From trend to threat? Assessing the sustainability of wild edible plant foraging by linking local perception to ecological inference

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Abstract

Wild edible plants as culturally-appropriate sources of nutrition and for food security are now well-recognised. In Europe, the use of wild edible plants is shifting from a subsistence activity to an emerging trend in high-end gastronomy. The environmental impacts of this shift are poorly known. Foraging is increasingly popular for personal consumption and commercially, not least in the Nordic countries where popularity is fuelled by the New Nordic Food movement. Here, we evaluate if this trend entails biodiversity conservation risks in Norway. In collaboration with the Norwegian Association for Mycology and Foraging, we conducted 18 face-to-face interviews with key stakeholders and we published an online questionnaire filled by 219 recreational and professional foragers. We enquired on what species are harvested, by whom and how, where do foragers learn and what are their perspectives on the sustainability of foraging. We combined these data with an assessment of foraging impact based on foraging pressure, ecological traits and conservation assessments. Our results show that 272 different wild edible plants are foraged and that this is mostly sustainable.

However, some risks arise from the harvest of threatened plants, the potential spread of invasive species, and the overharvesting of extremely popular or 'fashionable' species. Foraging fosters a strong connection with the natural environment and the majority of foragers report to forage as part of a sustainable lifestyle. We suggest that careful encouragement to forage and the participatory development of local guidelines for sustainable foraging in Norway can enhance people-nature relationships while safeguarding foraged plant populations.

Keywords: ecosystem services; New Nordic Food movement; plant conservation; Scandinavia; sustainable livelihoods; wild food

Introduction

Wild edible plants (WEPs) are plant species collected in the wild to be consumed as food or drink (Reyes-García et al. 2015). WEPs have always been an integral part of the human diet around the world (Reyes-García et al. 2015; Bharucha and Pretty 2010). However, the way humans select, prepare and consume wild edible plants changes over time. Recent ethnobotanical evidence shows a worrying trend of loss of traditional ecological knowledge (TEK) of WEPs and associated foraging practices (Łuczaj et al. 2012). Which plants are foraged and how this is done depends on the cultural, socioeconomic, and ecological contexts. For example, during times of food shortage, foraging activities often increase (Łuczaj et al. 2012; Łuczaj and Pieroni 2016; Vorstenbosch et al. 2017). Currently, foraging in and around urban settings is an emerging practice among city dwellers regardless of age, race, gender, and standard of living, both in the Global North and the Global South (McLain et al. 2014; Sardeshpande and Shackleton 2020).

Unsurprisingly, WEPs are most well-studied in developing countries where subsistence lifestyles remain common and wild goods are still part of people's daily lives (Bharucha and Pretty 2010; Shumsky et al. 2014). In these contexts, wild products are often being promoted as resources to ensure food security and socio-ecological resilience (Bacchetta et al. 2016; Beltrame et al. 2019). In Western societies, the role of wild food plants in sustainable development is being overlooked and ethnobiologists call for efforts to promote and revitalise these resources (Poe et al. 2014; Sõukand et al. 2021; Ulian et al. 2020). WEPs can contribute directly to improve health, foster local economies, maintain co-evolutionary relationships with the natural environment, enhance landscape multifunctionality, and facilitate the integration of migrant communities (Cambecèdes and Garreta 2017; Poe et al. 2014; Lovrić et al. 2020). While these are valuable benefits to foster the ongoing transition towards sustainable livelihoods, concerns on biodiversity conservation are central to the sustainable use of WEPs notably due to the risk of overharvest (Cambecèdes and Garreta 2017; Redford and Richter 2001).

In Europe, although research has been conducted on the documentation of TEK associated to WEPs use (Pardo-de-Santayana et al. 2010), how foraging practices affect biological diversity remains poorly known (Cambecèdes and Garreta 2017). Foraging practices in 21st century Europe are grounded in long-standing local traditions but also in rising innovative culinary approaches (Łuczaj and Pieroni 2016; Reyes-García et al. 2015). The revalorization of WEPs in gastronomic cuisines appeared in the 90s and has increased since then (Łuczaj and Pieroni 2016). The recent gastronomic revival that focuses on the significance and use of wild plants has been increasing, especially in the Nordic countries, where it was triggered by an interest for natural living, alternative medicine, and eco-friendly products. Specifically, a new focus on WEPs emerged from the New Nordic Cuisine led by pioneering restaurants such as Noma in Copenhagen or

Maaemo in Oslo (Hermansen 2012; Sloan et al. 2015). These new interactions between foraging traditions and innovations may entail the use of non-traditional plants and new harvesting techniques. In fact, they may pose new threats on specific plant species, potentially raising sustainable harvesting and conservation issues.

Sustainable harvesting considers that the "resource should be harvested within the limits of its capacity for self-renewal [… and] the manner of its harvest should be such as not to degrade the environment in other ways"(Hamilton 2005). Assessing the sustainability of WEP foraging activity requires an investigation of both social and ecological aspects that influence these practices. Such an assessment is inherently complex given the high diversity of actors involved (Pretty 1995), as well as the stakes perceived concerning the conservation of wild flora (Schulp et al. 2014). Characterising 'sustainable foraging' requires understanding the worldviews (i.e. perceptions of their impacts) and backgrounds (i.e. individual knowledge, experience) that drive foragers' attitudes and practices towards the collection of WEPs, as well as understanding the ecological characteristics of the plants harvested and the environments in which they are harvested. Thus, in order to valorise and promote WEPs in sustainable ways, new ethnoecological, interdisciplinary, and cross-sectorial conservation approaches are needed (Pardo-de-Santayana et al. 2010; Ulian et al. 2020).

