounding of these variables with profession) might have their influence on the perception of plant biodiversity. Further investigations are needed to disentangle the role of e.g. environmental care. The care for the environment can be assumed to influence the choice to enrol in a biology-education program and being a professional biologist might increase the care for the environment. This was also indicated by the results of this study since stating a high environmental care was not independent from the profession of the respondent. Therefore the role of attention and emotions in perceiving nature deserve more attention. This and other personal variables were not explicitly analysed due to the confounding with profession. To evaluate the influence of these, acquisition of respondent must specifically address different population groups, which is difficult to perform. One approach here would be to use international or national panels, which have a representative pool of participants. This was not feasible for the present study because the costs for this service exceeded the budget by far.

Summarizing, the ability to assess biodiversity in different levels and categories is dependent on the category assessed and the profession of the respondent. While people generally are able to distinguish species richness up to a number of species of 16, evenness and species turn over are mostly misperceived. The obtained success rates might be an overestimate when transferred to a larger population since 45.05 % of the respondents were biologists and non-biologists achieved a significantly lower success rate.

2. Appreciation: *Is the aesthetic appreciation influenced by different levels and measures of plant biodiversity? Are there influences of demographic or personal features?*

Appreciation of diversity differed between biodiversity categories. While there was a rather strong positive correlation for species richness, the positive correlation for evenness was weaker. For species turnover the correlation was weakly negative. These results indicate that of all biodiversity categories tested, species richness has the highest influence on the appreciation of a plant community and that higher species richness is preferred over lower species richness. This is consistent with the results of Lindemann-Matthies et al. (2010) who found that appreciation increased with increasing species richness. But it stands in contrast to the results of Graves et al. (2017) who found no effect of species richness on aesthetic preferences, while high evenness increased appreciation.

The effect of β-diversity has not been tested before and indicates a negative influence. Even though it is a weak correlation the difference to the results in α-diversity shows that also the appreciation of plant biodiversity is scale dependent. Furthermore the relationship of appreciation and the number of species might be nonlinear and changing with increasing species richness. This would be in contrast to the results shown by Lindemann-Matthies et al. (2010), who displayed a linear increase of appreciation to species richness up to 60 species. But this was performed in non-changing spatial conditions while the scale of the pictures in the present study changed. Therefore these results are not strictly comparable and more research into the spatial component is needed.

Other influencing factors Graves et al. (2017) found were colour and flower diversity. These factors were kept constant in the present study but 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 e.g. inflorescence size or structure. 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* (present in each picture) for which they found a positive effect on appreciation. The present study did not test these species identity effects since, even though the set-up of this study would allow for such an analysis, the low sample size (the number of pictures with different species) is too low for such investigations, since the study design was not tailored for this purpose.

Graves et al. (2017) also supposed personal features as determinants of appreciation even though their results were “remarkably constant across the psychographic groups”. Also previous knowledge about the flora of the sampling area had no significant impact in their study. This is in contrast with the results presented in here: Profession groups varied largely in their correlation of appreciation with the true biodiversity. Biologists always expressed a stronger correlation than non-biologists, with the exception of species turnover, where the correlation was insignificant. This might be explained with the familiarity to the topic and the knowledge about the effects of plant diversity on ecosystem processes combined with the greater ability to assess levels that matter for those. This indicates a connection of understanding and appreciation, further affirmed in the analysis of correlations between appreciation and perception ranks.

3. Perception and Appreciation: Does the perceived plant biodiversity influence appreciation?

The correlation between the appreciation ranks and the perceived biodiversity ranks was in all but one case stronger than to the actual biodiversity ranks. Also results of Lindemann-Matthies et al. (2010) show a high influence of perceived species richness on the appreciation. Here it could be shown that the perceived biodiversity had a stronger influence than the actual biodiversity. It also needs to be considered that the ability to order the pictures decreased for evenness and species turnover. This could lead the respondent to order the pictures in a way she/he seems fit. Without any tool to assess species evenness this could correspond with her/his preferences, leading to a higher correlation of the ranks in appreciation and perception. Still that means that the respondents liked what they thought is more divers, and vice versa. This implicates an intrinsic valuation of plant diversity in itself.

Condensed the present study showed that the participants were able to assess species richness widely correctly while evenness and species turnover are generally misperceived. Education in biology on university level increases the ability to assess biodiversity correctly. Therefore it can be concluded that the ability to correctly assess biodiversity influences people’s appreciation and itself is influenced by knowledge. Aesthetic appreciation is positively influenced by species richness up to 16 species. Evenness and species turnover have a lower influence on the appreciation with a negative correlation to β-diversity. Biologists’ appreciation is closer related to true biodiversity then the non-biologists’. Perceived biodiversity has a higher influence than actual biodiversity, especially in evenness and species turnover. The effects of the personal features need more specific analysis and further investigation.

