SYMBIOTIC HARVEST:
HUMAN MUSHROOM FORAGING
AND ITS IMPACT ON PUBLIC LAND

by

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I acknowledge the land on which I work and live and play, in which supports and sustains life. I give gratitude to the indigenous people who have stewarded this land for millennia, with the land now known as Minnesota being the traditional homelands of the Dakota and Ojibwe people.

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GLOSSARY or NOMENCLATURE

Foraging - the human practice of harvesting edible plant material or mushroom fruiting bodies from the wild for consumption.

Trampling - foot travel by humans or animal which can impact either soil compaction or plant recovery; referred to as foot travel in this professional paper.

ABSTRACT

Minnesota has seen an increased interest from 2020-2025 in free, wild food obtained through foraging on public land. Minnesota public land managers are concerned about negative impacts to public land, and as a result have considered restricting harvesting of mushrooms. One concern is that foragers walk off-trail and might negatively impact the forest ecosystem, but there has been little evidence synthesized to inform or validate this concern. Therefore, I examine human effects on soil compaction and mushroom productivity by performing a systematic review of peer-reviewed literature. Eight papers were selected in which field research was conducted in areas with seasonal changes including cold weather similar to Minnesota. An additional 16 papers were used to inform the context and discussion surrounding the main findings. I also interviewed five foragers local to the Midwest region of the United States to gain perspective on how foraging practices are carried out on public land.

Compaction seems to have a positive but non-linear relationship with foot travel, with foot travel of more than 100 passes not causing a significant increase in compaction. Mycelia is found to grow more readily in soil with greater porosity, but human foot traffic did not seem to have a cumulative negative effect on fruiting body productivity. Human removal of fruiting bodies and the methods of mushroom harvest did not alter fruiting body production in subsequent years. Although there is no evidence in the literature that suggests mushrooms decrease due to human harvest, permitting systems could be implemented to use foragers' expertise to gather data and teach sustainable and reciprocal practices to new foragers. When considering the carrying capacity of an area for foragers, it is also important to consider traditional ecological knowledge as well as the historic wildlife uses of that area and how that might be replicated by human interaction of foraging on public lands.

INTRODUCTION

Foraging has been a human practice since time immemorial, spanning cultures, continents, and countries. For readers familiar with grassland ecosystems and grazing animals, the word foraging may hold a different meaning. In this paper, I define the act of foraging as the human practice of harvesting edible plant material or fruiting bodies from the wild for consumption.

Humans have foraged for centuries to provide food for themselves. Much of the practice of foraging has diminished throughout the United States (U.S.) over time due to the rise of the modern industrial food systems that separate consumers from the food source, the privatization of land, and the removal of indigenous people groups from land access (Bellows et al., 2023; Serraj, 2018).

Interest in foraging reemerged during the COVID-19 pandemic and has continued to increase as food prices in the U.S. have risen. When the COVID-19 pandemic led to the global lockdown of 2020, it illuminated the supply chain issues of the U.S. industrial food system, which is reliant upon states or countries far from one's own home (Skalkos, 2022). The lockdown and corresponding supply chain disruption inspired many people to start gardening and spending more time outside, including foraging to compensate for rising food prices and supply shortages (Skalkos, 2022; Yossi Sheffi, 2021). Foraging, previously practiced by a few traditionally minded individuals, indigenous peoples, and immigrants, has now become a popular recreational activity among the masses.

Minnesota has, like so many other states and countries around the world, experienced a surge of interest in outdoor recreation during and after global pandemic shelter-in-place orders. With the outdoors being a safe place to see loved ones or to simply experience some stress relief, the number of visitors to state parks surged in 2020 (Juliot, 2024). In response to this continued increase, Minnesota Governor Walz in 2023 signed a $10 million budget increase for Explore Minnesota, a state department dedicated to tourism and parks and recreation management for the state (Smith, 2024). The increased interest in getting outdoors, coupled with the rising costs of food following the pandemic, has sparked interest among metropolitan area residents in the free harvesting of local food (Skalkos, 2022).

Additionally, foraging is an essential part of the cultural identity and heritage of many immigrating to Minnesota. According to the U.S. Census Bureau, 8.5% of Minnesota's population consists of foreign-born residents, but in the Twin Cities, this figure increases to 12% of the total population (Bureau, 2023). The majority of these immigrants are from Ukraine, Laos, and Somalia, which each have culturally specific traditions of foraging plants and mushrooms alike (American Immigration Council, 2023). Many of these immigrants live in environmental justice areas. They do not own property, and instead reside in apartments, relying on public land to recreate and practice these traditional methods of gathering food (American Immigration Council, 2023; Martignacco, 2024).

Environmental justice areas are defined by MN R. 116.065, and the areas have the following population makeup: 40% of the residents are people of color, 35% of the households have income at or below 200% of the federal poverty level, and or where 40% of the population has limited English proficiency (Minnesota Legislature, 2024, *Sec. 116.065 MN Statutes*).

The Minnesota Department of Natural Resources (DNR) manages more than 5,777,630 acres of public land available to Minnesotans, and over 76.5 % (4,424,110 acres) are within 10 miles of an environmental justice area (Figure 1).

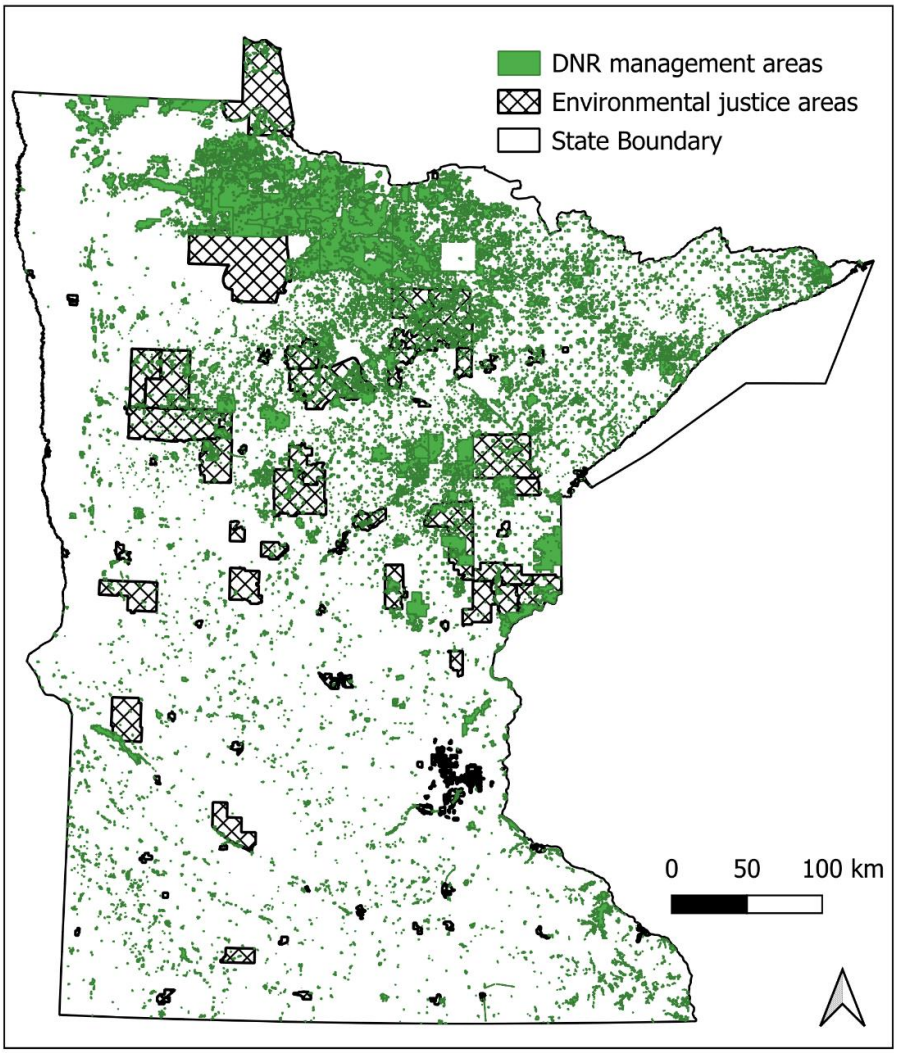

Figure 1: Map visualizing DNR managed land and locations of environmental justice areas. This map did not include Tribal Nation boundaries as additional EJ areas, as Tribal members have unique foraging rights due to treaty agreements. However, there is some overlap between the census-identified EJ areas and Tribal Nation areas. *(*MPCA Environmental Justice - Minnesota Geospatial Commons*, 2024;* State Administered Lands - DNR Management Units, Minnesota - Minnesota Geospatial Commons*, 2025).*

The increased interest in foraging can be seen in the surge of followers on the social media accounts of long-time homesteaders and makers. According to Linda Black Elk, Instagram, Tik Tok, and other social media platforms have become a form of oral history telling, passing traditional knowledge and identification information to new foragers (L. Black Elk, personal communication, February 13, 2025). One example of this is the Ironwood Foraging Co. social media profile on Instagram which had 3,000 followers in January of 2019, increasing by more than 17 times to 52,000 in January 2025 (T. Clemens, personal communication, February 6, 2025). Additionally, Alexis Nicole, known by her social media handle as @BlackForager, gained popularity in a viral fashion with over 2 million followers on TikTok as she shared how to find food right outside one's door even in urban environments (Mohtasham & Manoush, 2021).

Environmental educators have noted the same increased interest in their class offerings, allowing both Ironwood Foraging and Four Season Foraging to operate as independent foraging educators in the same metropolitan area in Minnesota. Tim Clemens of Ironwood Foraging Co. notes that he was able to make foraging education his full-time business in April of 2020, with classes filling to capacity quickly (Clemens, personal communication, 2025). In 2020, there were 300 attendees at Ironwood Foraging Co. workshops, but the number increased over sevenfold to 2,268 attendees in 2024, split between 70 workshops and 24 events (T. Clemens, personal communication, February 6, 2025). According to Maria Wesserle from Four Season Foraging, her introduction-to-foraging class and merchandise sale revenue have doubled since 2020 (Figure 2) (M. Wesserle, personal communication, February 18, 2025). Additionally, increased interest in identification education has caused consistent annual increase of the traffic to her

educational foraging blog with consistently high interest during the start of foraging season each year in May (Figure 3; M. Wesserle, personal communication, February 18, 2025).

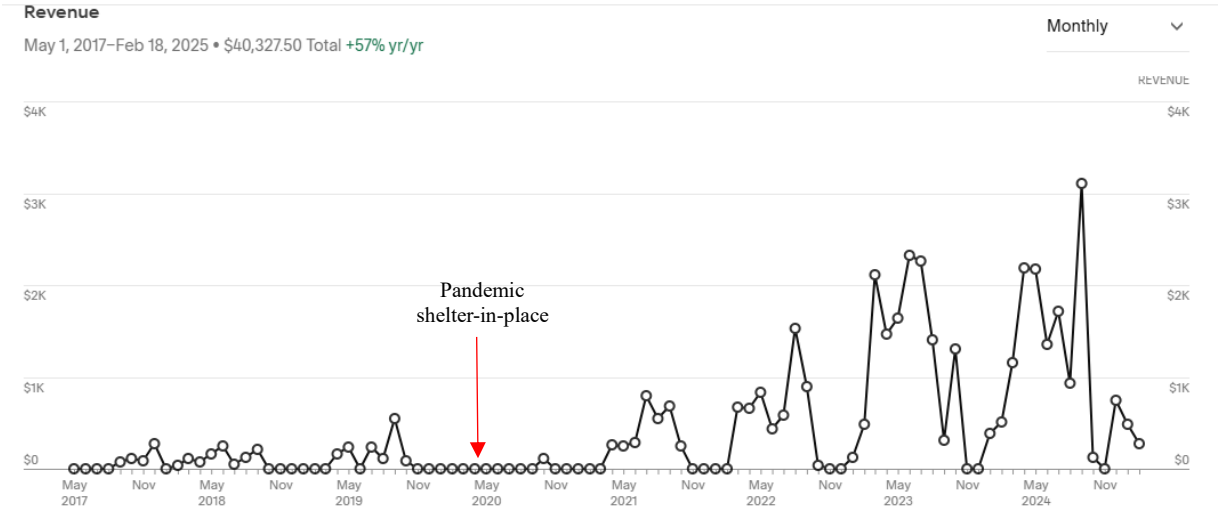

Figure 2: Class and merchandise sale revenue via Four Season Foraging website from 2017-2024 (M. Wesserle, personal communication, February 18, 2025)

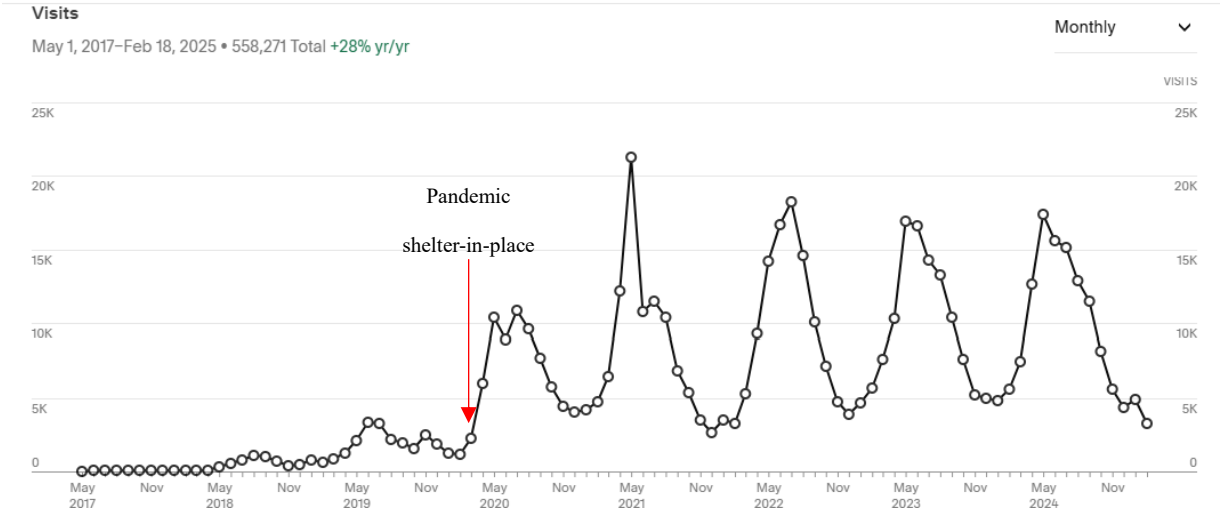

Figure 3: Four Season Foraging blog visits from 2017-2024 (M. Wesserle, personal communication, February 18, 2025)

Foraging education is especially crucial within the state of Minnesota due to this increased interest in foraging. Different rules for state parks, state forests, county parks, wilderness areas, etc. leave new foragers confused about how to interpret the rules or policy regarding the legality of foraging (Wilsey & Miedtke, 2013). This confusion, coupled with the increased pressure of human recreation on public lands, has led the Minnesota DNR to review and revise its public land use rules for the first time in 30 years (Minnesota Legislature, 2008; Kennedy, 2023; Nelson & Stockton, 2023; Pierce, 2024). This revision of Minn. R. 6100.0900 would limit use by urban residents, indigenous peoples, and immigrants who rely on public land access to practice their cultural heritage (Clemens, 2023; Wesserle, 2023). Professional land managers express concerns over the spread of invasive species, trampling of native plants, soil compaction, and overharvest by humans, which is causing a decreased food source for wildlife. These are reasons to consider restricting or banning foraging on MN public lands (Martignacco, 2024; Nelson & Stockton, 2023; Pierce, 2024). Foragers are concerned that prohibiting foraging on public land would result in a long-term decrease in biodiversity and undermine sustainable land protection principles (T. Clemens, personal communication, February 6, 2025; L. Black Elk, personal communication, February 13, 2025; P. Martignacco, personal communication, February 6, 2025; A. Toczydlowski, personal communication, February 8, 2025). Foraging educator, Tim Clemens, puts it this way,

> "I think foragers are critical to the well-being of forests and every other ecosystem. ...we need incentivized groups of highly motivated citizens to care about very specific areas of land and water and to understand the rhythms of these areas. Pigeonholing nature has led

to a decline in nature literacy and protections. Foraging widens the nature support base and increases nature ethic simultaneously." - T. Clemens

The DNR's review of public land rules was expected to occur during 2023, with final policy recommendations to come out in a public comment period in early 2024 (J. Templin, 2023). When the Minnesota Mycological Society (MMS) learned of the consideration that the DNR would restrict or ban foraging on state parkland, the word spread quickly among individual foragers and advocacy groups (Martignacco, 2023). This news of foraging rule changes resulted in viral social media posts from influential foragers, and as a result, comment letters were sent to the DNR requesting a pause on this policy review to allow appropriate public engagement (Alan Bergo, 2023; Clemens, 2023). Representatives from the legislature also became involved, resulting in the lengthened timeline of this public review (*Minnesota Sustainable Foraging Taskforce*, 2025). This review is now underway, but it no longer has a strict timeline as the DNR staff are internally considering the science and land management principles to determine what should be done to protect public land (S. Strommen, personal communication, January 10, 2025).

Foragers across the state have started a new advocacy group known as the Minnesota Foraging Alliance (MNFA). MNFA's mission, vision, and values strive to recognize foraging as a valid form of recreation on state lands, and as an inherent right of the public in using public land for personal use of food gathering (Minnesota Foraging Alliance (MNFA), 2025). One of the proposed considerations by the DNR is to create a one-gallon bag limit for mushrooms across MN State Parks (Pierce, 2024). Although foragers in MNFA argue that limiting plant gathering or creating a permit system may be warranted, there is no biologically reproductive reasoning to place a limit on mushroom harvest (T. Clemens, personal communication, February 6, 2025; P.