Concomitant to the new Nordic food movements within Scandinavia, there has been a recent and increasing trend in the commercial use of wild edible plants in Norway. This study aims to identify potential sustainability challenges of foraging WEPs in Norway by answering the following research questions: (1) Who is harvesting wild edible plants in Norway? ; (2) Which plants species are being harvested and why? ; (3) How are plants being harvested? ; (4) To what extent do local perceptions of sustainable foraging align with existing ecological and conservation data of harvested plants? To do so, we

study the emergence of new socio-economic trends of WEP harvest, the ethnobotanical diversity harvested and link local ecological knowledge and perceptions of sustainable foraging with sustainability inferences based on a dataset of ecological traits of the harvested plants. With the Norwegian Association for Mycology and Foraging (*Norges Sopp- og NyttevekstForbund*, NSNF), we investigated foraging practices and place them in perspective with the ecological characteristics of harvested plants. Ultimately, the goal is to establish context-specific sustainable foraging guidelines in Norway through a knowledge-exchange process with the foraging community.

Materials and Methods

This research was conducted from April to October 2020 as part of an interdisciplinary research partnership between the Natural History Museum of Oslo (NHM), UMR LISST-Dynamiques Rurales, and the NSNF. Research was grounded in a participatory and community-based approach to ensure ownership of these guidelines by the foraging community. The study was co-designed with NSNF representatives and conducted in four phases: (1) Topic exploration, (2) Ethnoecological data collection, (3) Ethnoecological data analysis, and (4) Sustainability inference. 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).

First, preliminary unstructured interviews were conducted with five key informants including the NSNF association leader, three professional foragers and one conservation expert in May and June 2020 to explore Norwegian WEP foraging practices, past and present. The research context was presented to each informant prior to commencing the interview. Free prior informed consent (FPIC) was obtained verbally before each

126 interview. Foragers were then asked about their experience and thoughts on foraging
127 sustainability. This method was chosen to allow the informants to bring their own
128 thoughts and opinions to further identify relevant and recurring themes (Albuquerque et
129 al. 2019). In August 2020, participant observation during WEP forays and informal
130 discussions with professional and non-professional foragers completed this preliminary
131 exploration of perceptions, values, and practices associated to WEPs (Cunningham
132 2001). This helped outline local expert knowledge and build trusting relationships.
133 Second, primary ethnobotanical data was collected via face-to-face interviews and an
134 online questionnaire with Norwegian recreational and professional foragers, including
135 members of the Nordic food movement. A forager was defined broadly as a person who
136 spends time outdoors to gather WEPs. The questionnaire allowed gathering information
137 across the country at a time where travelling was discouraged due to the covid-19
138 pandemic.
139 Building on the initial five interviews and the online questionnaires, snowball and
140 convenience sampling methods (Bernard 2011) were used to identify expert foragers
141 and cooks within the Norwegian foraging community. NJG and PK conducted field
142 trips to meet foragers and attend workshops and workdays in order to conduct
143 interviews (Figure 1). These 18 interviews provided in-situ observation of different
144 landscapes and WEPs as well as a diversity of local perceptions on WEPs distribution
145 and availability that would have been impossible to obtain from an online questionnaire
146 alone. Free prior informed consent (FPIC) was obtained in writing before each
147 interview.
148 <Figure 1>
149 In parallel, an online questionnaire was used to collect a comprehensive list of harvested
150 WEP species, practices, and sustainability perceptions from a larger number of foragers

151 to complement the detailed qualitative data provided during face-to-face interviews
152 (Table S1). The complete questionnaire consisted of three sections based on key themes
153 on WEP foraging identified during the exploratory interviews. After a brief introduction
154 to the research, the first section asked questions related to the practices used by foragers
155 to harvest plants as well as the knowledge of WEPs held by foragers. Listing and
156 multiple-choice questions were used for these questions and respondents also had the
157 opportunity to add comments. Lists of foraged WEPs were compiled per botanical plant
158 part harvested (e.g. berries, flowers, leaves). No minimum nor maximum were imposed
159 to fill these lists. The second section asked about individual perceptions and values
160 associated with foraging WEPs using Likert scale statements (e.g. "foraging contributes
161 to our sense of community"). In the final section, respondents were asked to provide
162 non-personal, socio-demographic data such as the foragers' type (professional and/or
163 recreational), membership of an association such as NSNF, respondents' subjective
164 experiences (e.g. perception of foraging impact) and self-assessed knowledge (i.e.
165 perceived 'cultural expertise').
166 The questionnaire was available in English and Norwegian for one month between June
167 and July 2020 on *Nettskjema*, the University of Oslo tool for creating and handling
168 online surveys and data. The questionnaire was distributed through various social media
169 platforms as well as via the social networks of some key informants. It was published
170 on the NHM's website, as well as the NSNF's June's newsletter and distributed through
171 the NSNF mailing list. The questionnaire was anonymous and had no time limit for
172 completion.
173 Three datasets were created as a means to analyse responses gathered from interviews
174 and the online questionnaire: (1) A floristic dataset with the list of WEPs mentioned in
175 the online questionnaire; (2) A dataset with the socio-ecological categorical variables

coded from the online questionnaire used for qualitative and quantitative statistical analysis; (3) A matrix of qualitative data collected during face-to-face interviews. The floristic dataset was organised per plant species and consisted of each plant's scientific name, botanical family, the most commonly used folk names, number of reports per plant part, total number of reports (NRs), Norwegian Red List of Species status (IUCN classification of plant species in Norway; Henriksen and Hilmo 2015), invasiveness, perennation, life form, woodiness, clonality, comments on ecology (sourced from BSBI 2021), and comments from respondents of the online questionnaire on conservation issues, if any. Most plants were originally mentioned on the online questionnaire through their folk or local names. The vernacular names provided were cross-referenced with scientific literature to accurately count the number of reports of each plant species identified (Henriksen and Hilmo 2015; Høeg 1974). Species that were not identifiable via these sources were discussed within the research team and identified when 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. XLSTAT was used to count the total number of different plant species listed by respondents (Plant Reports per respondent, PR), as well as the number of times plant species were cited (Number of Reports per plant species, NR). The cultural importance of WEPs was evaluated through their gathering frequency, i.e. the number of respondents foraging each species. Foraged plants cited in online questionnaires were processed as free-lists and the salience index calculated to infer the cultural importance of each plant. From each botanical part list, salience per species was calculated with the R package AnthroTools (Purzycki and Jamieson-Lane 2016) in RStudio (2021). Together with NR, salience calculations per plant part were used to

explore the importance of WEPs and to assess to what extent they might be vulnerable in relation to the plant parts being foraged.

