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# Traditional ecological knowledge to traditional foods: The path to maintaining food sovereignty in Hutsulshchyna

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The various ecosystems of the Carpathian Mountains spanning Europe, are a rich refuge for culturally important, endemic plant species as well as large carnivores. These biologically diverse landscapes are a principal source of subsistence to 16 million people, including various ethnographic groups. This paper focuses on a case study involving Hutsul communities, an ethnographic group of traditional pastoral highlanders, in the Southeastern Carpathian Mountains of Ukraine. Given ecosystem, climatic, and cultural challenges, especially the rise of illegal logging, commercial harvesting, increased frequencies of flooding, and now a war, Hutsul communities face extensive threats to maintaining socio-ecological resilience in the region. A contributing factor to the region's centuries-long resilience is traditional ecological knowledge upholding food sovereignty as seen through traditional foods derived from Carpathian Mountain ecosystems. Traditional ecological knowledge (TEK) is as a dynamic, generationally-held knowledge base, where language, gathering practices, landscape and culture inform livelihoods. In this article, we seek to answer the following series of questions within Hutsul communities: (1) What does TEK look like in the region? (2) What are the regional environmental challenges? (3) Given these challenges, what are coping mechanisms and adaptive strategies grounded in TEK, ensuring a resilient food sovereign system? Mixed methodologies guided by community-based participatory action research methods (CBPAR) between 2017 and 2019 provide a rich, context-driven perspective on regional TEK. Radiating out from the historical, cultural Hutsul capital, Verkhovyna, 40 experts (including knowledge holders, elders, foresters, and community members) were interviewed in 8 neighboring villages. We, along with Hutsul experts, explore the presence of traditional ecological knowledge (TEK) in Hutsulshchyna by identifying 108 culturally important species including wild plants (74 species), cultivated plants (23 species), fungi (9 species) and lichens (2 species); these species are gathered in 10 habitats with varying degrees of human interaction. We analyze species' presence in traditional foods in the past and present day, as well as contextualize regional environmental challenges impacting TEK practices, and responses to these challenges (coping mechanisms and adaptive strategies). Despite various regional challenges, we conclude that TEK provides a resilient foundation for supporting food sovereignty as seen through the presence of traditional foods.

KEYWORDS

**fallback food, Carpathian Mountains, traditional foods, traditional ecological knowledge (TEK), food sovereignty, culturally important species, resilience**

## Introduction

With climate change impacts not evenly distributed across the globe but felt more drastically over land, the poles, and more arid regions (Main et al., 2008; Wheeler and von Braun, 2013), areas and communities already experiencing food insecurity will be hit hardest. This reality deserves attention, as well as thoughtful and mindful action, especially for marginalized, communities worldwide, specifically Indigenous Peoples and underrepresented ethnic groups, who may experience these impacts more immediately. Many Indigenous and underrepresented ethnic communities are both societally and spatially marginalized, living in edged biomes near forests, oceans, and deserts. Although Indigenous peoples make up 5% of the world's population, these same communities steward an estimated 85% of the world's remaining biodiversity (Hoffman et al., 2021). Additionally, they are overrepresented among the world's poorest, most marginalized populations, as well as those displaced or threatened by environmental encroachment, wars, disasters, and socio-political stressors (Wheeler and von Braun, 2013) and climate change (Abate and Kronk, 2013). Climate change impacts threaten communities' access to land, water, and natural resources which are crucial for livelihood practices (Ford et al., 2020), ultimately threatening regional food sovereignty. Yet, many communities continue to survive and thrive. It is deep relationship with place that grounds identity, knowledge, belief systems, and livelihood practices, ultimately informing how communities experience, respond, and adapt innovatively to diverse regional changes.

In this case study, Hutsul communities, an ethnographic group of traditional pastoral highlanders, in the Southeastern Carpathian Mountains of Ukraine, illustrate a socio-ecological approach to maintaining food system sovereignty. Oak groves, spruce and beech forests, alpine grasslands, gardens, rivers, and community-derived resources including agricultural animals dot these Mountains (Figure 1); Hutsuls maintain a continual dialogue with these habitats seasonally, gathering culturally important species including *Vaccinium sp.*, *Ribes sp.*, mushrooms, and others to make traditional foods, such as *kulesh* and *banosh* for holidays (Figure 2). Hutsuls continue to survive, thrive, and adapt in the face of today's colonial invasions, current war, food shortages, regional challenges in addition to the synergistic impacts of climate change, especially regional illegal timber harvest causing an increase of regional flooding. Many Hutsul communities in the Carpathian Mountains are guided by traditional ecological knowledge (TEK) in their daily lives. Communities stress that ecosystem health is deeply tied to personal and community health, and continually reiterated in the phrase, "food is medicine". Lived and experienced by local and Indigenous communities worldwide, TEK is cultural, spiritual, intergenerational, dynamic, place-based, environmental knowledge, wisdom, and oral history; TEK, is an empirical knowledge base gained from continual observation of the environment which is revisited, reinterpreted, and re-evaluated (Molnár et al., 2008; Berkes, 2012). Monitoring environments including habitats, species, climatic conditions, and landscapes emerges as a result of place-based cultural practices. TEK acts as a well of stored experience and environmental knowledge (climatological, ecological, biological, and spiritual); it establishes a foundation of resilient practices to meet community needs, while adapting to environmental changes.

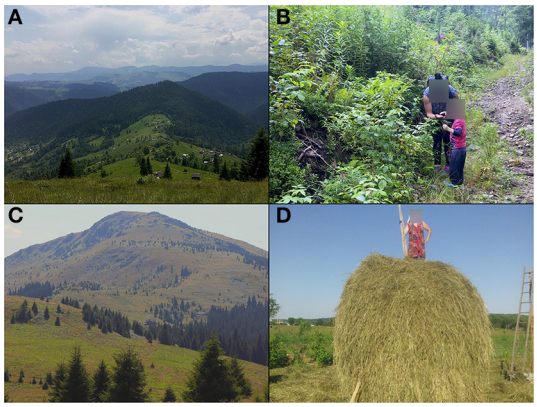


FIGURE 1
**(A)** A common landscape in Hutsulschyna (Photo credit: N. Fontana); **(B)** Nadia Perepelytsia and her son, Maxim, picking bilberry (*Vaccinium myrtillus*) in their nearby woodland and forest areas (Photo credit: N. Fontana); **(C)** *Polonyna*—an alpine grassland and culturally important ecosystem in Hutsulshchyna (Photo credit: O. Pohribnyi); **(D)** Work on a *toloka* (a culturally important field for grazing cattle). Here, Ivanna Kovaliuk is using her feet to compact grass into a haystack (Photo credit: M. Pasailiuk).

In this context, the path to achieving food security is informed by TEK; this path grafts cultural, place-based community needs with a resilient, ecologically-grounded approach, known as food sovereignty. While food security is mainly concerned about the distribution and protection of current food systems, food sovereignty advocates for an environmentally-just as well as an ecologically and culturally appropriate food system. Food sovereignty, as a term, can be controversial in its various meanings and origins (Coté, 2016; Hoover, 2017). Here, we refer to the definition stated in the Declaration of Nyéléni (2007) at the Forum of Food Sovereignty. "Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and the right to define their own food and agriculture systems." Within this definition emerges a powerful recognition of community self-determination in how food is grown, managed and sourced. In addition, a food sovereign approach affirms the importance of socio-ecological


FIGURE 2
**(A)** Local gathering trip (summer 2018) Mushrooms seen in this photo include red pine mushroom (*Lactarius deliciosus*), birch bolete *(Leccinum scabrum)* and Bare-toothed Russula (*Russula vesca*) (Photo: N. Fontana). **(B)** Traditional celebration basket with fruits, berries (*Rubus fruticosus*) and flowers on August 19th, Apple Spas, an Eastern Slavic folk holiday (Photo credit: M. Pasailiuk). **(C)** Traditional Food: *Kulesh* prepared from corn flour and *polonynska bryndza* (cheese made from sheep on the *polonyna*) (Photo credit: O. Pohribnyi). **(D)** Traditional Food: Holubtsi—stuffed cabbage rolls (Photo credit: M. Pasailiuk).

relationships, rooted in sustainable practices. Lastly, it infers that access to healthy environments and culturally important foods are inextricably linked.

Food sovereignty is not an endpoint in achieving food security; rather, it is an ongoing, adaptive capacity for a community to overcome food system threats, leading to resilience. The term resilience was first framed within boreal ecosystem functioning, attributed to Holling (1973). Since then, many nuanced definitions surrounding resilience have arisen (Folke, 2006). We will focus on the general characteristics of resilience which inform the "capacity of individuals, communities, and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it" (Holling, 2001; Berkes et al., 2003; Brown, 2016). In our case study, socio-ecological stresses and shocks are various regional challenges, which Hutsul communities encounter both in the past and present-day. In the face of these stressors, resilience emerges as a combined result of coping, adaptive, and transformative capacities, which leads to incremental adjustments, persistence, or transformative responses. We explore these resilient responses grounded in TEK, which include coping mechanisms (short-term responses) and adaptive strategies (transformative long-term responses). Referring to terms commonly used in developmental studies (Singh and Titi, 1994) and anthropology (McCay, 1978), coping mechanisms are short-term, quickly implemented strategies to situations that threaten livelihoods. Conversely, adaptive strategies are long-term changes implemented by communities, modifying local rules, institutions, and productive activities to ensure livelihoods. Coping mechanisms tend to emerge on individual or household levels, while adaptive strategies tend to emerge on community levels. Both coping mechanisms and adaptive strategies exist across temporal scales, whereby over time, coping mechanisms can become adaptive strategies (Berkes and Jolly, 2001).

In this article, we seek to answer the following series of questions within Hutsul communities: (1) What does TEK look like in the region? (2) What are the regional environmental challenges? (3) Given these challenges, what are coping mechanisms and adaptive strategies, ensuring a resilient food sovereign system? The information included here is drawn from long-term participatory research, personal and participatory observation, literature reviews, interdisciplinary approaches (both qualitative and quantitative) and includes co-authorship of Hutsul scientists. We, along other Hutsul experts, explore the presence of TEK in Hutsulshchyna by identifying 108 culturally important species and their presence in traditional foods in the past and present day, as well as distinct regional environmental challenges triggering resilient community responses (coping mechanisms and adaptive strategies). Therefore, the aim of this study is to trace the path to maintaining food sovereignty by exploring TEK in Hutsulshchyna and as a result the presence and sustainable management of culturally important species used in traditional foods (Figure 3).

# Research area and methods

## Regional background

The Carpathian Mountains span countries including the Czech Republic, Poland, Slovakia, Hungary, Serbia, Romania, and Ukraine. Containing Europe's largest remaining old-growth forest ecosystems outside of Russia, the Carpathians are a biodiversity hotspot, harboring one-third of all European vascular plant species. Considered the "Amazon of Europe", this region is one of Europe's last fully undeveloped landscapes, a rich refuge for large carnivores and a principal source of subsistence to 16 million people (Gurung et al., 2009). The Carpathian region in Ukraine covers 3.5% of Ukraine's area and 10.3% of total area of the Carpathian Mountains (Elbakidze and Angelstam, 2013). The flora species composition of the Carpathian alpine forest provides key indicators of ecosystem health in response to climate change (Geyer et al., 2010). As an ancient corridor and refuge for humans, the cultural landscape mirrors the breadth and depth of the biological landscape. Beginning over 2,000 years ago, many tribes established cultural roots in this region (Kibych, 2010).

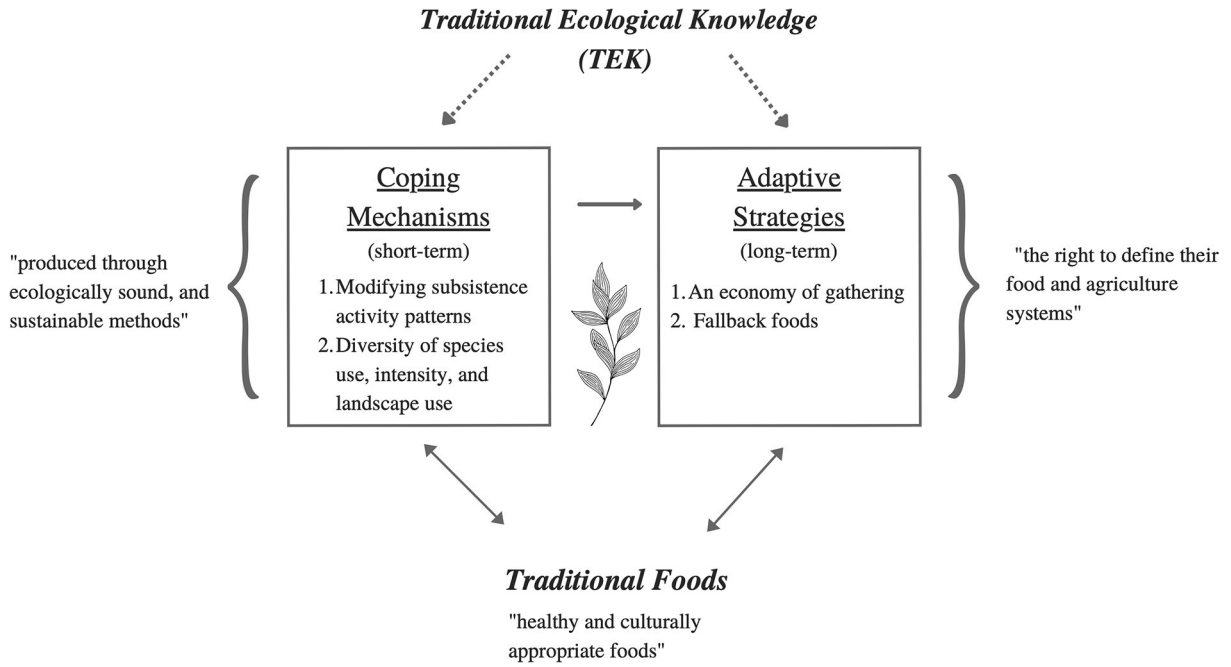


FIGURE 3
The path to food sovereignty in Hutsulshchyna. Using the definition stated in the Declaration of Nyéléni (2007) at the Forum for Food Sovereignty, as a framework to guide our study. "Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and the right to define their own food and agriculture systems."