Implications

Since biodiversity loss is caused anthropogenically, it is likely that most diversity will only survive under protection (Stokes, 2007). Therefore it is essential that humans choose to protect it. The ability to perceive changes in plant biodiversity can foster awareness for the potential drivers of these changes and therefore the importance assigned to mitigate these (Montgomery, 2002, Stokes, 2007). Conservation is dependent on public policy, which in turn is under major influence of public perception (Czech et al., 1998). The results presented here indicate that people are majorly able to perceive these changes, but only for α-diversity.

The shown inability of the majority of respondents to distinguish evenness differences implies that biodiversity aspects providing stability to the ecosystem (Hillebrand et al., 2008) cannot be recognized. Furthermore altered abundance of species shows transformations in the ecosystem before species get lost (Hillebrand et al., 2008). That implicates that with the difficulties in perceiving changes in evenness a possible “early warning system” which could trigger public awareness and a timely response, is unused.

Also the revealed inability to correctly assess β-diversity differences carries the implication of a low awareness about changes in the ecosystems in spatial as well as temporal scales. While differences in α-diversity, in the local scale, can be perceived correctly, β-diversity, indicative for the larger scale, was shown to be difficult for the majority. Since it might be possible that global biodiversity changes do not transfer to the local level (Vellend et al., 2013), this lack of perception on a larger scale represents a further hindrance for public awareness to plant biodiversity changes. Also transferred to a temporal turnover in species identity the shown misperception leads to an unawareness of changes that can influence ecosystem processes (Pyšek et al., 2012) : new arriving exotic species foreign to the community might be overlooked and the threat to local biota survival (Pyšek et al., 2012) is not realized.

Since the public awareness is a prerequisite for effective conservation (Czech et al., 1998) the results of this study point out a sensible approach to increase the involvement of people. Biological education increased the ability to correctly assess biodiversity. Therefore fostering the promotion of knowledge about the concepts of biodiversity and with that the perception skills can be considered efficient for conservation efforts. Additionally the valuation of local plant communities can be hampered by a misperception of its diversity, which was also supposed by Lindemann-Matthies et al. (2010). Here this could be affirmed by the stronger correlation of aesthetic appreciation to the perceived than to the actual diversity in all categories, but especially pronounced in evenness and turnover. That denotes another argument to increase the perception skills via knowledge increase, since valuation is a determinant for the importance assigned to conservation as well (Montgomery, 2002). Furthermore aesthetic appreciation of diversity was enhanced itself by the biological education.

Additionally the results of this study allow for a statement about plant biodiversity's role in the delivery of CES. The strong correlation between the aesthetic appreciation and actual biodiversity in α-species richness justifies the statement that plant biodiversity is a provider of CES. Nevertheless it must be considered that this was only the case for α-diversity in the range up to 16 species. Still that infers that ecosystem management action must consider this benefit obtained from plant communities additional to the supporting, regulating and provisioning services when taking actions that might reduce the number of species below this level.

Conclusion

The present study was able to broaden the understanding of the human-nature relationship through the assessment of the perception and appreciation of plant species diversity on the local scale. It could be affirmed that both components are influenced by the properties of the plant community as well as personal features of the beholder.

For the biodiversity categories assessed it was only α-diversity that could majorly be perceived correctly. Species evenness and β-diversity proved to be difficult for people to assess, implying a lack of awareness for changes influencing ecosystem stability, invasibility as well as an influence of spatial scale. Further investigations on the role of the spatial scale would be interesting to show if the misperceptions of species turnover can be confirmed or if they are biased by the different pictures sizes in this study.

The personal feature that significantly affected the ability to perceive plant species diversity correctly was experience in the form of knowledge and training through biological education. This implies the promotion of knowledge as an effective way to foster conservation involvement. Other personal variables assessed deserve more attention, e.g. the how environmental care influences the perception could be an interesting topic.

Also appreciation was different for the biodiversity categories, with α-diversity expressing the closest correlation of increased appreciation with increasing species richness. This qualifies it as a provider of cultural ecosystem services in the form of aesthetic appreciation. The results on β-diversity indicate that this is only true for up to 16 species. Research into the role of the plant species' identity on the appreciation could deepen the understanding about how appreciation for a plant community is shaped.

