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Local communities' perceptions of wild edible plant and mushroom change: A systematic review

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ABSTRACT

The use of wild edible plants and mushrooms can help to counteract the homogenisation of diets and decreasing resilience of food systems. We performed a systematic review to consolidate information about perceptions of wild edible plant and mushroom changes from the perspective of local communities. We found that 92% of all perceived changes of wild edibles relate to their decreased abundance. 76% of the wild edibles with perceived decreased abundance are fruits and vegetables and 23% crop wild relatives. The main drivers of decreased abundance are perceived to be land use change (38% of all taxa) and direct exploitation (31%). These changes have potential negative implications on food systems from local to global scales.

1. Introduction

Crops grown around the world have been standardised and diets homogenised in recent decades so that today only 94 species account for 90% of the world's food supply (Khoury et al., 2014). The homogenisation has led to enhanced global provision of energy-dense foods (Khoury et al., 2014) but poorer global diets characterised by high consumption of refined carbohydrates, added sugars and fats, and an increase of animal-source foods, while legumes, vegetables, minor crops and wild foods have become less relevant (Popkin et al., 2012; Tilman and Clark 2014; Pilling et al., 2020). These developments have been paralleled by a surge of diet-related illnesses like obesity, diabetes and hypertension (Popkin et al., 2012; Tilman and Clark 2014). Moreover, global food systems have become less resilient to changes and shocks, including climate change, extreme weather events and pests, as they are now built on narrow ranges of crop species with low genetic diversity (Guarino and Lobell 2011).

Wild edible plants and mushrooms are important features of diverse diets and resilient food systems from local to global scales and can therefore be useful in counteracting this trend. At the local scale, about 7000 wild plant (Ulian et al., 2020) and 2000 mushroom species (Li et al., 2021) are used in foods and beverages worldwide, which provide diverse, healthy and nutritious foods for local communities (Hickey et al., 2016). While energy provision of wild edible plants and mushrooms is usually low, they are important sources for micronutrients and can have a wide range of positive health effects (Roupas et al., 2012; Powell et al., 2015). Wild edible plants and mushrooms intensity of use varies significantly across world regions, for example one study showing that smallholder communities across Africa, Asia and Latin America source between 0% and 96% of their self-supplied fruits and vegetables from forests, the average being estimated at 14% (Rowland et al., 2017). Moreover, local communities may use wild edible plants and mushrooms as gap fillers and safety nets in times of crises (Paumgarten et al., 2018; Bélanger and Pilling 2019).

At the global scale, wild edible plants and mushrooms are important genetic reservoirs for cultivation and breeding. These reservoirs can be drawn upon to expand the range of 866 plant species that have so far been domesticated for food production (Milla 2020). Moreover, wild edible plants having close genetic relationships with crops, the so-called crop wild relatives, are important for protecting global crop production against adverse effects from environmental changes (Hajjar and Hodgkin 2007; Ford-Lloyd et al., 2011). These crop wild relatives adapt to

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environmental changes in their natural environments and thereby develop essential traits enabling, for example, disease resistance or drought tolerance. These traits are then useful for enhancing their domesticated crop relatives, which have less potential for adaptation (Hajjar and Hodgkin 2007).

Beyond making material contributions, wild edible plants and mushrooms are in many cases important for local food cultures. Gathering them can sustain local knowledge systems and traditions, foster cultural identity, strengthen social relationships, serve as a source of inspiration and recreation, and be associated with spiritual values (Reyes-García et al., 2015; Motiejūnaitė et al., 2019). For example, indigenous peoples in north-western North America consider traditional wild food gathering as deep engagement with their ancestors and their cultural heritage and they therefore use wild food gathering to restore their food systems in conjunction with cultural revitalization (Joseph and Turner 2020). The relevance of the cultural benefits of wild food gathering for local communities may even outweigh material benefits, especially in cultures where the latter seems already sufficiently satisfied (Reyes-García et al., 2015).

Whereas wild edible plants and mushrooms provide a wide range of material and non-material benefits to food systems from local to global levels, a recent global assessment at national-level indicated that most wild edible plant and mushroom species have decreased in abundance (Bélanger and Pilling 2019). Eleven percent of more than 2000 wild edible plants studied were even at risk of extinction (Ulian et al., 2020). A complex interplay of direct and indirect drivers of change acting at local to global levels is responsible for this decline, with the main direct drivers of decline being species overexploitation, habitat alteration, pollution and land use change (Bélanger and Pilling 2019). In Nepal, for example, the often cumulative effects of land use change and habitat alteration incited by agriculture and forestry, together with overgrazing and invasive species, have been identified as drivers in the decline of wild edible plant and mushroom populations (Bélanger and Pilling 2019). Moreover, climate change increasingly affects wild edible plants and mushrooms with, for example, a study from Alaska showing that the distribution, abundance and phenology of wild edible plant species is altered by climate change (Brown et al., 2021).