A second dataset based on qualitative responses to the online questionnaires was built where the units of analysis were the respondents. Categorical and quantitative variables were coded to allow for analysis on XLSTAT. Descriptive statistics were used to summarise the data gathered from the questionnaire. The mean and standard deviation of the number of plants listed by respondents in the questionnaire were calculated across types of foragers (professional or recreational, and association members or non-members). Expertise levels were compared between professionals and recreational foragers, and between members and non-members, through the Mann-Whitney test (because $n<30$), using the difference in the total number of plant reports elicited by these groups of foragers. A Fisher test was conducted to evaluate the consensus for the perceived impact of foraging on biodiversity and between types of foragers (professional or recreational, association member or non-member), including self-assessed expertise.

A third dataset gathered qualitative information from twelve face-to-face interviews with key informants were recorded and transcribed using the open-source software OTTER. Audio and transcripts were deleted from the online software after analysis to ensure data protection. 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 (University of Oslo). Seven other interviews were conducted in contexts with little opportunity to obtain a good quality audio recording and were not recorded. Instead, notes were taken and transcribed in a word document. Transcriptions and notes were analysed with theme colour-coding. Emergent themes were extracted from transcripts as variables in an

Excel file. Relevant and interesting quotes illustrating these themes were noted down to support the qualitative analysis.

An assessment of the impact of foraging on WEPs conservation was conducted to identify potentially vulnerable WEPs and risks in relation to foraging activities. We developed a sustainability index linking ecological (i.e. life cycle and reproduction traits: perennation, life form, woodiness, clonality) and conservation information (IUCN status in Norway, see Henriksen and Hilmo 2015) with foraging data collected from the online questionnaires. The total number of plant reports per species (NRs) was used as a proxy for foraging pressure. Together with salience calculations for each botanical plant part, this enabled the identification of two potential conservation concerns: the risk of overharvesting native species and the risk of dispersing invasive foraged species. These data were used to categorize each species with regards to potential sustainability impact under the current foraging pressure (Figure 2). Impact was defined and assessed differently depending on whether a plant was native (risk of extinction through overexploitation) or alien (risk of invasion through spread). With separate assessments for native and alien plants, WEPs were scored from green (G; no or little risk; with a nuanced assessment G*, indicating that exceptions to the main category may exist), orange (O; potential risk), and red (R; high risk). When a species was red-listed and being foraged it was directly indexed in the red category. If not red listed, our assessment depended on the plant parts that are collected and the harvesting pressure proxied from the popularity of each WEPs.

<Figure 2>

Results

Foraging wild edible plants in Norway

The online questionnaire was filled by 219 foragers (Figure S1) who collectively forage all across Norway (Figure 1). Of them, 207 foragers (94,5%) considered themselves as recreational and 11 (5%) forage professionally. Yet, most of those who forage professionally also had another job on the side. The professional foraging milieu in Norway is small, and our participatory approach ensured that we reached most professional foragers across Norway (Figure 1). According to the online survey, most recreational foragers are older than 50 years old, very few people under 30 forage, and most professionals are between 30 and 50 years old (Figure S1). Fifty-eight percent of the recreational and 95% of professional foragers are members of an association such as the NSNF.

Most foragers both gather, process and consume wild plants (online questionnaire, >96%). Other than food, foragers gather wild plants for their ornamental value (68% of online questionnaire respondents harvest plants for their ornamental value) and their medicinal properties (31%). During the foraging season (May to October), 3% go foraging every day, whereas almost 40% forage regularly one to three times a week. Around 25% gather WEPs between one and three times every two weeks and another 25% once a month. Most foragers (>91%) consume WEPs at least once a month. While most foragers only harvest WEPs from the wild, almost 40% of respondents mentioned either transplanting WEPs from the wild to their own garden (31%) and/or tending WEPs directly in situ (8%).

Ethnoecological knowledge of Norwegian foragers about wild edible plants

Professionals reported more plant taxa on average than recreational foragers (49 and 15 plants, respectively), which suggests that they have more knowledge in the domain of foraging (Mann-Whitney test, p-value<0.001). These estimations based on the number

of plants mentioned per respondent correlate with responses about self-assessed knowledge. While professional foragers forage often (varying from every day during high season to 1-3 times every two weeks in low season), so do many recreational foragers. Members of foraging associations reported significantly more plant taxa on average than people who forage but are not members of such associations (20 and 11 plant taxa respectively, Mann-Whitney test, p-value<0.05). Most respondents reported learning by themselves (78.5%), through literature and a personal practice of foraging. About two thirds (69%) learn from family and 36.5% from friends. Formal education such as courses and workshops are also an important source of knowledge for 16% of respondents. No significant relationship was found between types of foragers (i.e. recreational or professional foragers) and the learning modes (i.e. personal, family, or education-based sources of knowledge).

The wild edible plants foraged in Norway

A total of 272 taxa of wild edible plants belonging to 67 botanical families were identified at species or genus level from 3647 reports (NR), gathered from the online questionnaires. Seven families had high NRs and constituted 65% of the total NRs. The families with the highest number of reported species are Rosaceae with 29 taxa (10.5%) and Asteraceae with 27 taxa (<10%). Apiaceae and Brassicaceae were represented by 18 taxa each (6.5%), followed by Lamiaceae (5.8%; 16 taxa), Fabaceae (4.7%; 13 taxa), and Ericaceae (4%; 11 taxa). The remaining 60 families were represented by less than 8 taxa each (<3%).

According to the number of reports, the most popular WEPs foraged in Norway are *Vaccinium myrtillus* L. (208 reports), *Rubus idaeus* L. (165 reports), *Chamaenerion angustifolium* (L.) Schur (157 reports), *Taraxacum* sp. (155 reports), *Vaccinium vitis-*

idaea L. (150 reports), *Allium ursinum* L. (145 reports), *Urtica dioica* L. (144 reports), *Rubus chamaemorus* L. (122 reports), *Fragaria vesca* L. (104 reports), *Sorbus aucuparia* L. (101 reports), and *Filipendula ulmaria* (L.) Maxim. (100 reports). The remaining 263 taxa have fewer than 90 citations each and 124 taxa 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 (Table 1). Of the 272 taxa, 95 are assumed to be introduced to Norway, either recently or in a distant past, while the original origin of a further four taxa is unknown (Artsdatabanken, 2020; Henriksen & Hilmo, 2015). A total of 137 foraged taxa is assumed to be native (Table S2).