Martignacco, personal communication, February 6, 2025; J. B. Peterson, personal communication, February 16, 2025; A. Toczydlowski, personal communication, February 8, 2025). The main portion of a mushroom organism, the mycelium, lives underground or in decaying wood (Johnson et al., 2016). Mushrooms are self-limiting in nature of harvest, because these are the fruiting bodies of fungi, and harvesting may not harm the regrowth potential or damage mycelia, the main part of the organism (Egli et al., 2006; P. Martignacco, personal communication, February 6, 2025).

Some speculate foragers play a vital role in the spread of mushrooms, as walking through the woods with a basket of harvested fruiting bodies could spread spores along the way. There is currently no quantification of foragers using public lands due to the absence of a permitting system for mushroom foraging in Minnesota (J. Drimel, personal communication, February 4, 2025; Pierce, 2024). The absence of a permitting system leaves land managers to rely on speculation regarding the number of foragers using public land for mushroom harvest. Research needs to be conducted from comparative areas in Minnesota to inform land managers of the potential impacts, whether positive or negative, regarding foraging on public land.

One of the concerns brought about by land managers is the idea that foragers go off-trail to find mushrooms. This off-trail hiking has the potential to disturb or crush native plants, track invasive plant seeds on boots or clothing farther into the woods, and cause compaction, which might harm fruiting body growth in future seasons. A fruiting body is the fleshy and often edible spore-producing structure of a mushroom.

Although it is well known that the presence of mushroom mycelia increases the water holding capacity of substrate, David et al. (2024) and Frene et al. (2024) found increased

compaction caused reduced water-holding capacity or possibly had no effect on the water holding capacity in soil. As land managers consider better water retention in soil in the face of increased precipitation events or pending drought conditions, the potential of hikers causing compaction by going off-trail is worth exploring.

In this paper, I explore the effect of human foragers on mushroom growth and soil compaction. More specifically, I examined the effect of foot traffic and fruiting body removal on mushroom productivity. I expect to find that the influence of human foragers is negligible, as the main portion of the fungi is the mycelial layer underground which goes untouched by human harvest of fruiting bodies.

METHODS

Systematic review of peer-reviewed research

I used Montana State University's academic digital library search to identify peer-reviewed research articles relating to foraging and impacts from foot travel and compaction of soil. I conducted keyword searches on various days between February 3-March 1, 2025. Dr. Y. Yano, soil scientist and instructor on this project, recommended two additional papers not identified in the digital library search.

Keywords used (in combination): soil compaction, mycelium, fruiting body, trampling, hiker trampling, human gathering effects, human disturbance, mushroom, spore dispersal. I selected or eliminated research studies based on the following criteria. Papers were first selected if research was primarily based in Minnesota. There are many mushrooms in Minnesota that foragers gather that grow on wood or standing dead or live trees. In this paper, I focused the selection on the mycorrhizal mushroom species that grow from soil and are found in forested

areas. Papers were eliminated if they studied mushroom compost or focused solely on grasslands. I selected papers that had a focus on hiker/human trampling and eliminated any due to livestock trampling.

Because not enough research was found specific to Minnesota, I broadened the search to research conducted within North America using the same set of keywords. Due to Minnesota weather, soils freeze over the winter period and mycelia are dormant at that time, so I excluded studies in tropical or dry desert areas. Research within North America was limited to short-term studies or studies performed over five years. To search for longer-term research of 10 years or more, my paper selection was again broadened to include other countries. I included research from other states or countries for review if the climate of the studied area was like Minnesota with average freezing temperatures for one to three months of the year. Forest biomes also needed to include species that are comparable to those that grow in Minnesota, such as maples or spruce, to be considered for inclusion in the systematic review. I included Lei (2004), which was conducted in Nevada, even though it fell outside the parameters of habitats that experience 1-3 months of winter, because this paper replicated the findings of three other studies (Cole 1987a, 1987b, 1998) in Montana and was performed more recently within the past 30 years.

For all searches, I selected research studies if they collected data within the last 30 years. One exception was made for the Goeckermann & Bloemendal (1973) due to it being the only paper with research on soil compaction dedicated to habitats within Minnesota.

Many research studies regarding human foot travel do not demonstrate the direct effect on mushroom fruiting body production. Most research evaluated plant growth and response to human foot travel. Therefore, I selected additional studies that evaluated the relationships

between plant roots and mycelium, from the same keyword search and citations in the identified papers. I then used the potential effects of compaction on plants as a surrogate for the effects of compaction on a mycelial network.

The main results in the systematic review were based on the following identified papers. Egli et al. (2006), Ehlers & Hobby (2010), Goeckermann & Bloemendal (1973), Harris et al. (2003), Hoorman et al. (2011), Lei (2004), Marion & Cole (1996), Norvell (1995).

Additionally, I used the papers listed below that were identified through references in the main papers selected for review. Agerer (1985), Collins (2016), Cole & Spildie (1998), Cole (1995), Cole (1987a), Cole (1987b), Frene (2024), Greacen and Sands (1980), Kasparavicius (2001), Leonard et al. (1985), Nadian (1996), Püschel (2024), Straatsma et al. (2001), Thorud & Frissell (1969), Weaver & Dale (1978), Zakaria (2014).

Although we need to exercise caution in interpreting these findings because of the small number of studies relating to mycelial fruiting bodies and soil compaction, these findings nonetheless seem to be largely consistent with the overall understanding of foragers and mycology educators in the Midwest.

Land managers at state agencies creating policies for foraging on public lands have not shared with the public their methods for research or review of science demonstrating and supporting their policy decisions. In this paper, I seek to compile some peer-reviewed science regarding one of the topics of concern to land managers, soil compaction by foot travel, and make that research available to the public.

Personal Informational Interviews

I also conducted small-scale primary research through informational interviews. The goal of the interviews was to document the practices and principles of the foraging community in Minnesota.

Selected interviewees met at least two of the following criteria: resides in the Midwest, career focusing on sustainable food systems, foraging educator for over 5 years, president of a scientific mycological society, experienced forager (categorized as someone who has foraged mushrooms annually for over 10 years), Indigenous knowledge holder of foraging principles.

I contacted 15 different folks who are well-known in the Midwest foraging community and who met the listed criteria. Five participants agreed and were able to conduct interviews and have their answers published.

The five foragers interviewed fell into multiple categories including: two sustainable food system career focuses, three professional foraging educators, two current or past presidents of the Minnesota Mycological Society, three long-time mushroom foragers of 30+ years, one indigenous knowledge holder.

Three interviews were conducted using video chat and transcribed from the meeting recording. Two interviewees responded via written communication. Non-verbatim transcriptions of the interviews are available in Appendix A. All five interviewees responded to identical questions.

RESULTS

Section 1: Relationship between foot traffic and soil compaction

Literature review

Papers that evaluate human foot travel require multiple passes of foot traffic, with soil samples taken periodically between intervals of passes. The number of foot travel passes differs with each unique study, but typically increases by increments of 10 or 50.

In 2004, Lei (2004) studied hiking, biking, and off-road vehicle compaction on soil in Nevada. This study used a 78 kg person wearing hiking boots to perform the foot travel. To evaluate the effect of foot travel, soil samples were collected after 1, 10, 100, and 200 passes by foot. There was a significant increase in soil compaction when evaluating the 1 pass, 10 passes, and 100 passes. However, after 100 passes there was not a significant increase in soil compaction up to 200 passes (Table 1). These findings were consistent with older studies conducted by Cole (1987a, 1987b) in Montana. Lei (2004) replicated the two older experiments and used a heavier person than Marion & Cole (1996), likely showing more negative impacts of foot traffic than the other studies using lighter weight humans.

In a study performed in the Boundary Waters Canoe Area Wilderness (BWCA) in Minnesota during a 1968-1972 period (Goeckermann & Bloemendal, 1973), 33 campsites, located on islands, river side, and mainland, were evaluated for visitor use. Soil samples were collected twice every season for a total of 10 samples for each site throughout the study. Soils were primarily loam, to loamy sand. Sample collection occurred between June 1 and Sept 15, similar to a mushroom foraging window.

They found little change in the depth of organic matter overall, but compaction levels, measured with a penetrometer, steadily increased during the first two years and then leveled off during years three to five. They concluded that, after two years of use, the additional effect of human traffic on soil compaction was minimal. The findings on soil compaction was supported

by no significant changes found for any years in the old (control) sites. They also found that compaction levels increased only in spring when soil moisture levels were relatively high (Table 1), similar to findings by Marion & Cole (1996), who used experimental foot travel plots. Experimental foot travel plots were divided into transects. Each plot had two controls, and four other transects of 10, 50, 250, or 1,000 passes, respectively. Plots were placed in both forested areas and grassland areas. This experiment was performed once each season in August over the three years of 1986-1988. A 55-65 kg person wearing trail-running shoes was used for foot travel. Measurements were taken before and after foot travel, consistent with the organic matter depth, penetrometer, and moisture content samples of the campsite study. In the experimental foot travel plot results, significant changes in soil compaction were found in the measurements before and after foot travel when soil moisture content was high.

Table 1: Summary of evaluated papers and results for foot traffic and soil compaction

Location	**Time period**	**Disturbance Type**	**Data collected**	**Results**	**Reference**
Bob Marshall Wilderness, Montana	3 years, 1981-1984	Foot traffic, 5, 15, 25, 40, 75, 80, 100, 200, 300, 400, 600, 800, 900, 1200, or 1600 passes	Penetrometer (pore space/soil compaction), organic matter, vegetation cover	Insignificant increase in compaction >100 passes. (Compaction has a positive but non-linear relationship with foot travel).	Cole (1987b)
Montana	1 year, 1994-1995	Foot traffic at 25 & 150 passes	vegetation cover and height	Insignificant change in vegetation for 25-150 passes	Cole & Spildie (1998)

Washington, Montana, Colorado, New Hamphire, North Carolina	2 years	Foot traffic, 25, 75, 200, 500 passes	Plant cover measured 2 weeks and again 1 year after foot traffic	No additional decrease in plant recovery rate >75 passes. Grasses more resistant to foot traffic then shrubs, and have a faster recovery rate. Each plant species can tolerate foot traffic but have differing levels of threshold before plant cover decreases.	Cole (1995)
BWCA, Minnesota	5 years, 1968-1972	Campsite use	Penetrometer (pore space/soil compaction), organic matter, moisture, temperature	Compaction increased first 2 years with relationship to soil moisture. Compaction was caused more easily in wetter spring soils. Insignificant compaction effects years 2-5. Insignificant change in organic matter years 1-5.	Goeckermann & Bloemendal (1973)
Kyle Canyon, Nevada	1 year, 2002	Foot traffic, 1, 10, 100, and 200 passes	Penetrometer (pore space), organic matter, moisture, temperature	Compaction increased up to ≤100 passes, but no compaction change in 100-200 passes. Human foot traffic caused the	Lei (2004)

				least amount of compaction compared to biking and off-road vehicles.	
White Mountain National Forest, New Hampshire	4 years, 1978-1981	Foot traffic	soil compaction (penetrometer), trail width, soil recovery, vegetation response	Highest reduction in plant survival at ≤300 passes. Significant change in plant survival at 100-300 passes. Insignificant change in vegetation survival at ≥ 300 passes.	Leonard et al. (1985)
Water Gap National Recreation Area, Pennsylvania	3 years, 1986-1988	Campsite use	Penetrometer (pore space/soil compaction), organic matter, moisture, temperature	Campsites contained 1/3 less organic matter than control sites. Campsites had significant increase in soil compaction compared to control. Experimental foot travel: significant changes in soil compaction was found when soil moisture content was high.	Marion & Cole (1996)
Bozeman, Montana	1 year, 1973	Foot traffic, 100, 500, 1000 passes	Soil moisture, vegetation	Grasses more resistant to foot traffic than shrubs,	Weaver & Dale (1978)

			cover, soil density, trail width	flat sites more resistant than sloped sites. Hikers are the least compaction causing when compared to horses and motorcycles.	

Similar to the study by Goeckermann & Bloemendal (1973), a 5-year study was performed in Pennsylvania at the Delaware Water Gap National Recreation Area (Marion & Cole, 1996). Twenty-nine sites were categorized as high use (40-70 nights annually) and low use (3-10 nights). Site dynamics included eight high-use upland sites, seven high-use lowland sites, one low-use upland site, and three low-use lowland sites.

The effect of human traffic on various soil moisture levels was evaluated between June and September by measuring changes in organic matter depth, soil bulk density, and penetration resistance. Each site selected was compared to an undisturbed control site with matching vegetation type and elevation.

Regardless of the elevations, campsites were found to have about 1/3 less organic horizon layer and a significantly greater penetration resistance and bulk density than on undisturbed control sites. Goeckermann & Bloemendal (1973) and Marion & Cole (1996) had similar findings that the initial 2 years of human use caused the most soil compaction (Table 1). These findings are further corroborated by Cole (1995), who found that after 75 passes of foot travel, no additional decrease in plant recovery rate occurred.

Although initial foot traffic increased compaction, plants appeared more resilient with negative effects not appearing until foot traffic exceeded 100 passes. In Montana, Cole & Spildie

(1998) found that foot travel from 25 passes to 150 passes did not correlate with increased plant disturbance. Similarly, in a three-year plant recovery study in a maple- and conifer-dominated forest in New Hampshire, Leonard et al. (1985) found that the negative impact on plant recovery from hiker foot travel was insignificant with less than 100 passes. Although there were negative impacts to plant recovery found in the 100-300 pass range, no change in vegetation recovery was found after 300 passes (Table 1).

These findings show that after the initial effect by some amount of foot travel, additional foot travel will not increase negative effects. Goeckermann & Bloemendal (1973) were not able to get an estimate of passes of foot travel during campsite use like the other controlled studies (Lei, 2004; Marion & Cole 1996). However, there were more than 1,500 visitors to the campsites each year. Marion & Cole (1996) found that bulk density and penetration resistance were significant on campsites compared to control sites. However, both low-use and high-use sites were not found to have significantly more impact with more use (Marion & Cole, 1996). This is corroborated by studies by Lei (2004) and by (Cole, 1987) who states there is a positive but non-linear relationship with human use or foot travel. Goeckermann & Bloemendal (1973) and Marion & Cole (1996) found the levels of significant impact occurred within the first 1-2 years of foot travel or campsite use and leveled off after that. This is particularly important to note when land managers are considering the number of foragers allowed off-trail in a forest ecosystem. This research on the number of passes and its minimal effects may help land managers determine the number of foragers allowed in an area. More foot travel does not mean more compaction, there is a threshold after which compaction effects are insignificant.

Although many of the studies cited here were performed about 30 or more years ago, their findings are still relevant today because the human use of land, and the potential for hiking off trail and causing compaction remain a concern among land managers throughout the years. Because reduced soil pore space due to compaction can lead to less water retention in the soil, it is an important consideration in climates such as Minnesota with predictions of increased wet weather events to consider (DNR, 2025). In studies by Goeckermann & Bloemendal (1973) and Marion & Cole (1996), soil was found to be more compactable when it contains a higher moisture content. The start of the dry season is identified as June 15 in Minnesota, thus, care should be taken when traveling during the wet season as soil is more compactable (Goeckermann & Bloemendal, 1973; Marion & Cole, 1996).

The mode of traffic is also a consideration land managers should factor in, as Lei (2004) estimated just one pass of an off-road vehicle was the equivalent to 10 human passes. Additionally, Weaver & Dale (1978) compared hiker, motorcycle, and horse hoof travel on soil compaction, and hikers were found to have the least compaction effects. Lei (2004), Goeckermann & Bloemendal (1973) and Marion & Cole (1996) did not factor in compaction by deer trails or wildlife use of areas.

In Marion & Cole (1996) and Lei (2004), human impacts of foot travel were more significant when there were 50-100 passes made by a 55-78 kg person. An average whitetail deer weighs 66-79 kg, according to the Minnesota Conservation Federation (2016). With similar weights, it can be argued that deer trails would have similar compaction as the designated walking trails. Therefore, if foragers are traveling on deer trails, their foot traffic is likely contributing less to soil compaction than if traveling off-trail. However, foot shape and size are

different than hoof shape and size, and more research is needed on comparing compaction effects. The awareness and concern for causing environmental impact is dominant in the foraging community, as demonstrated by five informational interviews. This awareness reduces the possibility of compaction or disturbance of areas not managed for continual walking.

Informational interviews

Many foragers actively choose to decrease the impact of their foot travel by using established trampled paths. In all five interviews, foragers stated they walk on designated asphalt or well-used trails while traveling long distances and take care not to damage plants while walking off-trail. One interviewee identified they forage in primarily urban areas, so going off-trail is generally not a concern, with the other four interviewees identifying that walking off-trail is not the primary mode of travel while foraging. When veering off from main trails, they only walk a short distance when they see a spot that looks promising or when they have reached their intended location. One interviewee says they have seen evidence of increased erosion over the years in a deer trail at a state forest on the side of a bluff, but are unsure if this was due to foragers, hunters, or simply hikers using this path more frequently. This interviewee also cited climate change considerations and increased rain events as potentially exacerbating these effects.

As land managers consider visit frequency and use of an area, the evaluation of compaction potential can be an important consideration regarding setting policies, rules, or permitting regarding foraging in forested habitats that require off-trail exploration to find mushrooms.