Despite the potentially negative effects of changes of wild edible plants and mushrooms on local communities, there is little consolidated information available at the local levels. This is a shortcoming because most local communities continuously monitor the wild edible plants and mushrooms they use and collect detailed knowledge about their changes (Tomasini and Theilade 2019; Herse et al., 2020). Documenting and analysing such local perceptions of changes not only yields fine grained information about the types and directions of change but it also informs on how local communities may be affected by changing environments. Local perceptions of changes can therefore complement available seminal reports on the status of wild food species and enrich them with locally relevant perspectives.

In this systematic review, we therefore aimed to understand 1) the changes of wild edible plants and mushrooms from the perspective of local communities; 2) the potential implications of these changes on the dietary diversity of local communities and the availability of crop wild relatives; 3) the perceived drivers behind these changes; and 4) how the perceived changes and drivers are related to the geography and climates of local communities. We define wild edibles as non-domesticated plants and mushrooms that are used as foods or beverages and grow spontaneously in their natural habitats – even though they may be subject to management practices (Harris 1996).

2. Methods

2.1. Sampling

We performed a systematic literature review following PRISMA guidelines (Page et al., 2021) and using the Web of Science and Scopus academic literature databases on July 22nd 2020. To identify useful documents, we used a search string based on combinations of key terms in the categories 1) *food*, 2) *wild plants and mushrooms* and 3) *indigenous and local knowledge* to search the titles, abstracts and keywords of documents in the selected databases (Table 1). The query was restricted to peer-reviewed journal articles and book chapters, but the geographical range and time span of the documents was not restricted. We included documents written in Chinese, English, French, German, Italian, Portuguese and Spanish. Our query returned 993 unique documents. Of these, the full versions of 27 documents could not be found. We screened the remaining 966 documents to identify those that i) report original research based on primary data for which the field sites are mentioned (excluding reviews, opinion papers, editorials); and ii) report perceived changes of wild edible plants or mushrooms from the perspective of local communities, using social science methods such as semi-structured interviews, surveys or focus group discussions. Consequently, we excluded documents that examined changes through natural science methods or perceptions of changes from the perspective of researchers or other non-local sources. In most cases, we screened the entire document to assess whether a paper met our inclusion criteria, as the titles and abstracts usually did not provide enough information to decide on its inclusion or exclusion. All authors were involved in screening the literature. Each document was first screened by one author and all documents proposed for inclusion, and a sample of those to be excluded, were verified by another author. Regular meetings between authors served to standardise the screening process and clarify doubts. The screening process resulted in 77 journal articles and one book chapter that met our inclusion criteria and were retained for analysis (Fig. 1).

2.2. Data collection

For each study, we recorded bibliographic information along with the countries, the geographic coordinates and the main climate types – using the Köppen-Geiger climate classification (Kottek et al., 2006) – of the field sites. We searched the studies for information on the perceived types and directions of change of wild edible plants and mushrooms and the perceived drivers causing these changes. We recorded statements related to these topics verbatim. For each wild edible plant and mushroom species mentioned, we recorded the scientific name of the species perceived to be affected by change, the perceived drivers of change, the lifeforms of plants, and the plant parts consumed. In case the study did not identify the plants to the species level, we recorded the genus level only. The information on plant parts consumed was only partly available but we did not supplement this information from other sources because we were interested in the plant parts actually consumed by local communities from which knowledge was reported, not the plant parts that could be edible. For those species where a decrease in abundance was perceived, we also recorded whether the studies reported that local communities transplanted or cultivated the species as a measure to adapt to their perceived decrease in abundance. We verified and standardised the botanical and mycological names given in the studies

Table 1
Search string used to identify studies in the *Web of Science*.

Category	Search string used
Food	(food* OR edible* OR eatable* OR comestible*) AND
Wild plant or mushrooms	(((wild OR “non-cultivated” OR “non-domesticated” OR spontaneous* OR uncultivated OR undomesticated) AND (berr* OR flower* OR fruit* OR fungi* OR herb* OR mushroom* OR plant* OR root*)) OR (NTFP OR “non-timber forest product*" OR NWFP OR “non-wood forest product*")) AND
Indigenous and local knowledge	(((local OR indigenous OR traditional OR folk) NEAR/2 knowledge) OR ethnobotan* OR ethnomycolog*)

