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## RESEARCH ARTICLE

# A transdisciplinary approach to define and assess wild food plant sustainable foraging in Norway

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**Societal Impact Statement**

Foraging wild food plants is sometimes perceived as a conservation threat or, alternatively, as an opportunity for sustainable development. Little is known of how foragers themselves define and ensure sustainable foraging. Here, we collaboratively assessed the activities and motivations of the forager community in Norway in order to achieve a combined social and ecological assessment of foraging sustainability. Current foraging of wild food plants in Norway contributes to an increased appreciation of nature rather than generating negative environmental impact and is hence an opportunity for sustainable development.

**Summary**

- Wild food plants are well recognized as local sources of nutrition that can contribute to food security, but foraging is sometimes viewed as a threat to biological conservation. Here, we characterize and assess sustainable foraging in Norway through transdisciplinary research co-constructed with the Norwegian Association for Mycology and Foraging.
- We conducted 19 face-to-face interviews with key stakeholders and produced an online questionnaire returned by 219 recreational and commercial foragers to enquire about what species are harvested, by whom and how, where do foragers learn and what are their perspectives on the sustainability of foraging.
- Foraging fosters a strong connection with the natural environment. Foragers decide when and how much can be harvested considering location, plant and plant part being harvested. They pay attention to native plants' conservation status and local abundance and plant individual's survival after foraging and aim to not spread invasive species.
- We define sustainable foraging as the knowledge and practices that enable enriching forager–biodiversity relationships over time. Such a definition can support collaborative sustainability efforts between the academic community and civil society.

**KEYWORDS**

ecosystem services, harvesting, non-timber forest products, plant conservation, sustainable livelihoods, wild edible plants

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## 1 | INTRODUCTION

Wild food plants (WFPs) are non-cultivated plant species harvested to be consumed as food or drink. WFPs have always been an integral part of the human diet (Bharucha & Pretty, 2010) and foraging them provides both provisioning and cultural services (Landor-Yamagata et al., 2018). Foraging WFPs is a common practice among rural and city dwellers of different ages, races, genders and socio-economic status worldwide (Bharucha & Pretty, 2010; McLain et al., 2014; Reyes-García et al., 2015; Sardeshpande & Shackleton, 2020; Shumsky et al., 2014). As such, foraging entangles social and ecological systems (Berkes & Folke, 1998). Which plants are foraged and how this is done depends on the cultural, socioeconomic and ecological contexts. For example, foraging WFPs increases during times of other food shortages (Łuczaj et al., 2012; Łuczaj & Pieroni, 2016; Vorstenbosch et al., 2017). Currently, wild products and foraging practices are being promoted to contribute to sustainable development and social-ecological resilience (Bacchetta et al., 2016; Beltrame et al., 2019; Fischer & Kowarik, 2020; Landor-Yamagata et al., 2018; Poe et al., 2014; Sōukand et al., 2021; Ulian et al., 2020). WFPs can contribute directly to ensuring food security, improving health, fostering local economies, maintaining co-evolutionary relationships with the natural environment and facilitating the integration of migrant communities (Cambecèdes & Garreta, 2017; Fischer & Kowarik, 2020; Lovrić et al., 2020; Poe et al., 2014). While these are valuable benefits for the ongoing transition towards sustainable livelihoods, there are growing concerns regarding conservation of WFPs due to climate change, habitat loss and the risk of overharvesting (Borelli et al., 2020; Cambecèdes & Garreta, 2017; Redford & Richter, 2001). Concomitantly, loss of local knowledge about WFPs is a major issue (Fernández-Llamazares et al., 2021; Łuczaj et al., 2012; Reyes-García et al., 2015).

Although foraging WFPs is presented as an environmentally friendly response to the globalization of food systems (Bacchetta et al., 2016; Hermansen, 2012; Sōukand et al., 2021), what constitutes sustainable foraging is loosely defined. Moreover, how foraging practices such as harvesting roots or harvesting larger or smaller amounts of produce may affect plant populations remains poorly known (Bacchetta et al., 2016; Cambecèdes & Garreta, 2017). Foraging can lead to species extinction in specific sites (Garreta, 2015) and the selection of non-harvested phenotypes (Law & Salik, 2005; Niu et al., 2021), but it can also promote plant growth and dispersal (Rangan et al., 2014). From a biological conservation perspective, harvesting of wild plants is considered sustainable when the resource is 'harvested within the limits of its capacity for self-renewal [...] and] the manner of its harvest [is] such as not to degrade the environment in other ways' (Hamilton, 2005). Factors such as the species area of distribution, habitat specificity, population size, life form and plant part used can help assess the capacity limits of a plant population (Rabinowitz, 1981; Schippmann et al., 2002). IUCN conservation status for a plant can also be indicative of its vulnerability to foraging (Landor-Yamagata et al., 2018).