In Ukraine, there are various Indigenous, ethnographic groups, ranging from the Tatars in Crimea, who are currently facing intensified persecution due to Russia's occupation (Coynash and Charron, 2019), to the highlanders in the eastern Carpathian Mountains: including Hutsuls in Hutsulshchyna (Figure 4), Boykos, in the Bystrytsia Solotvynska River Basin, and Lemkos, in the Low and Middle Beskyd Mountains (Magocsi, 1997). Archaeological evidence points to human existence in the region dating back to 100,000 years before present (Stech, 2007). This study is centered in the cultural, historical center (Verkhovyna) of Hutsulshchyna, which translates to "Land of Hutsuls", a mountainous area of the Carpathian Mountains in Ukraine (Northern Bukovina) and in northern Romania (Maramureş and Southern Bukovina areas) (Figure 4). As Ukraine faces a current colonial war of aggression, financial insecurity, food scarcity and increasingly expensive medical care, trade, and direct consumption of NTFPs (non-timber forest products) in local diets has increased in the Carpathian region (Stryamets et al., 2015). According to the Food and Agriculture Organization of the United Nations, 80% of developing countries rely on NTFPs for nutrition and health purposes (Sorrenti, 2017). NTFPs, seen in this study, are culturally important species like wild plants and mushrooms; they contribute to the local economy, diversify diets, present possibilities for genetic research and development in new domesticated crops, and provide a lens for understanding cultural worldviews, language, and knowledge.

At a landscape scale, Hutsuls, traditional pastoral highlanders of the Ukrainian Carpathians, have maintained alpine grasslands (*polonynas)* through mountain shepherding of cows and sheep (Figure 1). There is a continuing threat of cultural loss of this practice due to low economic competitiveness and increasing disinterest among younger generations (Amato, 2020). Maintenance of these alpine grasslands is declining quickly with newer pressures including tourism infrastructure and emigration of younger generations to cities. This decline of grazing on secondary grasslands has led to reforestation of previously cleared areas (Elbakidze and Angelstam, 2013). However, mountain shepherding and other ecological practices, such as gathering of NTFPs, like wild edible plants and mushrooms, although threatened, have survived. Forests and other habitats (gardens, roadsides, pastures, fields, woodlands, alpine areas, meadows, *polonynas* (culturally-managed alpine meadows), and *tolokas* (generationally-held pastures)), bordering village settlements provide an integral zone of nourishment through the gathering of wild and cultivated species. Flowers, birch sap, resin, honey, mushrooms, and berries gathered in these diverse habitats form an essential part of the social fabric and political economy of Ukrainian culture (Bihun, 2005; Elbakidze and Angelstam, 2007; Demeter, 2016), particularly in forest-dependent Hutsul communities.

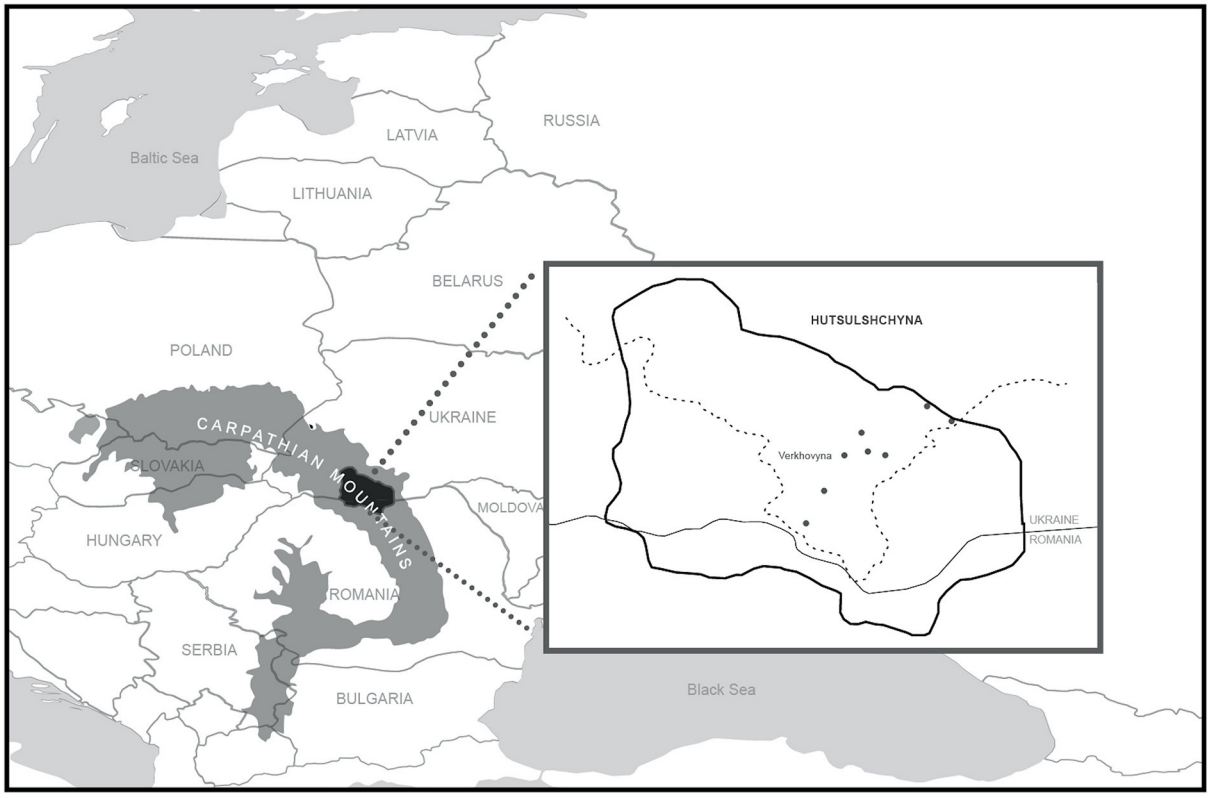


FIGURE 4
Map of Hutsulshchyna. The bolded outline marks the current area of Hutsulshchyna, the land of Hutsuls (Adapted from Figlus, 2009). Hutsulshchyna today borders both Ukraine and Romania. The dotted line transecting Hutsulshchnya represents borders established before World War II whereby Hutsulshchyna was split between Romania, Czechoslovakia, and Ukraine. In 1940, borders split Hutsulschyhna between the Soviet Union (now Ukraine) and Romania. The dots represent villages visited and places of interviewing. Verkovyna, the historical cultural center of Hutsulshchyna, and the surrounding villages all fall within a centralized area between borders established before World War II.

For centuries, local Hutsul people have creatively and effectively managed culturally important species in the Carpathian Mountains (Griffiths et al., 2014) maintaining their productivity and availability, thus creating a socioeconomic safety net to sustain them in times of scarcity. In this region, 59–91% of the population lives in rural areas (Bosch et al., 2008); this broad range is due to the socioeconomic inequality between rural and urban areas in the region (UNEP, 2007). The interdependence between nature and need is explicit. While most houses have electricity, most water is taken from nearby wells and rivers (Geyer et al., 2011) and most villages have no sewage system (Bosch et al., 2008). People trek to natural mineral water springs, which is an old spiritual tradition. There are over 800 natural mineral sources in this region (Kolodiychuk, 2008). Communities are self-sufficient in terms of their nutritional needs, relying on a diversity of habitats nearby. Food is grown, gathered, and stored (dried, pickled, canned, and fermented). Many households in this region rely on subsistence-based agriculture and additional income derived from family members going abroad for work. Low salaries demand multiple avenues of revenue from subsistence farming, gathering, and selling of culturally important wild species, as well as opening one's home to tourist stays (ecotourism).

Hutsulshchyna has been a place of extensive ethnographic work starting in the early 1800s and continuing well into the 1930s, when this region was under various colonial regimes (including Poland and the Austro-Hungarian Empire) (Falkowski, 1938; Łuczaj, 2008; Kujawska et al., 2015). In the last 6 years, a group of scholars have centered ethnobotanical research in Bukovina, the southeastern corner of Hutsulschyna (which falls along the Ukrainian-Romanian border) with studies focusing on Hutsul ethnobotany (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2020, 2021a,b; Stryamets et al., 2021b), and ethnomycology (Stryamets et al., 2022a). Excluding their most recent study, their methodologies generally consist of qualitative interviewing followed by quantitative analyses including detailed use reports (DUR) and calculations of the Jaccard Similarity Index (JI) to cross-culturally compare ethnobotanical uses on either side of the border.

Their studies suggest that the establishment of the border between Ukraine (under the Soviet Union) and Romania in 1940 and the resulting impacts of Soviet policies in Ukraine contribute to differences in ethnobotanical use (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2021a; Stryamets et al., 2021a), and knowledge transmission between Hutsuls in North Bukovina (Ukraine) and Hutsuls in South Bukovina (Romania) (Mattalia et al., 2020). Additionally, their other studies analyze differences between wild and cultivated species' use between Romanians and Hutsuls in Bukovina (Mattalia et al., 2021a), ethnomycological differences (Stryamets et al., 2022a), revitalization of ethnobotanical practices in religious holidays of Hutsuls in Northern Bukovina (Ukraine) and Ukrainians in Roztochya, western Ukraine (Stryamets et al., 2021b) as well as noting the biocultural diversity present in Ukraine (Stryamets et al., 2022b).

Recent studies infer that Hutsuls in Northern Bukovina (Ukraine) exhibit greater reliance and dependence on forest habitats than Hutsuls in Southern Bukovina (Romania) (Mattalia et al., 2021b; Stryamets et al., 2022a). The splitting of Hutsulshchyna between Ukraine (under the Soviet Union) and Romania in 1940 and the resulting policies implemented on each side of the border guide the narrative of these studies; differences seen in species uses, range of species as well as ethnobotanical knowledge transmission are attributed to this border creation. Broader questions arise: to what extent do these ethnobotanical and ethnomycological gathering practices inform and support Hutsul communities in maintaining food sovereignty? What are regional environmental threats and how are communities responding? Building upon these rich ethnobotanical studies, our study radiates from the heart of Hutsulshchyna, the cultural, historical Hutsul center. Unique to our study, we weave qualitative and quantitative mixed methodologies, include habitat diversity (recognizing the importance of place) in our analysis, and incorporate Hutsul voices through authorship. We explore TEK as seen through dynamic, generationally-held ecological knowledge, language, traditions and how it informs resilient responses to ecosystem challenges (coping mechanisms and adaptive strategies) to support regional food sovereignty.

## Methods

### Data collection

We framed our study through a community-based participatory action research (CBPAR) lens (Ballard and Belsky, 2010), utilizing mixed methods—in-person semi-structured interviews, ethnographic literature review, participant observation (Musante and DeWalt, 2010) including gathering trips, voucher collection/verification, and a community ecology approach (presence-absence species data); these methods generated quantitative and qualitative data for analyses.

This article, co-authored by Hutsul scientists, Mariia Pasailiuk and Oleh Pohribnyi, facilitates dissemination of knowledge on their terms, and serves as published affirmation of the importance of Hutsul TEK in regional economic development and environmental policymaking. We attempt to understand the synergistic social, economic, and eco-cultural spheres that inform Hutsul community livelihoods. By publishing this research, we show the interdependence between Hutsul communities and their own landscapes through TEK, while voicing Hutsul community members' perspectives on regional environmental challenges.