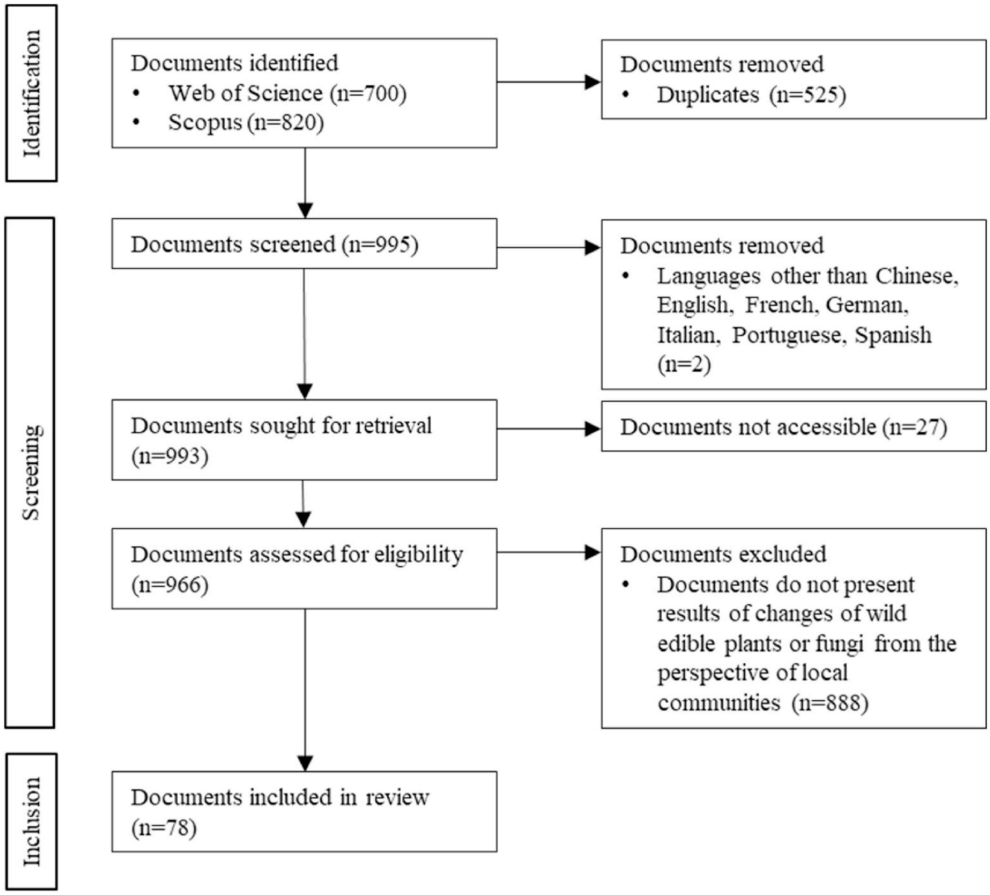

Fig. 1. Flow chart presenting the selection of documents following PRISMA guidelines (Page et al., 2021).

using the R package 'World Flora' (v1.5) (Kindt 2020), which is based on the World Flora Online (World Flora Online 2021), and the Mycobank (2020).

2.3. Data analysis

We structured the verbatim statements reporting on the types of change into a classification originally developed to capture the perceived impacts of climate change on terrestrial wild flora (Reyes-García et al., 2019). The direction of change was classified as positive if the availability or edibility of wild plants and mushrooms improved, negative if the same criteria decreased, and neutral if these two criteria were not affected by the change. The verbatim statements reporting on the drivers of change were structured into a classification of global threats to wild edible plants (Bélanger and Pilling 2019) (Supplementary File S1). The chosen classifications served as guiding frameworks but, when necessary, we inductively expanded the categories to classify the changes and drivers as accurately as possible using the information found in the studies. For the analysis of potential implications of changes on the dietary diversity, we classified the plant parts and mushrooms consumed into a dietary diversity classification scheme (Kennedy et al., 2011), using only those categories of the original scheme that were useful to classify wild edible plants and mushrooms, which were i) *fruits*, ii) *vegetables*, iii) *spices, condiments and beverages*, iv) *white roots and tubers*, v) *legumes, nuts seeds* and vi) *oils and fats*. To analyse the potential implications of changes on the availability of crop wild relatives, we identified which of the species with decreased abundance are crop wild relatives, using an available database (Milla 2020).

We analysed the perceived changes of wild edible plants and mushrooms, the perceived drivers of change, the potential nutritional implications and the geographic distribution of changes using descriptive statistics. We used Kruskal-Wallis tests to assess differences between continents and climate types regarding the number of taxa perceived to be decreasing in abundance. We used Fisher's exact tests to assess whether the taxa with decreased abundance are perceived to be influenced by different drivers in different continents and different main climates. For each of the 14 drivers, one test was calculated per continent and per main climate, for a total of 28 tests. For significant associations, adjusted residuals below -1.96 and above 1.96 were used to interpret which of the continents or main climates were responsible for the significant association. In these analyses, we only considered studies that could be clearly assigned to specific main climate types and we excluded the five studies in which the field sites were located in more than one main climate.