Mushrooms that foragers are harvesting do not grow in the same spots or habitat throughout the seasons, so repeated use of the same paths and subsequent soil compaction may be minimal. Foragers not returning to the same spots throughout the summer should be considered when estimating the quantity of foot travel that might occur in a given area. Moreover, interviewee J.B. Peterson, a marketing communications manager for Wild Grocery, explains the concept of why it is important to consider the effects of foragers as a group, versus individuals acting in succession.

> "It is a very valid concern that an increase in foraging could put things at risk...that is something we need to address and be thoughtful about. However, in that question there is an assumption that all those foragers are acting individually and in succession. That they are going one at a time, one right after the other and therefore that their impacts are in addition to one another. That whatever damage might have occurred from the person before them is compounded upon by the person after. Or that the successive person is harvesting beyond what the person before them did. In my experience, when there is an increase in foragers they are doing that in community or they are doing that in groups. So anecdotally I would argue that the increase in foragers occurs when there are multiple people together. Multiple people together actually strengthens the concern about sustainability practices. As a group, folks are much more conscious and divvy up what each individual is going to take or harvest, dividing up different species of harvest or different areas of travel. In my experience in the increased interest in foraging I have not seen a negatively impacted forest ecosystem, and if anything I think the increased interest in foraging is one of the fastest paths to increased conservation. It like a little coalition

> because people who care about conservation and saving what is out there are the people who are interacting with the environment and working to keep the natural world healthy. I'll say it in another way. I think there would need to be a limit on foraging if it was one person going in to harvest one pound and leave the next person to harvest one pound, and so on. If we are talking about a permanent system and a specific region then yes, there is realistically limits for what humans can harvest. But more broadly the increased number of people who learn to care about the forest and learn to care about the wild food in the natural world is a boon to sustainability efforts. The more people who care about those things, the more of a coalition we have for shifting policy and shifting culture."
>
> - J. B. Peterson

This research could be used in estimating the number of permits to be issued in each area to balance compaction concerns with human utilization of public land for recreation.

Section 2: Compaction effects on fruiting bodies

This next section evaluates the potential effects of soil compaction on recurring growth of mushrooms. How does soil compaction translate to mycelial growth? It is well documented that the presence of soil fungi is beneficial to plants, which in turn benefits mycorrhizal fungi, because the fungi increase soil carbon capture, the water-holding capacity of the soil, and the uptake of nutrients in plants during dry conditions (Collins, 2016; Nadian, 1996; Zakaria, 2014; Püschel, 2024).

Soil compaction can affect the ability of plant roots to penetrate the soil (Greacen and Sands 1980; Frene, 2024). "Soil compaction increases soil bulk density and reduces porosity,

limiting water and nutrient diffusion" which reduces the water and nutrients available for plant uptake (Frene, 2024).

Although it is well documented that soil compaction negatively affects the processes within the soil, such as water infiltration and plant root growth, less is known if this may include the growth of fungal mycelium (Hoorman et al., 2011; University of Minnesota Extension, 2018). Mycelium penetrates soil in a different way than plant roots, not relying heavily on pore space, so compaction may not have an effect (Hoorman et al., 2011). However, it is possible that the decrease of soil oxygen and nutrient availability in compacted soils may hinder proper mycelial growth (Frene, 2024; Hoorman et al, 2011).

Table 2: Summary of evaluated papers and results for compaction impacts on fruiting bodies

Location	**Time period**	**Topic of study**	**Parameter measured**	**Results**	**Reference**
Moosboden, southwestern Switzerland	10 years, 1990-2000	Harvesting effect on mushroom productivity with without foot travel	Number of fruiting bodies	Foot traffic did not have a cumulative effect on fruiting bodies.	Egli et al. (2006)
Laboratory	1 year	Compaction effects on the abundance of hyphae without plant root presence	Hyphae presence, soil porosity	More hyphae per gram of soil in non-compacted soil compared to compacted soil.	Harris et al. (2003)

Laboratory	1 year	Compaction effects on the abundance of hyphae and plant root growth	Hyphae presence, soil porosity	More hyphae found growing in samples with plant roots.	Hoorman, et al. (2011)

Literature review

One of the two sites studied by Egli et al. (2006) investigated whether soil compaction via human foot traffic affects the production of fruiting bodies. This study was conducted for 10 years from 1990-2000 in Moosboden, located in southwestern Switzerland in a forest of Norway spruce. There were four treatments in the study: harvesting fruiting bodies with foot travel, harvesting fruiting bodies without foot travel, no harvesting of fruiting bodies with foot travel, and control with no harvesting of fruiting bodies or foot travel. I define trampling as normal foot travel associated with mushroom picking to mimic that of a forager, and throughout the rest of this literature review will be referred to as foot travel. Plots with no foot travel used boards elevated above the soil so that no soil would be disturbed while picking the fruiting bodies.

A total of 250 fungal species were included and 50,222 fruiting bodies counted (edible: 51 species/10,173 fruiting bodies; nonedible: 199 species/40,049 fruiting bodies). Not all of these species are edible or prized for foragers to gather, however, all are mycorrhizal in the soil and are applicable in this literature review because of the DNR's concerns for wildlife use of mushrooms as well as ecosystem health and diversity of populations in general.

The study found that the foot traffic on the forest floor reduced the number of fruiting bodies within the first season of harvest (Egli et al., 2006). However, neither the total number of species present in the plots nor the number of fruiting bodies in the succeeding years decreased. The total number of species produced in the foot traffic versus controlled plots were not significantly different. Therefore, the results of this 10-year study do not show evidence of mycelium being damaged long-term due to foot travel or soil compaction.

Foot traffic can reduce fruiting body production by 30% when comparing the foot traffic to control sites, but this effect is not cumulative as the mycelium persists in the soil (Egli et al., 2006). The researcher's hypothesis of causes for this reduced fruiting body production per season on foot trafficked plots are that the small fruiting bodies may become crushed by foot traffic in their early stages of growth in the duff leaf litter cover of the forest floor. Meaning that the time of year that a harvester is walking off-trail makes a difference, not the actual compaction of the foot travel making a difference in mycelial growth or fruiting body production.

There are limited studies related to the effects of soil compaction on the growth of mycelium. Plant growth and mycelium are interconnected. In Hoorman, et al. (2011) the abundance of hyphae and root growth in land cultivated with corn is used to evaluate the potential compaction effects on mycelial growth.

Compacted soils contain less mycelium, however most of these studies were performed with tilled soil, which is compacted by heavy farm equipment, and not by simple foot travel (Hoorman et al., 2011). This decrease of mycelium could also be related to the decrease of host plant roots in the compacted soil, as corn is an annual plant, with less roots additionally impacting mycelium growth.

Interactions between soil compaction and plant roots may be related to air and water movement through the soil; mycelia need oxygen in the soil, and plant roots increase porosity in the soil for oxygen movement (Hoorman et al., 2011). Mycelia also need a food source in the soil, which can be supplied by plant roots. With plant root growth decreasing when there is increased soil compaction, this relates to a decreased carbon food source for the mycelia so fewer hyphae are produced in compacted soil because there is less food source (Dance, 2017). When soils were planted with continuous cover crops there were more plant roots and therefore more hyphae growth.

Harris et al. (2003) evaluated the presence, absence, and quantity of the mycelium from the fungus *Rhizoctonia solani*, which is a pathogenic fungus with inedible and insignificant fruiting bodies and has a parasitic relationship with the roots of soybeans or potatoes. Harris et al. (2003), similar to Hoorman et. al. (2011), focused on the evaluation of hyphae which make up the mycelial structure of the mushrooms, however, Harris et al (2003) investigated the effect of compaction without the presence of plant roots (Table 2).

Harris et al. (2003) evaluated the density of soil and the expansion of mycelial network into soil pore spaces of the organic soil layer. Autoclaved sterile soil was inoculated with the mycelium and five days of mycelium growth were allowed. Thin sections of soil were used to visualize hyphae and the soil matrix, with percent pore space calculated. Because autoclaving releases nutrients, the availability of nutrients in each of the soil samples was not thought to be a limiting factor in mycelial growth. They found that there were more hyphae per gram of soil in non-compacted soil compared to compacted soil.

Although mycelia was still present in the densest soil with only 5% pore space, the presence of mycelia was greater in the less dense soils that had more pore space (Harris et al. 2003). This increased presence of mycelia with less dense soil may be partly because the rate of oxygen distribution is 10^4 times faster through air than water (Harris et al. 2003) and because pore space in soil is filled with more air than water, the less dense soil encourages the spread of hyphae into those air-filled pore spaces. Harris et al. (2003) findings seem to indicate that mycelium alone can spread more readily in less compacted soils.

Thorud & Frissell (1969) found that it may take up to six years for soil to reach a non-compacted state once it is compacted. This finding might sound alarming when comparing that it may take only one to three years or about 200 passes, according to the other studies, for soil to become compacted by foot traffic. However, according to Ehlers and Hobby (2010) and Egli et al. (2006), foot traffic compaction does not seem to reduce the mycelial growth or have cumulative effects, resulting in a steady fruiting body production in the following years (Table 1, Table 2). Moreover, Goeckermann & Bloemendal (1973) showed that when a site was closed from human use, that site had plant recovery that was comparable in plant growth to the controlled undisturbed sites within just two years, suggesting a faster recovery from foot-traffic compaction than Thorud & Frissel (1969) had found.

Informational interviews

Five foragers reported in interviews that they visit public land weekly or multiple times a week during the foraging season. Areas visited range from forest service land to urban area parks. All five interviewees stay on established trails for traveling long distances and take care

not to step on plants. They only take what they can eat or process, minimizing unnecessary foot traffic. Four out of five interviewees identified picking up trash or pulling invasive species as a method of reciprocity. One of the five interviewees identified advocacy in public policy as their way to reciprocate with the land.

All five foragers noted that younger more inexperienced foragers tend to take more mushrooms than they can necessarily eat or process at a time due to the excitement of a new hobby. This could increase unnecessary foot traffic. Two interviewees, whose profession is foraging education, teach new foragers how to intentionally walk without breaking plant stems (T. Clemens, personal communication, February 6, 2025; L. Black Elk, personal communication, February 13, 2025). Four interviewees also noted that foraging in community is actually more sustainable and causes less impact. Foragers acting as individuals in succession could cause concern. Foraging in community causes people to hold each other accountable for not taking too much and following intentional walking practices.

In my interviews, I found that four out of the five stated harvesting of fruiting bodies has a positive environmental impact, and no negative impact because foragers pick up trash and pull invasive species. The remaining fifth interviewee said that harvesting fruiting bodies has a neutral impact. All five foragers identified negative impacts to mushrooms are not due to compaction by foot traffic, but rather due to land use change or other anthropogenic factors such as the use of herbicides, urban development of paved trails, and climate change exacerbating flooding, erosion, or increased temperatures.

Section 3: Human removal of fruiting bodies

Literature review

Egli et al. (2006) contained a second site with results from between May and December. The second site is named Chane´az and is in southwestern Switzerland forest with deciduous and coniferous tree species. This study contained the same four plots of varied foot travel and harvesting of fruiting bodies as mentioned previously. This second research site evaluated the effect of harvest method, picking versus cutting the fruiting bodies, on edible mushrooms over 27 years during 1977-2003. A total of 436 species were included and 97,700 fruiting bodies counted (edible: 103 species/53,863 fruit bodies; non-edible: 333 species/43,837 fruit bodies).

Egli et al. (2006) states, “edible fungi, which were selectively harvested, did not decrease relative to unharvested non-edible ones with respect to either the abundance of fruit bodies or species richness.” Their study was performed over 27 years and even in this long-term study no trends were detected as far as the quantity of fruiting bodies in subsequent years, or number of diverse species returning. “Excessive ground trampling during the harvest can affect young mushrooms developing under the duff and reduce total production within a fruiting season; however, it does not appear to have any measurable influence on future production in subsequent fruiting seasons” (Egli et al. 2006). There seems to be no effect on fruiting bodies related to the method of harvesting, whether picking or cutting.

Ehlers & Hobby (2010) evaluated the management of a forest ecosystem on Vancouver Island in British Columbia for the population, growth, and harvest potential of the golden chanterelle (*Cantharellus formosus*). The chanterelle (*Cantharellus cibarius*) is a commonly foraged edible mushroom in Minnesota, and grows throughout North America (T. Clemens, personal communication, February 6, 2025; P. Martignacco, personal communication, February

6, 2025; A. Toczydlowski, personal communication, February 8, 2025). The chanterelle information in Ehlers & Hobby (2010) is thought to be comparable to the growth of the chanterelle in Minnesota, since there are multiple different species of chanterelle in Minnesota. This B.C. forest is managed for non-timber forest products, such as commercial mushroom harvesting. In Minnesota, forests are not managed for the goal of mushroom production because foraging for personal use is what is allowed per policy (Wilsey & Miedtke, 2013).

Ehlers & Hobby (2010) study was done on forests in the Nimpkish Valley, which are dominated by hemlock and fir and experience mild winters. The understory was sparsely vegetated, mostly dominated by ferns and huckleberries. The survey was conducted in 2006 when there was a very hot and dry summer. Harvesting of chanterelles typically begins in July and ends in December. A non-random survey was conducted with 15 participants of foragers and two participants of mushroom buyers in this B.C. community. Harvesters either cut or pulled mushrooms from the ground or used both methods. Survey respondents said they actively harvested from 2–8 hours/day over 2–20 weeks, depending on the season.

This study raises the question of whether removing fruiting bodies affects spore dispersal or production of mushrooms in future seasons. Ehlers & Hobby (2010) found that many foragers believed picking mushrooms spreads the spores around when carried in baskets. The idea of foragers spreading spores by harvesting was consistent with the findings from several of my interviews (T. Clemens, personal communication, February 6, 2025; L. Black Elk, personal communication, February 13, 2025; J. B. Peterson, personal communication, February 16, 2025). These interviewees also stated that picking smaller mushrooms is discouraged. All five of my informational interviews also noted that small mushrooms are allowed to grow, and larger over-

mature mushrooms are allowed to remain in order to spread spores (T. Clemens, personal communication, February 6, 2025; L. Black Elk, personal communication, February 13, 2025; P. Martignacco, personal communication, February 6, 2025; J. B. Peterson, personal communication, February 16, 2025; A. Toczydlowski, personal communication, February 8, 2025).

Half of survey respondents in Ehler & Hobby (2010) stated they were concerned about climate change affecting local mushroom populations. All five informational interviews of mine also stated climate change concerns are a driver of mushroom population fluctuations. Ehlers & Hobby (2010) states logging and fire suppression may contribute to lower populations of chanterelles but does not provide evidence further in the paper to back up that hypothesis. Chanterelles being ectomycorrhizal fungi that have symbiotic associations with trees, Ehlers & Hobby (2010) also states that forests with trees younger than 40 years are not targeted by harvesters as they have fewer mushrooms than older stands of trees. This finding is supported by Hagerman et. al (1999), who found that ectomycorrhizal fungal species richness was greater near the rooting zone of mature trees.

The last study evaluated in this paper is that of a 13-year study in Oregon by Norvell (1995), which aimed to identify the threats to mushroom populations in Oregon. This study was spurred on by the Oregon Mycological Society making claims that overharvesting may be leading to the decrease of chanterelles that harvesters were finding. Hypothesis included the following possible causes of mushroom population decline: air pollution, short timber rotations, clearcutting, depletion of soil litter layers, and over-harvesting.

The study was conducted by volunteer mycologists and conducted in the Mt Hood National Forest in a stand of western hemlock and Douglas-fir. Fruiting bodies harvested were *Cantharallus cibarius*, although there is some future research to determine if the species might have been *Cantharallus Formosus* (Norvell, 1995). Every two weeks fruiting bodies and plants present were identified and recorded. From 1986-1989 baseline data was collected in the established plots, with no fruiting bodies harvested during those three years. Plots were divided into three categories, either control with no fruiting bodies removed, fruiting bodies removed by picking, or fruiting bodies removed by cutting the stems. Fruiting bodies were removed every two weeks during five months when they were one centimeter in diameter, as this size was determined to be small and not yet have dropped significant spores for reproduction.

Fruiting bodies picked were weighed and biomass calculated. In control plots biomass was estimated by harvesting the fruiting bodies at the 10^{th} year of the study and extrapolating that data to the number of fruiting bodies recorded in those plots. Control plots were compared to baseline years to determine that they had comparative and insignificant changes in growth during the study period.

One hundred and four other ectomycorrhizal fruiting bodies besides chanterelles were also identified in this site. Harvesting did not reduce mushroom productivity between the harvested plots and the control plots in the study. Instead, for a few years, the harvested plots produced more fruiting bodies than the control plots. Therefore, it is possible that chanterelle species benefit from some disturbance by humans, but more research is needed to find out if that is true.

Pulling versus cutting the chanterelles did not affect fruiting body abundance in successive years. The study concluded that harvesting of fruiting bodies had no significant negative impact on the quantity of fruiting bodies produced in successive years (Norvell, 1995).

It is challenging to isolate factors controlling mushroom productivity, because multiple factors can interact to affect mushroom productivity. For example, there appear to be years of high chanterelle abundance and low abundance, and it is unknown what the mycelium life span of a mushroom may be. The study also discussed the weather impacts on fruiting body growth, with warmer summer temperatures resulting in more fruiting bodies. Three studies are cited by Norvell (1995) which suggest that abundant mushroom years are determined mainly by weather conditions (Agerer, 1985; Kasparavicius, 2001; Straatsma et al., 2001). Soil compaction occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few large pores, less total pore volume and, consequently, a greater density. A compacted soil has a reduced rate of both water infiltration and drainage. This happens because large pores more effectively move water downward through the soil than smaller pores (Hoorman et al., 2011; University of Minnesota Extension, 2018).