Incorporating CBPAR approach, connections and relationships with community members and colleagues were made 4 months prior (between August 2017 and December 2017) to our extensive field seasons (2017–2019) in order to center in-depth participation, research framing, and ethical considerations in the research process. There were ethical considerations made when thinking about how this publication could harm and benefit communities, especially since eco-cultural and economic livelihoods are dependent on culturally important species mentioned here. To address these issues, community members are not named here, unless explicit permission was granted; current prices for species sold for economic purposes are also not listed. Oral consent was obtained prior to each interview. All authors strictly followed guidelines prescribed the International Society of Ethnobiology (2006). However, since there is no official ethical review process regarding the protection of human participants in Ukraine, the first author obtained a local ethical review and approval of the project from the Verkhovyna National Nature Park in Ukraine (since most villages visited were centered around Verkhovyna). The local ethical review of the project was translated into English and then approved by the Institutional Review Board Committee at the University of California, Davis.

Between December 2017 and August 2018, the first author conducted in-depth, semi-structured, in-person interviews of 40 Hutsul experts (including elders, foresters, and community knowledge holders) in eight villages, and two national parks (Verkhovyna National Nature Park and Hutsulshchyna National Nature Park) through snowball sampling methods (Höft et al., 1999; Martin, 2004). Interviews were conducted in Ukrainian, and participants responded in Hutsul and Ukrainian. All interviewees were over the age of 18 (aged 25–93), with an average age of 53, with each interview ranging from 30 min to 4 h. The gender ratio was 43% men and 57% women. Participants were intentionally selected for their expert knowledge and were recognized by community members as highly knowledgeable. Throughout both field seasons, key elders and knowledge holders were interviewed multiple times. To understand the extent and depth of regional TEK, question topics included species' uses, parts used, names (Hutsul and common names), stories/rituals, habitats found, gathering methods, ecological cues, and ways of preparation.

In discussions, all participants shared information about environmental, climatic, and cultural threats to gathering practices and resulting strategies (coping mechanisms and adaptive strategies).

Between June and August 2019, all authors participated in follow-up interviews and participant observation (gathering trips) to further clarify TEK surrounding species use, gathering methods, names, habitats and more specifically to interview elders about species gathered during times of scarcity. To understand species' use during times of scarcity in the past, the first and second author conducted an extensive ethnographic literature review (in English and Polish) comparing our findings on a species-by-species basis with noted fallback foods (species) identified in the past (Falkowski, 1938; Fischer, 1939) and current studies (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2020; Stryamets et al., 2022a).

In interviews and participant observation, knowledge holders clarified plant names and plant uses with the aid of photographs and specimens. Alignment of common names with botanical names, and plant identification of specimens were confirmed and cross-referenced with existing voucher specimens, botanists (Lyubomyr Derzhipilsky, Roman Lysiuk), forest ecologist Oleh Pohribnyi, and mycologist Mariia Pasailiuk. Taxonomic texts from the Hutsulshchyna National Nature Park library were also used to identify species including plants, mushrooms, and lichens. Additionally, throughout both field seasons, guided by elders and specialists, the first author participated in trips throughout the gathering seasons (typically, fall, spring, and summer) to the Chornohora Mountain range and local areas to better understand gathering practices in the region.

## Data analyses

Interviews and data from participant observation were audio recorded, transcribed, and translated into English; data were organized in Excel and in R. The ethnobotany R packaged developed by Whitney (2020) was used to calculate quantitative ethnobotanical indices. The first field season provided data for calculations to derive indices including use report (UR), frequency of citation per species (FC), cultural importance index (CI index), number of uses per species (NU), relative frequency of citation index (RFC), fidelity level per species (FL) for wild species (including plants, lichens, and fungi) and commonly cultivated plants. In this study, we focus on species' cultural importance derived from the cultural importance index (CI index), which is the sum of use reports divided by the number of participants to account for the diversity of uses for each species (Tardío and Pardo-de-Santayana, 2008). The diversity of uses include food (alcoholic beverage, fruit, recreational beverage, seasoning, vegetable, tea, fungi), medicine (tincture, topical treatment, ground) and other uses including ecological marker, symbolic, toxic, veterinary, textile, repellant, and economic (Table 1).

TABLE 1 Gathering site types or habitats.

| Gathering site types | Description |
|---|---|
| Roadside | Roads provide thoroughfare to buses, cars, motorcycles, bicycles and people. People walk along and sell local products (berries, mushrooms, crafts) along roadsides. Harvesting along roadsides happens but is undesirable due to pollutive effects. |
| Forest | A dynamic ecosystem consisting of trees and understory plants, with various interactions and species composition changes including: (1) firewood harvest, (2) collection of berries and mushrooms, (3) introduction of hitchhiker species, (4) recreation (hiking), (4) occasional livestock grazing, and (5) logging. |
| Garden | A field planted with fruit trees (apples, cherries, plums, peaches). It is planted once and harvested every year, resulting in a relatively static species composition. |
| *Toloka (Толока)* | This culturally place-based fenced field is held within families intergenerationally near homes. It typically borders forests and serves as a grazing area for small cattle year-round. |
| *Polonyna (Полонина)* | This culturally place-based high alpine meadow on a forestless mountain peak. Every year, there is a festival marking the transfer of cattle to high mountain shepherds. Grazing animals have a significant influence on plant species diversity. |
| Field | A place where plowing and agricultural work occurs. Hay is harvested and vegetative propagation of plants and species composition is impacted by hay harvesting. |
| Pasture | This is a meadow where cattle graze together but no mowing occurs. Due to land privatization (after the collapse of the Soviet Union), there are not a lot of pastures. Pastures and fields have similar plant species composition. |
| Meadow | A field of grass that is used specifically for gathering hay. Cattle do not graze here and this habitat supports native vegetation. |
| Woodland | These are edge habitats with more open canopies than forests. |
| Alpine | Human and animal impact is minimal. There is no grazing. Minimal shrub and grass vegetation. |

Quantitative indices, based on in-depth and semi-structured interviews, assess passive knowledge and "participant consensus", the degree of agreement among interviewees (Albuquerque et al., 2006). When analyzing the indices, we found that context-driven understanding of species use, like habitat, are valuable in understanding species' impact on the day-to-day lives of people but are not incorporated in ethnobotanical indices. To amend this knowledge gap and get an understanding of human interaction and species distribution across habitats, we used a community ecology approach by noting each species' presence or absence (Gaston, 2009) in various habitat types (roadside, pasture, *toloka*, meadow, woodland, forest, field, *polonyna*, alpine area, and garden).

Additionally, the range/gradient of human interaction or structuring in each of these habitats (gathering site types) was also noted. Each of these habitats (gathering site types) encompasses a range and gradient of human interaction (from high-roadside to low-alpine) as seen in Table 1.

After calculating these indices, knowledge was further organized by using a mix of inductive and deductive codes (Saldaña, 2021), derived from interviews, and participant observation. The first field season captured qualitative data on general TEK including current species use, gathering practices and ecology, while the second field season of interviews focused on species relied on in times of scarcity. A discussion emerged from data collection from the two field seasons—between species currently gathered and used to those relied upon during times of scarcity, which was coupled with data from our extensive ethnographic literature review.

Coded information included species' use in holidays, songs and stories, plant knowledge acquisition, use in traditional foods, economy of gathering, environmental challenges, and habitat distribution. Coping mechanisms and adaptive strategies emerged from these analyses. Outings, informal group discussions, and long-term presence in Hutsulshchyna with key elders allowed for the development of shared trust and the witnessing of lived knowledge. By delving into these qualitative experiences, context and meaning emerge to provide a deeper understanding that cannot be captured in strictly quantitative ethnobotanical indices. By merging these collaborative, qualitative approaches with quantitative indices, a richer perspective can be gained, based not only on informant consensus on species use, but on how this knowledge forms a broader dynamic knowledge base (TEK), and the resulting strategies that support a food sovereignty.

## Results

With the direction, guidance, and cooperation from Hutsul experts, we recorded a total of 108 species from 79 genera and 48 families (Supplementary material 1) in 10 different habitats (Table 1). While the goal was to understand wild plant use and resulting TEK in Hutsulshchyna, other species arose such as use of cultivated plants (23 species), mushrooms (9 species), and lichens (2 species) in discussion. Interviewees noted species as wild or cultivated. Additionally, we noted instances where observed wild species were seen growing in cultivated spaces such as gardens. Among the wild plants, the most well represented families included Rosaceae, Asteraceae and Gentianaceae. Among the cultivated plants, the most well represented families include Apiaceae and Asteracea. A total of 1,508 UR for wild plants, a total of 220 UR for cultivated plants and a total of 68 UR for mushrooms were provided by participants. Out of 97 plant species examined, 23 plants were cultivated, and 74 plants were wild. Out of 97 plants stated as culturally important (as indicated by the CI index), there are 4 species of evergreen trees, 11 species of deciduous trees, 15 species of shrubs, 62 species of perennials, 4 species of annuals, 1 aquatic plant species along with 2 species of lichen.

### Culturally important species and their habitats (quantitative ethnobotany meets a community ecology approach)

The Cultural Importance index (CI index) is useful since the measure is independent of the number of informants and can be used for comparing regional botanical knowledge (Tardío and Pardo-de-Santayana, 2008). Overall, St. John's wort (*Hypericum perforatum*), bilberry (*Vaccinium myrtillus*), and raspberry (*Rubus idaeus*) were considered the most culturally important wild plant species (Table 2). The top three cultivated species with the highest noted cultural importance and highest noted use reports (UR) were chamomile (*Matricaria chamomilla L.*), apple (*Malus* spp.), and chokeberry (*Aronia melanocarpa*). Unique to this study are two noted lichen species: *Cetraria islandica* and *Cladonia rangiferina*.

Among the nine fungi species, Boletaceae was the most well represented family. Considering cultural importance (CI), frequency of citation (FC), relative frequency of citation (RFC), relative importance (RI), and use reports (UR) among mushrooms noted, fly agaric (*Amanita muscaria*) ranks first followed by penny bun (*Boletus edulis*). Chanterelle (*Cantharellus cibarius*) ranks third in terms of cultural importance (CI) and relative importance (RI); it also ranks fourth in terms of relative frequency of citation (RFC). Mushrooms indicating the most uses (NU) were penny bun (*Boletus edulis*) followed by fly agaric (*Amanita muscaria*) and chanterelle (*Cantharellus cibarius*). While fly agaric was discussed the most, it is very sparingly gathered. Its bold presence in the analysis has more to do with its symbolic importance and ecologically presence in the region than its use in everyday life. This dataset is small since it was incidental knowledge gathered through interviews and participant observation on plant knowledge; it does not fully capture the extensive deep and rich mycological knowledge rooted in this region. Incidental gathering of wild plants typically occurs when mushroom hunting, hence their inclusion in the analysis. This incidental gathering of knowledge presents a starting point in understanding the importance of ethnomycology in Hutsulshchyna.

In addition to species' cultural importance and use, an understanding of human interaction within various habitats/gathering sites emerged through a community ecology approach. There is a gradient of human interaction across habitats (from most to least): roadside, forest, garden, *toloka*, *polonyna*, field, pasture, meadow, woodland, and alpine area (Figure 5). Many of the same culturally important species are found in a variety of habitats with different degrees of

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TABLE 2 Top 20 species of noted cultural importance in Hutsulshchyna.

| Botanical name | Habitat | Mode of use | NU | FC | UR | CI index |
|---|---|---|---|---|---|---|
| **Hypericum perforatum* | RD, PAS, TOL, MEA, WD, POL, FIE, (GAR) | Medicine: TEA, TIN (stomach, antibacterial)<br>Other: TOX, ECO, SYM | 6 | 28 | 87 | 2.175 |
| ***Vaccinium myrtillus* | TOL, WD, FOR, POL, ALP | FOOD: ALC, FRU, REC (juice, jam), SEA<br>Medicine: TIN, TEA (stomach)<br>Other: ECO, SYM, ECON | 8 | 22 | 81 | 2.025 |
| ***Rubus idaeus* | RD, WD, FOR, POL, ALP, (GAR) | FOOD: FRU, REC<br>Medicine: TEA, TIN (liver/inflammation/female reproductive organs)<br>Other: ECO, SYM, ECON | 6 | 23 | 77 | 1.925 |
| ***Arnica montana* | MEA, WD, ALP, POL, (GAR) | FOOD: TEA<br>Medicine: TIN (lungs, stomach), TOP<br>Other: ECO, TOX, ECON | 7 | 26 | 69 | 1.725 |
| ***Mentha* spp.** | WD, POL, FIE, (GAR) | FOOD: TEA<br>Medicine: TEA, TIN (calming)<br>Other: ECO, SYM, REP | 7 | 22 | 53 | 1.325 |
| ***Thymus serpyllum* | RD, PAS, TOL, MEA, WD, POL, (GAR) | FOOD: REC, SEA, VEG<br>Medicine: TEA (colds)<br>Other: ECO, SYM, ECON | 8 | 18 | 51 | 1.275 |
| **Gentiana lutea* | MEA, ALP, POL | FOOD: FRU, REC<br>Medicine: TEA (heart disease) | 5 | 16 | 50 | 1.250 |
| ***Fragaria vesca* | RD, PAS, TOL, MEA, WD, FOR, POL, (GAR) | Medicine: TEA, TIN (stomach)<br>Other: ECO, SYM, ECON | 7 | 14 | 50 | 1.250 |
| **Rosa canina* | RD, PAS, TOL, MEA, WD, (GAR) | Medicine: REC (juice), TEA, TIN (liver, Vitamin C)<br>Other: ECO, SYM | 5 | 19 | 48 | 1.200 |
| ***Rubus idaeus* | RD, PAS, TOL, MEA, WD, POL, (GAR) | FOOD: FRU, REC (juice)<br>Medicine: TEA, TIN (intestine/hypertension)<br>Other: ECO, SYM, ECON | 5 | 20 | 45 | 1.125 |
| *Rhodiola rosea* | POL, ALP | Medicine: TEA, TIN (stomach)<br>Other: ECO, SYM, ECON | 4 | 16 | 43 | 1.075 |
| ***Vaccinium vitis-idaea* | TOL, WD, FOR, POL, ALP | FOOD: ALC, FRU, REC (juice, kvass), SEA, TEA<br>Medicine: TIN (blood pressure)<br>Other: ECO | 6 | 18 | 43 | 1.075 |
| ***Tilia cordata* | MEA | FOOD: REC (juice)<br>Medicine: TEA (cold)<br>Other: ECO, ECON, SYM | 7 | 16 | 41 | 1.025 |
| *Cetraria islandica* (Lichen) | FOR, POL, ALP | Medicine: TEA (bronchitis)<br>Other: ECO, ECON, SYM | 6 | 10 | 38 | 0.950 |
| ***Carum carvi* | RD, PAS, TOL, MEA, POL, (GAR) | FOOD: SEA<br>Medicine: TEA (immunity, digestion)<br>Other: ECO, SYM | 5 | 11 | 35 | 0.875 |