3. Results

We identified 78 studies reporting local communities' perceived changes of wild edible plants and mushrooms (Supplementary File S2). Although studies have been published almost every year since 2001, 50% of them have been published since 2016. The field sites of these studies were in Africa (30 studies), Asia (20 studies), North-America (11 studies), Europe (10 studies), and South-America (7 studies). The main climate types were mostly temperate (38 studies) and tropical (23 studies) and to a lesser degree dry (7 studies) and continental (5 studies).

3.1. Perceived changes of wild edible plants and mushrooms

In the 78 studies, seven types of changes of wild edible plants and mushrooms perceived by local communities are reported, although the plant and mushroom species affected are specified only in 48 studies. Overall, 332 changes of specific taxa are reported, affecting 266 different plant and mushroom species plus 10 different taxa that were identified only to the genus level. Changes in the abundance of plants and mushrooms are most frequently perceived and reported changes (71 studies, 314 taxa specified). Other changes reported relate to plant distribution (3 studies, 2 taxa), plant quality (3 studies, 6 taxa), taste (2 studies, 5 taxa), plant productivity (1 study, 4 taxa), fruiting time (1 study, 1 taxa), and plant height (1 study, 0 taxa). Regardless of the type of change, nearly all perceived changes, relate to a negative trend (322 taxa), rather than a positive (9 taxa) or neutral trend (1 taxa).

By far, the most common perception of change is the decrease in plant or mushroom abundance. This change has been reported in 46 studies in relation to specific plant or mushroom species (96% of studies reporting changes on taxa level). According to these studies, 305 taxa (92% of all species for which changes are perceived) relating to 96 plant and mushroom families, 199 genera and 241 plant and 21 mushroom species are perceived to be decreasing in abundance whereas each study reports an arithmetic mean of 6.4 taxa being affected (SD=12.9; Min=1; Max=80; Med=2) (Fig. 2). Taxa for which decreasing abundance are reported include trees (127 taxa, 42% of all taxa perceived to be decreasing in abundance), herbaceous plants (83 taxa, 27%), vines (35 taxa, 11%), mushrooms (26 taxa, 9%), shrubs (17 taxa, 6%), palms (14 taxa, 5%) and ferns (3 taxa, 1%). As the most prominent perception of change is the decrease of abundance, we focus on this particular change in the subsequent analyses.

3.2. Food groups and crop wild relatives with decreasing abundance

For 216 (71%) out of the 305 taxa with perceived decreased abundance, the plant parts gathered are specified in the studies examined. Mainly fruits are reported to be gathered (108 taxa, 45% of all plant parts gathered), followed by leaves (46 taxa, 19%), fruiting bodies of mushrooms (26 taxa, 11%), seeds (21 taxa, 9%), underground organs (18 taxa, 7%), all above ground plant materials of herbaceous plant species (10 taxa, 4%), flowers and shoots (4 taxa each, 2%), stalks (2 taxa, 1%), bulbils (2 taxa, 1%), and bark, sap, pods, cones and stems (1 taxa each, 0.4%). These edible plant parts belong to the food groups *fruits* (102 taxa, 43% of all plant parts for which food groups could be identified), *vegetables* (78 taxa, 33%), *spices, condiments and beverages* (21 taxa, 9%), *white roots and tubers* (16 taxa, 7%), *legumes, nuts, seeds* (13 taxa, 6%) and *oils and fats* (5 taxa, 2%).

Among all 241 different plant species perceived to be declining in abundance, 55 species (23%) are crop wild relatives and 39 species (16%) were reported to be cultivated by local communities. The 39 cultivated plant species include 15 herbaceous plants, 11 trees, 6 vines, 4 shrubs and 3 palms and 16 of these plant species are crop wild relatives.