Foraging is a practice embedded in place-based knowledge systems that has developed over long periods of time through

experimentation and adaptation. Foragers often have biodiversity stewardship practices (e.g., pruning fruit trees or dispersing seeds), are mindful not to deplete plant populations or plant individuals' reproductive structures, are observant of plant population variations over time and actively share this knowledge (Charnley et al., 2018; Comberti et al., 2015; Emery, 2001; Landor-Yamagata et al., 2018; McLain et al., 2017). Foragers' 'internal moral judgements' may help prevent overharvesting of common natural resources such as WFPs (Charnley et al., 2018, p. 744). Despite these behaviours, many are concerned, including the foraging community, that foraging may become harmful to the environment if it rises in popularity without social mechanisms for transmitting knowledge on low-impact practices (McLain et al., 2017). Thus, assessing the impact of foraging on wild plants also requires understanding the knowledge systems that sustain foraging practices. To date, studies addressing WFP foraging sustainability consider the issue from either a social or an ecological perspective, but these perspectives have not yet been explicitly combined.

Foraging practices in Europe are grounded in long-standing local traditions but also in rising innovative culinary approaches (Łuczaj & Pieroni, 2016; Pardo-de-Santayana et al., 2010; Reyes-García et al., 2015). The use of WFPs in gastronomic cuisines gained popularity since the 1990s (Łuczaj & Pieroni, 2016). In the Nordic countries, the New Nordic Cuisine emerged in the early 2000s as a new gastronomic trend with a focus on healthy, ethical, local, and environmentally friendly produce and practices, led by chefs across the Nordic region and spearheaded by NOMA, a restaurant in Copenhagen (The New Nordic Food Manifesto, 2004). While NOMA is a gourmet-oriented, high-end restaurant, the movement has resulted in the establishment of a number of new restaurants, bars, bakeries, food markets and the publication of multiple Nordic cuisine cookbooks that have boosted the demand for quality local produce, cultivated and wild, across all Scandinavian countries (Hermansen, 2012). The movement has influenced the everyday food choices of consumers across the region to the extent that wild plants such as ground elder (*Aegopodium podagraria* L.) and wild garlic (*Allium ursinum* L.) can now be found in supermarkets (Hermansen, 2012). The movement has prompted a renewed interest in foraging, increased commercial harvesting and promoted a range of wild plants that were previously not widely used (Münke et al., 2015).

This is also the case in Norway. Norway has a complex system of protected areas ranging from National Parks to nature reserves, protected landscapes and protected biotopes (Miljødirektoratet, 2019). Nature reserves have the strongest protection, and foraging is not allowed apart from berries and mushrooms. Some nature reserves are completely closed for the public during certain seasons or all year long and site-specific foraging regulations also exist. Regardless whether the land is private or public, foraging rights are protected through *fri-luftsløven* (the Outdoor Recreations Act; Lovdata, 2021) that allows people to forage mushrooms, berries, wild flowers and wild plants in so-called *utmark* (outfields, outside cultivated areas). Collection of roots from herbaceous plants is also allowed as long as it is done carefully and they are not protected. Wild nuts can only be collected when

they are eaten at the site. To forage bark, tree roots and twigs one needs the permission of the landowner. In northern Norway, there is a special set of rules pertaining to cloudberry (*molte*, *Rubus chamaemorus* L.), commonly known as the *molte* rule (Statsforvaltaren i Troms og Finnmark, 2019). Outside protected areas, cloudberry can always be foraged, except when the landowner explicitly forbids picking by displaying clearly visible signs. In that case, cloudberry can be eaten where harvested but may not be transported off the premises, unless the owner is clearly not picking them, for example, if rotting cloudberry are found. This combination of the right of public access protecting foragers' rights and a diverse set of protection rules for various plant species, plant parts, and areas is unique for the Nordic countries. While some information about regulations may be displayed in protected area information signs, it is up to foragers to get informed about the breath of all these rules on government webpages (which are also translated to English).

Here, we aim to define what sustainable foraging of wild food plants is and to assess if foraging is sustainable in Norway. This research addresses a concern shared between the Norwegian foraging and academic communities. After initial scoping talks, research was framed, methods co-constructed, and data collected and analysed by an interdisciplinary team of researchers including a representative of the Norwegian Association for Mycology and Foraging (*Norges sopp- og nyttevekstforbund*, NSNF).

## 2 | MATERIALS AND METHODS

This research was conducted in 2020 as part of a transdisciplinary research partnership between the Natural History Museum of Oslo (NHM), the LISST-Dynamiques Rurales laboratory, and the NSNF. A collaborative spirit manifested through continuous discussions among the co-authors throughout the research process, from co-design to co-writing, ensured a transdisciplinary research approach. The Code of Ethics of the International Society of Ethnobiology (2008) was followed, and approval from the Norwegian Center for Research Data, *Norsk senter for forskningsdata* (NSD), was granted (Reference number 157596).