*(Continued)*

TABLE 2 (Continued)

| Botanical name | Habitat | Mode of use | NU | FC | UR | CI index |
|---|---|---|---|---|---|---|
| ***Origanum vulgare** | RD, PAS, TOL, MEA, WD, FOR, POL, (GAR) | FOOD: SEA, VEG, TEA<br>Medicine: TEA (stomach)<br>Other: ECO, SYM, VET, REP | 7 | 12 | 33 | 0.825 |
| *Chamaenerion angustifolium* | MEA, WD, FOR, POL, (GAR) | Medicine: TIN, TOP<br>Other: ECO, TOX, SYM | 5 | 12 | 32 | 0.800 |
| *Amanita muscaria (Fungi)* | FOR | Medicine: TEA (restorative)<br>Other: ECON | 5 | 10 | 32 | 0.800 |
| ***Pinus cembra*** | FOR, POL, ALP | FOOD: REC (syrup)<br>Medicine: TEA, TIN (bronchitis)<br>Other: ECO, SYM | 6 | 7 | 29 | 0.75 |
| ***Arctostaphylos uva-ursi*** | TOL, WD | FOOD: TEA<br>Medicine: TIN (kidneys)<br>Other: ECO, ECON | 7 | 12 | 27 | 0.675 |

*Plants that show consistent use on both sides of the border of the Ukrainian-Romanian border, as well as the historical region of Hutsulshchyna; Bold—Species with a food use.
NU, Number of uses; FC, Frequency of citation; UR, Use report; CI index, Cultural importance index. Mode of use codes: Food includes alcoholic beverage—ALC, fruit—FRU, recreational beverage—REC, seasoning—SEA, vegetable—VEG, tea—TEA, and fungi—FUN. Medicine includes tincture—TIN, topical treatment—TOP, and ground—GRD. Other modes of use include ecological marker—ECO, symbolic—SYM, toxic—TOX, veterinary—VET, textile—TEX, repellant—REP, and economic—ECON. Habitats—RD, Roadside; PAS, pastures; TOL, toloka—local family pasture land; MEA, meadows; WD, woodlands; FOR, forests; FIE, fields; POL, polonyna—summer shepherding pastures; ALP, alpine areas; GAR, gardens. Species noted as (GAR) show extended and observed ranges for typically wild plants seen growing in gardens. This exemplifies their potential extended range.

human interaction, providing accessibility in times of need or disturbance. For example, if a particular habitat becomes impacted (flooding, logging, and pollution), there are other habitats harboring that same species. No specific habitat harbors all or even a majority of culturally important species, providing a layer of redundancy, accessibility and ensures resilience within communities.

## Use categories: "Food is medicine" and the tie between ecosystem and human health

The highest use category was medicinal use (30.8%), followed by food use (30.6%), along with subsequent use categories (Table 3) (96% of culturally important species exhibit at least two or more uses). Fifty-eight percent of culturally important species exhibit a food use, while 49% of species serve as food uses either as their primary or secondary use, as determined by fidelity level calculations (Supplementary material 1). Primary and secondary uses of each species were based on the fidelity level calculations (FL), which calculates the percentage of informants who use the plant for the same purpose as compared to all uses of all plants (Friedman et al., 1986), signifying use consensus among community members.

The phrase, "food is medicine", came up continually in discussions relating to regional environmental changes; community members described impacts of pollution on habitat health, gathering practices and ultimately peoples' health. Areas exhibiting high areas of pollution (roadsides), or disturbance tend to be avoided; species gathered there have deleterious properties, impacting human health, if consumed. Many of the highest ranked culturally important food species were noted for their medicinal qualities, such as bilberry (*Vaccinium myrtillus*), raspberry (*Rubus idaeus*), and various mushroom species. Thirty-point six percent of species shared both medicinal or food use categories as either their primary or secondary use. Thirty-five-point two percent of species shared both medicinal and "ecological use" as either their primary or secondary use. "Ecological use" denotes specific ecological significance surrounding a particular species. For example, certain species that are primarily gathered for medicinal purposes were continually noted by interviewees to be gathered in higher, more remote areas, therefore exhibiting ecological importance. There is a convergence of importance and connection at the intersection of food, medicine, and ecological use categories. Diverse ecologically healthy habitats, as preferred gathering sights, harbor species that are more sought-out for their medicinal quality. Gathering species from various culturally important landscapes that are directly used as medicine or food reinforces the clear tie between ecosystem and human health.

## Species of economic importance: Traditional forest foods and medicines

In the calculation of ethnobotanical indices, one of the use categories listed was economic use (Table 4). Out of 108 culturally important species, 9 species are consistently

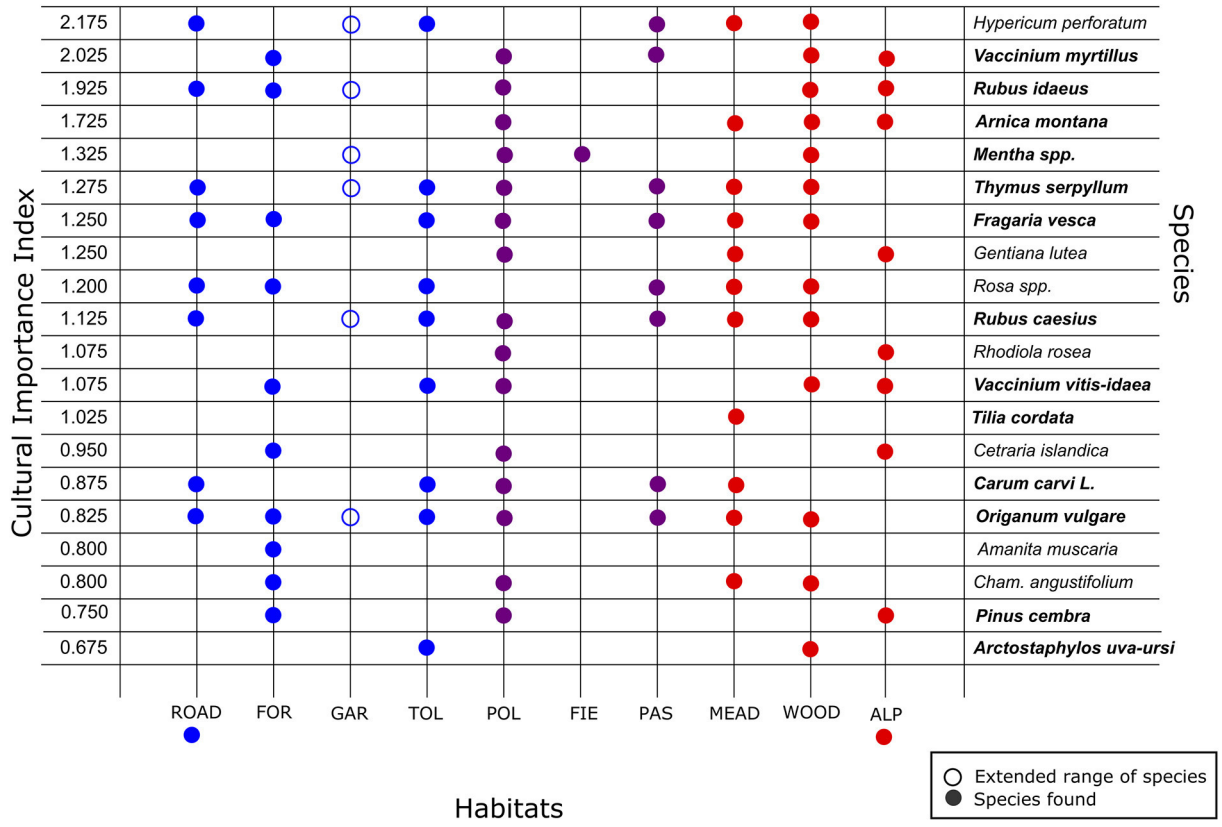


FIGURE 5
Top 20 culturally important species (according to the CI index) and the habitats found from most impacted (blue) from human structuring to least impacted (red) (ROAD, roadside; FOR, forest; GAR, garden; TOL, toloka; POL, polonyna; FIE, field; PAS, pasture; MEAD, meadow; WOOD, woodland; ALP, alpine). Bold—Species with a food use.

mentioned as sold or traded in small markets, personal contacts, or pharmacies. They include *Cetraria islandica* (lichen), *Arnica montana, Cantharellus cibarius* (mushroom), *Boletus edulis* (mushroom), *Vaccinium myrtillus, Rubus idaeus, Rubus caesius, Rhodiola rosea*, and *Gentiana lutea*. As noted in Table 4, seven of nine economically important species are in the top 20 culturally important species in Hutsulshchyna. Fifty-five percent of economically significant species are food, while 77% of species are used medicinally. *Arnica montana*, *Rhodiola rosea*, *Boletus edulis*, *Gentiana lutea*, and *Cantharellus cibarius* are species that sell at the highest prices. It is also worthwhile to note that two profitable medicinal root species, *Gentiana lutea* and *Rhodiola rosea*, are also listed as endangered species and are significantly impacted by external commercial harvesting efforts.

Bilberries (*Vaccinium myrtillus*), are one of the most culturally important plants in Hutsulshchyna (according to the CI index), and are the most popular product for sale and household consumption. Along with bilberries, mushrooms (specifically *Boletus edulis* and *Cantharellus cibarius*) are also traditional forest foods for which demand is consistent and their price remains stable. Fresh mushrooms are sold continuously from summer until fall, while dried mushrooms are sold during the winter months. The variance in price is dependent on yearly harvests. However, the demand for these species is continual and does not change, due to their importance as traditional foods. Berries and lichens are typically sold in the summer, while roots and mushrooms are sold all year round (dried or fresh).

## Species use of the past and present: A comparative analysis of fallback foods

Two well-known Polish ethnographers, Adam Fischer and Jan Falkowski, led several Carpathian Mountain expeditions in the 1930s (Patsai, 2018), and tangentially addressed wild food use during scarce times in Hutsulshchyna in the last century. In one study, Adam Fischer sent out a total of 235 ethnobotanical questionnaires; 70 of them were sent to primary school teachers in three Hutsul counties in the Carpathian Mountains (Fischer, 1939; Łuczaj, 2008; Kujawska et al., 2015). The questionnaires contained one question asking about wild plant consumption during periods of food shortage. The most common cited taxa in Hutsul counties were the leaves of *Chenopodium album*, *Rumex*

*acetosa*, *Urtica dioica* and *Tussilago farfara*. In a later study led by Falkowski (1938), the same plants including *Chenopodium album*, *Rumex* spp. and *Urtica dioica* were also mentioned. Also noted in Fischer's earlier study were mushrooms that grow on beech (although no species was listed). Coltsfoot leaves (*Tussilago farfara*) were used for wrapping cabbage rolls (a traditional food called *holubtsi*) and often mentioned in Hutsul villages (Figure 2). Unique to Falkowski's study was the mention of berry gathering for holiday and personal sale. Here, the convergence of berries as fallback traditional foods, contributing to a diverse local economy is recognized. These studies provide a mention of a few fallback foods used in times of food shortage and colonization in Hutsulshchyna.