Table 3: Summary of evaluated papers and results for human removal of fruiting bodies

Location	**Time period**	**Topic of study**	**Parameter measured**	**Results**	**Reference**
Chane´az, southwestern Switzerland	27 years, 1977-2003	Foot traffic: with vs. without & Harvest method: picking vs. cutting	Number of fruiting bodies, species of fruiting bodies	Quantity of fruiting bodies and diversity of fruiting bodies	Egli et al. (2006)

				did not decrease over time in harvested plots. No decrease of either quantity or diversity of fruiting bodies in picked vs. cut plots.	
Vancouver Island, British Columbia	2006	Harvest method: picking vs. cutting	Survey, foragers & mushroom buyers	No difference in quantity of fruiting bodies with differing method of harvest. More fruiting bodies occur in forests with >40 year old trees.	Ehlers & Hobby (2010)
Mt Hood National Forest, Oregon	13 years, 1986-1999	Harvest method: picking vs. cutting	Fruiting body weight	No difference in quantity of fruiting bodies with differing method of harvest. Quantity of	Norvell (1995)

				fruiting bodies did not decrease over time in harvested plots.	

Informational interviews

None of the five informational interviews were aware of any harvesting situations in Minnesota that have led to a decline of fruiting bodies in the following years. Several stories related to the decreased finding of mushrooms only due to another harvester having collected the fruiting bodies first, and the foragers stated this did not mean there were fewer fruiting bodies that grew. These interviewees identified always finding more fruiting bodies nearby, but they had to search to find a new location.

> "There are times when someone else clearly beat me to a patch of morels and I only find a bunch of cut off stumps or someone has harvested a clump of Dryad's saddle before me. So, the availability of mushrooms to ME has sometimes declined, but only because someone else has harvest them, not because there are fewer mushrooms. Even in these cases I usually still find other mushrooms in the area, maybe further from the path or in a harder to get to place." - A. Toczydlowski

All five interviews cited climate change considerations of exacerbating flooding and erosion, and habitat destruction as the two biggest impacts to recurring mushroom populations. Other sources of negative impact are stated as invasive species encroachment, mountain bike trails, pipeline installations, and overengineering of trails. "Less mushrooms are signs of changes in the habitat rather than people taking mushrooms." said Peter Martignacco as he told a story

about chanterelles decreasing at a site, and credited the decreased fruiting bodies found as due to flooding and sedimentation occurring the summer before. He stated fruiting bodies recovered in future years at the same site.

Interviewees also made statements regarding the varied methods they use in harvesting mushrooms, either picking or cutting, depending on the species of mushroom being harvested. All five interviewees identified they will either pull or cut mushrooms, depending on the species, but that mycelium does not stick to the end of the fruiting body so that the disturbance to the mycelium network is minimal. Traditional knowledge has taught foragers sustainable principles in harvesting is to always leave some mushrooms behind and never take the smallest or the largest available.

> "A mushroom is just the fruiting body of a much larger structure. Picking a mushroom is like picking an apple off of a tree, right? Picking an apple off of a tree does not hurt the tree, as long as you're doing it respectfully. We try not to disrupt the mycelial structure underneath or behind the bark, and still, even though we are aware, you know — even off of an apple tree, we wouldn't pick every apple. So, we don't pick every single mushroom that we see. We try to leave some so that they can release their spores."
>
> - L. Black Elk

All interviewees identified the most common issues of harvesting more mushrooms than one can eat occur with those who are young and new to foraging. This underlines the value in education of sustainable harvesting methods.

> "On public lands, I have seen some negative impacts of foraging, but whenever people in my experience, are educated on like protocols and the spirit behind foraging in thinking

> of these plants as relatives instead of just things that we take, it changes. It totally changes the dynamic, I've seen damaged systems go to repaired systems through foraging.” - L. Black Elk

Two interviewees noted the self-limiting nature of harvesting mushrooms that are only available for a short season and then will not fruit again until the following year. One interviewee additionally noted that it is not possible to overharvest mushrooms from a biological sense, because the main portion of the mushroom is the mycelium underneath the ground. No interviewees were concerned about overharvesting mushrooms from an exploitive sense, only from the concern that they should only pick as many as they can process or consume. Because the main portion of the fungus is the mycelium and lives underground, foragers explain that overharvesting is not a possibility because the mycelium is not harvested (Ehlers & Hobby, 2010).

Three interviewees identified that foraging in groups or community promotes sustainable harvesting practices. Interviewees cited control of invasive non-native species, picking up trash, and education on sustainable foraging as common practices among foragers. Two interviewees noted that foragers in groups tend not to over-harvest a single species, because they divvy up what everyone is gathering thus taking the pressure off one species and diversify what is being gathered. “Gathering, harvesting, foraging in community, I think, is more sustainable than harvesting as individuals,” said Linda Black Elk, “we are not meant to forage alone."

DISCUSSION

This paper sought to evaluate the impact of foragers' foot traffic on soil compaction and the removal of fruiting bodies on fruiting body productivity in future years. The results show that large amounts of foot traffic do influence soil compaction. This was an expected result, but what is interesting is that after a certain amount of foot traffic, the impact of foot traffic does not increase. Several studies demonstrate that after initial impacts of 200 passes of foot traffic or two years of use, there is no increasing effect on soil compaction, root growth, or mycelial growth (Cole & Spildie, 1998; Egli et al., 2006; Goeckermann & Bloemendal, 1973; Harris et al., 2003; Hoorman et al., 2011; Lei, 2004; Leonard, 1985; Marion & Cole, 1996). This information should be further evaluated in Minnesota forests and incorporated into permitting considerations in determining an appropriate amount of foot traffic, including that of wildlife, to be allowed in a harvesting area. When considering the carrying capacity of an area for foragers, it is also important to consider the historic wildlife uses of that area and how that might be replicated by human interaction of foraging on public lands.

Humans walking off-trail and causing soil disturbance or potential compaction may very well be mimicking the ancestral land use of the area previously filled with the presence of large land animals such as horses, bison, moose, etc. In many cases these land animals have been pushed out of their native habitat due to urbanization and the introduction of standardized hiking trails and therefore the land does not receive its typical disturbance that it might see from the presence of these animals using the land. Some foragers argue that humans moving in and around off-trail is still less disturbance than would have occurred had these animals been present, as humans are not consuming grass or shrubs like large ungulates.

According to two interviewees, the consideration of wildlife use of the land applies to both invasive species spread as well as soil compaction. One forager identified that foragers do not track into the deeper parts of the woods any additional seeds that coyotes, squirrels, birds, or other wildlife don't already transport. Invasive species transportation and crushing of plants are outside the scope of this study, although these were common topics mentioned in the interviews of local foragers so more research should be dedicated to answering these topics.

Egli and Ayer (1997) demonstrate that the highest fruiting body production plots were those that had no foot traffic and had fruiting body harvest. Soil compaction studies suggest that soil is more compactable in wet spring seasons. Coupled with the research done by Egli et. al (2006) that suggests young fruiting bodies may be crushed by early season foot traffic, these findings demonstrate that the time of year for foot travel could influence the yield of that season. This potential crushing of young fruiting bodies under can be discussed as the need for foragers to be knowledgeable about their surroundings, and cautious about weather conditions and time of year to stay on established trails. Better education about time of year and conditions that foraging should be performed would be a more suitable solution than placing restrictive laws or rules on walking and foraging.

> "I think the interaction of foragers and the land creates a greater appreciation for and understanding of the land. When a person receives the gift of food from the land, I believe they develop a two-way relationship that causes them to be more mindful of our impact on the ecosystem. For example, if I am out in the woods and find a great patch of berries, I am excited to eat them and take them home. This makes me think 'wow, what

> could I do to get more berries here next year.' I think that receiving something from the land makes it more likely that a person will give back to the land." - A. Toczydlowski

The findings by Egli et. al (2006), Norvell (1995), and Ehlers & Hobby (2010), do seem to back up the five interviewee's claims that humans cannot over-harvest mushrooms (Table 3). The removal of fruiting bodies from a plot does not correspond to decreased fruiting body growth in successive years, and in some cases suggests an increased production. It is documented that the method of mushroom harvest, either picking or cutting the stems, also does not affect future fruiting body production (Egli et al., 2006; Norvell, 1995). More research will need to be done to determine if human harvest allows the spreading of spores farther than would be possible without human transport of fruiting bodies, or if that spreading of spores leads to increased mycelium and fruiting body growth in future years.

> "I do *not* believe in the mantra of "leave no trace". You know that whole concept of leave only footprints, I don't believe that, because in our Lakota philosophy, we actually should be having a net positive impact on the natural world, not just net zero." - L. Black Elk

This literature review highlighted the need for research to be conducted that is specific to Minnesota soils and climate conditions. Limitations in drawing conclusions in this systematic review is that only one study had primary research conducted in Minnesota. However, due to Minnesota's varied biomes and landscape, the results were thought to be comparable. The research should include foot traffic impacts in differing soil types of deciduous and coniferous dominated forests, as well as harvest impacts for Minnesota specific species of mushrooms. Foragers' participation would be extremely useful in data collection for the research. Foragers are already spending time in the woods and are passionate about protecting the ecosystems they

collect from. Similar to the Oregon study (Norvell, 1995) which used volunteer mycologists, there are foraging advocacy and education groups such as the Minnesota Mycological Society (MMS) and the Minnesota Foraging Alliance (MNFA) that can provide volunteers to assist with data collection.

Another limitation is that the studies reviewed were conducted for 5-10 years. As some of the researchers identified, ideally a 20-year study would show longer-term trends regarding soil compaction, recovery, and fruiting body growth. Although difficult to obtain funding and consistent volunteers for such a long-term study, this is something that state agencies and or land managers across Minnesota should consider pursuing in partnership with a university in addition to using foragers as research participants.

With more time, I would have sought to conduct further interviews with the remaining 10 people identified. Additional interviews would have increased the number of indigenous knowledge holders, long-time foraging educators, and would have included an additional mycological society president from the Midwest region in the interview documentation. However, the availability of interviewees did not make this possible in the scope of this study.

Due to the increased interest in foraging across the state, as described in the introduction, land managers are starting to think about permitting systems. Other recreational activities such as hunting, fishing, and wild rice harvesting already require permitting systems to manage the carrying capacity of the land and populations. Foragers interviewed are not opposed to permitting systems being put in place for plants. There are many plants that could be harvested from public lands that currently are not allowed and have no permitting system to accommodate. However, upon evaluation of current research, and the response from interviewed foragers, there

is little evidence to support that a mushroom foraging permit is needed. The abundance of fruiting bodies does not seem to be influenced by harvesting in previous years, and foot traffic does not seem to decrease the quantity of fruiting bodies.

Foot traffic off-trail is already allowed on many public lands for hunting, so the quantity of hunting permits would need to be considered in partnership with foraging permits. The discussion here on permitting needs relates to the need for policies and practices regarding personal and recreational foraging and does not apply to commercial or commodification of natural resources which should not be allowed. As two interviewees noted, those who are seeking to harvest for financial gain are not considered foragers seeking land protection practices, but rather considered business people.

Climate change introduces uncertainties and increases potential risks. With predicted increased precipitation, severe weather, and erosion across the state, negative effects can be multiplied. Climate change impacts could be used as a reason why a permitting system, which includes training and recruiting volunteers, is a good idea. Those volunteer scientists will be able to provide data that will help inform practices in response to a changing climate. Foragers are an obvious and easy volunteer basis to recruit from as they are eager to have more public land access and participate in reciprocal relationships with the land.

For millennia, indigenous peoples have cultivated deep understandings of and reciprocal relationships with their ecosystems. The corresponding oral traditions can continue to inform adaptation to environmental shifts as result of a changing climate. Ancestral knowledge, coupled with long-standing practices of sharing knowledge and other goods across vast networks, offer invaluable lessons for our current climate challenges. As Minnesota's climate shifts, we can look

to the wisdom of indigenous communities in regions that experience similar conditions, both historical and contemporary. For instance, when facing drought pressure in Minnesota, the stories and practices of those communities accustomed to arid environments, such as the reciprocal offering of water to plant communities after gathering, as shared by A. Toczydlowski in his interview, can inform our land management strategies for greater resilience.

Restricting off-trail foraging in erosion-prone areas or on saturated ground during heavy rains are tangible applications of traditional ecological knowledge (TEK). Bare ground is susceptible to erosion, especially under extreme rain events. Not walking on ground that is saturated and muddy will prevent soil compaction and further help plant recovery in those areas. Even in one park there may need to be areas where foraging is not allowed due to varied terrain and conditions, however, that does not mean foraging needs to be banned from that entire park. Practices like following deer trails in forests or avoiding single-file walking in grasslands, long observed and shared by indigenous foragers, align with the findings from my systematic review of literature on soil compaction and plant resiliency. By thoughtfully integrating these long-held indigenous principles into land management, such as allowing foraging in designated areas while educating the public about sustainable practices through permitting, we can foster a more reciprocal and resilient relationship with the land.

Climate change effects were not happening at the rapid rate we now see when the land was managed under indigenous people. I do not suggest that foraging practices reverse the impact of climate change, but rather that indigenous practices are applicable and adaptable, perhaps all the more so in the face of anthropogenic climate pressure. We need practices and

policies which adapt to increasing ecological volatility and vulnerability, even if those practices cannot wholly reverse the accelerated change.

Returning foraging to public land provides opportunities for land stewardship and learning. It is a false dichotomy that to preserve nature it must be left alone, because Dakota people have been actively managing the land for millennia. Prescribing burns to allow bison to congregate in an area of a fresh flush of prairie grasses, tending to berry patches to ensure thorny areas are navigable by humans and wildlife as food sources, and many more examples can be shared from indigenous knowledge. The study of indigenous knowledge as applied to climate change impacts is outside the scope of this project, but further evaluation and study of indigenous practices and integration in land management is occurring in other research.

Ultimately, humans have evolved with the land, and our policies need to evolve as well. Overall, findings show that there is an impact from foot travel, although this impact may be just on plant growth and not mycelium. Many foragers seek to minimize any negative impact and seek to increase yield and production throughout an area in their practices. If policies currently do not allow foraging, those should be re-evaluated with scientific evidence. Permitting systems could require foragers to volunteer a certain number of hours in data collection or invasive species or trash removal to ensure a positive impact on the land. Experienced foragers already perform these practices as reciprocity with their harvest. Permitting systems could require new foragers to take a sustainable harvest class to learn reciprocity principles. Permitting system education would be a great way to teach new foragers how to reduce the spread of invasive species by cleaning equipment properly, how to correctly identify plants and/or mushrooms, collect useful data, and how to avoid harvesting too much from an area because of excitement.

Mentorship programs could also be used, requiring first-time permit applicants to go on a foray with an experienced forager to fulfill their training requirement. Mentorship programs would allow for training on foraging to be ongoing, interactive, and not only conducted indoors with PowerPoint slides. It would mitigate the concerns over new foragers taking more than they can reasonably consume, and train more stewards of the land. Promoting foraging on public land provides potential opportunities for data collection and contributions to sustainable land practices.

> "People have a scarcity mindset toward nature, mostly due to western esotericism, and think foragers will destroy it…a land of foragers would have larger budgets for public land, they would be more knowledgeable, leading to positive 2nd and 3rd order effects, they would volunteer at much higher rates to remove invasive species and plant native species on their own time. When we change the paradigm, foraging becomes a necessity for the health of our public lands over the next 300 years" (T. Clemens, personal communication, February 6, 2025).

REFERENCES

Minnesota Legislature. (2008, June 11). 6100.0900—MN Rules Part. https://www.revisor.mn.gov/rules/6100.0900/

Alan Bergo (Director). (2023, July 4). *Freedom Day PSA for Mushroom Hunters and Foragers in MN.* [Instagram Video]. https://www.instagram.com/reel/CuSzYhgqmCy/?utm_source=ig_web_copy_link&igsh=MzRlODBiNWFlZA==

Bellows, A. C., Raj, S., Pitstick, E., Potteiger, M. R., & Diemont, S. A. W. (2023). Foraging Wild Edibles: Dietary Diversity in Expanded Food Systems. *Nutrients*, *15*(21), 4630-. https://doi.org/10.3390/nu15214630

Black Elk, L. (2025, February 13). *Informational Interview—Linda Black Elk* [Personal communication].

United States Census Bureau. (2023). *American Community Survey 5-Year Data (2009-2023)*. Census.Gov. Retrieved March 15, 2025, from https://www.census.gov/data/developers/data-sets/acs-5year.html

Clemens, T. (2023, July 30). Minnesota DNR Proposed Rule Changes—Foraging [Blog]. *Ironwood Foraging*. https://ironwoodforaging.com/blog/f/minnesota-dnr-proposed-rule-changes---foraging

Clemens, T. (2025, February 6). *Informational Interview—Tim Clemens* [Personal communication].

Clemens, T. (2025, February 17). *Research Paper—Ironwood Foraging Metrics*. https://www.instagram.com/ironwoodforaging/

Minnesota Department of Natural Resources (DNR). (2025). *Climate trends*. Retrieved March 15, 2025, from https://www.dnr.state.mn.us/climate/climate_change_info/climate-trends.html

Cole, D. N. (1995). Experimental Trampling of Vegetation. I. Relationship Between Trampling Intensity and Vegetation Response. The Journal of Applied Ecology, 32(1), 203–214. https://doi.org/10.2307/2404429

Cole, D. N. (1987a). Research on soil and vegetation in wilderness: a state-of-knowledge review. Pages 135-177. U.S. Forest Service General Technical Report, INT-220.