3.3. Perceived drivers of decreased abundance

Drivers of decreased abundance of wild edible plants and mushrooms perceived by local communities were mentioned in 56 studies, whereas in 38 studies the taxa concerned were specified – altogether adding to 203 taxa perceived to be affected and 624 reports of driver effects on taxa. The most frequently perceived specific drivers of decreased abundance of wild edible plants and mushrooms were overexploitation (24 studies, 92 taxa (15% of all taxa being reported to be affected by drivers)), agricultural land expansion (21 studies, 90 taxa (14%)), deforestation (20 studies, 96 taxa (15%)), climate change (16 studies, 25 taxa (4%)), agricultural intensification (12 studies, 76 taxa (12%)), destructive harvesting (11 studies, 54 taxa (9%)) and infrastructure development (10 studies, 23 taxa (4%)). Aggregated in larger categories, land use change (42 studies, 155 taxa (38%)) and direct exploitation (32 studies, 130 taxa (31%)) are the largest categories of drivers of decreased abundance (Fig. 3). Among the 38 studies reporting drivers on taxa level, each study mentioned an arithmetic mean of 3.1 specific drivers per taxa (SD=1.5; Min=1; Max=5; Med=3).

3.4. Geographic distribution of decreased abundance and perceived drivers

Decreased abundance has been reported for most wild edible plant and mushroom taxa across Africa (161 taxa, 96% of all reported changes on this continent), Asia (55 taxa, 87%), South-America (46 taxa, 100%), Europe (24 taxa, 92%) and North-America (19 taxa, 63%). The

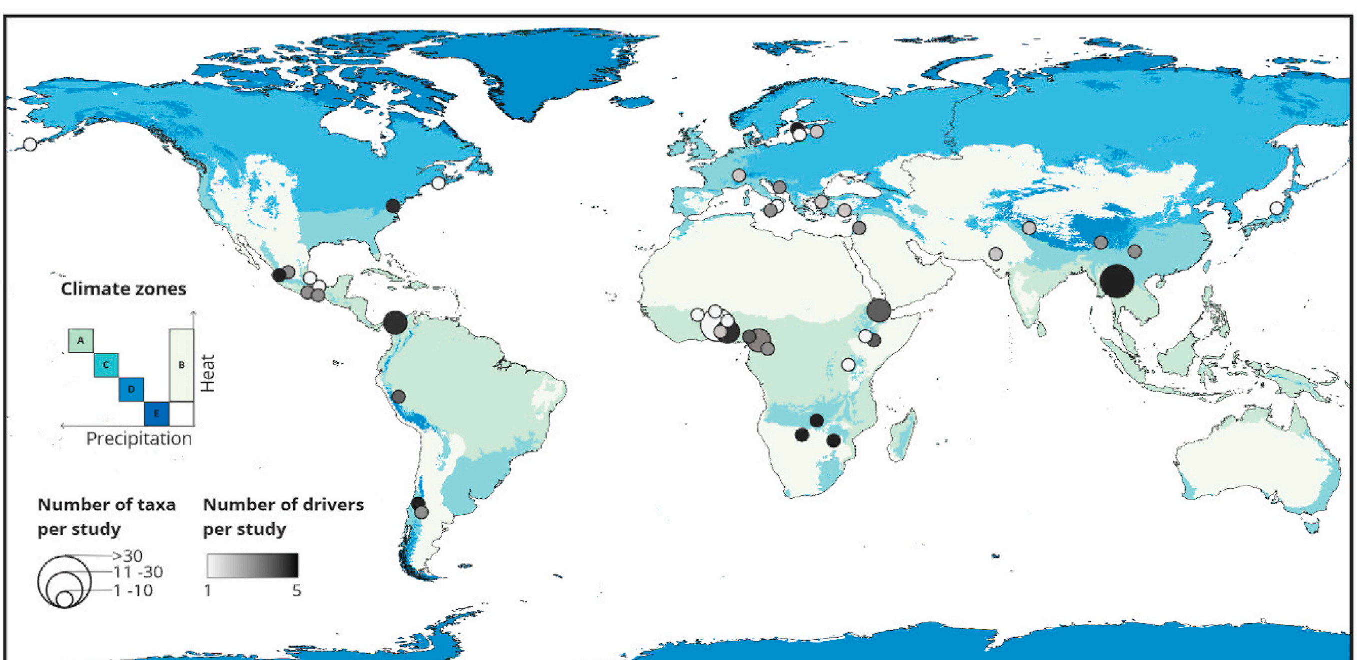

Fig. 2. Local communities perceived decreased abundance of specific plant and mushroom taxa in 46 studies (Climate zones based on Köppen-Geiger classification, A = tropical, B = dry, C = temperate, D = continental and E = polar).