Interestingly, some of these same plants mentioned by Adam Fischer, a Polish ethnographer, in his 1934 questionnaire are still used today, not necessarily noted as fallback foods, but for other uses including food and medicine (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2020, 2021a,b; Stryamets et al., 2021b). By referring to Fischer's list of fallback foods used in 1934, there are certain plants that still hold significance and importance in the region today (Table 5). *Chenopodium album, Ribes* spp., *Rumex acetosa, Thymus* spp., *Tussilago farfara,* and *Vaccinium vitis-idaea* showed prevalence as fallback foods in the 1930s and are still used today in all current studies in Hutsulshschyna (both Romania and Ukraine). *Chenopodium album* as well as *Rumex acetosa* are still used in soups in all studies. Unique to our study, young shoots are noted to be fried with onion. *Ribes* spp. (including *R. nigrum* and *R. rubrum*) are used in the fermentation of cucumbers, as well as in various recreational drinks (juice, tea, and wine), jam and marmalade. Additionally, both species have medicinal value (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2020). *Thymus* spp. (specifically *Thymus serpyllum*) are used as seasoning in soups and traditional foods as well as medicine for cold-related ailments like coughing.

*Tussilago farfara* is primarily used medicinally today in syrups, tinctures, and teas to treat colds, bronchitis, and coughs. Interestingly, it was also noted to be used only during famine times as traditional food in cabbage rolls (*holubtsi*)

TABLE 3 Percentages by use category.

| Use category | Percent |
|---|---|
| Medicinal | 30.8% |
| Food | 30.6% |
| - Tea | 13.9% |
| - Fruit | 6.6% |
| - Vegetable/Mushrooms | 3.1% |
| - Recreational beverages | 2.8% |
| - Seasoning | 2.6% |
| - Alcoholic beverages | 1.6% |
| Ecological | 23.7% |
| Symbolic | 9.7% |
| Toxic | 2.3% |
| Economic | 1.8% |
| Veterinary | 0.4% |
| Textile | 0.4% |
| Repellant | 0.3% |

Use category percentages of cultivated and wild plants, lichens, and mushrooms. Some species have multiple uses, falling into more than one category. Grey denotation indicates food use category and subcategories.

TABLE 4 Species noted as economically important in Hutsulshchyna.

| Species (Most commonly cited first) [CI index ranking] | Part sold | Uses | Seasons sold | Preparation |
|---|---|---|---|---|
| *Arnica montana* [4] | Roots | MED, ECO | All | Dried |
| | | | | Fresh |
| | Flowers | MED | All | Dried |
| **Gentiana lutea* [7] | Roots | MED, ECO | All | Dried |
| ***Boletus edulis* [42]** | Mushroom | FOOD | All | Dried |
| | | | | Marinated |
| | | | | Fresh |
| ***Vaccinium myrtillus* [2]** | Berries | FOOD, MED | Summer, Fall | Fresh |
| ***Cantharellus ciborius* [69]** | Mushroom | FOOD | All | Dried |
| | | | | Fresh |
| **Rhodiola rosea* [11] | Roots | MED, ECO | All | Dried |
| *Cetraria islandica* [14] | Moss | MED, ECO | Summer, Fall | Fresh |
| *Rubus caesius* [10] | Berries | FOOD | Summer | Fresh |
| *Rubus idaeus* [3] | Berries | FOOD, MED | Summer | Fresh |

Data derived from collaboration with the Hutsulshchyna National Park.
*Listed as endangered species*.
Uses—Med, Medicinal use; Eco, Ecologic use; Food, Food use; Econ, Economic use.
Bold—Species with a food use.

TABLE 5 Comparative uses of fallback foods as noted by Adam Fischer questionnaires in Hutsulshchyna and current studies.

| Noted species used in Hutsulshchyna according to Fischer (1939) | Uses noted from recent studies Sõukand and Pieroni (2016)* Pieroni and Sõukand (2017)** Mattalia et al. (2020)*** Stryamets et al. (2022a)**** | Our Study |
|---|---|---|
| *Allium ursinum* | Food (*Allium* spp.)—soups and omelets (*; **) | CI index: 0.625<br>Food—raw, salads<br>Medicine—tincture (cholesterol)<br>Veterinary—snake bites<br>(Noted: endangered) |
| *Carlina acaulis* | X | CI index: 0.125<br>Food—humans, cows<br>(Noted: people used to gather it more) |
| *Chenopodium album*<br>−42 people (leaves boiled/fried as greens/soup) | Food—boiled and eaten in soup (**);<br>Eaten with sour cream (*; ***) | Infrequently mentioned (3 people and therefore not included in the CI index calculation)<br>Food—Used to cook soup (grandmothers made this) |
| *Cirsium oleraceum* | X | X |
| *Crataegus* spp. | Food—fruit (tea) —good for heart (***)<br>Medicine—flowers (tincture) —good for blood pressure (***) | CI index: 0.575<br>Food—fruit (tea)—good for heart<br>Medicine—flowers (tincture) —regulates blood pressure |
| *Fagus sylvatica*<br>(leaves, bark pulp as bread ingredient) | Used for smoking pork meat by Romanian Hutsuls (***) | Infrequently mentioned (not included in the CI index calculation)<br>Food—inner part of the part of young trees, roasted seeds<br>(Mentioned use during time of famine/food shortage) |
| *Lamium* spp. | Medicine (*Lamium album*) —tea (used for heart problems) (*) Medicine (*Lamium album*) —tea (blood pressure, heart, nerves (***) | X |
| *Malus domestica* | Medicine—fruits boiled with onion (cough) (***) | *Malus* spp.<br>CI index: 0.525<br>Food—recreational drinks (uzvar, compote)<br>Medicine—good for teeth |
| *Oxalis* spp. | Food (*Oxalis acetosella*) —snack, salad (**; ***) | X |
| *Pyrus* sp. | Medicine—tea and tincture (salt in joints) (***) | CI index: 0.275<br>Food—compote, fresh fruit, jam, compote, jam, marmalade<br>Medicine—Vitamin C, nerves |
| *Ribes* sp. | *Ribes nigrum*<br>Food—added to lacto-fermented cucumbers; leaves—recreational tea; (**) Medicine—fruits (high blood pressure) (*; **) tea (cough), juice (blood pressure), jam (food for hemoglobin), jam (eyes), raw (blood pressure) (***) *Ribes rubrum*<br>Medicine—raw (kidney stones), tea (fever, flu) (***) | CI index: 0.175<br>*Ribes nigrum, Ribes rubrum*<br>Food—Fruit, jam, wine; recreational drink (juice); seasoning (fermenting of cucumbers and added to *kulesh* (traditional food) |
| *Rumex* spp. (14 people)—both raw and cooked in soup | *Rumex acetosa* Food—Soup—borshch (leaves—fresh/dried) (*); Green borshch but only a few people use it; salad (**); Ingredient in soups/leaves (soup, snack, salad) (***) | CI index: 0.150<br>Food—Soup in spring, cooked with *Urtica dioica*, cooked with eggs, snack (fresh leaves) |
| *Thymus pulegiodes*/*Thymus* spp.—exchanged for parsley | *Thymus serpyllum* Food—seasoning for soups (*); recorded as used in the past as seasoning for soups (**)<br>Medicine—tea (cough/cold) (*;**) tea (stomach aches) (**)<br>*Thymus serpyllum, Thymus vulgaris* Medicine—tea (cough, stomach, lung, alcoholism) seasoning; syrup and tea (cough) (***) | *Thymus serpyllum*<br>CI index: 1.275<br>Food—added to *holubtsi* (*Holubtsi* are a traditional food consisting of cabbage rolls), soup, tea<br>Medicine—tea (cough/colds, digestion, inflammatory processes, traditional rites) |

*(Continued)*

TABLE 5 (Continued)

| Noted species used in Hutsulshchyna according to Fischer (1939) | Uses noted from recent studies Sõukand and Pieroni (2016)* Pieroni and Sõukand (2017)** Mattalia et al. (2020)*** Stryamets et al. (2022a)**** | Our Study |
|---|---|---|
| *Tussilago farfara* −14 people, wraps for cabbage rolls/soup | Food—*holubtsi* (*); only during famine times—cabbage rolls (holubtsi); —in the past (**) Medicine—flowers (tincture) for rheumatic pains (*); tea (cough) (*; **; ***); syrup (throat), whole plant boiled (cough) (***) | CI index: 0.425<br>Food—*holubtsi* (traditional food—cabbage rolls)<br>Medicine—syrup (colds/bronchitis/respiratory system) |
| *Urtica dioica* −18 people, leaves (fried/cooked) | Food—soup (borshch), tea (*; **; ***), snacks (**), salad, seasoning (***) Medicine—washing hair (shine) (*; ***), fever (*; **); soup (blood cleansing), tea (blood pressure, good for heart, stomach, and others) (***) | Infrequently mentioned (not included in the CI index calculation)<br>Eaten in conjunction in soups with *Chenopodium album* |
| *Vaccinium vitis-idaea* | Food—fruit (*), jam, juice (*; **; ***); recreational tea (**; ***), kvass, compote, syrup, snack (***) Medicine—juice (diarrhea, high blood pressure), tea (high blood pressure, heart problems) (*), diabetes (*; **; ***), eye diseases, stomachache (**) juice (kidney problems) (*; ***), fruit (blood pressure), tea (panacea) (***) | CI index: 1.075<br>Food—berries, recreational drinks (juice, kvass), tea<br>Medicine—tincture (blood pressure, liver) |
| *Armoracia rusticana* | Food (*Armoracia* spp.)—leaves: seasoning (fermented cucumbers), sauerkraut (*; **; ***), fermented tomatoes (**; ***), roots (salads), whole plant (seasoning) (***) Medicine—topical application (toothaches) (*; **); topical application (joint pain and rheumatic pains) (***) | Infrequently mentioned (not included in the CI index calculation)<br>Food—fermented foods (Used during time of famine), horseradish eaten with beets during holidays (traditional food) |
| Mushrooms growing on beech as well as other mushrooms not specifically identified | Ethnomycological study (****) | 9 species of mushrooms (food and medicine) |

X—No uses noted; The * symbols indicate specific study noted in table heading.

(Pieroni and Sõukand, 2017), like Fischer's observations in 1934. However, in our study, coltsfoot is still occasionally used today to make *holubtsi*. This plant's use in foods could have been reserved to times of scarcity since it can exhibit latent liver toxicity (Chen et al., 2020). Typically eaten as a berry, *Vaccinium vitis-idaea* is used as a food in jam, juice, tea, and medicine to treat blood pressure. These wild species are not simply reserved for times of scarcity; they are culturally important species of active importance, prevalence and use in traditional foods and medicine.

Other species mentioned in Fischer's study that continue to exhibit cultural importance today include *Vaccinium vitis-idaea* (CI index: 1.075), *Allium ursinum* (CI index: 0.625), *Crataegus* spp. (CI index: 0.575), *Tussilago farfara* (CI index: 0.425), and *Rumex* spp. (CI index: 0.150). These species exhibit a diversity of uses in addition to serving as nutrient-dense foods during times of scarcity. Unique to our study, knowledge holders also mentioned many additional common and prolific species including *Elytrigia repens, Typha latifolia, Elymus repens, Fagus sylvatica, Quercus robur, Orchis mascula, Plantanthera bifolia, Rhodiola rosea, Plantago major, Trifolium pratense, Carduus nutans, Carduus natuns, Armoracia rusticana* (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017), and *Urtica dioica* (Sõukand and Pieroni, 2016; Pieroni and Sõukand, 2017; Mattalia et al., 2020). Most importantly is the continual reliance of berries including Vaccinium species (*V. myrtillus, V. Vitis-idaea*), Rubus species (*R. idaeus, R. caesius*), Ribes species (*R. nigrum, R. uva-crispa*), *Fragaria vesca, Sambucus nigra, Aronia melanocarpa, Sorbus aucuparia*, and mushroom species (particularly *Boletus edulis* and *Cantharellus cibarius*) (Stryamets et al., 2022a). Mushrooms, specifically within the family of Boletacea, contain proportionally high amounts of protein (Turner et al., 2011). The importance of wild berries and mushrooms in Hutsul traditional foods, while not specifically mentioned by interviewees (unless asked), is an integral part of culture and survival.

## Regional environmental changes and their impacts on gathering

In interviews surrounding species use, ample discussion of regional environmental change and its impact arose. Ecosystem, climatic and cultural changes are testing local and

regional resilience; there are specific factors impacting culturally important species in the region (Table 6) as stated by local Hutsul community members. Colonial legacies documented from the 1700s up until 1991 have impacted the landscape, including grass and forest communities and with it culturally important medicinal species. Commercial harvesting, a more recent development, threatens accessibility for local gathering of medicinal species such as *Vaccinium myrtillus*, *Arnica montana*, *Cetratria islandica,* and *Gentiana lutea*. Additionally, erosion and accompanying flooding have increased in frequency and severity because of extensive sanitary logging practices. Lastly, the continuing impacts of climate change have caused more dysregulation of phenological plant cycles as well an increased the uptick of pest infestation.