<Table 1>

Foraging motivations and trends: from necessity to recreation and human-nature connection

Traditionally, foraging was "driven by necessity" and done in combination with farming, hunting, or fishing, as explained by the foragers and experts interviewed face-to-face. The concept of *matauk* literally means 'food increase' (from Norwegian mat = food and auk = increase). It refers to a traditional practice of subsistence lifestyles, which was common in Norwegian households in the past, before the major industrial and green revolutions. People would complement their food sources from small-scale farming, through *matauk* activities that were mostly done in the wild but not exclusively. *Matauk* mostly refers to hunting and fishing activities that are famously embedded within the Norwegian culture, but also to growing vegetables in the garden, or going out in the forest for a 'mushroom hunt' or 'berry picking'. Foraging WEPs

326 though, apart from berries and very common plants such as nettles, *brennesle* (*Urtica*
327 *dioica*), is not part of the *matauk* tradition. As a subsistence activity, *matauk* also fulfils
328 certain economic and nutritional goals, especially because the idea of *matauk* was to
329 collect and store nutritious summer foods for the long and dark winter.
330 Most interviewees explained that the practice of *matauk* is in decline. The need to store
331 wild foods decreased and subsequently disappeared following the industrial and green
332 revolutions. Foraging became much more a means to enjoy the *friluftsliv* (from fri =
333 free, luft = air-outdoors, and liv = lifestyle) or the famous Nordic outdoors lifestyle.
334 Similarly, based on interviews, from gathering to processing, cooking, and eating
335 WEPs; having a 'goal' with foraging activities, seems to motivate the use of WEPs by
336 foragers. On the one hand, foragers enjoy the 'hunt' and the sense of freedom, as well as
337 the nutritional and gastronomic rewards. This is particularly reflected in the value
338 assigned to the knowledge required to forage for one's own food. On the other hand,
339 chefs use WEPs within their cuisines as a way to express their Nordic identity while
340 telling a story of Scandinavian culture. According to most foragers and chefs,
341 integrating wild food plants in their cooking is a way to express their 'freedom' as part
342 of their 'lifestyles' and their identity. They feel free in developing a strong connection
343 with the natural environment in which they act, and they are looking for something
344 'different' than what the societal norm has to offer. For most of them, foraging and
345 cooking WEPs is a way to 'relocalize' and put all their energy into something
346 'meaningful' that makes sense not only at a local level, but also at a global scale.
347 'Knowledge sharing' about these 'lifestyles' is as important as being able to live a 'free
348 life', thereby showing the world that another way is possible.
349
350 *Local perceptions of sustainable WEPs foraging*

Respondents of online questionnaires and those interviewed face-to-face have different interpretations of what sustainability means. Some participants define sustainability in relation to the direct impact foraging has on plant communities, others in relation to the larger effect the foraging lifestyle has on society. Despite these different interpretations, most people believe that foraging is or can be sustainable. The majority of respondents of the online questionnaire (90.5%) agree that some WEPs are more vulnerable than others, and therefore deserve specific foraging practices. Even though most people (75%) agree that foraging WEPs is a sustainable activity, there was less agreement as to whether foraging WEPs might be unsustainable in some cases. While 50% agree to some extent, 21% have no opinion and almost 24% disagree. Respondents who believe that foraging is potentially 'unsustainable' also mentioned that some 'plants are more vulnerable than others' (Factorial analysis, correlation coefficient 0.262; p-value<0.05). Younger people are more likely than older people to think that foraging might be unsustainable (Factorial analysis, correlation coefficient -0.134; p-value<0.05). Regular foragers (i.e. people foraging one to three times a week) believe that foraging is a sustainable activity (0.203; p-value<0.05).

Informants interviewed face-to-face (n=18) were adamant that foraging is not a major threat to biodiversity, yet they also mentioned that some conservation issues may arise at a local scale. The decline of WEPs in Norway was also reported in the online questionnaire, and overharvesting may happen locally for some species (e.g. wild garlic, *ramsløk*, *Allium ursinum*) in densely populated areas. Thirty-nine observations on the local decline of this species were reported in the online questionnaire and the *ramsløk* case was mentioned in each and every interview. Ostrich fern, *strutseving* (*Matteuccia struthiopteris* (L.) Tod.; 24 mentions in online questionnaires), and sea kale, *strandkål*

(*Crambe maritima* L.; eight mentions in online questionnaires), also seem to be 'fashionable' plants on which an increased foraging pressure may occur locally.

In terms of harvesting quantity, most informants self-reported being guided by 'common sense' and referred to those that over-exploit resources as 'greedy'. However, the concept of sustainable harvesting remains vague and subjective, and illustrates the little available information on foraging best practices. Indeed, only half of respondents were aware of regulations written in law such as not being allowed to collect plants in nature reserves. Interestingly, the *molte* rule that was written in law (Statsforvaltaren i Troms og Finnmark 2019) remains a powerful feature of the foragers' common sense and they do sometimes apply it to other edible plants. It states that people are free to forage unless the landowner has put up a sign that it is not allowed, but even then berries can be picked if they are consumed on site and the landowner is obliged to pick the berries him- or herself and not let them rot on the ground. However, aspects of this rule are interpreted subjectively by different foragers. For instance, one guideline states that "one should not collect more than a third of what is on site", which is problematic if several foragers visit the same site. Also, only 20% of online respondents could recall exact harvesting volumes, and those that did reported a wide range of weights unspecific to any listed WEPs.