Biological education was shown to also increase appreciation for diversity, an additional argument for the stimulation of knowledge as conservation effort. Further importance for this was emphasized by the finding that appreciation is closer correlated to the perceived plant diversity than to the actual diversity. This leads to the deduction that misperception could compromise the appreciation of plant communities.

Concluding the research on perception and appreciation represents an important area of research where much remains undiscovered and little described. Especially in the face of rapid biodiversity loss and environmental changes the interconnections revealed in this study need more disentangling.

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Appendix

Questionnaire

Can you detect changes in plant biodiversity?

Plant diversity is the number or the abundance of different plant species in nature. It supports stability and productivity of our ecosystems.

However, it is this diversity that is changing due to changed climate, changed land use and more.

But are we able to detect these changes easily?

With the participation in this survey you can help to investigate this question.

No previous knowledge about plants is needed and it takes 5 to 10 minutes.

Eva Breitschopf: ebr052@post.uit.no

If you have any questions or considerations please do not hesitate to contact me.

This study examines the public awareness and appreciation of plant diversity. It is part of a Master Thesis project at the University of Tromsø - The Arctic University of Norway at the Department of Arctic and Marine Biology in cooperation with the Institute of Landscape Architecture.

All your information is anonymized and used for the purpose stated above, only.

Your identity will be hidden.

Read more about confidentiality and hidden identity here. (Opens in a new window.)

1) Please click "Next" to start the survey.

Next >>

These 4 pictures show plant communities in different diversities. Please take a look at each of them and scroll down to see the questions.


C
D

2) Please order the pictures (drag and drop the letters into the box) from the highest to the lowest diversity. The picture with the highest diversity on the top and the one with the lowest on the bottom.

A

B

C

D

3) Please order the pictures (drag and drop the letters into the box) according to your personal preference. The picture you like best at the top and the picture you like least at the bottom.

A

B

C

D

Next >>

These 3 pictures show plant comunities with different diversities. Please take a look at each one and scroll down to see the questions.

5) Please order the pictures (drag and drop the letters into the box) from the highest to the lowest diversity. The picture with the highest diversity on the top and the one with the lowest on the bottom.

A	
B	
C	

6) Please order the pictures (drag and drop the letters into the box) according to your personal preference. The picture you like best at the top and the picture you like least at the bottom.

A	
B	
C	

These 3 sets of pictures show plant comunities with different diversities. Please consider one set as one unit and compare between the sets. Scroll down to see the questions.

8) Please order the picture sets (drag and drop the letters into the box) from the highest to the lowest diversity. The set with the highest diversity on the top and the one with the lowest on the bottom.

A

B

C

9) Please order the picture sets (drag and drop the letters into the box) according to your personal preference. The picture you like best at the top and the picture you like least at the bottom.

A

B

C

You are almost finished.

These are only a few questions about you.

11) Please select:

- ☐ I am female.
- ☐ I am male.

12) How old are you?

[ ]

13) Please select what applies most to you.

- ☐ I care a lot about the environment.
- ☐ I care intermediately about the environment.
- ☐ I do not care about the environment.

14) How many hours per week do you spend in nature approximately (when circumstances are good)?

[ ]

15) What is your profession? Please write in the box below. (As precisely as possible, e.g. "Master Student, Plant Ecology")

[ ]

16) Please enter the country you grew up in or you feel most belonging to.

[ ]

Thank you very much, for your time and participation. You contributed an important part to this study and my Master Thesis.

Should you have any questions, input or complaints please do not hesitate to contact me.

If you want to take part in the lottery for the price please send me an E-Mail with subject "I want to win". Good luck!

Eva Breitschopf: ebr052@post.uit.no

Supporting Tables

Table A1: *Distribution of the pictures rankings in the species richness category for perceived biodiversity. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank.*

	picture			
rank	**A**	**B**	**C**	**D**
1	1,5% (n=5)	8,41% (n=28)	87,09% (n=290)*	2,1% (n=7)
2	0,3% (n=1)	78,68% (n=262)*	8,41% (n=28)	11,7% (n=39)
3	1,2% (n=4)	11,71% (n=39)	1,8% (n=6)	84,38% (n=281)*
4	96,1% (n=320)*	0,3% (n=1)	1,5% (n=5)	0,9% (n=3)
NA	0,9% (n=3)	0,9% (n=3)	1,2% (n=4)	0,9% (n=3)

Table A2: *Distribution of the pictures rankings in the species evenness category for perceived biodiversity. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank.*

	picture		
rank	**A**	**B**	**C**
1	39,94% (n=133)	42,94% (n=143)*	14,71% (n=49)
2	35,14% (n=117)*	23,12% (n=77)	38,74% (n=129)
3	21,62% (n=72)	31,23% (n=104)	43,54% (n=145)*
NA	3,3% (n=11)	2,7% (n=9)	3%(n=10)