## Discussion

Culturally important species in the historical heart of Hutsulshchyna include a total of 108 species (including plants, fungi, and lichens) from 79 genera and 48 families commonly found in a total of 10 different habitats. Many highly ranked culturally important food species are noted for their medicinal qualities [with medicinal use being ranked first in use category (30.8%)]. Food use (30.6%) is the second highest use category cited by Hutsul community members. Culturally important species are found in a variety of habitats, with different degrees of human interaction, providing accessibility during times of need or disturbance. Transformative uses of fallback foods provide an additional layer of resilience. Various regional changes, including lasting reverberations of colonial policies, commercial harvesting, illegal logging, and climate change are impacting the landscape with its effects cascading down to culturally important species, which also have economic importance (*Arnica montana, Gentiana lutea, Rhodiola rosea, Cetraria islandica*).

Comparing ethnographic data to our findings on a species-by-species basis of noted fallback foods of the past show that many fallback foods have maintained cultural importance in the day-to-day lives of Hutsul community members; these species exhibit a diversity of uses, while also serving as nutrient-dense foods in times of scarcity, uncertainty, and regional disturbance (even seen today with Russia's current, and ongoing invasion of Ukraine).

It is this deep emergent response to disturbances, resultant of years of tumult seen through world wars, food shortages, shifting borders, colonialism, that drives resilience-thinking and action. A resilience-based approach includes mitigating disturbances by strengthening and encouraging the self-healing capacity of ecosystems. Resilience looks directly into the face of change, crisis and uncertainty, as embedded parts of life. Ecosystems continually adapt to disturbances at various scales and cannot be managed formulaically to maintain optimal levels of functioning (Bottom et al., 2009). It is the coupling and intertwining of both spheres, social and ecological, that elicits the complexity in understanding the dynamics of resilience in the region.

In our discussion, we frame the analyzed ethnobotanical knowledge shared in the results as part of a broader knowledge base known as traditional ecological knowledge (TEK). TEK, by its very nature is resilient in its iterative, dynamic, time-tested, generational process of knowledge gathering and implementation. In response to regional challenges, we explore both coping mechanisms and adaptive strategies that are informed by TEK in Hutsulshchyna. The stewardship and management practices embedded in local TEK support the presence of traditional foods and are a testament to this resilient food sovereign system.

### Traditional ecological knowledge: Language, practice, holidays

TEK is a dynamic empirical knowledge base gained through generational observation of the environment which is revisited, reinterpreted, and re-evaluated (Molnár et al., 2008; Berkes, 2012); it serves as the groundwork for maintaining resilience in communities. As noted in the methods, interviews were conducted in Ukrainian, while participants responded in Ukrainian and Hutsul. Language is a critical part of memory formation and knowledge retention; culturally distinctive values, knowledge, meanings, and worldviews transit and emerge through language (Simpson, 2008). How do Hutsul names relate to the environment? In Table 7, we highlight a few names that allude to plant phenology, habitat, physical characteristics, medicinal qualities, gathering cues, taste, stories of colonial invasions, and historical land uses. For example, during Mongol invasions of the 1200s, plants such as *Acorus calamus* and *Orchis mascula* (endangered), which are considered culturally important plants, were brought to Hutsulshchyna. The local, Hutsul name for *Acorus calamus*, Татарске зілля (Tatarske zillia) translates to "Tatar potion/herb", illuminating the ecological, medicinal, and historical relevance of this plant in Hutsulshchyna.

Other local species' names are connected to landscapes that are prevalent in Hutsul lifeways, including "tolokнianka/толокнянка" (*Arctostaphylos uva-ursi*) and "polonynskyi hran/полонинський грань" (*Cetraria islandica*). In our study, these species display "ecological use", since their names address specific culturally important landscapes. These plants are found, respectively, on *tolokas* and *polonynas*; culturally and biologically managed habitats for centuries. As described in Table 1, *tolokas* are traditionally held pastures located typically on a nearby hillside from the home, and passed down from one generation to the next, ensuring both connection and access to land. *Polonynas* are summer alpine meadows, providing grazing for communal livestock, which

TABLE 6 Community observations of factors impacting culturally important species in Hutsulshchyna.

| Factors impacting culturally important species | Community observations | Predicted effects |
|---|---|---|
| Socio-ecological consequences of historical colonial policies | • Soviet policies (1939–1991)<br>- Mass aerial fertilizing of land changed structure of grass cover (*Trifolium pratens* dominates) (3)<br>• Austrian-Hungarian empire (1772–1918)<br>- Excessively logging of culturally and ecologically important, endangered species (*Pinus cembra*) (1)<br>- Planting of monoculture pine species (E) | • Slow recovery of grass plant communities (Example: *Thymus serpyllum* has recovered; *Matricaria chamomila* still recovering) (E)<br>• Impacts cultural use of species (weddings) (1)<br>• Limits ecosystem functioning of forests (2)<br>• *Pinus cembra* stays endangered status/reaches extinction (1)<br>• Increase in pine dieback (*Pinus sylvestris*) due to pine bark beetles (1) |
| Commercial harvesting | • Improper harvesting techniques (*Arnica montana*) (1)<br>- Not leaving root behind (E)<br>- Gather flower before seed release<br>• Mass harvesting (*Cetraria islandica*) (2)<br>- No recovery growth of slow-growing lichen (4) | • Culturally important plants become rarer; less accessible to local Hutsul populations (1) |
| Logging | • Legal/illegal logging practices on mountainsides (1) | • Impacts succession of species (berries and mushrooms) (1)<br>• Increase of regional flooding (1) |
| Climate change | • First mowing of hayfields occurring earlier in the season (2)<br>- Plants of importance are being cut down before reseeding occurs (*Carum carvi*, *Centaurium erythraea*) (E)<br>• Elevation shifts of plant habitats (*Arnica montana, Rhodiola rosea, Veratrum album*) (1)<br>• Extreme weather conditions (shortened time frames between flooding events) (1) | • Dysregulated phenological cycles of plant communities (1)<br>• Stay at endangered status (*Gentiana* spp., *Allium ursinum, Orchis mascula, Platanthera bifolia*)(1)<br>• Increased incidence of pests (*Leptinotarsa decemlineata*) on cultivated crops (1)<br>• Increase in pine dieback (*Pinus sylvestris*) due to pine bark beetles (1) |

Observation rankings: 1 = widely shared (many observations and expert generalizations across villages), 2 = place specific (well-accepted within a particular community), 3 = somewhat common (various participants), 4 = less common (one or a few local experts), E = observation mainly reported by elders.

produce culturally important dairy products. All livelihoods of Carpathian highland people are somehow tethered culturally or economically to the maintenance of *polonynas* (Geyer et al., 2011). For example, ecocultural memories, forming TEK, are reinforced through language and practiced through maintenance of *polonynas*. Language, specifically names, provide critical insights into understanding species' natural history, medicinal use, gathering cues, and importance in day-to-day life.

Hutsul communities in the Carpathian Mountains have maintained and passed down many ecocultural memories and practices, embodied in traditional ecological knowledge. TEK is embedded not only in the spoken language or words that are used to describe culturally important species or landscapes; it is practiced as a part of daily life starting from childhood. In forest-dependent communities, human interdependence with the land is nurtured and recognized daily—whether it is gathering specific medicinal species on the way to milk cows on the communal hillside (*toloka*), gathering mushrooms with a grandparent in neighboring conifer forests for a meal or taking a basket filled with forest foods for blessing. This continual interaction with the landscape is a type of biomonitoring, enabling communities to make decisions about harvesting, mobility, and land use, especially when environmental stressors are detected.

Holidays, songs, traditional foods, embroidery, and dance keep this knowledge alive through practice. Observation of specific Holy days typically includes blessing of culturally

TABLE 7 Ecocultural meanings of 9 Hutsul, local names.

| Names | Hutsul names—Translation | Ecological context | Cultural context |
|---|---|---|---|
| Common Name: Sweet flag<br>Scientific name: *Acorus calamus*<br>Hutsul name: татарске зілля; аїр болотний<br>Standard Ukrainian name: Аїр тростиновий | "Татарске зілля"—Tatar potion/herb (Tatarske zillia) | Tatars, a Turkic ethnic group, relied on sweet flag to purify water and for this reason was carried on their conquests. Current research explores sweet flag's purification properties. | The story behind the introduction of this marsh plant in this region coincides with Tatar invasion of Ukraine, beginning in 1200s. It is used in tinctures, and helpful for treating stomach issues. |
| | "Аїр болотний"—marsh plant (Ayir bolotnyi) | Sweet flag grows in marshy areas. | |
| Common name: Bearberry<br>Scientific name: *Arctostaphylos uva-ursi*<br>Hutsul name: толокнянка<br>Standard Ukrainian name: ведмежі вушка; мучниця звичайна; вапянка | "Толокнянка" —little toloka (Tolokнianka) | *Toloka* has two definitions: (1) a pasture for livestock near a home (2) collective mutual assistance within the community. This plant can be found on the toloka. | Toloka is rapid voluntary work done by community members on a toloka (pasture). In addition to having economic value, it is commonly used in tinctures to treat kidney problems. |
| Common name: Fireweed<br>Scientific name: *Chamaenerion angustifolium*<br>Hutsul name: іван чай, чайок, димник | "Іван чай"/"Чайок"—John's tea (Ivan chai/Chaiok) | There is convergence of the feast day of a St. John the Baptist with the phenological timing of fireweed blooming. | Fireweed is prepared as a medicinal tea and exceedingly more so in recent years due to its popularity on the internet. |
| Standard Ukrainian name: хаменерій вузьколисти | "Димник"—little smoke (*diminuitive*) (Dymnyk) | This refers to the blooming characteristics of fireweed - "When it blooms, it comes up like smoke - so quickly and it spreads!" as stated by an elder in 2018. | Since it is a pioneer species, Hutsuls note that fireweed grows were there was recent logging. This provides a gathering cue. |
| Common name: Icelandic moss<br>Scientific name: *Cetraria islandica*<br>Standard Ukrainian name: ісланских мох<br>Hutsul name: полонинський грань, золотинь мох, гарячий камінь, вананец, баранчики | "Полонинський грань"—on the face of polonynas (Polonynskyi hran) | Icelandic moss is found on the face of alpine pastures (called *polonynas*) and when the sun hits it, the moss is blinding. This quality is used as a sensory cue to find gathering places. | *Polonynas* are an important place in the Hutsul landscape. This species is considered a natural antibiotic and has great economic value. |
| | "Гарячий камінь"—hot stone (Hariachyi kamin) | This name alludes to growing conditions. This lichen grows on exposed (hot) rocks. | It also refers to its medicinal quality—treating fevers. It is used to make tea and helps with bronchitis. |
| Common name: Reindeer lichen<br>Scientific name: *Cladonia rangiferina*<br>Standard Ukrainian name: ягель<br>Hutsul name: кашлянек, оленячий мох, баранець | "Кашлянек"—coughs (Kashlianek) | Name alludes to helping heal coughing fits. | This lichen is a source of medicinal tea which facilitates coughing. |
| | "Оленячий мох"—deer moss (Oleniachyi mokh) | Deer eat this lichen as a source of nutrition. | |
| Common name: Horsetail<br>Scientific name: *Equisetum arvense*<br>Standard Ukrainian name: хвощ полевой<br>Hutsul name: падиволос | "Падиволос"—hair falls off (Padyvolos) | This name refers the plant's anatomical characteristics. The leaves of the plant come off like hairs. | Culturally it is gathered and medicinally, it is used externally for the treatment of boils and sepsis. |

*(Continued)*

TABLE 7 (Continued)

| Names | Hutsul names—Translation | Ecological context | Cultural context |
|---|---|---|---|
| Common name: Alpine avens<br>Scientific name: *Geum montanum*<br>Standard Ukrainian name: сиверсія гірська<br>Hutsul name: підойма, вівсик | "Підойма"—to uplift the spirits (Pidoima) | There is a specific story that highlights the timing of gathering, as well as preparation of tea. | Medicinally, alpine avens is uplifting, relieving tired muscles (inflammation). |
| Common name: Early-purple orchid<br>Scientific name: *Orchis mascula*<br>Standard Ukrainian name: зозулинець<br>Hutsul name: люби мене, не покинь | "Люби мене, не покинь"—Love me, don't leave me (Liuby mene, ne pokyn) | – | This name addresses its medicinal use entirely. Its romantic connotation aligns with its usage as an aphrodisiac for men. |
| Common name: Wild pear<br>Scientific name: *Pyrus pyraster*<br>Standard Ukrainian name: дика грушка<br>Hutsul name: дичка; гнилички | "Дичка"—little wild one (diminutive) (Dychka)<br>"Гниличка"—little rotten one" (diminutive) (Hnylychka) | Wild pear species is hardy—disease and frost resistant.<br>Wild pears are the tastiest (sweetest) when they become overripe/rotten. | The wild species is valued over the cultivated species, hence its diminutive name—"little wild one".<br>The relationship joining gathering time with taste preference is shown in the name—little rotten one. |

important species (Stryamets et al., 2021b). For example, August is a particularly important month for the blessing of healing herbs, plants, flowers, and grain, which coincides with the time where many summer herbs, flowers, stems, leaves, and roots are collected (Figure 2). Among many observed holy days, there are four holy days that occur in the summer that integrate plant use into Christian church calendar (August 9, August 14, August 19, and August 28). The importance of the environment in daily nourishment is seen through community gatherings on church holy days. In the face of dynamic regional challenges, TEK helps maintain a food system that culturally ties people, health, and land; it is the thread that unites ecosystem health and resilience to create a food sovereign system.