Sustainability assessment of foraging in Norway based on WEPs ecological traits

The sustainability assessment shows that some important WEPs may be vulnerable to foraging activity. We did not observe any differences between recreational foragers and professionals regarding the conservation risks of the species they forage, and the pressure they could put on vulnerable species. No conservation risks were observed for the vast majority of foraged species (216 in G and 46 in G*; >95%), but conservation

risks exist for ten plants (O, R, and R*) of which seven are native and three are alien (Tables 2, 3). Four native species were scored red (R). These are rarely harvested (Table 3) but the fact that they were mentioned in the questionnaire justifies attention as they are classified in the Norwegian Red List, either as vulnerable or near threatened. *Malus sylvestris* (L.) Mill. (scored R*) is rare and most likely foragers harvest the fruits of hybrid species, yet the fact that real *M. sylvestris* is difficult to identify puts it at risk. *Allium ursinum* was scored orange because, even though no conservation concerns exist for the species in Norway as a whole, our participants reported local overharvest, a trend which has also been discussed in Norwegian media (Statsforvaltaren i Troms og Finnmark 2019). A large fraction of foraged taxa (95 out of 272) was either introduced long ago during the introduction of agriculture, during the Middle Ages or as garden- or agricultural plants during the past 400 years.

<Table 2>

<Table 3>

Some species are very commonly harvested and foraging may be damaging to the plant's survival when roots, stems, or seeds are removed including *Angelica archangelica* (NR 35), *Carum carvi* L. (NR 51), scored G* (Table S2). The collection of the berries of *Rubus chamaemorus* is very popular (NR 121), and regulations exist for this specific plant. Also scored G* were plants where species-level identification was challenging. This included the genera *Cirsium sp.*, *Artemisia sp.*, *Viola sp.*, *Myosotis sp.*, *Salicornia sp.*, *Dianthus sp.*, *Trifolium sp.*, *Vicia sp.*, *Geranium sp.*, *Thymus sp.*, *Epilobium sp.*, *Euphrasia sp.*, *Papaver sp.*, *Rumex sp.*, *Primula sp.*, *Alchemilla sp.*, *Rosa sp.*, and *Rubus sp.* Except for *Viola sp.* (NR 37), these are currently not popular WEPs and harvesting pressure is low, but foragers may be harvesting a threatened species unknowingly (Table S2). Foraging roots (e.g., *Arctium lappa*, which

425 was introduced before 1800 and *Rhodiola rosea* L.), bark (e.g., *Picea abies* (L.) H.
426 Karst. and *Pinus sylvestris* L.) and sap (e.g., *Betula pendula* Roth.) can be highly
427 detrimental to individual plants and plant communities (G*; Table S2). These foraging
428 practices are sustainable when local knowledge exists to ensure that a specimen's bark
429 or sap is not too heavily foraged or that the removal of individuals to harvest their roots
430 does not compromise the health of the plant community. Many alien species foraged for
431 their leaves were also scored as G*, since foraging practices could potentially contribute
432 to sustainability through removal of invasive plants.
433
434 **Discussion**
435 *The emergence of a professional foraging activity within the "back to the land" trend*
436 Echoing wider European trends of WEPs use (Grasser et al. 2012; Łuczaj and Pieroni
437 2016), foraging appears to be shifting from a survival to recreational activity in Norway.
438 This shift is reflected as the cultural transition from *matauk* to *friluftsliv*. A parallel
439 trend can be seen in the movement from non-commercial to professional foraging in
440 Norway. Many values associated to the foraging activity remain grounded in Norwegian
441 history and traditions, yet this practice is also subject to new socio-ecological context
442 that is altering the motivations and attitudes behind foraging. The modernization of
443 lifestyles, arising from the industrial and green revolutions, appears as the main driver
444 for the declining necessity and use of wild foods in general (Łuczaj and Pieroni 2016;
445 Vandebroek and Balick 2012). Evolving nutritional needs and diets have changed
446 societal motivations for going outdoors to gather foods from the 'wild' (Reyes-García et
447 al. 2015; Łuczaj et al. 2012; Turner et al. 2011). As observed elsewhere in Europe (e.g.,
448 Pardo-de-Santayana et al 2010; Reyes-García et al. 2015), this study found that
449 Norwegian foragers and chefs appreciate WEPs for their culinary value, and as a

450 symbol of independence from a standardized and globalized food system. Foraging has
451 become a cultural feature or means for achieving the goal of feeling free, and a way to
452 foster local identities as most clearly expressed through the New Nordic food
453 movements (Hermansen 2012). In Norway, foraging is seen as a feature of a sustainable
454 lifestyle, where the many benefits of WEPs are used and valued as symbols of freedom,
455 alternative culture and eco-friendly lifestyles in opposition to modern lifestyles (Turner
456 et al. 2011). Foraging WEPs provides a sense of place and a true connection with nature
457 within a 'glocal' landscape (Stano, 2018) potentially triggering foragers to act as local
458 ecological stewards (Waygood 2019).
459
460 *Is foraging in Norway sustainable?*
461 In this study, 272 taxa were reported as being used as foods, more than three times the
462 number reported by Schulp et al. (2014) from a synthesis of ecosystem services
463 provided by vascular plants used as wild foods in Europe. Our results show that there
464 are no conservation issues for most foraged species yet attention should be paid to
465 specific practices and some red-listed plants, a trend observed elsewhere (Landor-
466 Yamagata et al. 2018; O'Neill et al. 2017; Teixidor-Toneu et al. 2021). Here, some
467 sustainability issues have been identified including (1) botanical identification
468 challenges, (2) potentially damaging foraging practices, (3) the emergence of
469 'fashionable' WEPs that might be overharvested locally, and (4) the spread of alien and
470 potentially invasive species. Based on our interviews, we also show that local ecological
471 knowledge enables foragers to harvest a wide variety of plants at different times of the
472 year, hence reducing localized pressures on fashionable species. The fact that regular
473 and professional foragers known more about a larger number of edible plant species