Cole, D. N. (1987b). Effects of three seasons of experimental trampling on five montane forest communities and a grassland in Western Montana, USA. *Biological Conservation*, *40*(3), 219–244. https://doi.org/10.1016/0006-3207(87)90087-5

Cole, D. N., & Spildie, D. R. (1998). Hiker, horse and llama trampling effects on native vegetation in Montana, USA. *Journal of Environmental Management*, *53*(1), 61–71. https://doi.org/10.1006/jema.1998.0192

Dance A. (2017). Inner Workings: Special relationship between fungi and plants may have spurred changes to ancient climate. 114(46), 12089–12091. https://doi.org/10.1073/pnas.1716319114

David, P., Jana, R., Radka, S., Jan, J., & Michael, B. (2024). Soil compaction reversed the effect of arbuscular mycorrhizal fungi on soil hydraulic properties. *Mycorrhiza*, *34*(4), 361–368. https://doi.org/10.1007/s00572-024-01153-9

Design, V. (2016, October 20). Minnesota deer facts. Minnesota Conservation Federation. https://www.mncf.org/minnesota-deer-facts/

Drimel, J. (2025, February 4). *Permits issued in 10 years* [Personal communication].

Eagleston, H., & Marion, J. L. (2017). Sustainable campsite management in protected areas: A study of long-term ecological changes on campsites in the boundary waters canoe area wilderness, Minnesota, USA. Journal for Nature Conservation, 37, 73–82. https://doi.org/10.1016/j.jnc.2017.03.004

Egli, S., Peter, M., Buser, C., Stahel, W., & Ayer, F. (2006). Mushroom picking does not impair future harvests – results of a long-term study in Switzerland. *Biological Conservation*, *129*(2), 271–276. https://doi.org/10.1016/j.biocon.2005.10.042

Ehlers, T., & Hobby, T. (2010). Chanterelle Mushrooms on Vancouver Island, British Columbia. *BC Journal of Ecosystems and Management*, *11*(1 & 2).

Frene, J. P., Pandey, B. K., & Castrillo, G. (2024). Under pressure: Elucidating soil compaction and its effect on soil functions. *Plant and Soil*, *502*(1–2), 267–278. https://doi.org/10.1007/s11104-024-06573-2

Goeckermann, K., & Bloemendal, J. A. (1973). *Newly Developed Campsites in the Boundary Waters Canoe Area: A Study of Five Years' Use.* https://hdl.handle.net/11299/163831

Hagerman, S. M., Jones, M. D., Bradfield, G. E., Gillespie, M., & Durall, D. M. (1999). Effects of clear-cut logging on the diversity and persistence of ectomycorrhizae at a subalpine forest. *Canadian Journal of Forest Research, 29*(1), 124-134. Retrieved from https://www.proquest.com/scholarly-journals/effects-clear-cut-logging-on-diversity/docview/230522180/se-2

Harris, K., Young, I. M., Gilligan, C. A., Otten, W., & Ritz, K. (2003). Effect of bulk density on the spatial organisation of the fungus Rhizoctonia solani in soil. *FEMS Microbiology Ecology*, *44*(1), 45–56. https://doi.org/10.1111/j.1574-6941.2003.tb01089.x

Minnesota Department of Natural Resources (DNR). (n.d.). Harvesting plants. Minnesota Department of Natural Resources. Retrieved March 1, 2025, from https://www.dnr.state.mn.us/state_parks/harvesting.html

Hayes, A. (2020). *Minnesota Travel and Tourism Landscape During the Pandemic*. Explore Minnesota, September 2, 2020. Retrieved from https://www.exploreminnesota.com/media-room/news-releases/minnesota-travel-tourism-landscape-during-pandemic

Hoorman, J. J., de Moraes, J. C., & Reeder, R. (2011). The Biology of Soil Compaction. *Science*, 583–587.

American Immigration Council. (2023). *Immigrants in Minnesota*. Retrieved March 15, 2025, from https://map.americanimmigrationcouncil.org/locations/minnesota/

The Writing Center. (2025). *Incorporating Interview Data*. Retrieved March 1, 2025, from https://writing.wisc.edu/handbook/assignments/interviewdata/

Johnson, N. C., Gehring, C., & Jansa, J. (2016). *Mycorrhizal Mediation of Soil: Fertility, Structure, and Carbon Storage*. Elsevier. http://ebookcentral.proquest.com/lib/montana/detail.action?docID=4733958

Juliot, J. (2024, December 10). Explore Minnesota Reports Record-Breaking Tourism Growth in 2023 | Explore Minnesota. https://www.exploreminnesota.com/media-room/news-releases/explore-minnesotareports-record-breaking-tourism-growth-2023

Kennedy, T. (2023, June 29). *Conflict sprouting over wild mushroom hunting in Minnesota as DNR considers bag limits*. The Minnesota Star Tribune. https://www.startribune.com/conflict-sprouting-over-mushroom-hunting/600286041

Lei, S. A. (2004). Soil Compaction from Human Trampling, Biking, and Off-Road Motor Vehicle Activity in a Blackbrush (Coleogyne Ramosissima) Shrubland. *Western North American Naturalist*, *64*(1), 125–130.

Leonard, R. E., McMahon, J. L., & Kehoe, K. M. (1985). Hiker Trampling Impacts on Eastern Forests. Northeastern Forest on Eastern Forests Experiment Station.

Marion, J. L., & Cole, D. N. (1996). Spatial and temporal variation in soil and vegetation impacts on campsites. *Ecological Applications*, *6*(2), 520–530. https://doi.org/10.2307/2269388

Martignacco, P. (2023). *MMStoGovWalzJune2023*. https://www.documentcloud.org/documents/23884585-mmstogovwalzjune2023/

Martignacco, P. (2024, October 7). *Personal communication—Foraging Town Hall* [Hosted by Senator Po]. Foraging Town Hall.

Martignacco, P. (2025, February 6). *Informational Interview—Peter M.* [Personal communication].

Minnesota Foraging Alliance (MNFA). (2025, January 10). *Minnesota Foraging Alliance—Mission, Vision, Values*.

Minnesota Department of Natural Resources (DNR). (n.d.). Minnesota state park and recreation area rules. Retrieved March 15, 2025, from https://www.dnr.state.mn.us/state_parks/rules.html

Minnesota Sustainable Foraging Taskforce. (n.d.). Retrieved March 15, 2025, from https://ironwoodforaging.com/blog/f/minnesota-sustainable-foraging-taskforce

Mohtasham, D. & Manoush, Z. (2021, September 9). Meet Alexis Nikole Nelson, The Wildly Popular "Black Forager." *NPR*.

Minnesota Pollution Control Agency (MPCA). (2024, July 12). Environmental Justice—Minnesota Geospatial Commons. https://gisdata.mn.gov/sv/dataset/env-ej-mpca-census

Nadian, H., Adelaide U., Smith, S. E., Alston, A. M., & Murray, R. S. (1996). The effect of soil compaction on growth and P uptake by Trifolium subterraneum: Interactions with mycorrhizal colonization. Plant and Soil, 182(1), 39–49. https://doi.org/10.1007/BF00010993

Nelson, T., & Stockton, G. (2023, July 21). *Minnesota DNR's potential park rule changes get pushback from fungi foragers*. MPR News. https://www.mprnews.org/story/2023/07/21/minnesota-dnrs-potential-park-rule-changes-get-pushback-from-fungi-foragers

Norvell, L. (1995). Loving the chanterelle to death? The ten-year Oregon Chanterelle Project. Journal of American Amateur Mycology, 12(1), 6–26.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. BMJ, 372, n160. https://doi.org/10.1136/bmj.n160

Peterson, J. B. (2025, February 16). *Informational Interview—JB* [Personal communication].

Pierce, A. (2024, May 20). *Personal Communication—DNR & MMS* [Meeting]. Meeting regarding foraging laws on public land

Minnesota Legislature. (2024). Sec. 116.065 MN Statutes. Retrieved March 24, 2025, from https://www.revisor.mn.gov/statutes/cite/116.065

Serraj, R. (with Pingali, P. L.). (2018). *Agriculture & Food Systems To 2050.* World Scientific Publishing Co.

Sheffi, Y. (2021). What Everyone Gets Wrong About the Never-Ending COVID-19 Supply Chain Crisis. https://learning.oreilly.com/library/view/what-everyone-gets/53863MIT63213/

Skalkos, D. (Ed.). (2022). *Innovative Agrifood Supply Chain in the Post-COVID 19 Era*. MDPI - Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/books978-3-0365-4187-7

Smith, K. (2024, March 2). *MN starts new outdoor rec office*. https://www.startribune.com/minnesota-launches-new-outdoor-recreation-office-in-a-bid-to-be-top-10-state-for-recreation/600347697

University of Minnesota Extension. (2018). Soil compaction. https://extension.umn.edu/soil-management-and-health/soil-compaction

Strommen, S. (2025, January 10). *Personal Communication, DNR round table* [Personal communication].

Templin, J. (2023). *Possible Amendments to Rules Governing Use of State Parks, State Recreation Areas and Waysides, State Trails, and Forest Lands.* Minnesota Department of Natural Resources. Retrieved January 15, 2025 from https://www.dnr.state.mn.us/input/rules/parks/rule_revisions.html

Thorud, D. B., & Frissell, S. S. (1969). Soil Rejuvenation Following Artificial Compaction in a Minnesota Oak Stand. *University of Minnesota Forestry Library*, *208*.

Toczydlowski, A. (2025, February 8). *Informational Interview—Alan T.* [Personal communication].

Weaver, T., & Dale, D. (1978). Trampling effects of hikers, motorcycles and horses in meadows and forests. The Journal of Applied Ecology, 15(2), 451–457. https://doi.org/10.2307/2402604

Wesserle, M. (2023, September 25). Take Action to Protect Foraging in Minnesota. Four Season Foraging. https://www.fourseasonforaging.com/blog/2023/8/5/take-action-to-protect-foraging-in-minnesota

Wesserle, M. (2025, February 18). *Research Paper—FourSeasonForaging Metrics* [Personal communication].

Wilsey, D., & Miedtke, J. (2013). *Minnesota Harvester Handbook, First Edition*. https://hdl.handle.net/11299/173824sal

APPENDICES

APPENDIX A

INFORMATIONAL INTERVIEWS

Interview Method

A set of standard questions to ask that relate to their foraging practices on public land, their sustainable foraging principles, their reciprocity principles, and their anecdotal evidence on the impacts of foragers. Used an audio or video recording that automates a written transcript from the audio to aid in note taking for the final synthesis of the information, or provided the option for written answers to include in an appendix at the end of the thesis.

Context

The answers to these questions will be used in Leya Charles' thesis paper titled "Symbiotic harvest - evaluating the impact of anthropogenic harvest of mycelial fruiting bodies forest ecosystem health on public land." You have the option of providing your name and title along with the answers to your questions, or to remain anonymous. Your answers will be included in an appendix at the end of the paper and cited as "personal communication."

This paper will be published by Montana State University and housed in their ScholarWorks database (https://scholarworks.montana.edu/). Please let me know if you have a proprietary conflict regarding answers to the questions that should not be included.

Interview questions

1. Foraging Practices on Public Land

- How often do you forage on public lands, and what areas do you typically visit?
- What types of mushrooms do you primarily forage for, and what methods do you use to identify them?

- Are you familiar with any regulations or guidelines regarding foraging on public lands? If so, how do you ensure that you follow them?
- What tools or techniques do you use when harvesting mushrooms to minimize disturbance to the environment?
- How do you determine how much to harvest from a specific area or patch?

2. Sustainable Foraging Principles

- How do you define "sustainable foraging" in your practice?
- What steps do you take to ensure that your foraging activities do not negatively affect the local mycelial networks or the overall health of the forest ecosystem?
- Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? If so, how do you make these decisions?
- How do you manage your harvesting activities to prevent over-harvesting of any particular species?
- Are there specific foraging seasons or conditions under which you refrain from harvesting, to allow fungi populations to regenerate?

3. Reciprocity Principles

- Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?
- How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think foragers play in maintaining ecosystem health?

- Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?
- Are there any traditional or cultural practices that inform your foraging behavior, especially in relation to stewardship of the land?

4. Anecdotal Evidence on the Impacts of Foragers

- From your perspective, how has foraging impacted the ecosystems you've visited? Have you seen any positive or negative effects over time?
- Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent? Do you think this is due to human harvesting activities?
- Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of over-harvesting in certain locations?
- Have you observed any changes in biodiversity in the areas where you forage, either as a result of human activity or natural changes?
- How do you think the presence of multiple foragers in a forest could affect its ecosystem health? Do you think there is a threshold for sustainable foraging in specific areas?

Transcripts included below are non-verbatim as described in Incorporating Interview Data – The Writing Center – UW–Madison

Tim Clemens

Ironwood Foraging Co.

Experience: 16 years of foraging

February 6, 2025

1. **Foraging Practices on Public Land**

How often do you forage on public lands, and what areas do you typically visit?

From late April through October, I forage on public lands multiple times per week. Teaching classes or scouting for these classes accounts for 1-5 weekly visits. Gathering for myself is 1-2 additional visits. The areas I typically visit are Minneapolis Parks, various county and regional parks, Minnesota and Wisconsin State Parks and State Forests, Minnesota Wildlife Management Areas, and US Forest Service land.

What types of mushrooms do you primarily forage for, and what methods do you use to identify them?

I forage for probably 200-300 species, focusing on edible species. Maybe more species, but not less. Everything from the first Gyromitra of April, to the Clitocybe and Flammulina of November. I identify them mostly through peer-to-peer interaction on Facebook, followed by using websites and books to verify. It depends though. When I first started out, I used field guides and in-person experts telling me what something was, which I remembered by rote and then associative learning.

Are you familiar with any regulations or guidelines regarding foraging on public lands? If so, how do you ensure that you follow them?

I am familiar with the guidelines and have my finger to the pulse of many changes. The guidelines are somewhat of a byzantine mosaic when considering all the different land management organizations and crossing state lines, but like any skill you learn it over time.

What tools or techniques do you use when harvesting mushrooms to minimize disturbance to the environment?

I mostly stay on trail or on deer paths. I do "intentional walking" whenever off trail. I teach this in my classes too. It involves an increased visual awareness so we're not stepping on plants. If that is unavoidable, there is a sort of "shimmy" of the foot on the descent that can help move plant stems so they don't snap or have a chance to move out of the way. This change is also cultural. Many people think that "bushwhacking" is the only, or best, way to find mushrooms.

How do you determine how much to harvest from a specific area or patch?

I first evaluate land history and trajectory of this spot. Then I quantify the local abundance or lack thereof. I then determine if the plant is native or invasive. Natives are taken much less. Invasives are taken in abundance. I also consider what part of the plant I'm harvesting. Is it a vegetative structure? If so, does it kill the plant? Does it kill the plant but help the colony? Or can the plant afford to part with some. If an item is a fruiting body, I spread the seeds/spores some distance away to offer gratitude.

2. **Sustainable Foraging Principles**

How do you define sustainable foraging in your practice?

I call it reciprocal conservation. There should be reciprocity between you and whatever you're harvesting. Whenever possible, there should be positive reciprocity, meaning you give more than you take. This can look vastly different depending on species (and their dependents), the person, the times, and setting.

What steps do you take to ensure that your foraging activities do not negatively affect the local mycelial networks or the overall health of the forest ecosystem?

Again, I stick mostly to trails, then deer paths, then intentional walking. I also cut down invasive shrubs and pull invasive herbaceous plants in spots and pick up trash when I find it.

Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? If so, how do you make these decisions?

In my experience, you'll usually find mushrooms at different states of maturity in a patch. I leave undersized mushrooms and over-mature mushrooms in place. As 99% of spores fall within 1 meter of the fruiting body (for terrestrial mushrooms), I often disperse these fruiting bodies into a wider area on suitable host species or substrate. For native plant

fruiting bodies, I will often spit seeds, broadcast, or intentionally plant seeds in suitable habitat.

How do you manage your harvesting activities to prevent overharvesting of any particular species?

Evaluating a site is critical. Not just what's in front of you, but temporally (will this change over time?), socially (what is the harvest pressure?), and then botanically (is this native? Is this ideal habitat? How does this species react to harvest?) with that careful evaluation in place, I decide how to engage with this plant positively.

Are there specific foraging seasons or conditions under which you refrain from harvesting, to allow fungi populations to regenerate?

For fungi, there aren't any seasons I avoid or conditions I avoid. Although, in a burned area, in 3-5 years when the terrestrial mushrooms come back (if they do), that first year back I will help disperse the entire harvest and not take any.

3. **Reciprocity Principles**

Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?

I always seek to be in positive reciprocity with whatever I'm harvesting. Whether that is harvesting in a good way, refraining from harvest, propagating the species, picking up

trash, invasive species removal, or teaching people how to do this to magnify my effect. I also donate money or in-kind donations to organizations aligned in this goal. Culturally, I will offer tobacco or red osier dogwood bark and kneel to pray in the Ojibwe language in gratitude. Especially for maple and birch syrup, wild rice, oak trees, and hickory groves.

How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think foragers play in maintaining ecosystem health?

In this culture and at this time, I think foragers are critical to the well-being of forests and every other ecosystem. This could be an essay in itself, but my main thrust is that we need incentivized groups of highly motivated citizens to care about very specific areas of land and water and to understand the rhythms of these areas. Pigeonholing nature has led to a decline in nature literacy and protections. Foraging widens the nature support base and increases nature ethic simultaneously.

Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?

The biggest negative changes in population I see are the steady encroachment of invasive species, the overengineering of trails and pavement, and off-label herbicide use killing native species from overspray on public land. I've had a positive impact by relocating native species from proposed trailway and pipeline construction. If there were more people doing what I do, we could make a meaningful positive difference on public land.

Are there any traditional or cultural practices that inform your foraging behavior, especially in relation to stewardship of the land?

My Swedish and Ojibwe heritage, plus my own personal culture, inform my foraging behavior. Concepts like the Swedish "Allemansrätten" and the Ojibwe "Bimaadiziwin".

1. **Anecdotal Evidence on the Impacts of Foragers**

From your perspective, how has foraging impacted the ecosystems you've visited? Have you seen any positive or negative effects over time?

I have seen no negative impact of my foraging practices since I began in 2009. The negative changes I see are due to the mismanagement of invasive species, which despite my best efforts, have encroached on all my metro area foraging spots. My victories are when native species I've planted, or transplanted, produce seed or clones.

Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent? Do you think this is due to human harvesting activities?

Mushroom availability has stayed very level. Perhaps interesting to note is that in my decade of foraging mushrooms, half of that has been severe drought. Human harvest pressure, while more noticeable in the closest metro area public land (Afton State Park and Lebanon Hills Regional Park, for instance). The biggest negative impacts I've seen are two mountain bike trails in Battle Creek Regional Park and Theodore Wirth Regional Park, which have destroyed mushroom patches and led to intense invasion by invasive species.

Also a gas pipeline laid under Lebanon Hills Regional Park led to a massive and unchecked influx of invasive species.

Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of over-harvesting in certain locations?

I think generally other foragers are mindful and more than that are open to improving. However, there is a subset of people harvesting for financial gain and these people sometimes lack a nature ethic, damaging populations. Even when someone is harvesting for personal use, they may lack the knowledge required to harvest sustainably. There must be greater outreach to help people be better foragers. I encountered a group of latino women in 2019 harvesting Cinnamon Fern fiddleheads in Reservoir Woods Park. It is illegal to do this. They were also harvesting unsustainably by taking every frond from each cluster. The Hmong community also is very worried about overharvest (according to a town hall meeting with Senator Pha in 2024) as there are people who overharvest Solomon's Seal, brack fern, and ostrich fern. Ramps are overharvested in the metro area across all foraging groups (but mostly due to destruction of habitat). Most of this problem will be solved by better education, which will take generations.

Have you observed any changes in biodiversity in the areas where you forage, either as a result of human activity or natural changes?

Drastic increase of invasive species in the metro area. Mostly caused by MNDOT, development, mismanagement of public lands, low-funding, low-prioritization, etc.

How do you think the presence of multiple foragers in a forest could affect its ecosystem health? Do you think there is a threshold for sustainable foraging in specific areas?

I like to describe it this way: the best candlemakers couldn't have made the light bulb. The paradigm had to fundamentally change first with the creation of electricity and the infrastructure to supply it. In that same way, people have a scarcity mindset toward nature, mostly due to western esotericism, and think foragers will destroy it. Yes, that's possible, but it's also candlemaker mentality. A land of foragers would have larger budgets for public land, they would be more knowledgeable leading to positive 2nd and 3rd order effects, they would volunteer at much higher rates to remove invasive species and plant natives (on their own too!). When we change the paradigm, foraging becomes a necessity for the health of our public lands over the next 300 years.

Alan Toczydlowski

Research Professional, Department of Forest Resources, UMN

Experience: 30+ years of foraging

February 7, 2025

1. **Foraging Practices on Public Land**

How often do you forage on public lands, and what areas do you typically visit?

In the spring, summer, and fall I forage on public lands probably once per week on average, but will often forage 3-4 times per week when certain mushrooms or fruits are in season. I

mostly forage in the metro area so I utilize county and city parks a lot. I also forage on state forest land when I'm traveling in greater Minnesota.

What types of mushrooms do you primarily forage for, and what methods do you use to identify them?

I have personally identified, harvested, and consumed more than 25 species species of mushrooms including Honey mushroom, Giant puffball, Golden chanterelle, Dryad saddle, Shrimp of the woods, Hen of the woods, Sweet tooth (hedgehog) mushroom, Purple-gilled laccaria, Chicken of the woods, Black morel, Yellow morel, Half-free morel, Golden oyster mushroom, oyster mushroom, Hemileccium subglabripes, Lobster mushroom, Entoloma abortivum (un-aborted), Shaggy mane mushroom, Black trumpet mushroom, Leccinum scabrum, Elm oysters, Blewits, Yellowfoot chanterelle, Chaga, Bear's Head Hericium, and Late fall oysters. I intentionally seek out and harvest the greatest quantities of chanterelles, morels, hen of the woods, chicken of the woods, honey mushroom, and purple laccaria. I use several field guides and mushroom books in tandem to identify new mushrooms, however I commonly am introduced to a species in a foraging class before seeking it out on my own.

Are you familiar with any regulations or guidelines regarding foraging on public lands? If so, how do you ensure that you follow them?

I know there are regulations and restrictions on most public land and I have a general idea which places don't allow collection of plants and/or mushrooms. My first resource I check

for a new location is Google. I also have used the DNR website and its pages for specific areas.

What tools or techniques do you use when harvesting mushrooms to minimize disturbance to the environment?

I usually stay on designated or well-used walking paths until I see mushrooms, then I will leave the path to look for more. When off trail, I am careful to not step on sensitive (native) plants. I will also commonly remove invasive plants as I am foraging.

How do you determine how much to harvest from a specific area or patch?

I am not concerned about harvesting too many mushrooms from any given area from a biological (reproductive) perspective. I consider other foragers and intentionally leave some behind for them. Typically, I harvest as many mushrooms as I know I can eat or preserve without wasting any. Many mushrooms are difficult to spot so I know even if I take every fruiting body I see, there are others that I am leaving behind.

2. **Sustainable Foraging Principles**

How do you define "sustainable foraging" in your practice?

I consider my harvest to be sustainable when I have no doubt that I can come back next year and expect to find just as many if not more of the species I am harvesting.

What steps do you take to ensure that your foraging activities do not negatively affect the local mycelial networks or the overall health of the forest ecosystem?

I am careful not to damage native plants when foraging. I remove invasive species from the places I forage. I only pick mushrooms that are in prime condition and only take what I'm sure I will use to not waste any.

Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? If so, how do you make these decisions?

I typically only harvest mushrooms that are in prime condition. I leave the ones that are too small to eat as well as the ones that are on the older side. With large fruiting bodies such as chicken of the woods, I will take the parts in the best condition and leave the more mature, tougher parts behind. I also don't usually pick mushrooms until I see several of them to ensure I will have enough to make it worth cooking. This way I'm not picking one or two only to toss them because I didn't get enough for a meal.

How do you manage your harvesting activities to prevent overharvesting of any particular species?

The only fungi I have concern about overharvesting is chaga because it is a slow-growing fungi. I don't harvest a lot of chaga, and I typically only take a portion of each one I find when I do harvest.

Are there specific foraging seasons or conditions under which you refrain from harvesting, to allow fungi populations to regenerate?

I mostly harvest mushrooms in wet seasons when they are abundant. During times of drought, I don't harvest much because it's generally not worth my time to search a large area and only find a few mushrooms. I guess this allows the few mushrooms to release spores, but I do it more from an efficiency perspective than an ecological perspective.

3. **Reciprocity Principles**

Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?

My most impactful actions are the removal of invasive species and trash from the areas I forage. I have considered carrying water for the plants I forage in the dry season, but haven't actually done this yet. I always express my gratitude mentally to the plants, fungi, and forest when foraging.

How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think foragers play in maintaining ecosystem health?

I think the interaction of foragers and the land creates a greater appreciation for and understanding of the land. When a person receives the gift of food from the land, I believe they develop a two-way relationship that causes them to be more mindful of our impact on the ecosystem. For example, if I am out in the woods and find a great patch of berries, I

am excited to eat them and take them home. This makes me think "wow, what could I do to get more berries here next year". I think that receiving something from the land makes it more likely that a person will give back to the land.

Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?

I have not personally noticed changes in fungal communities other than weather related population cycles. I have seen places where there is a direct link to abundance of mushrooms and lack of invasive species. For example, in a popular park in the metro area, I noticed that the trees that produce good flushes of morels have a circle of cleared garlic mustard around them. Neighboring trees that don't produce morels are thick with garlic mustard. While the direct impacts like this are important, I also think that foragers develop a greater care for the land and are likely to support and develop policy that positively affects natural areas where they might forage.

Are there any traditional or cultural practices that inform your foraging behavior, especially in relation to stewardship of the land?

As a child, I was raised to respect the land and its inhabitants. As an adult I have been more involved with Native communities and exposed to their practices of giving back and expressing gratitude towards the land. Literary works like Robin Wall-Kimmerer's have also been influential in my perception of the land.

4. **Anecdotal Evidence on the Impacts of Foragers**

From your perspective, how has foraging impacted the ecosystems you've visited? Have you seen any positive or negative effects over time?

As mentioned above, I have noticed the removal of invasive species in popular foraging areas. I have also unfortunately noticed the decline of an already tiny population of ramps in a couple metro area parks. I think most people's foraging activities are neutral and don't greatly affect the environment positively or negatively.

Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent? Do you think this is due to human harvesting activities?

There are times when someone else clearly beat me to a patch of morels and I only find a bunch of cut off stumps or someone has harvested a clump of Dryad's saddle before me. So, the availability of mushrooms to myself as an individual has sometimes declined, but only because someone else has harvested them, not because there are fewer mushrooms. Even in these cases I usually still find other mushrooms in the area, maybe further from the path or in a harder to get to place.

Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of over-harvesting in certain locations?

I have noticed the decline of an already minimal population of ramps along the Mississippi River in the metro area, but I do think that most foragers are aware of their impacts on the land and are mindful of sustainability.

Have you observed any changes in biodiversity in the areas where you forage, either as a result of human activity or natural changes?

Many parks in the metro area are choked with garlic mustard and buckthorn. However, lots of these areas are also receiving management to remove the invasive species. The efforts to remove invasives are much more obvious than the spread may be in other areas.

How do you think the presence of multiple foragers in a forest could affect its ecosystem health? Do you think there is a threshold for sustainable foraging in specific areas?

Yes, I think multiple foragers have a greater chance of producing a positive change in forests. It's easier to accomplish change with more hands involved. When foraging things like fruits, nuts, and mushrooms I think the threshold is the amount of food produced. When the berries are gone, you can't harvest more, but they will be back next season. When harvesting plants (leaves, roots, flowers, etc.) there is a limit to what can be harvested, but if done right it can be sustained for many people. If I pinch off the top of a hyssop plant at the right time, it will produce twice as many flowers allowing for both greater harvest and greater reproduction later. So yes, there is a threshold to sustainable harvest for a given area, but I think it is pretty high, especially if each forager has that in mind.

JB Douglas

Marketing communications manager, Wild Grocery & freelance work in wild food space

Experience: 6 years foraging

February 16, 2025

1. **Foraging Practices on Public Land**

How often do you forage on public lands, and what areas do you typically visit?

Fairly frequently I'm foraging in public spaces. Often from spots that are the edge of a park or a tree lawn, urban spaces, or the side of a road. I am respectful of the rules that are set up and do not go out to forage in spaces that do not allow it.

What types of mushrooms do you primarily forage for, and what methods do you use to identify them?

Pheasant backs, chanterelles, chicken, maitake, wood ear, amber jelly roll, morel, black trumpet, puffballs, shaggy mane or ink caps. There are also some species I harvest for crafting purposes but not for eating.

Only harvest ones that are really easy to identify, and really hard to mess up. I rely on experience and knowledge from books, video, social media, friends, teachers who are more experienced mycologists than myself, also some training from mushroom mountain company.

Are you familiar with any regulations or guidelines regarding foraging on public lands? If so, how do you ensure that you follow them?

I live in Cleveland, Ohio. I completed a masters degree project about the legality of foraging of mushrooms in the state of Ohio. It details what those regulations look like, and how they are different from state to state and park to park. The unenforceability of the

regulations and how gray they are is confusing for people. I bring more nuance to the conversation then many people do. In the Cleveland Metro Parks where I frequent for pleasure and daily walks, it is strictly forbidden to take anything at all. Therefore in those areas I am careful to not pull plants by the root, cut plants, or go there specifically with the intent of foraging. However, I do still harvest to a small degree things like berries or a large log of chicken of the woods in the summer. In those instances, there are many many pounds of food, and I will only harvest what I can eat for dinner that night. The rules need to be more inclusive and thoughtful about including foragers and indigenous people in the regulations. There is broad community support in the Cleveland community to defend this position of why occasional foraging should be allowed in the parks.

What tools or techniques do you use when harvesting mushrooms to minimize disturbance to the environment?

I am often lacking the knife, so I will pull a mushroom up if it is safe to do so. Mycelium does not stick to the fruiting bodies. I'll hand-harvest whatever I can and throw it into my pockets, bag, or fanny pack.

How do you determine how much to harvest from a specific area or patch?

There are several ways to evaluate this. One is the assessment of abundance. In my experience I've seen enough mushroom patches and often go back to the same places several years in a row. So I have an idea of what is a lot for that particular area, or what

feels like a large flush. I also don't harvest anything unless I have an idea of what I am going to use it for immediately. Some people get into the habit of collecting for the pantry of items that get consumed later, because the act of foraging is more stimulating than the actual utilization of it later. But for me personally I only collect what I know I can utilize within that season, such as enough for one jar of pickles. However, there are times when there are fall flushes of abundance where storage of mushrooms makes sense so they don't go to waste. Examples of that are amber jelly rolls or golden oysters that proliferate and many people consider them an invasive species that outcompetes native mushrooms. I take higher percentages of those because I know there will be a lot more of them quickly and these species have no trouble spreading in abundance.

You cannot apply a quantitative metric to it, or you lose the nuance of experience in knowing how much is too much to harvest in an area. It comes down to knowing the context they are in, knowing the nature of the species, and noticing those patterns over time.

2. **Sustainable Foraging Principles**

How do you define "sustainable foraging" in your practice?

I don't have a condensed answer for this because this is what my Masters project looked at. My research was about sustainable food systems as it related to the foraging community in North America. When folks talk about the concept of sustainability there are three generalized pillars people tend to agree on. No matter what the definition of sustainability looks like, it should be socially sustainable, economically sustainable, and environmentally sustainable. These are broad concepts we can break down into about 1,000 different pieces.

To me, what makes it sustainable is that I'm harvesting in a way that supports or proliferates or reinforces a population or species that are native or beneficial to the ecosystem they grow in. It is also important that I am helping to cull, mitigate, or temper the proliferation of species that can be invasive or detrimental to the overall ecosystem. Sustainability also includes the thought about the cultural practice of how the mushroom is used. For example, puffball mushrooms proliferate easily. I could harvest 10 lbs of puffball and not make a dent in the quantity of puffball mushrooms in the forest. However, if those 10 lbs of mushroom aren't being consumed, then that is not a sustainable practice to be harvesting unless they are being used. That is not socially sustainable. There needs to be a reflection or acknowledgement of how the person is interacting with the mushroom, consuming or using it, and that needs to play a part in the sustainability conversation while still allowing the key driver to be focused on biodiversity and environmental sustainability.

What steps do you take to ensure that your foraging activities do not negatively affect the local mycelial networks or the overall health of the forest ecosystem?

Most of the species I am interested in are harvested off of deadwood or sticks that have fallen. Such as chicken of the woods, hen of the woods, etc. I know when that season for those woody mushrooms is going to be and keep a knife handy with me during that season, because otherwise it would be cumbersome and frustrating to try to harvest those species with my hands. If I am harvesting mushrooms from those that grow terrestrially in the soil, I am more focused on the gentle pull. It doesn't cross my mind to not disturb the mycelial layer because the mycelium does not stick to or is affected by harvesting.

Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? If so, how do you make these decisions?

When I was a more novice forager, I wasn't able to see the full scale of what this particular mushroom looks like over the course of the season, so I was less discerning about when to harvest or perhaps took mushrooms that were too old.

As I've grown in experience, I've been able to narrow down and be selective that just because there is a beautiful chicken of the woods in front of me right now doesn't mean I have to harvest it. It is species by species specific in needing to understand the maturity level of that mushroom and what that mushroom looks like from younger, to mature, to past prime. Some in fact I only want at one stage where I know it's going to be what I like culinarily. So I have narrowed the scope into what I want, and what is best for the species. Definitely leave older mushrooms behind to mature or disperse spores, and don't take the first mushroom you see. Similar to the Robin Wall Kimmer quote – don't harvest the first you see because it might be the last. I think as a novice forager it's really hard to not be so excited that you have just positively identified a mushroom for the first time and want to grab it. Then you get home and realize that might not have been the best choice for the population or how you like to cook it. Some of this experience comes with learning from more experienced people, and being out there more and more and doing more observing then harvesting.

How do you manage your harvesting activities to prevent over-harvesting of any particular species?

As mentioned in an earlier question, I'm trying to limit harvest to what I know I can use myself. And again, I don't love to quantify the amount. I tend to only harvest a small percentage of the abundance. Example being if I go into the woods in the spring and notice two little pops of a pheasant back, I don't need to leave with the only pheasant backs in the forest at the time because I know there will be more throughout the season. Like I said, that is harder to temper when you are young and excited about it. Now I have learned that when I see more I know there is enough in this forest that it can support me, and as I harvest to consume a few I am further engaging and spreading those spores about.