Preliminary unstructured interviews were conducted with five key foragers including the NSNF association leader, three commercial foragers and one conservation expert. A forager was defined broadly as a person who spends time outdoors for the purpose of gathering WFPs. The research context was presented to each participant and Free Prior Informed Consent (FPIC) was obtained. Foragers were asked about their experience and thoughts on foraging sustainability in Norway, to further identify relevant and recurring themes (Albuquerque et al., 2019). These interviews served to define the questions for an online questionnaire and further face-to-face interviews. Snowball and convenience sampling methods (Bernard, 2011) were used to identify expert foragers and key stakeholders within the foraging community, including representatives of the New Nordic Food movement. We define expert foragers as those with extensive foraging experience who forage often. In August 2020, NJG and PK conducted five field trips to meet experts and attend workshops and

workdays in order to conduct interviews (Figure 1). Data was also collected through participant observation.

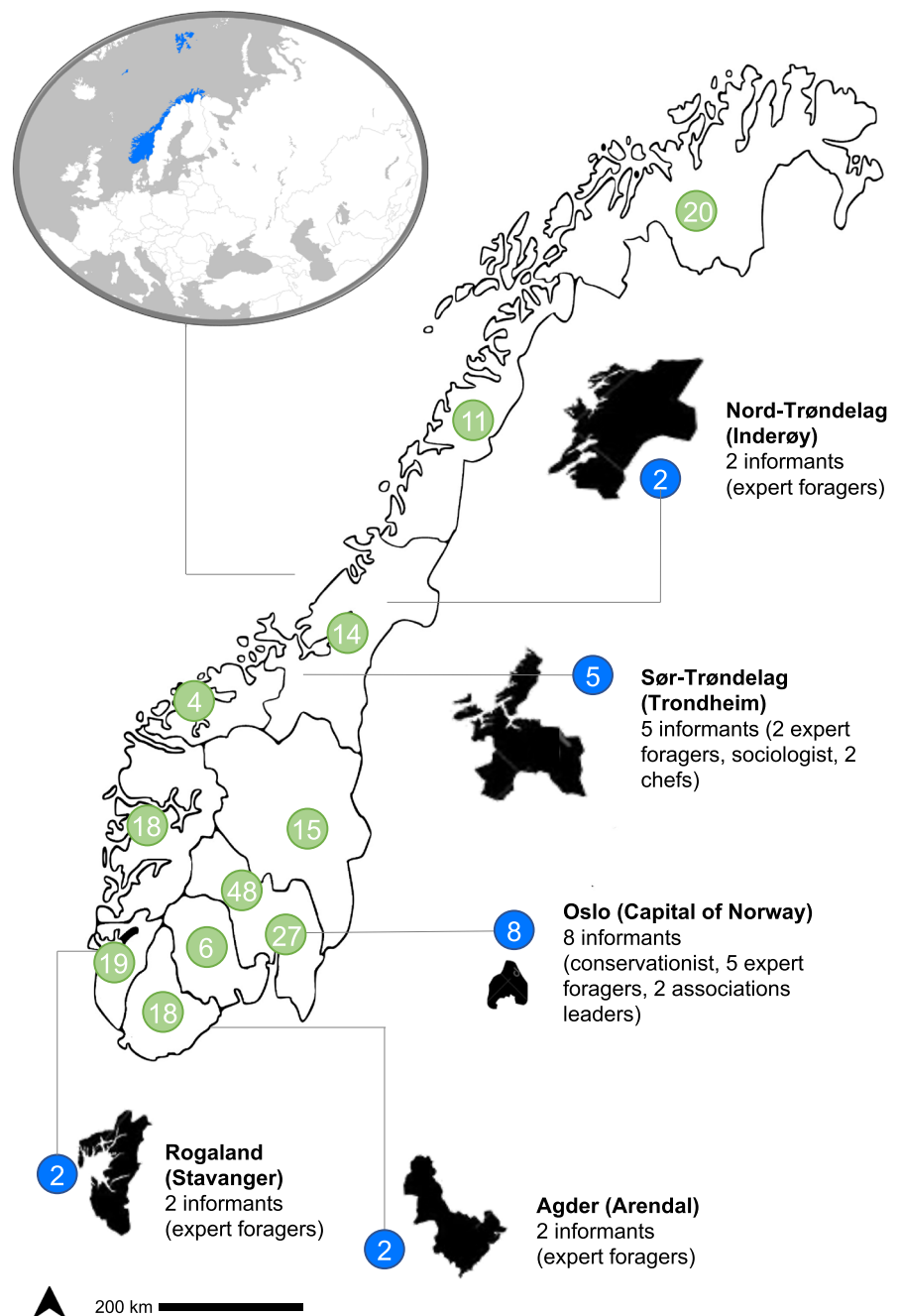
The online questionnaire was used to collect a list of harvested WFP species, information on foraging knowledge and practices, and perceptions about foraging sustainability from a large number of foragers to complement the detailed qualitative data provided during face-to-face interviews (Methods S1). Respondents also provided anonymous, socio-demographic data such as age group and foraging motivation (commercial and/or recreational; Dataset S1). The questionnaire was available in English and Norwegian for 1 month and distributed through various media platforms including the NHM and NSNF websites and newsletters, and a diversity of online communities dealing with foraging and wild foods.