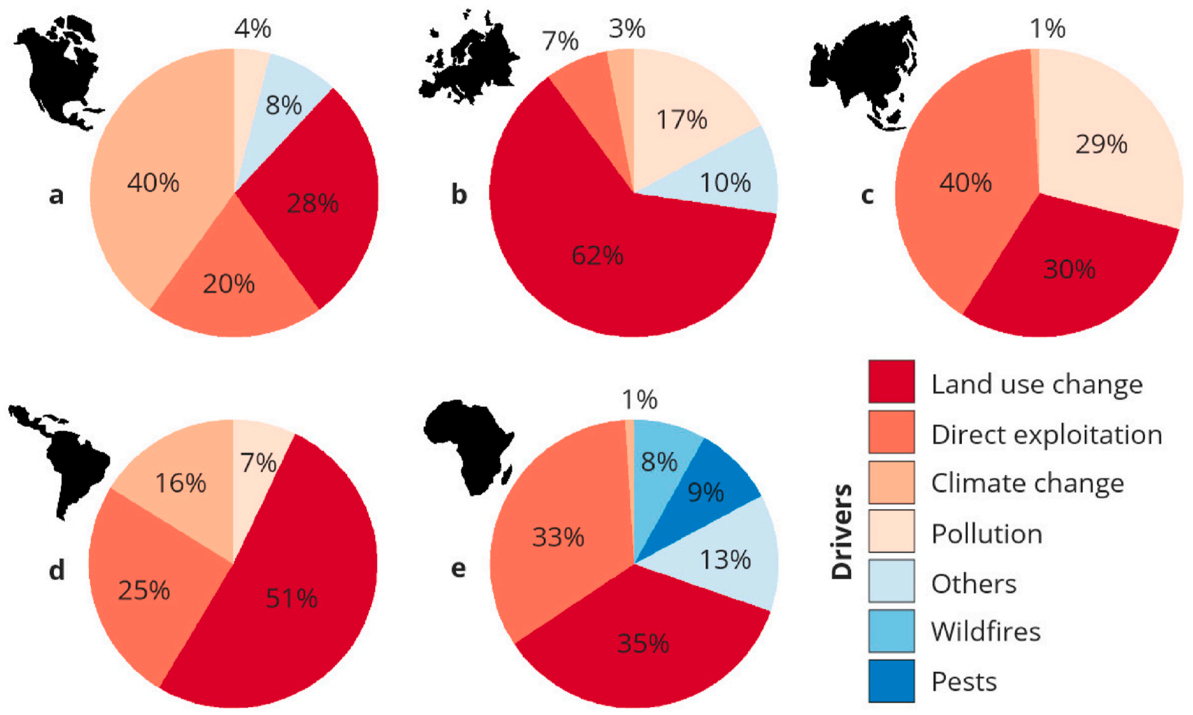

Fig. 3. Distribution across continents of drivers perceived by local communities to reduce the abundance of wild edible plants and mushrooms (n=38 studies; North America: 100%=25 reports of driver effects on taxa, South America: 100%=67 reports, Europe: 100%=29 reports, Africa: 100%=160 reports, Asia: 100%=133 reports).

frequency of specific drivers of decreased abundance per taxa were significantly associated with the continents ($p_{Kruskal\text{-}Wallis}<0.001$) and main climates ($p_{Kruskal\text{-}Wallis}<0.001$) where the change was reported. Most drivers per taxa were perceived by local communities in Asia (M=3.9), followed by Africa (M=3.2), South America (M=2.9), North America (M=2.1) and Europe (M=1.4). Local communities in the dry and tropical climates (M=4.5 and M=3.7) perceived significantly more drivers of change per taxa than local communities in the temperate and continental climates (M=1.9 and M=1.0).

Most of the 14 specific drivers that were perceived to trigger the decreased abundance of wild edible plant and mushroom taxa were perceived to significantly different extents in different continents (Supplementary File S3). Local communities in Africa perceived infrastructure development ($p_{Fisher}<0.001$), wildfires ($p_{Fisher}<0.001$) and pests ($p_{Fisher}<0.001$) to drive the decreased abundance of taxa more frequently than local communities in other continents. In Asian field sites, overexploitation ($p_{Fisher}<0.001$), pollution ($p_{Fisher}<0.001$) and agricultural intensification ($p_{Fisher}<0.001$) were more frequently mentioned as drivers of decreased abundance of taxa than in other continents, whereas local communities in Europe perceived changes in management ($p_{Fisher}<0.001$) more often than local communities in other continents. Moreover, wood use of trees ($p_{Fisher}<0.001$) was more commonly perceived in Africa and South-America than in other continents; deforestation ($p_{Fisher}<0.001$) and agricultural land expansion ($p_{Fisher}<0.001$) were more widespread as drivers of wild edible plant and mushrooms abundance decrease in Asia and South America compared to the other continents; and climate change ($p_{Fisher}<0.001$) was more often perceived in North America and South America than in other continents. The only driver that was perceived with similar frequency on all continents was habitat destruction ($p_{Fisher}=0.073$).