## Short-term coping mechanisms

In the face of regional environmental changes highlighted (Table 6), there are two distinctive responses to mitigate disturbances and maintain resilience: short-term response (coping mechanisms) and long-term responses (adaptive strategies). TEK informs these varied, time-tested responses. In Hutsulshchyna, two important coping mechanisms are present: (1) modifying subsistence activity patterns (changing how, where, and when to gather culturally important plants), and (2) gathering species across various habitats at varying intensities These are adaptive, immediate responses based environmental changes such as shifts in climate patterns and logging practices, compounded by land degradation seen continuously through erosion (57.5% of territory), pollution (20% of territory), and flooding (12% of territory) (Dovbenko, 2014).

### Modifying subsistence patterns: Changing how, when, and where to gather

Increased seasonal variability and logging have caused local Hutsul communities to adjust the timing of their seasonal gathering and garden planting. Phenological shifts in flowering, and extended rainy seasons as described by local experts have resulted in shifts in gathering practices of culturally important plants. Waiting has become a common coping strategy for community members as they inform one another on the status of flowering or fruiting of economically important species. Another response has been following plant communities, especially medicinal species, as they shift to higher elevations. For example, due to climatic shifts, community members now to hike to higher elevations to gather species like *Arnica montana*. The question of community accessibility arises in response to climatic shifts; it impacts distance and time needed for community members to gather cultural important medicinal species.

In addition to climatic changes, illegal logging remains a significant regional challenge, causing increased flooding and erosion in the last decade (Geyer et al., 2010; Soloviy et al., 2011). WWF Ukraine World Wildlife Fund, 2018 has determined that 44% of the timber harvested from the Carpathian Mountains

and exported to the EU is illegal, reinforcing the fact that sanctions for committing forest crimes remain unenforced. The use of multi-time satellite images, DNA and isotope analyses of wood, and local activism has recently helped combat illegal logging in the region (Associação Natureza Portugal, 2020). In a recent study in Northern Bukovina of Ukraine, Hutsul knowledge holders stated that exploitation of forest resources is driven by immediate economic return, with logging companies harvesting timber year-round (Mattalia et al., 2021b). In our study, the impacts of illegal logging, as stated by Hutsul locals, encourages succession of species such as *Rubus idaeus, Rubus caesius, Vaccinium myrtillus, Chamaenerion angustifolium, Orchis mascula*, and *Aronia melanocarpa*. These culturally important species are gathered and used for personal use and sold fairly frequently. However, community members note that species such as *Rubus caesius* can hinder forest growth and regeneration, and that gathering this species helps manage forest health. Illegal logging also weakens mushroom growth and nutrient cycling, impacting gathering of mushrooms. By modifying and continually adapting to both climate change and logging impacts within the region, coping mechanisms arise such as waiting, communicating with other community members, and shifting gathering practices to higher elevations.

### Diversity of species use, intensity of use, and habitat use

Another coping mechanism, informed by TEK, includes varying the intensity of habitat use (temporally) as well as gathering culturally important species in various habitats (spatially). Communities are reliant on a diversity of habitats for their nutritional and medicinal needs, spatially radiating from their homes to gardens (whereby agroforestry techniques are employed), pastures, fields, *tolokas* (where grazing promotes plant diversity), meadows, woodlands, forests, alpine areas, as well as *polonynas* (which provide communal grazing and medicinal root plants), and more recently the incorporation of local, grocery stores. These radiating layers of habitats nest spatially and vary in use intensity temporally. Some landscape levels (like gardens, pastures, woodlands, alpine areas, meadows, *tolokas*, fields, and *polonynas*) are used more intensely during specific seasons, ensuring time for regeneration and growth. Other levels (like forests and small markets) are used at a constant low intensity and require accounting of time and distance to resource. Each of these nested habitats provides a layer of redundancy, ensuring a societal effort to live sustainably within the limits of the environment, while actively monitoring habitat changes from season to season. Additionally, most culturally important species are found in a range of habitats with varying levels of human structuring, ensuring availability to communities (Figure 5). Diversification is a well-known risk-spreading strategy used to mitigate unexpected events and uncertainty (Kelly and Adger, 2000; Berkes and Jolly, 2001), by increasing system complexity (Sterk et al., 2017). By identifying potential food and medicinal resource redundancies and spreading out use intensities in a variety of habitats, a coping mechanism emerges, helping to secure both ecosystem and community survival.

Among the diversity of habitats relied upon, community members mentioned cultivated plants and their gardens. Gardens typically contain a variety of trees including sweet cherry, cherry, plum, apricot, apple, pear, nut trees along with perennial bushes including strawberry, raspberry, currant, gooseberry, and grape. In the Carpathian Mountains, home gardens provide a source of food and medicine. In some cases, elders mention transplanting wild plant species into their own home gardens including *Fragaria vesca* and medicinal root species such as *Rhodiola rosea* and *Arnica montana*. These agroecosystems create another function and layer of resilience in a larger ecosystem; they act as centers of experimentation, introduction, and crop improvement.

Reliance on local forests, *tolokas*, fields, gardens, meadows, woodlands, and pastures requires observation of conditions and vegetative states of preferred plants. If family pastures are maintained (*tolokas*), grazing and milking of livestock requires interactions with landscape and monitoring of ecological and weather changes. Dialogue between locals and their surrounding ecosystems occurs during gathering seasons and ritualistically, during holidays, when sharing traditional foods (made from culturally important species). These coping mechanisms are crucial for maintaining resilience within food systems, with communities adapting to a variety of convergent environmental stressors.

## Long-term adaptive strategies

While coping mechanisms play an immediate, responsive role in maintaining resilience, Hutsul communities have also integrated long-term adaptive strategies. Adaptive strategies emerge at larger spatial scales. In their work in Arctic communities, scholars Krupnik and Jolly (2002) among others present two adaptive strategies including 3) inter-community trade as well as 4) social networks to provide mutual support (Krupnik, 1993; Freeman, 1996; Berkes and Jolly, 2001; Galappaththi et al., 2019). In the context of this study, the adaptive strategy of intercommunity trade is expressed through the economy of gathering; another adaptive strategy includes the transformative use of fallback foods.

## An economy of gathering and impacts of commercial harvesting

The act of gathering plants and mushrooms for personal use in Ukraine is embedded in seasonal and holiday rhythms, with harvesting carried out mainly from spring until fall. In the forests of Ukraine, 25 tons of birch juice are harvested annually, 150 tons of commercial honey, more than 7,000 tons of dried mushrooms, 7,000 tons of wild fruits and berries, as well as 5,000 tons of medicinal plants (FAO, 2008). Hutsulshchyna is considered one of the most economically depressed regions of Ukraine; gathering and selling of medicinal roots and berries is common. Gathering and selling of wild species has intensified since the dissolution of the Soviet Union in 1991 (Stryamets et al., 2015). Additionally, with current high unemployment rates in the region exacerbated by the pandemic (Yarmosky, 2020) and now Russia's invasion of Ukraine, locals continue to rely on gathering and selling wild food species. More than half of local Hutsuls in interviews described the economic and cultural value of gathering plants through an *economy of gathering*. While the local *economy of gathering* provides a local flow of income through the gathering of economically important species, as mentioned in the results, there is an external force in the region—commercial harvesting (Table 6). Locals noted a rise of commercial berry (*Vaccinium myrtillus*) and medicinal plant harvesting in the Carpathian Mountain region.

Species that are culturally, nutritionally, and economically valued can be split into the following categories: mushrooms, lichens, berries, and roots. Many of these species are found on *polonynas*, alpine meadows and forests. The more remote a village is from roadsides and grocery stores, the more gathering for personal use (medicinal and food purposes) is practiced. Often these species are also collected for further sale. There is an understanding that each year's harvests will be variable and subject to change based on impacts of externalities (weather, commercial harvesting, pests, phenology, etc.) Forest species are used primarily for filling cyclical income gaps. In terms of providing supplemental income, the sale of all these species helps subsidize costs to buying other food items, agriculture equipment, school supplies, clothing, and household cleaning supplies. In a recent study analyzing Hutsul forest use in Northern Bukovina (Ukraine) vs. Southern Bukovina (Romania), Hutsuls in Ukraine expressed more dependence on forests, stating that selling berries and mushrooms was a primary source of income (Mattalia et al., 2021b). In our collaborative study, the *economy of gathering,* as an adaptive strategy, also highlights Hutsul forest dependence, promotes trade and social support between communities, and allows for the supplementation of income while also recognizing the variability of local markets based on seasonal cycles of harvest and resource use.

An *economy of gathering*, as an adaptive strategy, faces the pressure of commercial berry and medicinal plant harvesting. *Arnica montana*, a plant prevalent in local markets, is also noted to have suffered a population decline due to the over-harvesting. In addition, there has been a rise of commercial harvesting of endangered plants such as *Rhodiola rosea* and *Gentiana lutea*. *Rhodiola rosea* has been greatly impacted due to industrial production, with tinctures being very popular. However, as noted by elders, *Rhodiola rosea* roots need 3–4 years to mature and, because of early harvesting, local plant populations have diminished. In addition, international medicinal plant companies have shown a growing interest in harvesting medicinal plants in the Carpathians and target vulnerable plant species. To address the demand for medicinal plants, various national parks have integrated the development of medicinal plant plantations to offset the endangered status of native medicinal plants such as *Arnica montana* and *Rhodiola rosea*. As stated by a local park authority, these plants are grown in controlled outdoor environments and, for tinctures to be as effective, proportions need to be amplified by 20–30% to be just as effective as wild plant harvests. External commercial harvesting of culturally relevant and economically profitable plants such as *Arnica montana, Rhodiola rosea* and *Gentiana lutea* in Hutsulshchyna, in addition to regional impacts of illegal logging and climate change present layers of complexity in retaining resilience.

There is a tension between local economies (an *economy of gathering*) and external economies (including but not limited to commercial harvesting). As explained by numerous elders in various ways, "once gathering becomes a business, there [also] appears a consumer and corporate interest". Most elders in the region adamantly oppose putting medicinal plants in the rank of industrial production due to accompanying habitat destruction. Intensive commercial harvesting in the region began 20–30 years ago and has impacted the region and endemic plant populations. There is a local saying, "After me, [there will be] a flood", reflecting the business-driven aspect of over-harvesting. It implies that environmental destruction is an inevitable result of corporate presence. Both logging and increased mean temperatures increase erosion, causing an uptick of hydrological events such as flooding in the region (Farley et al., 2009; Geyer et al., 2011). In terms of maintaining resilience, the local economy of gathering is based on a centuries-long practice of gathering a range of species inhabiting diverse environments both temporally and spatially, inviting constant dialogue between communities and the landscape. Additionally, local gathering is based upon gathering methods that are selective and species-specific. Yearly harvests of locally gathered species are variable and reflective of the current state of ecosystem functioning. This knowledge is embedded within the local communities and serves as a participatory method of resource monitoring. Local, place-based economies are resilient

by nature, while extractive economies tend to be divorced of the immediate needs, values, and ecocultural memories of locals reliant on those landscapes.

## Fallback foods: Transformative uses of culturally important species

Another adaptive long-term strategy informed by TEK is the incorporation of fallback foods. During the famines of the nineteenth and twentieth centuries, gathering of wild species provided a source of medicine and food for Ukraine (Komendar, 1971). Fallback foods mostly consist of plant and mushroom species that serve as nutritional support during times of restricted movement [war, crop failure, weather (flood), and disease]. Many of these species remain culturally important and provide a variety of functions in the nested habitats in the Carpathian Mountains for at least the last century. In our analysis, there is little distinction between specific fallback foods used only during times of scarcity and those used today. Instead, these critical fallback species are nested within everyday cultural uses of medicine, seasoning and food, thereby ensuring a long-term adaptive strategy.