From the questionnaire responses, a dataset was organized per species and consisted of folk names and scientific name, botanical family, the number of reports per plant part, total number of reports (Number of Reports, NR), Norwegian Red List (IUCN classification of plant species in Norway, Solstad et al., 2021) and List of Alien Species status (invasiveness assessments, Artsdatabanken, 2018), species ecological traits (perennation, life form, woodiness, clonality, comments on ecology; BSBI, 2021) and any comments regarding conservation issues. Plants were mentioned by their local names in Norwegian and these were cross-referenced with scientific literature to botanically identify plant species (Artsdatabanken, 2018; Høeg, 1974). Species that were not identifiable via these sources were discussed within the research team and identified where possible. If species-level identification was not possible, taxa were identified at genus level. The resulting scientific nomenclature and plant families were checked against The Catalogue of Life (Roskov et al., 2019) to update to current botanical accepted names.

Qualitative information was collected from 19 face-to-face interviews with key informants. Twelve were recorded and transcribed using the open-source software OTTER. Personal data were anonymized using codes instead of names in any paper or electronic document. A key linking names with codes was written on paper and kept locked in a cabinet at the Natural History Museum of Oslo. Audio and transcripts were deleted from the online software after analysis to ensure data protection. Seven interviews were conducted in contexts with little opportunity to obtain a good quality audio recording and were not recorded. Instead, notes were taken. Theme analysis was used to analyse transcriptions and notes.

Based on both face-to-face and questionnaire responses, we developed a flowchart that represents foragers' 'internal moral calculations' (Charnley et al., 2018) or the considerations foragers take when aiming at foraging sustainably. We used this flowchart together with ecological (i.e., life form and reproduction traits: perennation, woodiness and clonality), social (i.e., plant parts harvested and foraging demand) and conservation information (IUCN status in Norway; Solstad et al., 2021) to assess the impact of foraging per plant species by assigning a sustainability score for each foraged species on a Norway-wide basis. We used the total number of reports per species (NRs) as a proxy for foraging demand of the species reported by respondents. The flowchart can also be used at a local level to decide whether or not to forage a certain plant and in a certain place.

**FIGURE 1** Map of Norway showing the number of informants interviewed (in blue circles) and the number of respondents (in green circles) that indicated the region where they forage in the online questionnaire. Basic socio-demographic information on interviewed informants is included.



### 3 | RESULTS

#### 3.1 | Foraging wild food plants in Norway

The online questionnaire was returned by 219 foragers who collectively forage across Norway (Figure 1), including 148 expert foragers (as defined above; Dataset S1). Thirteen expert recreational and/or commercial foragers were also interviewed face to face, along with six practitioners and academics working on plant conservation, gastronomy and/or foraging. Of the questionnaire respondents, 207 (94.5%) had recreational (including gastronomic) motivations and 11 (5%) forage commercially as well as for personal use. Foragers not only gather, but also process and consume WFPs (>96%). Commercial foragers are

engaged with and are part of the recreational foraging community, and often have another job on the side. The commercial foraging milieu in Norway is small, and our transdisciplinary approach ensured that we reached most commercial foragers across the country (Figure 1). While most foragers only harvest WFPs from the wild, respondents mentioned transplanting WFPs from the wild to their own garden (31%) and/or tending WFPs in situ, mainly through weeding (8%).

As explained by the four expert foragers interviewed face to face, traditionally foraging was ‘driven by necessity’ as part of *matauk*, literally meaning ‘food increase’. *Matauk* are the traditional practices to increase household food security, mostly referring to hunting and fishing activities that are famously embedded within Norwegian culture,

but also to growing vegetables in the garden for family consumption, or going out in the forest for a ‘mushroom hunt’, ‘berry picking’ and foraging other WFPs. Fifteen online questionnaire respondents indicated collecting WFPs as *matauk*, often also indicating that foraging filled nutritional purposes (Dataset S1).