474 shows the potential for foraging becoming more sustainable when people forage more,
475 not less.
476 Vernacular taxonomies do not completely match botanical ones (Berlin 1973, 1992).
477 Here we observe that some WEPs are not identified at species level by non-botanists
478 and they refer to genera that include red-listed species. This issue can be addressed
479 through training programmes for foragers given by associations such as the NSNF.
480 The majority of WEPs reported in this study were harvested as berries, leaves, and
481 flowers. The limited harvesting of roots and bark appears to confirm Turner et al. (2011)
482 who suggest that the physical, visual, and cognitive access to WEPs determines the
483 likelihood of a plant being harvested, but also because it is less destructive and less
484 time-consuming. The collection of bark, sap and underground organs can significantly
485 damage the individual or destroy it completely (Hamilton 2005; Mathismoen 2020). In
486 Norway, these are not the most popular harvests, but they are common enough and part
487 of the Norwegian tradition (Teixidor-Toneu et al. 2020). The digging of roots is
488 probably less common today than in the past, a trend also observed in the British Isles
489 (Łuczaj et al. 2021). We observed that, under the label of 'common sense', local
490 knowledge exists to guide foragers' decisions on how much to harvest from one tree or
491 population.
492 Locally sourced and available, low-input, free, non-cultivated, fresh, and nutritious
493 WEPs are valuable natural resources considered and promoted as sustainable
494 ingredients by high-end gastronomic restaurants that aim at doing "Nordic" with
495 "multicultural influences" (Byrkjeflot et al. 2013; Hermansen 2012; Mithril et al. 2012).
496 Acknowledged by the local media (Mathismoen 2020), some edible plants have shifted
497 from neglected to popular. 'Fashionable' edible plants can be overharvested in some
498 localities, primarily in and around densely populated areas in Norway, where they are

499 easily found and recognized for an increasing number of gatherers. The wild garlic
500 (*Allium ursinum*) example best showcases this (Mathismoen 2020).
501 While the use of invasive alien plant species may appear to be a positive aspect of
502 foraging WEPs as harvesting may contribute to eliminating the plant, great care on
503 harvesting procedures should be taken in order not to spread it across the landscape.
504 Promoting the harvest and consumption of invasive plants may help create new
505 traditions and markets and ultimately encourage the preservation of these species
506 (Nuñez et al. 2012), but well-educated foragers can contribute to the control of invasive
507 aliens. Invasive aliens foraged for their berries or seeds should be transported properly
508 in closed bags and leftovers should not be composted. For those alien species that can
509 spread vegetatively, it is also important to not lose them on the way and not to compost
510 them (Filippi and Aronson 2011).
511 Local ecological knowledge about foraging sustainability is labelled by Norwegian
512 foragers as 'common sense'. As in other places (e.g., North America; Turner et al.
513 2011), foragers' attitudes are framed within cultural appreciation, societal regulations,
514 and personal ethical considerations. In Norway, such 'common sense' primarily referred
515 to the quantity of WEPs harvested, and the quality or care taken in foraging practices.
516 Being careful to not trample soil, considering plant ecology and community structure, or
517 'leaving some foods for other living-beings' are general considerations amongst the
518 foraging community in Norway and elsewhere (Hamilton 2005). Overall, there is very
519 little concern for a major negative impact of foraging of WEPs in Norway, while an
520 increased awareness of the use potential of WEPs is likely to have a positive impact on
521 their conservation.
522 Foraging can facilitate respectful relationships between humans and nature, especially
523 in urban environments (Landor-Yamagata et al. 2018) thereby contributing to nature

524 conservation in general. Rules such as the *molte*-rule showcase the moral value of
525 WEPs and foraging. However, more technical guidelines could be useful for supporting
526 the sustainability of foraging in Norway, as has been done in France with the French
527 association of foraging and wild plant professionals (Cambecèdes and Garreta 2017;
528 Chaber et al. 2013). In Norway, recreational foragers have legal freedom almost
529 anywhere to pick WEPs for their own uses. Unlike recreational foragers, professionals
530 have no legal rights and they should ask for land owners permission even for the
531 smallest harvest. Yet, professional foragers are the ones who are more likely to harvest
532 sustainably given their larger ecological knowledge and they have a key role to play in
533 educating the recreational foraging community. Interviewees called for more efforts in
534 connecting people all along the wild food chain in order to share their knowledge about
535 the land and wild edibles, about their 'sustainable' lifestyles, and the practices that
536 underlie their activity. Because their activity is not legalized but accepted only by
537 common practice, they claim the need to work for a framework where commercial
538 foraging can be more easily predictable and organized, but not restrictive. Show-casing
539 this desire, some professionals already organized gathering workshops with chefs.
540 Following the New Nordic food movements, discussing the responsible promotion of
541 foraging and associated 'best practices' appears as the missing link towards a
542 sustainable 'Wild Food System' in Norway (Hermansen 2012; Mithril et al. 2012).
543

544 **Conclusions**

545 The results of this research indicate that, overall, current foraging activities of wild
546 edible plants in Norway is not generating negative environmental impacts and is rather
547 contributing to an increased appreciation and hence conservation of natural ecosystems.
548 However, both recreational and professional foraging activity may pose certain risks

549 locally or in the future and hence there is a need for greater guidance on sustainable
550 harvesting practices for all stakeholders.
551 Despite foraging being perceived by many practitioners as part of a sustainable lifestyle,
552 the increased popularity of this activity is beginning to cause localized overharvesting
553 pressures in and around urban centres and can contribute to the spread of invasive alien
554 edible species. Some foraging practices are destructive and should be limited.
555 Moreover, some botanical identification issues exist that could lead to the harvest of
556 threatened species.
557 These issues can be avoided through maintaining and promoting both local and
558 scientific knowledge and cultural expertise amongst the foraging community. This can
559 be achieved through sharing information on sustainable harvesting practices and
560 promoting knowledge exchange amongst local key stakeholders within the Norwegian
561 foraging community including recreational foragers, professional foragers, and chefs.
562 The recent 'fashionable' interest surrounding wild food plants offers a great opportunity
563 for bringing together the Norwegian foraging community to co-create a common vision
564 and outline clear guidelines to support and promote sustainable foraging in Norway.
565

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741

742

743 **Tables**

744

745 **Table 1.** Most salient species harvested by plant part. The salience index value is
746 indicated in brackets.