Drivers of decreased abundance of wild edible plant and mushroom taxa also relate significantly to main climate types (Supplementary File S4). In the sample of studies analysed, local communities living in the tropical climate perceived more taxa to be affected by agricultural intensification ($p_{Fisher}<0.001$), wood use of trees ($p_{Fisher}<0.001$) and pests ($p_{Fisher}=0.009$) than local communities living in other main climates. In the dry climate, taxa were perceived to be more frequently affected by overexploitation ($p_{Fisher}=0.007$) and destructive harvesting ($p_{Fisher}=0.002$) than in other main climates. And changes in management ($p_{Fisher}<0.001$) were more frequently perceived in temperate and continental climates than in other main climates.

4. Discussion

In this systematic review, we set out to understand changes in wild edible plants and mushrooms from the perspective of local communities. For the sample of studies reviewed, we most importantly found i) that 92% of all perceived changes of wild edible plants and mushrooms on taxa level relate to their decreased abundance; ii) that 76% of the wild edible plants and mushrooms with perceived decreased abundance are fruits and vegetables and 23% crop wild relatives; iii) that the main perceived drivers of the decrease in abundance are land use change (38% of taxa affected) and direct exploitation (31%); and iv) that almost every specific driver of decreased abundance is significantly associated with a continent and a main climate.

The first result finds support in the literature, as a recent worldwide assessment of the actual status of wild foods found that among the 1039 wild edible plants assessed, 63% are decreasing in abundance, 18% are stable, and 18% are increasing (Bélanger and Pilling 2019). We therefore argue that decreased abundance is the most frequent change perceived by local communities in relation to wild edible plants and mushrooms, most likely because this is also the most frequent change actually occurring. Moreover, it is consistent with another review that studied local observations of climate change impacts, including impacts on wild flora, which also found that observations of changes in the abundance are the most commonly documented changes for wild flora (Reyes-García et al., 2019).

It should be noted, however, that – in comparison to worldwide assessments based on biological data – the change of decreased abundance is particularly pronounced in our results, representing 92% of all changes on taxa level. Indeed, in the few studies included in this review that take a closer look on trends of specific wild edible plant and mushroom species (e.g., (Johnson 2002; Cruz-Garcia 2017), we do find that decreases in abundance, maintenance, and increases in abundance are perceived to a more balanced extent than when considering all the articles in our review. Moreover, another review examining observations of changes in wild flora found that, in addition to the most commonly cited changes in abundance, other changes, including changes in the phenology, composition and structure of wild flora and changes in the quality of the harvested products, are also commonly perceived by local communities (Reyes-García et al., 2019).

We can provide two plausible explanations for the difference in the importance of decreasing abundance between biological data and perceptional data. First, this difference might indicate that decreased abundance is the change to which local communities attribute the largest relevance. Having wild edible plants and mushrooms available is a prerequisite for their use and if the wild edibles local communities gather and eat become less abundant, other changes related to phenology or quality may be less evident or less relevant in practical terms, and thus less perceived or reported. Second, the result can also be explained by a general bias in the research approaches of the papers reviewed. In almost all studies included in this systematic review, local perceptions of change of wild edible plants and mushrooms are side topics within a wider research. In fact, in our database we only found one study (Johnson 2002) specifically focusing on local perceptions of changes of wild edible plants and mushrooms. The fact that local perceptions of changes were not the main focus of their research may have led researchers to restrict their studies to changes that seemed to be more relevant to them or just easier to observe, i.e., decreases in abundance, neglecting perceptions of more subtle changes in species phenology or distribution. It is then possible that wild edible plants and mushrooms maintenance or increase in abundance as well as changes not related to abundance might be underreported in the studies reviewed.

Given this potential methodological bias, we do not claim that our results are representative of the variety of changes to wild edible plants and mushrooms that occur, not even to the variety of changes that local communities perceive. However, we do argue that the high proportion of perceptions of decreased abundance suggests that local communities in all continents and climate types perceive and are concerned by many wild edible plant and mushroom species being less abundant in their local environments.

The decreasing abundance of wild edible plants and mushrooms has potentially negative implications for the nutrition of local communities. Our results show that the wild edibles perceived to be decreasing in abundance are very diverse in terms of species affected, the lifeforms of plants, and the parts harvested. Most importantly, 76% of the wild edible plants and mushrooms with decreasing abundance are fruits and vegetables, whose consumption has many positive impacts on health and nutrition, including being an important source of micronutrients, such as vitamins (de Cortes Sánchez-Mata and Tardío 2016) and minerals (García-Herrera and de Cortes Sánchez-Mata 2016), and having a high antioxidant potential (Barros et al., 2016; Bvenura and Sivakumar 2017). Although generalisation is difficult because fruit and vegetable consumption varies greatly across countries and world regions (Rowland et al., 2017), it might be argued that the decrease in abundance of wild fruits and vegetables may – in conjunction with the better availability of energy-dense foods (Khoury et al., 2014) – generally have a negative impact on the intake of these foods by local communities. This is more so as research shows that fruits and vegetables are not commercially available in sufficient quantities on a global scale, and especially in low-to middle-income countries where a supply gap exists (Siegel et al., 2014) and where local communities largely depend on their own production and gathering for consuming fruits and vegetables.