Many interviewees explained that the practice of *matauk* is in decline, because the crucial nutrition-provisioning role it played has been replaced by fridges and often imported fresh produce available year-round. As the need to store vitamin-rich wild foods throughout winter decreased, foraging became much more a means to enjoy the *friluftsliv* (from *fri* = free, *luft* = air-outdoors, and *liv* = life) or the famous Nordic outdoors lifestyle. Foraging for recreational purposes was important to 193 questionnaire respondents, who also mentioned foraging for nutritional purposes. This indicates a continuity between *matauk* and *friluftsliv*. Recreational foragers enjoy the ‘hunt’ and the sense of ‘freedom’, valuing highly the knowledge required to forage for one’s own food, which allows them to be ‘free’ from the market-based economy. Foraging allows them to develop a strong connection with the natural environment, and to obtain something ‘different’ from the societal norm. Moreover, chefs use WFPs within their cuisines as a way to express a Nordic identity while telling a story of Scandinavian culture (see also Hermansen, 2012). For most foragers, foraging and cooking WFPs is a way to live a ‘meaningful life’ that makes sense to them not only at a local level, but also at a global scale.

### 3.2 | Perceptions of sustainable WFPs foraging

Participants have different interpretations of what sustainability means. Some define sustainability in relation to the direct impact foraging has on plant communities, others in relation to the impact that a foraging-based lifestyle has on society. For example, to explain their own sustainable foraging practices, many respondents to the online questionnaire wrote statements similar to these: ‘I just forage a small amount and leave the rest, so that it regrows again next year’, ‘Rare plants should not be touched’ and ‘I cut with scissors and do not pull up roots’. Foraging sustainability was also described with regard to human health. Avoiding pollution and exercising was described by some informants as important in sustainable foraging, as well as both learning and teaching while foraging. For example, an interviewee explained that ‘[sustainable foraging is also about] spreading the knowledge, it’s not only a commercial idea. It’s also political, an idealistic idea, to spread knowledge so people get wiser. [...] It’s not about having so many things, the freedom is about knowing a lot of what we need to live, foraging for me, it gives a new knowledge’. Despite these different interpretations, most participants believe that foraging is or can be sustainable (75% of the respondents of the online questionnaire) and most agree that some WFPs are more vulnerable than others to being harvested (90.5%) and therefore have specific foraging practices for those species.

Interviewed foragers ( $n = 13$ ) explained sustainable foraging in terms of maintaining viable plant populations relies on the forager’s ‘awareness of the surrounding environment’, that is, their local ecological knowledge. Informants explained that they use ‘common

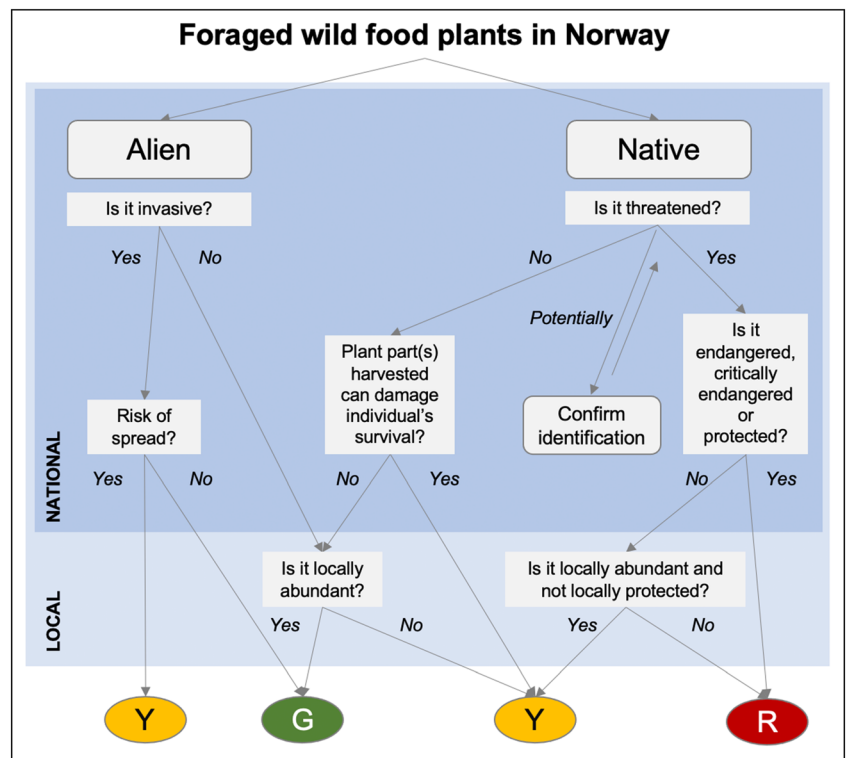
sense’ to decide what and how much to forage, and referred to those that over-exploit resources as ‘greedy’. They also appealed to individual ‘responsibility’ to seek the necessary knowledge to forage sustainably. Foragers limit their harvest to ensure future yields but also to leave ‘food for nature’; they are mindful of how they harvest invasive species in order to not contribute to their spread, and when unsure of a plant’s identification, they do not forage it. We can visualize foragers ‘internal moral calculations’ (Charnley et al., 2018) when making decisions about foraging on a plant per plant basis as a flowchart (Figure 2). Some participants noted a lack of available information on plants’ vulnerability to harvest and expressed interest in having ‘best practice’ WFP foraging guidelines, especially in regards to very popular species for which conservation issues have been observed at specific locations. These results echo the initial community concern and interest that motivated this research. For example, overharvesting has been observed locally for wild garlic (*ramsøløk*, *A. ursinum* L.) around densely populated areas. Thirty-nine observations on the local decline of this species were reported in the online questionnaire; wild garlic was mentioned in every interview and has also been discussed in local media (e.g., Mathismoen, 2020). Ostrich fern, *strutseving* (*Matteuccia struthiopteris* [L.] Tod.; 24 mentions in online questionnaires), and sea kale, *strandkål* (*Crambe maritima* L.; eight mentions), are also ‘fashionable’ plants that participants believed may be vulnerable to increased foraging demand. Overall though, respondents to the questionnaire as well as interviewees were adamant that foraging is not a major threat to biodiversity in Norway.