Fruits and berries	**Leaves**	**Flowers**	**Stems and leaf stalks**
Vaccinium myrtillus L.(0.76)	*Urtica dioica* (0.43)	*Chamaenerion angustifolium* (L.) Schur (0.33)	*Chamaenerion angustifolium* (L.) Schur (0.38)
Rubus idaeus L. (0.46)	*Allium ursinum* L. (0.36)	*Filipendula ulmaria* (L.) Maxim. (0.32)	*Matteuccia struthiopteris* (L.) Tod. (0.17)
Vaccinium vitis-idaea L. (0.45)	*Aegopodium podagraria* L. (0.25)	*Taraxacum sp*. (0.31)	*Angelica archangelica* L. (0.14)
Rubus chamaemorus L. (0.31)	*Taraxacum sp*. (0.20)		*Rheum rhabarbarum* L. (0.10)
Fragaria vesca L. (0.26)			

747

748 **Table 2.** List of alien WEP with identified sustainability issues due to potential
749 invasiveness. Invasiveness classification coding follows *Artsdatabanken* (2020). Severe
750 impact = SE; High impact = HI; Potentially high impact = PH; Low impact = LO
751

Species	Invasiveness classification	Score	Parts harvested (NR)	Sustainability issues
Barbarea vulgaris W. T. Aiton	SE	O	Flowers (10), leaves (8)	Seeds could be spread while foraging, but foraging the flowers reduces the spread of seeds.
Aronia melanocarpa (Michx.) Elliott	LO	O	Fruits (17)	As fruits are harvested, foraging may contribute to spreading the seeds
Armoracia rusticana P.Gaertn., B.Mey. & Scherb.	HI	O	Leaves (2), rhizomes (4)	Rhizome cuttings made while foraging may contribute to spreading this species

752

753 **Table 3.** List of native WEP with identified sustainability issues due to harvesting of
754 threatened species or potential overharvesting. Conservation classification coding
755 follows *Artsdatabanken* (Henriksen and Hilmo 2015). LC = Least Concern; NT = Near
756 Threatened; VU = Vulnerable

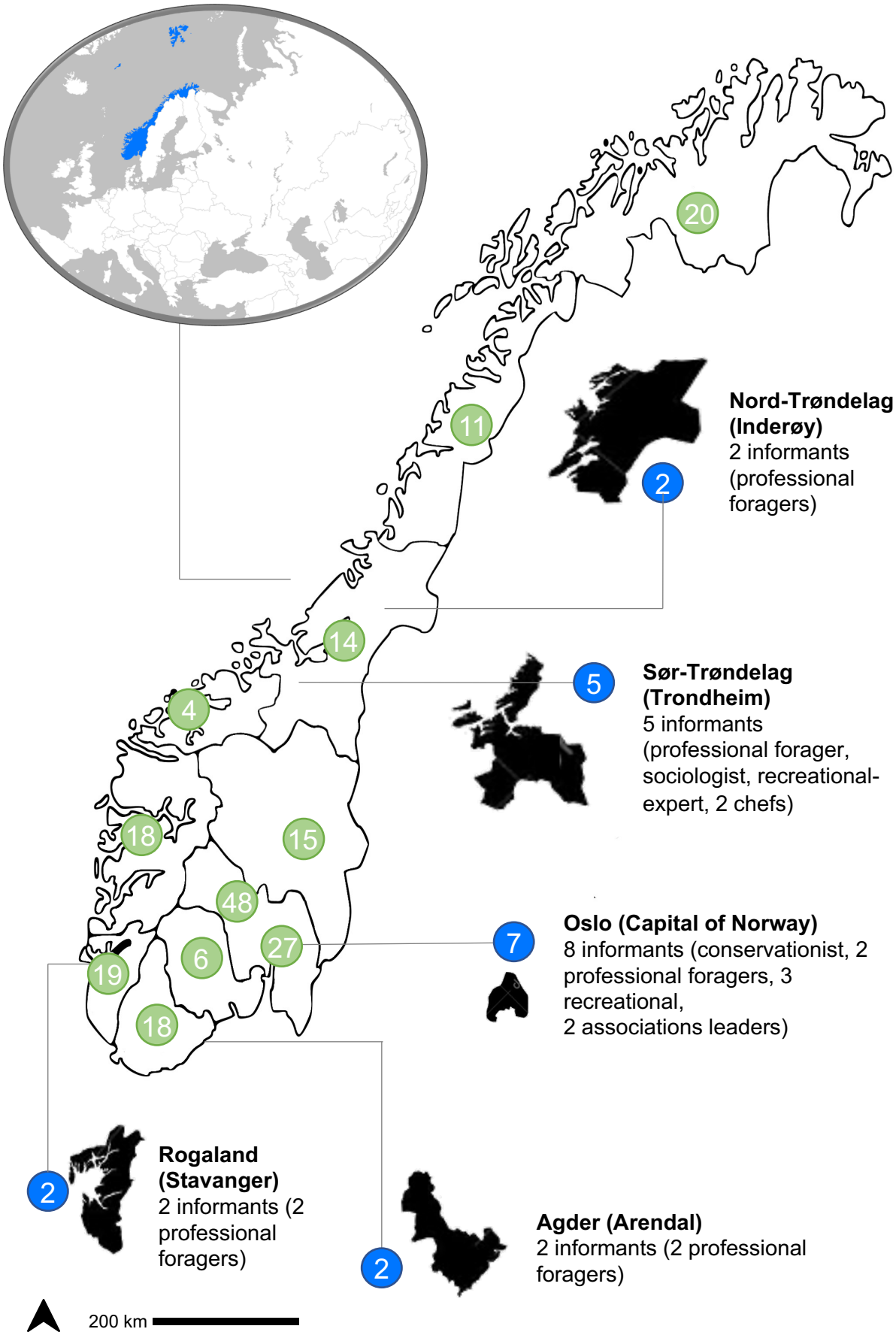
Species	Conservation threat classification	Score	Parts harvested (NR)	Sustainability issues
Allium ursinum L.	LC	O	Flowers (30), leaves (92)	Localized overharvesting has been documented
Polypodium vulgare L.	LC	O	Roots (19)	Popular roots, foraging can be very detrimental to plant communities