Hutsulshchyna has experienced battles due to invasions from Tartar hordes (1000s), the Polish regime (1340), and the Austrian-Hungarian Empire (1780s—1918). In the interwar period, Hutsulshchyna was divided at the borders with the central part belonging to Poland, the southern and eastern part under Romania, and the western part under Czechoslovakia (Figlus, 2009). The part of Hutsulshchyna in this study was occupied by Poland (1919–1939), followed by Germany (1939–1943) and then the Soviet Union (1943–1991). Political boundaries running through the territory have had less effect on Hutsul unity since it is the mountains that form the natural boundary among states, not the artificial lines drawn through it (Domashevsky, 1985). The geography of the Carpathian Mountains served as a buffer up until late 1930s against political terrors, war, genocide, and violence waged in Ukraine by German Nazis, Soviet Communists and Russian czars. The Austrian-Hungarian colonization of Hutsulshchyna meant that this region was spared from the Holodomor (meaning "death by starvation") of 1932–1933, a Soviet-Russian orchestrated genocide in Central and Eastern Ukraine (Klid and Motyl, 2012; Bezo and Maggi, 2015). However, in interviews, elders mentioned that another Soviet famine of 1946–1947 affecting Ukraine, Moldova, Russia, and Belarus (Gráda, 2015), causing an influx of Moldovans to migrate to the Carpathian Mountains. These demographic shifts of refugees caused more reliance on neighboring ecologies and species' usage. Currently, due to Russia's invasion of Ukraine, the Carpathian Mountains are again serving as a refuge, with an estimated 65,000 internally displaced people within Ukraine fleeing from the east of the country (Frankfurt Zoological Society, 2022).

While literature highlights a deep history of berry and mushroom reliance during times of scarcity in Ukraine, finding information on other fallback foods in Hutsulshchyna is both scattered and primarily written in Polish. Hutsulshchyna, along with Western Ukraine, was under Polish Republic rule from 1918 to 1939. Books by Ukrainian authors were censored (Gráda, 2015) and scholarly ethnographic works were mainly published in Polish. In the postwar years, literature surrounding Hutsulshchyna was written but there is practically no focus on foods. It is important to note that this type of knowledge is generally passed down orally, generationally, and infrequently documented in written form. Lastly, this rich knowledge is embedded in the daily rhythms of Hutsul life which cannot be fully captured in an extensive literature review or interviews; knowledge of fallback foods has survived and thrived in the face of colonization, famine, and war.

Many of the species mentioned as fallback foods by Polish ethnographers in the early twentieth century are still used today in diverse ways (Table 5). In Hutsulshchyna, during times of scarcity, species use transitions from a medicine or seasoning to a food. Knowledge of plant use transformation is embedded in TEK. Here is an example of resilience, which is the combined result of coping, adaptive and transformative capacities leading to transformative response. Interestingly, according to Lukasz' analysis of Polish ethnographer Adam Fischer's work, as early as 1934, memory of wild plants used in times of shortage was fading, and most respondents in non-Hutsul counties spoke about using fallback foods in both past and present tenses (2008). However, in Hutsul counties of 1934, the people talked about fallback foods being used presently in 94% of places. Many of these same plants including *Chenopodium album, Ribes* spp., *Rumex acetosa, Thymus* spp., *Tussilago farfara,* and *Vaccinium vitis-idaea* are still used today. Past uses inform present formation and retention of ecocultural memories forming TEK, thus propelling and ensuring future sustainability and community resilience.

## The presence of traditional foods: An expression of food sovereignty

In rural Hutsulshchyna, households produce most of their own food with relatively low expenses on food compared to the total amount of expenses. In Ivano-Frankivsk province, which encompasses the area of Hutsulshchyna in this study, 42.8% of average monthly monetary expenditure is spent on food and non-alcoholic drinks, which is one of the lowest monthly expenditures documented in the country (Babych and Kovalenko, 2018). (Comparatively, in the Dnipropetrovsk region, the average monthly monetary expenditure spent on food is 59.3%; these statistics have drastically changed since the time of the study due to the impacts of war.) In our study, we

found that 55% percent of economically significant species are food; 55% of culturally important species exhibit a food use, while 49% of species serve as food uses either as their primary or secondary use. The highest use category was medicinal use (30.8%), followed by food use (30.6%), with the convergent importance of "food is medicine". In addition to gathering wild and cultivated species from a range of multi-functional landscapes, livelihood is also composed of community-derived resources including agricultural animals (primarily cattle, cows, pigs, goats, and chickens), which supply both dairy and meat. Rivers and ponds provide fish. Beekeeping is a common activity, with the endemic Carpathian bee (*Apis mellifera carnica*) providing honey.

Short-term responses (coping mechanisms) and long-term responses (adaptive strategies) result in the presence and maintenance of culturally important species used in traditional foods in the region. Many commonly gathered berry species are traditional foods including Vaccinium species (*V. myrtillus, V. Vitis-idaea*), Rubus species (*R. idaeus, R. caesius*), Ribes species (*R. nigrum, R. uva-crispa*), *Fragaria vesca, Sambucus nigra, Aronia melanocarpa*, and *Sorbus aucuparia.* As noted earlier, berries are considered a fallback food and contribute to the local economy. Berries are eaten fresh, frozen, and dried, or cooked into jams, jellies, fillings for traditional dumplings, syrups, and sauces, or used in recreational drinks including fermented kvass, as well as juice, uzvar (a compote), and wine. The culturally important bilberry (*Vaccinium myrtillus*) is used in *varenyky* (dumplings), and as a flavoring in alcoholic tinctures, fruits, and juice. In terms of health benefits, there are diverse phytochemicals present in berries, specifically wild berries of the *Vaccinium* genus, which are seasonally harvested. Wild *Vaccininum* berry species are renowned for their high concentrations of phenolic and polyphenolic compounds that interact to improve human health (Grace et al., 2014). In addition to berries providing a source of vitamins and medicine, they also infuse an array of flavor to teas, recreational drinks, jams, and jellies. Raspberries are consumed recreationally, and their leaves, stem, and berries used as a medicinal tea. Wild raspberries have slightly better medicinal properties, taste, and aroma than garden raspberries. Chokeberry (*Aronia melanocarpa*) has a wide range of uses including consumption as a fruit, tea, kvass, wine and as a medicinal tincture. As noted many times, a diversity of berries serve as important staples in Hutsulshchyna.

Hutsul traditional foods incorporate an important dairy product from *polonynas*, a cheese made from Carpathian cows or sheep (*polonynska bryndza*), and as well as many mushroom species (particularly *Boletus edulis* and *Cantharellus ciborius*). Mushrooms are used traditionally in cooking of holiday meals (Figure 2). Most people and families go out and gather mushrooms in summer and fall, a recreational and intergenerational, seasonal activity. For example, one elder mentioned, "I take my grandson and we go together to pick mushrooms. I show him the place where mushrooms grow." [Mykola (L.)] Mushrooms are very popular during winter holidays, where large quantities of marinated mushrooms, and mushroom dishes are eaten. During specific Christian holidays, fasting is a practice and "it is important for people to stock with dried mushrooms" [Katya (K).]. They are added to traditional dishes including *banosh* and *kulesha*. The main components of *banosh* and *kulesha* are corn flour (*Zea mays*) and *polonynska bryndza* (cheese made from *polonyna*) (Figure 2). Both traditional dishes serve as a base to add either berries or mushrooms, depending on the holiday. Forest mushroom soup is also a very common first course and has long been a part of the Hutsul, traditional diet. Overall, mushroom hunting is embedded in Ukrainian culture overall (seen in traditional foods) but even more so in the Carpathian forests, where these species thrive.

The presence of traditional food in Hutsulshchyna is an expression of food sovereignty, as "healthy and culturally appropriate food", which is "produced through ecologically sound and sustainable methods", as seen through coping mechanisms (modifying subsistence activity patterns, and relying on a diversity of species, intensity of use, and diversity of landscape use). Lastly, we see "the right to define their own food and agriculture systems" (Declaration of Nyéléni, 2007) through the economy of gathering and fallback foods, as adaptive strategies (Figure 2). Not only does gathering provide food and medicine, but it is also a cultural activity that upholds personal and community wellbeing and relationship-building through religious holidays, harvesting, and processing (Lynn et al., 2013) as seen in Figure 2. Direct reliance on ecosystems confirms the necessity of maintaining regional biodiversity, while culturally-informed economies drive regional economic stability. Nested in TEK, these types of community-based food systems not only provide medicinal and nutritional needs, but also present an active opportunity to connect with the land, which in turn allows community members to, quite literally, nourish one another.

## Polonynas: The tie between landscape and traditional food

The role of *polonynas* (transhumance) in Hutsul landscape is intertwined with traditional foods, specifically in the making of sheep's cheese (Figure 2). *Polonynska bryndza* is made during the summer months (June through September) and obtained from milk of local Carpathian sheep or cows. The process of making bryndza is at least a 600-year-old tradition and is deeply intertwined with traditional food and the *polonyna* landscape (at least 700 m above sea level). This tradition, passed down from generation to generation, preserves ecocultural memories tied to culturally important plant species found on *polonynas* as well the process of making *polonynska bryndza*.

The decline of *polonynas* is linked to cattle population decline after the collapse of the Soviet Union, when keeping cattle became economically difficult and expensive. Due to this decline, it began to synergistically change the landscape and its biodiversity, leading to overgrowth. Without grazers and active management of the land, this biocultural reservoir faces loss. The decline of livestock numbers and *polonyna* pasture use is directly related to intergenerational decline of interest and low economic competitiveness, as well as the time constraints on working populations (Bitter and Bomba, 2008). This has rippled down to demographic shifts and work migration seen Hutsulshchyna. Migration was observed in many of the villages visited, where residents migrate seasonally to work in Poland, Russia or Western Europe with predominant sectors being seasonal agricultural work, construction, and service (Zhyla et al., 2014). Government subsidies to uphold Hutsul pastoral traditions are non-existent in Ukraine. One recent positive development in 2020 that works to preserve *bryndza*, and by proxy, *polonynas*, is the European Union's incorporation of *bryndza* as a geographical indicator. The EU states use a system of protected geographical indicators, which include names that are applied to products made within a specific area (like "champagne" in Champagne, France) (Druzhuk, 2020). It is the ecological processes within the landscape, climate, and soil that ensures the tradition, and its perpetuation of local economy within the region and unique taste. This is the first product in Ukraine with this geographical indication mark, ensuring its authenticity, promotion on the economic market, and guaranteeing its quality.

Traditional foods in Hutsulshchyna are tethered to the landscape and the various habitats that species are found. *Polonynas*, as a critical and culturally significant habitat in Hutsulshchyna, are concretely linked to the traditional food of *bryndza*, as well as many other culturally important plants (Figure 2); their survivals interlinked. The significance of the EU's incorporation of *bryndza* as a geographical indicator provides a layer of resilience in maintaining these practices and thus providing a step to ensuring regional food sovereignty.

## Conclusion

Attributes of socio-ecological resilience include adaptive capacity, which consists of both short-term, immediate responses (called coping strategies) and long-term, culturally valued responses (called adaptive strategies). TEK is an environmental knowledge base upheld by language, gathering practices, holidays, song, and culture; it ultimately sustains the adaptive capacity of Hutsul communities to survive wars, food shortages, shifting borders, long-lasting impacts of colonialism as well as competing environmental challenges such as illegal logging, commercial harvesting, and climate change. While Hutsulshchyna along with the entirety of Ukraine face many socio-ecological impacts due to Russia's invasion of Ukraine, resilient communities continue to survive, thrive, and adapt. Ecocultural memories thread together to form a dynamic knowledge base called TEK, which provides a continual opportunity for knowledge sharing within communities. It can be seen as a time-tested, repeated, readjusted knowledge base resulting in resilience. Coping strategies include gathering a diversity of foods (culturally important species) from a diversity of habitats, mitigating the possibility of food scarcity by redistributing reliance on any one habitat type or food source. Another coping strategy includes modifying and continually adapting harvesting of where, when, and how of culturally important species are gathered, dependent on disturbances and climatic changes. Adaptive strategies include an *economy of gathering,* which provides a diversified way of supplementing income and personal needs, while providing trade and social connectivity between communities. Additionally, fallback foods used in the early twentieth century are still used today, with uses transforming from medicine or seasoning to food, under times of stress. Fallback foods provide a transformative capacity to overcome future adversities. It is the integration of coping mechanisms and adaptive strategies that provide the pathway to maintaining traditional foods in the region, which explicitly connect people to land through sustainable gathering practices, religious holidays, meal sharing, and customs. Food sovereignty is an emergent characteristic of community-driven, sustainably maintained ecosystems that provide culturally relevant sustenance, nurturing both community and landscape especially critical today.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by International Review Board (IRB). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## Author contributions

NF devised the study project, the main conceptual ideas, goals, research, field work, data analysis, review of bibliography, analysis of results, writing of the manuscript, and manuscript revision. MP and OP contributed to goals, research, field work, analysis of

results, writing of the manuscript, and manuscript revision. All authors contributed to the article and approved the submitted version.

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## Dedication

We dedicate this paper to all the people in Ukraine who are bravely standing resiliently in community with one another and fighting for their freedom.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.720757/full#supplementary-material

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