Based on these results, we define sustainable WFP foraging as the knowledge and practices that maintain enriching forager–plant relationships over time. Our definition expands those that consider only long-term persistence of species populations by including the knowledge necessary for the maintenance of the social-ecological system, closing the reciprocal loop between humans and nature (Cocks, 2010; Comberti et al., 2015; Maffi, 2005).

### 3.3 | The wild food plants foraged in Norway

A total of 267 taxa of wild food plants in 67 botanical families were identified at species or genus level from 3,637 reports (NR), gathered from the online questionnaires (Dataset S2). The most commonly foraged plants are abundant and common species. According to the number of reports, the top 11 most often foraged WFPs in Norway are extremely common berries, like blueberries (*Vaccinium myrtillus* L.) and herbs, like nettles (*Urtica dioica* L.) and meadowsweet (*Filipendula ulmaria* L.; Dataset S2). The remaining 257 taxa have fewer than 90 citations each and 119 are only cited by one or two respondents. Fruits and berries were collected by 216 respondents, 188 respondents reported collecting leaves, and 160 respondents reported collecting flowers. Of the 227 taxa identified at species level, 80 are assumed to be introduced to Norway, either recently or in a distant past, while the origin of a further four species is unknown (Artsdatabanken, 2018). Some foraged species are considered threatened or invasive by the Norwegian Red List (Table 1; Dataset S2).

**FIGURE 2** Decision flow-chart based on foragers' judgements when harvesting plants to identify Wild Food Plants (WFPs) foraging sustainability issues at national and local level combined with ecological, ethnoecological, and conservation data (Dataset S2). Three outcomes indicate that no sustainability issues are identified (G, green), sustainability issues are identified (Y, yellow) or the plant should not be foraged (R, red).



**TABLE 1** Summary of foraged plants in regards to their conservation in mainland Norway status according to the Norwegian Red List (Solstad et al., 2021, special status in Svalbard is not considered here; see information at taxon level in Dataset S2)

Level of identification	Alien/native	Threatened/invasive	Protected
227 species level	178 native	168 species are not threatened; five species are near threatened; three species are vulnerable; two species are endangered; none is critically endangered.	None
	49 alien	Twenty-one species are not assessed; for four there are no known risks; for seven there are low risks; for 17 there are potentially high, high, or very high risks of invasiveness.	-
40 generic level	All plants identified at generic level but two include native plants.	For seven genera there is not enough information on the red list; 16 genera do not include any threatened species; two include at least one vulnerable species; nine include at least one endangered species; six include at least one critically endangered species.	Three genera include at least one protected species.
	Thirty plants identified at generic level contain alien species.	Fifteen genera contain invasive alien species.	-

Note: Alien taxa are not protected (indicated with a dash).

### 3.4 | Sustainability assessment for foraged WFPs in Norway

The long-term viability of plant populations is an important aspect of maintaining enriching forager-plant relationships over time. We combined forager's 'internal moral judgements' (Figure 2) with ecological,

ethnoecological, and conservation data (Dataset S2) to assess whether harvesting a plant can impact species' conservation. This assessment can be implemented at national or local level and distinguishes between three outcomes: no sustainability issues are identified (G, green), sustainability issues are identified (Y, yellow) or the plant should not be foraged (R, red; Figure 2; Dataset S2). Foragers

distinguish between alien and native plants. Alien plants can be invasive, and when collecting invasive plants, foragers are mindful not to contribute to their spread. Several foragers mentioned clearing populations of invasive species. Considerations in regards to native plants have a point of departure in classifying the plant as threatened or not. While alien plants are often easy to identify, identifying native plants is not straightforward for species-rich genera. As some WFPs were only identified at genus level (Table 1), we included a step to confirm species-level identification in the flowchart (Figure 2). Many participants mentioned that they do not collect plants that are rare, endangered or protected. If plants are not threatened, foragers will be mindful of the plant parts harvested and practice low-impact harvests of plant parts that can damage the survival of individuals (e.g., roots of long-lived species or bark or sap of woody species).