Malus sylvestris (L.) Mill.	VU	R*	Fruits (5), flowers (2), leaves (1)	Vulnerable species, however foragers probably harvest hybrids
Ulmus glabra Huds.	VU	R*	Fruits (10), leaves (1)	Vulnerable species, but foraging its fruits is not likely to have any major impact
Peucedanum ostruthium (L.) Koch	NT	R	Leaves (1), roots (1)	The species is near threatened, yet likely introduced before 1800, and roots should not be foraged
Meum athamanticum Jacq.	VU	R	Leaves (1), seeds (1)	The species is threatened, yet likely introduced before 1800, and should not be foraged
Valeriana officinalis L.	NT	R	Roots (2)	The species is near threatened, yet likely introduced before 1800, and roots should not be foraged

Figure legends

Figure 1. Map of Norway showing the number of informants interviewed and that responded to the online questionnaire per region. Basic socio-demographic information on interviewed informants is included.

Figure 2. Decision flow-chart to categorize conservation pressure on WEPs according to foraging activity.



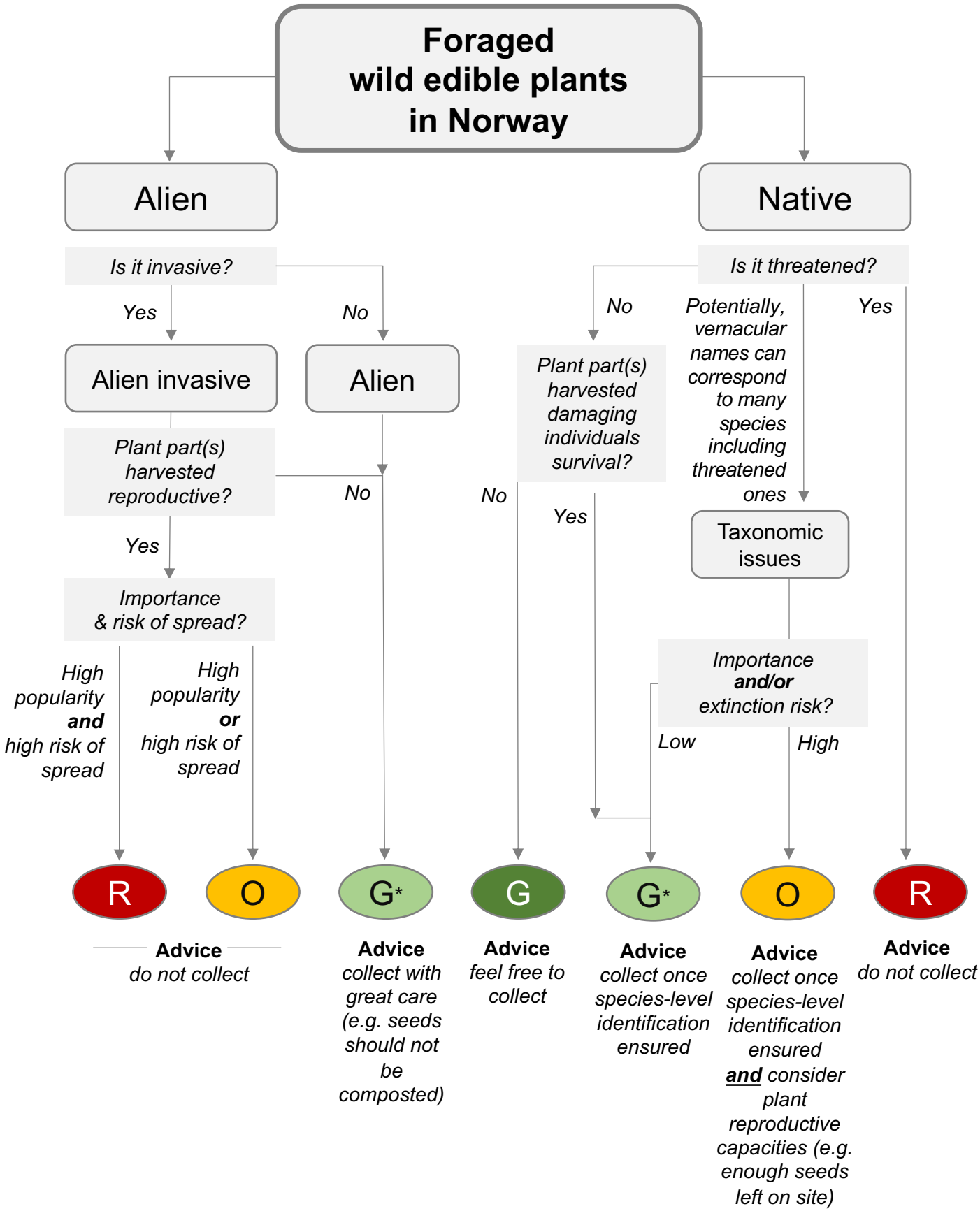
Nord-Trøndelag (Inderøy)
2 informants (professional foragers)

Sør-Trøndelag (Trondheim)
5 informants (professional forager, sociologist, recreational-expert, 2 chefs)

Oslo (Capital of Norway)
8 informants (conservationist, 2 professional foragers, 3 recreational,
2 associations leaders)

Rogaland (Stavanger)
2 informants (2 professional foragers)

Agder (Arendal)
2 informants (2 professional foragers)


Foraged wild edible plants in Norway
Alien
Native
Is it invasive?
Yes
No
Alien invasive
Alien
Plant part(s) harvested reproductive?
Yes
No
Importance & risk of spread?
High popularity and high risk of spread
High popularity or high risk of spread
Is it threatened?
No
Potentially, vernacular names can correspond to many species including threatened ones
Yes
Plant part(s) harvested damaging individuals survival?
No
Yes
Taxonomic issues
Importance and/or extinction risk?
Low
High
R
O
G*
G
G*
O
R
Advice do not collect
Advice collect with great care (e.g. seeds should not be composted)
Advice feel free to collect
Advice collect once species-level identification ensured
Advice collect once species-level identification ensured and consider plant reproductive capacities (e.g. enough seeds left on site)
Advice do not collect