Are there specific foraging seasons or conditions under which you refrain from harvesting, to allow fungi populations to regenerate?

I don't know how to answer this question. I'm only going in looking for those few common species that I know that I'm not concerned about proliferating, and not concerned about damaging the environment, so no. There aren't any specific conditions I avoid.

3. **Reciprocity Principles**

Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?

Yes! I always make sure to put the mushrooms in a basket or open sourced mesh bag, or even carry them around in my hand to allow spore dispersal as a way to give back.

I grew up in a conservative evangelical home and that is not where I have landed as an adult, however I'm learning to find my place and what it looks like to pray when in the forest. I sing, find new hymns, and it feels like having a conversation with what is there. I practice a moment of silence or medication to practice gratitude before foraging. This has become an important part of the foraging practice for me.

In a more practical sense, on a plant related topic, Ohio has a lot of paw paw plants that won't fruit and are just clonal patches. So I collect the seeds of fruiting plants and carry these around to different patches to the areas that don't fruit to spread the fruiting trees around, and produce more fruit in the forests. I practice nibbling or trail snacking when collecting berries or other fruits in order to disperse seeds around.

In a different way of practicing reciprocity, I always teach other people how to give back to the forest as an active way of reciprocity with the natural world. Teaching and sharing knowledge I believe is a form of reciprocity.

How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think foragers play in maintaining ecosystem health?

There is a myth that humans and the natural world are separate or exist differently from each other. We are of nature. We are a part of it. We evolved together. We have lost a lot of the knowledge over many years and as humans have killed off entire populations of people

that were managing land stewardship and know this to be true, which has caused land managers to further distance ourselves from the integration of humans as nature. Even in supposed "untouched" nature preserves there are still humans in there managing things. I like to start educating people by helping people understand that shift, and break down that assumption that humans are somehow not a part of the nature space.

Foragers are super important because foragers are actively observing and noticing more, have potential to take actions to reduce destructive patterns or invasive species and can simulate species that are beneficial to those native systems.

Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?

I see more changes from weather and climate change and biodiversity loss. That occurs far more than impacts from other foragers. Of course there is the possibility of increased uneducated foragers could be negative to the ecosystem, however in my experience foragers are so well intentioned and well informed and act with reciprocity that foragers are adding either positive benefit or at least a neutral impact.

One example is foragers creating less crowding of trees in paw paw patches to create more fruit. Trimming of overgrowth in crowded urban forest spaces allows more sunlight to produce more fruit. Another example is where I grew up in California. I've watched this pond surrounded by oak forest for about 20 years now where the lack of human intervention and the lack of harvesting has resulted in a reduction in biodiversity. Everywhere around the pond there is a proliferation of Himalayan blackberries and cattails that have not been

managed properly. Of course I cannot imagine what it would be like if there were foragers in there, however I have seen where even beavers have now lost habitat because of the blackberry encroachment there are no longer paths and it is impossible to access the pond. I have a strong vision of what it looks like when foragers are more active land managers and a part of the natural world, where intervention does not damage things. And reciprocity is at the core of that.

Are there any traditional or cultural practices that inform your foraging behavior, especially in relation to stewardship of the land?

Something one of our fellow foraging experts teaches, is that the most intimate thing you can do is to put something into your mouth. Into your body. Where it literally becomes a part of you. And that is a beautiful example of the intimate relationship that foragers have with nature and the stewardship of it. It is a way of thinking that is not shared by the general population. The approach that foragers have to what is around you and what are you choosing to make a part of you? When I'm able to share that mindset or experience with different individuals, that becomes part of that forager culture. Because I would argue that foragers have their own culture. There are huge overlaps with indigenous north american culture, but they are not the same and I want to take care to not conflate the two. Foragers have these ingredients that come each with their own different techniques of how to prepare them, or we have our own songs and texts that we consider core to what we as foragers do and think about. There are people and leaders in the forager gatherings that are considered

elders in the community, and different vocabulary or ways of chatting with one another. The part of becoming a forager also is learning these North American cultural practices of foraging.

4. **Anecdotal Evidence on the Impacts of Foragers**

From your perspective, how has foraging impacted the ecosystems you've visited? Have you seen any positive or negative effects over time?

I think there are very few if any negative effects. Once I stumbled upon a log where somebody took all of the mushrooms and thought, well this person could learn a little bit more. However, I'm not presently concerned about the proliferation of mushrooms in the united states. The biggest change I've seen on an individual environment is that example of the Himalayan blackberries and the pond in california which is not being managed by foragers. That pond has also been experiencing a higher frequency of algal blooms.

Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent? Do you think this is due to human harvesting activities?

I do not have the experience of noticing patterns of over harvesting. I see mistakes in novice foragers, but for the most part I don't know a single forager who is not very mindful or very assertive about sustainable practices.

Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of over-harvesting in certain locations?

I think the fear of sustainability in some cases becomes a barrier to entry of foraging. I have never been to a foraging class where sustainability has not been talked about. Classes always talk about it. I have the widest foraging cookbook collection in the country, and there is not a single book that doesn't mention the concern of overharvest or sustainable foraging practices. For example, recently I was at a gathering in Cleveland and someone I met said they would really like to get into foraging, but they were so scared about doing it unsustainably that they haven't even started to forage. So that paranoia that foragers have in their community of sustainable practices can sometimes be a barrier to entry. The fear of being sustainable has definitely out-scaled the reality of that being a true concern. There are certainly individuals who make the headlines such as the overharvesting of ramps, or the harvesting of matsutake before it's mature, which was done largely by people not within the foraging community but rather businessmen. However I do not know any foragers who are harvesting thousands of ramps at scale. That is a sign they are not in our community, and we do not call them foragers.

Have you observed any changes in biodiversity in the areas where you forage, either as a result of human activity or natural changes?

Only seen changes as a result of natural changes. I've seen longer, drier seasons and temperatures increase overtime. Especially when I'm thinking about California where there has been fewer diverse species and more encroachment of invasive species that proliferate very rapidly and choke out other species. I've also seen in California the weather has transformed enough in the last 20 years that fig trees have popped up much

more quickly and spread much more rapidly. They grow large, and fast. I can think of a particular riverbank where there used to be so many different plants growing and now it is just one big fig tree because everything else is so shaded. Also, again that pond with Himalayan blackberries. The beavers, cranes, and deer cannot access because there are branches that have taken over the paths. That pond has algae blooms happening more frequently.

I also think of how it is well documented that places that have more biodiversity are also where humans are recorded to have the most diverse diets. There is certainly direct engagement in what humans are eating and the tracking of biodiversity loss. In this region we have a broken relationship with the natural world.

How do you think the presence of multiple foragers in a forest could affect its ecosystem health? Do you think there is a threshold for sustainable foraging in specific areas?

This is a valid concern that an increase of foragers could be putting individual species at risk. That is something we need to address and be thoughtful about. However, in that question there is an assumption that the foragers are acting individually in that they are acting in succession. That they are going into the woods one at a time, and when one leaves another comes and goes after another to add to any damage or harvesting beyond what the person before them did. However, when there is an increase in foragers they are generally doing that in community or in groups. When there are multiple people together it actually strengthens the practice of being sustainable. In those scenarios, some foragers are foraging for one species, and other people foraging for another species. There is then

a larger coalition of people who care about keeping the natural world healthy, and keep each other in check. More people together strengthens the concern about sustainability and I've seen that being practiced in a group where they are more conscious of who is going to take what. I think the increased interest in foraging is one of the fastest paths to an increased coalition of sustainable land managers. People who care about conserving and saving food also care about keeping the natural world healthy. To say it in another way, I think there would need to be a limit on foraging if it was the scenario of one person going in and harvesting one pound and leaving the next person to go in and harvest one pound, and so on. If we are talking about a permanent system in a specific region then yeah, there are realistically limits for what we can do in those scenarios. But more broadly, an increased number of people that learn to care about the forest and learn to care about the wild foods in the natural world is a boon to sustainability efforts. The more people that care about those things, the stronger coalition we have for shifting policy and shifting culture.

Peter Martignacco

Minnesota Mycological Society (MMS) president

Experience: 30+ years

February 6, 2025

1. **Foraging Practices on Public Land**

How often do you forage on public lands, and what areas do you typically visit?

I forage on public lands about 20 times per year or season, with significant parts on state park land, state forest land, and the rest is mixed use. I also utilize urban areas which are owned by the public but not entirely thought of as public lands.

What types of mushrooms do you primarily forage for, and what methods do you use to identify them?

Typically I focus on foraging edible culinary species, and may collect other species for ID purposes only. If there is a species I am not 100% familiar with, I use books and the internet, as well as friends and associates who are more knowledgeable than I am.

How did you become knowledgeable in foraging for mushrooms?

I have been a lifelong hunter and fisherman. I have always enjoyed berry picking, and had an interest in foraging mushrooms but no one really to learn from growing up since my mother was afraid of mushrooms – myco-phobic you could say. It wasn't until I met my now wife and one of her close family friends was a forager. That brought foraging to my mind again and I took a community education class, where the teacher was a former president of the Minnesota Mycological Society (MMS). So I joined the MMS and continued my education of mushrooms. They helped me learn how to use books for identification and made friends and spent a lot of time with them, folks who are very knowledgeable and I learned from them.

Are you familiar with any regulations or guidelines regarding foraging on public lands? If so, how do you ensure that you follow them?

I am involved with some advocacy through the Minnesota Foraging Alliance (MNFA) regarding regulations and guidelines on foraging on public lands. I work to follow any regulations, and also work to change them when I feel they are not backed by data or science or are biologically justifiable. MNFA coalition partners are working on how to protect the right to forage responsibility and safely on public land through regulation, policy, and law.

What tools or techniques do you use when harvesting mushrooms to minimize disturbance to the environment?

Generally stay on game trails, avoid bucking brush, which is what old people like me call bushwhacking. I avoid woods that are too thick. I walk as much as possible in ways to not crush plants or disturb them. If it's too thick I just avoid going into those woods. I stay on the established trails if those are available when walking any distance in a park, and just go into the woods for small distances to look around, then come back to the trail to continue walking to a different patch or go further.

I used to cut most of my mushrooms. Some mushrooms I do cut more, such as morels where there are crevice's dirt can get stuck in and hard to clean. Boletes I pull out of ground rather then cut. Chanterelles pull out and trim. Chicken of the woods I trim and cut. Pull up riffola or hen of the woods. Some research I have read about cutting a mushroom shows that since the stem is still connected to the mycelia, it actually exposes the entire mushroom

to disease. Therefore it is actually better in some species to remove the entire mushroom. Mushrooms typically don't carry mycelium with them when you remove them. One example is in northern Minnesota, chanterelles grow in moss, so you have to pull the whole thing up in order to get the stem and most of the mushroom but you can pat the moss back in place. The research I have read shows there is no particular advantage to either method of cutting or pulling for mushroom conservation.

How do you determine how much to harvest from a specific area or patch?

When I harvest I'm always looking at the condition of what I'm harvesting. If the mushroom is very small and immature, I don't harvest it. You might as well leave it to grow. For those mushrooms that are overmature, harvesting those is generally not productive from a forging standpoint of collecting food. You should always only harvest what you are in a position to use. The quantity you have the time and willingness to want to process. Therefore my guidance on how much to harvest is really about what I know I'm going to utilize and what I have time to process. I don't take young mushrooms. I don't take old mushrooms. I'm not vacuuming the woods scouring for every last mushroom. I'm just harvesting here and harvesting there. I always know I leave some behind. In my enthusiasm when I was younger and newer to foraging, there were times where I can look back and see I perhaps took more than was appropriate. In the sense that I had to search out and find something to do with the mushrooms and I wasn't in a good place to process all of them. Now that never happens as I have learned and have a greater appreciation for all the work that goes into processing them. I always tell a story about a woman I showed how

to positively identify hen of the woods. She called me one day, just livid, swearing at me, and I asked what was wrong. She said she was out picking hen of the woods and found the seven of them. "Oh that is great!" I said. "No it is NOT!" she said. She said she was up until 3 in the morning cleaning them, and was very upset. I told her there is a solution for that – don't pick them all. "But I was so excited," she said. I told her I understand, but if you don't want to be awake until 3 in the morning then it is not sustainable to pick them all. These mushrooms are very tedious to clean, although they do grow in great quantities, so that is my word of advice. You need to make sure you have the time to properly process what you pick.

2. **Sustainable Foraging Principles**

How do you define "sustainable foraging" in your practice?

Make sure you will utilize all the harvest. Leave mushrooms that are not in edible or perfect condition. There is no reason to harvest those. If that is all you find, then keep looking. That is why you are out mushroom hunting – to look. Take care you are not damaging the environment. That you aren't overly disturbing plant life. Be careful where you are walking. From a biological standpoint there is no concern on overharvesting mushrooms. Don't harvest too many, there is a reason from a relationship with other foragers to leave some behind and not to act greedy about it.

What steps do you take to ensure that your foraging activities do not negatively affect the local mycelial networks or the overall health of the forest ecosystem?

Don't collect species that are uncommon. As a forager my goal is to pick things to eat. So if there are only two of a mushroom I won't pick them unless I confirm there is more. Two mushrooms don't make up a meal. You cannot make a whole meal out of it. Not even a side dish. Like mica caps. They are so small and thin it isn't even worth harvesting, even though they do grow in abundance. When you have three cups of mica cap in a frying pan, it cooks down to like a half cup so that just isn't worth it.

Or inky caps you have to do something with them right away before they go bad, so unsustainable because it just isn't worth it. Or black trumpets. What am I going to do with 10 black trumpets? That is not enough to even taste. So don't pick it. A very practical approach. Foragers at a basic level are going out to find things to eat. If there is a drought and all you get are a few dozen chanterelles, that isn't worth it because that isn't considered very common in that area. They can be quite plentiful other times in abundance. That is my viewpoint on sustainability.

Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? If so, how do you make these decisions?

Yeah, we already talked about how I do that. There are times where people are new foragers and will go out and pick every Russula that is in the woods. Experienced foragers will ask why did you do that? What are you going to do with that? The answer is nothing because they aren't edible. So don't pick anything unless you are 100% certain you know what to

do with it. It is legitimate criticism for some people that are new, they will pick something hoping it is something good and come home to ID it and find out it is not. So, just pick one of something to ID or take photos of it. In all fairness there is nothing wrong with picking one or two of something to ID. Then you go back and get more if you find it is something good. We as foragers have a responsibility to be respectful. As a hunter and fisherman I have a responsibility to be respectful of the fish and game harvest limits. I need to be respectful of plants, and mushrooms as well.

I do take steps to not excessively compact soil, don't walk on soil that is wet or muddy for example if off trail. Obviously I don't go out there with garden rakes or shovels to harvest mushrooms. In the pacific northwest there are instances where folks will go out with rakes or shovels and folks who are un-respectful foragers will rake pine duff to expose mushrooms – which is illegal. I don't consider those people foragers. They are businessmen. Foraging regulations should be set with the concept of people, and make sure that people comply. It's not a matter of just enforcement, but encouraging and educating people so they want to comply.

I wish there was more information and actual science on dispersion of spores. Many european regulations require (in mountainous terrain) to use backpacks with baskets and non-solid bottom. The whole reason is to encourage spore distribution. This is poorly studied, but it sure doesn't hurt. I do most of my foraging with woven baskets, not grass baskets, something that if you poured water in it, it would just go through. Grass baskets are too tightly wound and don't properly disperse spores, even though they are beautiful baskets. I discourage others from using plastic bags for different reasons than spore

dispersal. Because plastic. I have no reason to believe that spore dispersal by humans is a direct benefit to mushrooms, due to other wildlife spreading spores.

At the same time mushrooms produce such huge quantities of spores. Science is unsure how statistically viable one spore is – because you are already spreading thousands of spores. I just don't see a lot of evidence that mushrooms are spreading out from where they normally would because of humans spreading spores in a basket.

Certain forest types in Minnesota have less mycelial networks and mycorrhizal benefits because of the practices that were carried out when the state was clear cut, severely burned to a crisp to the rock layer, and any mycelial layer that survived clear cutting didn't survive the fires. The new forest that then inhabited wasn't what the mushrooms were used to. Example: pine forests being replaced with popple. Pine plantations have a lot of mushrooms in them. Popple not so much. So for this reason, habitat destruction is much more harmful to mushrooms than humans picking mushrooms.

How do you manage your harvesting activities to prevent overharvesting of any particular species?

I have a problem with how this question is worded. This question assumes that overharvesting is possible. There is a question scientifically if that is even possible with mushrooms. With certain species like chaga that may be more of a problem, but at least the science doesn't reflect that for other species. As a president of a state mycological society, I have conversations and partnerships with people in other states as well as internationally in the academic field. Folks that study mushroom conservation. Most say that it is not

possible to overharvest mushrooms. When humans go out mushroom picking, we aren't that good at finding them as a human species compared to other wildlife, and we just aren't going to be able to find all the mushrooms. There are too many in an area. Some people emotionally feel like there is such a thing as overharvesting mushrooms so that should also be respected. So from a biological standpoint there is no concern with overharvesting, but from a social standpoint there might be, like we talked about before with picking too many to process. For folks who have not spent time looking at and studying mycology the concept of overharvest they might jump on as a valid reason to prevent foraging in an area. But it is not a concern that should drive regulation because the science does not support it.

Similarly to what I describe above by not picking just a few because it is not worth it for dinner, foraging is self-limiting. If I go out and pick in an area and come back in a few days there will be more, but fewer to pick. So, you go on and search for somewhere else. If someone is already harvested there you might be upset, but it drives you to find a new place and oftentimes that newer spot may be even better. There is no one secret spot in the wood to find mushrooms, I can tell you that from my years of experience. There is always a better spot. There isn't just one spot.