Figure 2 can guide assessing the impact of foraging at a national scale but also support low-impact foraging at a local scale. When foraging in a specific site, foragers will consider local abundance to regulate the quantities they harvest and will also take into consideration local rules for specific plants. In the national level assessment (Dataset S2), 220 WFPs were classified as G, 24 as Y and 1 as R (*Meum athamanticum* Jacq., a cultural relict plant). Most of those identified at genus level could not be assessed using the flowchart, although some genera only contain unproblematic species and were assessed as G and others almost only contain invasive species and were classified as Y. Only three WFPs identified at genus level (*Papaver*, *Zostera* and *Cirsium*) include species that are protected (Table 1; Dataset S2). Overall, foraging does not pose a threat to plant biodiversity at a national scale to almost any species.

## 4 | DISCUSSION

### 4.1 | Co-defining sustainable foraging

Sustainable foraging is grounded on dynamic, reciprocal relationships between foraged plants and foragers. Our definition of sustainable foraging is based on a biocultural diversity framework whereby humans and ecosystems can contribute to each other's health and are understood as being in reciprocal, co-evolutionary relationships to each other (Cocks, 2010; Comberti et al., 2015; Maffi, 2005). Such definition enables acknowledging foragers as effective environmental stewards that have an important role to play in nature conservation and policy making (Barron, 2011; Charnley et al., 2018; Doble & Emery, 2001; McLain et al., 2017; Poe et al., 2014), but also allows addressing sustainability from a conservation biology perspective. Our results on primarily recreational foraging practices of wild plant species show that direct negative impacts are extremely rare, an observation also made in Africa (Teixidor-Toneu et al., 2021), Asia (O'Neill et al., 2017), and in urban environments in Europe (Landor-Yamagata et al., 2018). Literature detailing overharvest threats to plants' conservation notes that these are fuelled by a commercial demand beyond the local market (Ghimire et al., 2005; Law & Salik, 2005; Ouarghidi et al., 2017). Furthermore, if foragers are in a socio-economically

vulnerable situation, existing considerations of plant availability can be overridden by high market pressures, leading to overharvest (Aziz et al., 2022). Sustainable large-scale commercial foraging, spanning multiple geographical scales and sites and where foragers' are not also the final resource users, requires a different definition and assessment that is not necessarily based on the reciprocal individual relationships of foragers with the harvested biodiversity. For that, various organizations provide sustainability certifications based on large sets of ecological and socio-economic criteria (Kathe, 2011; Marx & Cuypers, 2010).

### 4.2 | Combining local and academic knowledge to assess sustainability

Local ecological knowledge is key to making sustainability and biodiversity assessments (Brondízio et al., 2021). Combining foragers' moral judgements (Figure 2) with local and academic knowledge allows to determine if there is reason for concern of a realistic threat from foraging for a specific plant. While this exercise does not address every dimension of the sustainability of foraging such as considerations about people's health (e.g., emerging from collection of polluted or toxic plants) or the care for the plant's habitat (e.g., being mindful not to disturb the soil or leaving enough resources for the local fauna), it may be helpful to move from a polarized discourse where foraging is presented as either a solution to environmental challenges or a threat to biodiversity conservation by allowing analysis on a plant-by-plant basis.

Co-creating the flowchart and assessing the sustainability of WFPs in Norway raised the issue of local and academic differences defining and naming a plant species. Folk taxonomy is integral to local ecological knowledge systems. So-called 'generic taxa' are the basic units of ethnobiological classification referring to discontinuities among living beings easily recognized by many morphological and ecological characteristics (Alcántara-Salinas et al., 2016; Berlin, 1992). Generic taxa often correspond to botanically defined species but can also over- or under-differentiate them (Berlin, 1992). Here, 40 vernacular WFP ethno-taxa refer to botanically identified genera, including genera like *Alchemilla* and *Euphrasia*, for which species are challenging to identify even for those botanically trained. Of these, 18 include endangered or protected species. Although it is less probable that foragers will encounter endangered than non-endangered plants, foragers may be harvesting endangered species unknowingly. To forage these plants, specific botanical identification expertise can contribute to identify if the plant to be harvested is threatened or not. On the other hand, conservation practitioners should be aware of local taxonomy to better engage with foragers.