Table A3: *Distribution of the pictures rankings in the species turnover category for perceived biodiversity. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank.*

	picture		
rank	**A**	**B**	**C**
1	24,92% (n=83)	32,13% (n=107)	40,84% (n=136)*
2	44,44% (n=148)*	21,02% (n=70)	32,13% (n=107)
3	28,23% (n=94)	44,14% (n=147)*	24,32% (n=81)
NA	2,4% (n=8)	2,7% (n=9)	2,7%(n=9)

Table A4*: Model selection. 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 (dAIC) are given. The best model is displayed in bold.*

model	**residual df**	**null deviance**	**residual deviance**	**AIC**	**dAIC**
Biodiversity Category (BC)	969	1339.50	1121,69	1127,68	136,6
Profession	874	1210.00	1193,66	1197,66	206,5
BC + Profession	872	1210.00	991,88	999,88	8,8
BC*Profession	870	1210.00	990,39	1002,38	11,3
BC + Profession + Hours in Nature	**859**	**1194.13**	**981,11**	**991,11**	**0**
BC + Profession * Hours in Nature	858	1194.13	979,97	991,97	0,9

Table A5*: Model estimates, standard errors in logit scale and p-values for the best model (correctness ~ BC + Profession + Hours in Nature). Significance is notated with *.*

	Estimate	**Std. Error**	**p**
Intercept (species richness)	1.51598	0.21818	< 0.0001*
evenness	-2.25125	0.19754	< 0.0001*
species turnover	-2.17641	0.19612	< 0.0001*
Profession: Nonbiologist	-0.69846	0.15790	< 0.0001*
Hours in Nature	0.01251	0.00987	0.01251

Table A6: *Distribution of the pictures rankings in the species richness category for personal preference. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank.*

	picture			
rank	**A**	**B**	**C**	**D**
1	5,39% (n=18)	29,04% (n=97)	52,04% (n=175)	11,98% (n=40)
2	11,68% (n=39)	47,6% (n=159)	18,56% (n=62)	20,36% (n=68)
3	11,68% (n=39)	14,37% (n=48)	15,57% (n=52)	56,29% (n=188)
4	69,76% (n=233)	6,89% (n=23)	11,38% (n=38)	9,58% (n=32)
NA	1,5% (n=5)	2,1% (n=7)	2,1% (n=7)	1,8% (n=6)

Table A7: *Distribution of the pictures rankings in the species evenness category for personal preference. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank*

	picture		
rank	**A**	**B**	**C**
1	40,42% (n=135)	45,51% (n=152)	12,57% (n=42)
2	36,83% (n=123)	20,66% (n=69)	40,42% (n=135)
3	20,6% (n=67)	32,04% (n=107)	44,61% (n=149)
NA	2,69% (n=9)	1,8% (n=6)	2,4%(n=8)

Table A8: *Distribution of the pictures rankings in the species turnover category for personal preference. Given is the proportion (%) and the number of participants that assigned a specific picture to a specific rank*

	picture		
rank	**A**	**B**	**C**
1	28,44% (n=95)	46,41% (n=155)	21,86% (n=73)
2	40,42% (n=135)	20,06% (n=67)	36,23% (n=121)
3	27,54% (n=92)	30,24% (n=101)	38,32% (n=128)
NA	3,59% (n=12)	3,29% (n=11)	3,59%(n=12)

Table A9: *Kendall's rank correlation coefficients for appreciation ranks and actual biodiversity ranks.*

appr. - actual	all		biologists		nonbiologist	
	τ	**p**	**τ**	**p**	**τ**	**p**
species richness	0.495	<0.0001	0.603	<0.0001	0.421	<0.0001
evenness	0.216	<0.0001	0.314	<0.0001	0.176	<0.0001
species turnover	- 0.152	<0.0001	-0.0377	0.37118	-0.258	<0.0001

Table A10: *Kendall's rank correlation coefficients for appreciation ranks and perceived biodiversity ranks.*

appr. –perc.	all		biologists		nonbiologist	
	τ	**p**	**τ**	**p**	**τ**	**p**
species richness	0.506	<0.0001	0.643	<0.0001	0.416	<0.0001
evenness	0.451	<0.0001	0.489	<0.0001	0.430	<0.0001
species turnover	0.388	<0.0001	0.356	<0.0001	0.425	<0.0001