Besides the potential impact on nutritional quality, the decreasing abundance of wild edible plants and mushrooms may also have negative effects on the amount of food available to local communities. This is especially relevant since about 77% of the rural population with forest access in Africa, Latin America and Asia gather wild foods, mostly plants but also animal products and mushrooms, which are an important component of their livelihoods (Hickey et al., 2016). Moreover, the decrease in abundance tends to disproportionally affect poorer community members, who depend more on wild edibles for nutrition and income than other groups (Angelsen et al., 2014; Hickey et al., 2016). In addition, wild edibles provide safety nets in times of severe crises, a function that is lost with their decreasing abundance (Paumgarten et al., 2018; Bélanger and Pilling 2019).

The decreasing abundance of wild edible plants and mushrooms not only loosens the safety net for their direct use, but it also jeopardizes agronomic backups for cultivation and breeding. Our results show that local communities do not only gather wild edible plant species, but they also transplant them to their home gardens and fields and thus bring them into cultivation. Although we do not know the distribution of potential motivations in the sample studied, the fact that 16% of wild edible plants with decreasing abundance are reported to be cultivated suggests that people might have important reasons to do so. Motivations to cultivate wild edible plants may include to preserve access to species with a decreasing abundance in the wild, to compensate for crop failure, or to use them for genetic improvements of crops through cross-breeding with domesticated plant species (Pilling et al., 2020). Moreover, since 23% of the wild edible plants in our findings that were perceived to decrease in abundance are crop wild relatives, their decreased abundance may have a significant negative impact on the pool of genetic traits available for plant breeding on a global level, weakening the resilience of global food systems (Pilling et al., 2020).

The most frequently perceived drivers of decreased abundance of wild edible plants and mushrooms in our sample are land use change, triggered by agriculture, forestry and infrastructure development, and direct exploitation of wild edible plant and mushroom taxa. Pollution and climate change follow at some distance. This result largely dovetails with global assessments of the drivers of decline of wild foods (Bélanger and Pilling 2019), the drivers of decline of threatened plant and animal species (Maxwell et al., 2016), and the drivers of decline of life on earth in general (Díaz et al., 2019). Despite this general agreement of global trends, it is important to note that the relative importance of the different drivers varies between different continents and climate zones. In our results, almost every specific driver was significantly associated with a continent and main climate type and also the number of drivers perceived by local communities varied significantly between continents and main climate types. This is plausible since the types of ecosystems from where wild edible plants and mushrooms are gathered and the kinds of wild edibles consumed vary considerably between local communities, continents and main climates (Powell et al., 2015). Considering local socio-cultural and geographic contexts when developing approaches to facilitate the sustainable use of wild edible plants and mushrooms is therefore crucial, in addition to targeting indirect drivers at higher governance levels, in order to achieve sustainable improvements (Visseren-Hamakers et al., 2021).

5. Conclusions

In this study, we explored perceptions of changes of wild edible plants and mushrooms from the perspective of local communities. We found that the by far most common perception is a decrease of abundance, having a range of potential negative implications to nutrition and food systems from local to global scales. This finding draws attention to the need for initiatives supporting the sustainable use and management of wild edible plants and mushrooms. Currently, the most widespread measures to halt their decrease are to monitor and inventor them, and to establish protected habitats and areas (Bélanger and Pilling 2019).

These measures target the conservation of wild edible plants and mushrooms, whereas ensuring their sustainable management for ongoing use by local communities is also critical. A central goal must also be the preservation of local knowledge about wild edibles, since the loss of knowledge is just as detrimental to their ongoing use as the loss of the species itself (Cámara-Leret et al., 2019). Given the range of inter-related direct and indirect drivers of decreasing abundance of wild edible plants and mushrooms, comprehensive, transformative change that targets multiple aims at multiple governance levels simultaneously is needed to achieve these goals (Díaz et al., 2019). Moreover, comprehensive approaches to mitigate the decreasing abundance of wild edibles need to give voice to local communities, who hold critical knowledge about the changes of wild edible plants and mushrooms and their drivers.

6. Data repository note

The data used for this manuscript are archived in the Zenodo Data Repository once the manuscript is accepted for publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2021.100601.

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