A mismatch between local and academic knowledge also arises when deciding whether a plant is threatened. While local and national Red Lists are often used as the ultimate authority on this subject, conservation status is perceived and evaluated differently at different scales and across knowledge systems (Teixidor-Toneu et al., 2021). Discrepancies arise when, for example, plants that are locally very



abundant are red listed because they have their few northernmost populations in Norway. In those cases, we have observed that foraging does not seem to be a threat to biodiversity but foragers' environmental stewardship practices may actually contribute to maintaining them. Foragers actively contribute to species conservation through practices aimed at maintaining ecosystem health (Charnley et al., 2018; Combetti et al., 2015; McLain et al., 2017), such as weeding invasive species, assisting plants' dispersal through spreading seeds, or replanting popular species, as we observed foragers in Norway do. These local contributions to biodiversity conservation should be acknowledged by the academic community and considered when assessing biodiversity status (Brondizio et al., 2021; Tengö et al., 2017). At the same time, red listing allows synthesizing information at large scales and this can complement the local-based observations made by foragers. Many of our research participants mentioned consulting the national Red and Alien Species lists. Foragers and other non-academic communities can contribute to these large-scale assessments by sharing their observations with the academic community (e.g., Barron, 2011). Academics increasingly use crowd-sourced data (MacPhail & Colla, 2020; Mesaglio & Callaghan, 2021) and new conceptual frameworks arise to help bridge local and academic knowledge (Obura et al., 2021; Tengö et al., 2014, 2017). Another instance where a large-scale synthesis of information is important in assessing the sustainability of foraging is in regards to defining foraging demand. Having information on the relative frequency of harvest and number of foragers over a large area gives an idea of a plant's popularity that may contribute to assessing foraging demand beyond local observations. We have therefore not indicated specific definitions of threatened and abundant in the flowchart, but recognize that by addressing different scales, academic and local knowledge can complement each other in a case-by-case analysis.

### 4.3 | Application of co-created knowledge about sustainable foraging

Knowledge co-created through this study will guide future research, serve as a base for dissemination events and training programmes targeted to both the academic and foraging community, and may also be useful to address the issue of foraging sustainability elsewhere. In Norway, we identified cases where the validation of local ecological knowledge on sustainable foraging of some plants by means of ecological monitoring (Tengö et al., 2014) may be desirable. Specifically, this is the case of wild garlic, which has recently been added to the Norwegian Red List as Near Threatened based on observations of intensive foraging in a few locations (Solstad et al., 2021). Foragers have observed localized high demand too but are adamant that foraging does not pose a threat to the species at national level and some of them actively contribute to maintaining wild garlic populations through replanting. In Berlin, foraging is reported to have had a positive impact on the species' survival (Landor-Yamagata et al., 2018). Technical guidelines combining foragers' empirical knowledge and ecological population analyses that specify sustainable volumes

foraged per species or population could fill local and academic knowledge gaps for very popular WFPs (Cambecèdes & Garreta, 2017; Chaber et al., 2013).

The flowchart and assessment presented here will also serve as a guide for foragers to think about and strengthen knowledge transmission about low-impact foraging practices. At present, knowledge about foraging is transmitted both formally and informally, orally and through written sources in Norway (Storaker, 2022). Our results will be especially useful when foraging new plants or for newcomers to the foraging community, both instances fuelled by the New Nordic Food movement (Hermansen, 2012; Münke et al., 2015). The flowchart can also help foragers seek for new knowledge (e.g., on local protection regulations). The NSNF plans to develop a specific page within their website in 2022–2023 to present guidelines to sustainable foraging based on foragers' own knowledge and moral judgements including its ecological, social, and health dimensions in Norwegian. Dataset S2 will be made available as a searchable database linked to Artsdatabanken (which includes the national red list assessments), allowing foragers to check plants' ecological traits, conservation status, if a plant species is being foraged by many others, and information on low-impact foraging practices. New training programs on foraging sustainability will be offered and existing training on botanical identification include challenging taxa.

Indigenous and local knowledge is place-based and embedded in specific cultural and epistemological contexts (Agrawal, 2002). Decision-making to assess sustainability and the kinds of evidence this process recalls can vary across geographical and cultural contexts, and thus the decision flow presented here (Figure 2) does not represent a one-size-fits-all solution. However, the process of co-creating this flowchart, whereby we visualize foragers' judgements and combine this with the full list of species harvested may be useful to other cultural, legal or taxonomic contexts.

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## CONFLICT OF INTEREST

One of the co-authors is the leader of the Norwegian Association for Foraging and Mycology, which aims to promote sustainable foraging. We did not consider authors' personal opinions in our assessment of foraging sustainability. This is based on ecological traits, conservation status as per the national Red List and ethnobotanical data compiled through a large sample of foragers including >25% of non-members (55 respondents).

## AUTHOR CONTRIBUTIONS

The problem was raised independently by the academic and non-academic community, and together, we framed it into a research question (PK, AK and ITT). The interviews and questionnaires were co-constructed by all co-authors. Data were mostly collected by NJG, with contributions by PK, AK and ITT, and results were analysed by all co-authors: ITT, NJG, PK, AA and AK. ITT wrote the manuscript with NJG and AK. All co-authors revised and edited the manuscript. All co-authors contributed to ongoing discussions through all stages of research.

## DATA AVAILABILITY STATEMENT

Data used in this research is published as supporting information. Transcripts and notes from interviews are not published to ensure participants' anonymity.

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## SUPPORTING INFORMATION

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

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