Are there specific foraging seasons or conditions under which you refrain from harvesting, to allow fungi populations to regenerate?

Legitimate criticism for people who are just starting out is that they pick more quantity than is appropriate because they don't know exactly what it is and they are just hoping it's something good. If you don't know what it is, pick a couple for ID, but leave the rest. If you

find out it's something good, go back and get more. That isn't good stewardship. As foragers we have a responsibility to be respectful as a hunter and fisherman, be respectful of the plants and mushrooms as well.

That being said, mushroom foraging is self-limiting. During drought conditions there aren't any mushrooms to look for, so people aren't out there looking for them. Foragers know the seasons when mushrooms are ready and they aren't out there picking them when it's off season.

3. **Reciprocity Principles**

Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?

Yeah, I pull invasive species, clean up the woods from trash, and be mindful of the gifts the forest is providing. As more time has passed I've put more time and energy into protecting and advocating for the forest. It's in my heart to give that back to the forest and all the wonderful places. Sorry I got choked up a bit. Forests need to be protected by people, who are abusing or ignoring them. They deserve to be cherished. In order for them to be protected, people need to engage with them. I feel privileged to be able to recreate in all these wonderful outdoor places in MN and to share them with others. I feel like I need to be helping protect them. And that is my way of advocating for law and policy to protect them, that I give back. So my reciprocity is a little bit different from others in that standpoint. My time and energy is a way of reciprocity.

How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think foragers play in maintaining ecosystem health?

Foragers play a great role, they are interacting with the forests and ecosystems. Hikers are more goal oriented. Foragers develop a much more close connection with the ecosystem because they are involved in more of it and connected to more of it. They are paying attention to more of it.

Someone at the DNR roundtable said mushroom hunters are more engaged in the forest around them then hunters are. I agree with that. Foragers are looking at all things, focused on the ecosystem as a whole, rather than someone walking through looking for one species of game or bird, a deer or grouse. Foragers are concerned with the ecosystem as a whole. Foragers are in a position to monitor and provide information about forest, forest ecosystems, and how to maintain those ecosystems.

Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?

I have seen changes in the forest ecosystem in age and species progression. I go back to the same spots over time. I notice there are areas where the mycorrhizal species of mushrooms are less common than they were, but my gut tells me from observation its ecosystem changes that drive less mushrooms and not foragers.

For example, I have a spot where I picked a lot of black trumpets. One year I went to the spot. I usually pick about 3-4 baskets full of black trumpet in this spot. However, that year there were none. Not a single one. Not a little one. Not an old one. Not one. I have no idea

what was going on there. There was nothing growing there, not other mycorrhizal species either. I went to every tree and moss pile and there was nothing growing. It was very very odd. But, also very very dry. From my experience I know that when it is dry there are no black trumpets, and we have had a couple seasons now of drought so I suspect it is more related to climate change than anything else. If it was related to foragers, I would have found stumps of mushrooms, or some little ones or dried up ones or something that a forager left behind. It was the most bizarre thing I have ever seen to not find a single one that grew that season.

Another example is there is a spot near the Kettle River where I picked a lot of chanterelles for years. However then there was a big flood, and silt and sand dropped out all over the terrain. For a few years after that there were no chanterelles that grew in that area. That was about 10 years ago now, and I have seen the chanterelles recover substantially, but not to the same amount of flushing that they used to be. I have seen similar things with morel patches where the flooding over the course of a couple years of floods submerges the trees that the morels are partnered with and the river causes a lot of erosion and in the years subsequent to that there are no morels because the trees have washed away.

So from that standpoint there are a variety of natural causes that can be exacerbated by climate change that affect mushroom growth. But I just haven't seen personally anywhere I can point to and say that spot had too many people there picking, or clearly make the connection that a lack of mushroom return was due to human harvesters. In fact, there might be less mushrooms you find because more people are out there picking them, but it

just spurs you on to find a new spot. That doesn't mean there are less mushrooms. They are out there.

Are there any traditional or cultural practices that inform your foraging behavior, especially in relation to stewardship of the land?

There was no foraging tradition in my family. My cultural practices are more revolved around hunting, and that absolutely shares the same viewpoint and sensibility of engaging and respecting the outdoors and the ecosystem. I have gotten to know others who have greater cultural connections to and traditions revolving around foraging in the indigenous community. I have learned some of those and appreciated them.

4. **Anecdotal Evidence on the Impacts of Foragers**

From your perspective, how has foraging impacted the ecosystems you've visited? Have you seen any positive or negative effects over time?

I have seen a place that was ravaged by people. Chanterelle spot I was driving past and went to go check on, but it looked like a herd of elephants went through, it was so trampled, very disturbing. Only time I've ever seen that.

Occasionally seen evidence of someone's walking path because they walked through a path of ferns. Even if you are careful with ferns, you can see evidence a couple days later of someone walking through with a small path or broken fronds. However, if that happens infrequently, maybe see it just once a year. However, I am not sure if this was from foragers,

or just hikers. Also, unsure if that is actually impacting mushroom growth or just the ecosystem in general. I have also seen evidence of folks following game trails along a bluff edge and seeing some erosion there, but not sure if those are foragers or just hikers. This is something we need to be aware of and conscious of, and when I find places like that I tend to walk somewhere else.

Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent? Do you think this is due to human harvesting activities?

There is a state park that is well known and frequented by foragers. It is a good place to forage mushrooms. Folks have said that they see less mushrooms there now, but it isn't because the availability of mushrooms is less but rather that someone has already picked them. You see evidence of stumps of mushrooms already picked. Less mushrooms are signs of changes in the habitat rather than people taking mushrooms. Foragers often run into other foragers in this particular park and yeah, 20 years ago that didn't happen as much. However, people need to get out of the scarcity mindset. Keep a mindset that there are unlimited resources out there. Well not limitless, but there are resources that are far more available and utilized then you think. If you go somewhere and there is no more of what you are looking for, just keep walking. I mean, if they are fruiting. If they are not fruiting, good luck. The guy there before you didn't find them either then.

For an example of how mushrooms are self-limiting I have a spot where I have never gone more than 50 yards off the road for hundreds of porcini. One person went on Tuesday, and then someone else came back on Thursday, and the following Tuesday it was all over. I

know these people because I already had enough so I told them to go there. Great example of self-limiting. Couldn't overharvest if I wanted to! Virtually endless amount of mushrooms until they were overmature and done. Keep in mind this area is many square miles of habitat. It is just hard to get your head around how prolific some mushrooms can be. I had five dehydrators going and didn't even scratch the surface of what was out there. Mushrooms are self-limiting because they have a short season and window of when they are good. But there, I couldn't overharvest even if I wanted to. It was virtually endless. Nobody could pick them all.

Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of over-harvesting in certain locations?

Yeah, other foragers are mindful of sustainability. Folks become more mindful as they become more experienced. Like my friend who picked seven hen of the woods. She doesn't do that anymore. She picks one or two.

Another example is I used to fish on Lake of the Woods. For many years it was truly outstanding and DNR had special limits to encourage folks to come there. DNR actually purchased all the commercial fishing licenses so the walleye populations exploded. This encouraged vacation destinations for tourism. We went up there and caught a lot of big fish. We would say, "oh we aren't going to keep any fish over such and such a length," and as each year went by that length kept shortening. Over time you don't need to bring home big fish. You've caught big fish before and the size doesn't matter, it is more about the fun and the food. I'd rather put the big fish back in the lake to make more fish. You become

mindful of what you are doing. Similarly with mushroom hunting, when you first start out you go a little crazy when there is unbelievable fruiting, and then you learn "Oh, I don't need that much."

An example of self-limiting is folks that go out to a place several times a week because they live near there. But what is available is strictly dependent on the weather and not on people over-harvesting. Many species are one flush and then done for a particular area.

Have you observed any changes in biodiversity in the areas where you forage, either as a result of human activity or natural changes?

I have seen many changes in biodiversity but not sure how much is due to human activity. Mostly due to climate conditions or weather events. When in parks near metro areas you get covered in burrs. When you go back farther into the woods, there are no burrs. Because there aren't humans walking through there to carry the burrs with them. However, there are plenty of wildlife who carry burrs with them so I seriously think the idea of a forager bringing invasive species with them is a bit of a red herring situation. Of course you need to be careful, and clean off your boots, but foragers are not some special vector to carry invasive species, there have already been mechanisms to make that happen. Humans are not the only way stuff gets spread around. There is an area up north I go where there are no burrs in the woods, and over the years as foragers have increased in the woods there are still no burrs. You would think if it was due to human transport they would have made it there by now. How much spreading is due to animals? How much spreading is due to birds? How much spreading is due to people? I don't know. That is a good research

question. I mean when you look at emerald ash borer or dutch elm disease there are examples of humans spreading things much farther than nature might make possible on a slower timescale. We need some real evidence to back up if humans are causing extra transport of invasive species. We need to not ignore this concern, but we need evidence.

Another example of self-limiting is if people go to a spot two or three years in a row, and then they go to a spot and don't find anything for two or three years in a row, they are going to not go back and go to a different spot. It isn't worth their time to keep going back there. Then the mushrooms recover. Why would I add extra effort to check a spot if it isn't going to be beneficial to me. It is self-limiting.

How do you think the presence of multiple foragers in a forest could affect its ecosystem health? Do you think there is a threshold for sustainable foraging in specific areas?

Another story is an area where Russian folks go to harvest porcini and the woods are just crawling with people. However my friend who goes uses the tactic of finding the spots where people stop to trim their mushrooms, and find the mushrooms people drop or miss. And she ends up with a nice basketful. There is enough for everyone. When the conditions are right, it's impossible for foragers to overharvest or come near to taking them all. I know a mycologist who is on the international mushroom conservation committee. He said that in most situations, in most habitats, it is functionally not possible to harvest everything. And even if you would harvest everything, and I mean every last fruiting body, the mycelium are still there. Still living. Still thriving. Still going to put out their fruit when they have the energy and things are right.

You know, our American tradition is we treat everything as if it's endless. Limitless. Then we learned that is not so. So even with mushrooms sure there is a limit, but there are some species that are far more available to utilize then anyone ever appreciates. I am just constantly taken aback by the bounty in the forest. And if you bring people into the woods when they have this limited scarcity resource mindset, they would have trouble reconciling to know that there is so much waiting on the ground to appear when the conditions are right. It's truly magical.

Linda Black Elk

Community Engagement and Education Director at NATIFS

Experience: 30+ years

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1. **Foraging Practices on Public Land**

How often do you forage in public land and what areas do you typically visit?

Okay, so foraging on public lands, like once a week, if not more than that, at certain times of year. In our family, we really believe that food sovereignty requires us to do something every day toward food sovereignty. And so that means we are constantly going out and gathering or processing, you know, even if it's just communing with the plants and with the land, we feel like that's important for food sovereignty.
So we are probably out there doing some type of foraging at least once a week, if not more than that. We do visit a lot of different types of public lands, you know, city parks, the occasional State Park, and we do also ask landowners for permission to go on to their

land. So we go to private lands as well, but all kinds of public lands, state forests, state and national grasslands.

What types of mushrooms do you primarily forage for, and how do you identify them?

I am a member of a family of indigenous people. We focus on not only edible and medicinal mushrooms, but also mushrooms that are otherwise culturally important. So, for example, chaga, which we do forage sustainably, is not just – for my husband's people, they're not just medicinal, but they are also used almost as a spice, and they are used ceremonially as well. So we forage that very sustainably and carefully.

So yeah, I mean we do forage a lot of different mushrooms, but we also forage morels and other things that a lot of people know of. We have our very productive, specific spot for field mushrooms which we love and I would say probably in our family and in my husband's tribe and for our kids, probably the most important mushroom to them is one that people don't think about.

In Dakota and Lakota, it's called Chanakba, which means the tree's ear. I think the scientific name is Hypsizygus ulmarius.

And I think they call it the Elm oyster. Some people call it that, and it specifically grows on boxelder maple trees, so that's really interesting because the boxelder maples are so important culturally as well, and we know that boxelder maples need a really healthy primarily high water table riparian system in order to flourish. And that means, you know, if the boxelders are flourishing, then we get lots of good mushrooms as well; lots of good Chanakba. So that's very important to our family. And I mean, there's all kinds of other

mushrooms that we forage for medicine, like if we find Lion's Mane, we feel really lucky. If we find Reishi, we feel really lucky.

One thing that we say is that the range of the Oceti Sakowin people is very large.

So we do end up travelling quite far just to gather specific mushrooms so that our family and community, who don't follow those trade routes anymore, and don't have the opportunity to travel or forage as much anymore— so that they are exposed to those mushrooms and know that they're still out there. That's become very important to us; foraging even far away on public lands out of Minnesota is important, so that we can have access to certain species.

When you're foraging mushrooms, what tools or techniques do you use when harvesting?

We follow a lot of different protocols. We always feel like reciprocity is super important, so we'll practice reciprocity in terms of songs and prayers. And we will also practice little offerings sometimes of other plants, a spiritual reciprocity, but also service – sort of a fertilizer. So we'll do various plant mixtures that we offer.

Another protocol we follow is not to take too many like we're very aware that a mushroom is just the fruiting body of a much larger structure. And so it'd be like picking an apple off of a tree, right? Picking an apple off of a tree does not hurt the tree, as long as you're doing it respectfully. I mean, I'm sure someone could try to hurt the tree if they wanted. But you know, there's a good, respectful way, and we make sure to do that. We try not to disrupt the mycelial structure underneath or behind the bark, and still, even though we are aware, you

know — even off of an apple tree, we wouldn't pick every apple. So we don't pick every single mushroom that we see. We try to leave a couple so that they can release their spores. When it comes to something like chaga, which you're pulling off of a tree, we do not like to saw chaga off. Instead, we pull it off so that we're not accidentally cutting into the tree's tissues, the xylem or the phloem. We always make sure to leave plenty, plenty, plenty of the chaga on the tree.

And then the other protocol that we follow is that we want to try to leave some for other community members. So even if it's something we know we will eat, we will still only take half or less than half depending on how much there is of something. Because we want other community members to be able to harvest. But also to come receive that education, you know like, I remember actually there was a spot that I had found where there were a bunch of chanterelles, which is another native mushroom that we harvest. And I wanted to use that for a walk – a mushroom and plant walk. And when I went back there, every single one of them was gone. Every single one. There weren't even two, so that I could show people what a chanterelle looked like, you know? And so, I always make sure to leave a few just in case someone is trying to use that patch for educational purposes.

How do you determine how much to harvest from a specific area or patch?

Yeah. We just try to think about the future. We try to think about whoever else might come that way, and if people are using that spot for education. But other than that, we, like, let our hearts guide us and we're like, OK, like we can stop now and you know, like honestly, I can eat a lot of mushrooms, but even I can't eat every mushroom. Why be greedy? And

then my friend Sam Thayer said something to me once, because, the thing is I grew up experiencing poverty, and so did my husband. And so we both in many ways have a poverty mindset. And when we get out there and we see something delicious that we love, our instinct is to be like, okay take it all and then hoard it, you know. Like take it home and don't eat it until we absolutely need it. You know, save it for a rainy day kind of thing. And Sam said don't do that, because they'll always be there the next year and it really is better to cycle out the mushrooms that you have at home, like it's better to cycle them out than to keep one thing of mushrooms for years at a time. 'Cause they do lose flavor and medicinal properties as well, over time. Yeah, so we try very hard to cycle through them even though our instinct is to hoard everything.

2. **Sustainable Foraging Principles**

How do you define sustainable foraging in your practice?

So I do not believe in the mantra of "leave no trace". You know that whole "leave only footprints" thing, I don't believe that because in our philosophy, we actually should be having a net positive impact on the natural world, not just net zero, right? We want to actually have a positive impact. So that means, you know, foragers should always develop relationships with whatever they're foraging and look at them as relatives who are making a sacrifice for us and for the greater good. Because that's really what's happening. And so we really feel like one of the best ways to do this, sort of a rule that we follow, is that if a mushroom will do better if we harvest one and then sort of throw it around to spread the

spores around, we will do that we will take one of the mushrooms and you know, throw it up against a tree, or mash it up and spread it around.

We, you know, different mushrooms, like different things, just like people, right? We all have our own preferences on how we want to be treated, and so we try to learn that about each mushroom. And then make sure that we're sort of following those protocols and if that includes leaving it alone for a while and you know, coming back some other time to see if you know they're more receptive to giving, then that's fine too. But yeah, so that's just a big rule that we follow is that we want a net positive impact. Not net zero.

Do you leave certain mushrooms or fruiting bodies behind to allow them to mature or disperse spores? And if so, how do you make those decisions?

Yeah, we usually try to leave some of the oldest that we see and some and some of the youngest as well, and mostly only harvest what's in the middle.

How do you manage your harvesting activities to prevent any overharvesting of a particular species?

Yeah. I kind of touched on this too. So yeah, we just, we just make sure that we when we when one thing that we try to do is when we go to an area we don't want it to look completely different than when we got there. I mean, you know, there are cases when you know, we're foraging certain things, usually not mushrooms actually. Aerating the soil and digging up the soil and things like that are a good thing and pruning is a good thing you know. But when it comes to mushrooms, we are a bit more careful.

We try to make sure to leave plenty of the older specimens that are already dispersing their spores and then we try to leave the younger ones, because that's a whole other time period of spore release. So. So yeah, we just try to try to do that, be conscientious and not take too much.

Are there any foraging seasons or conditions that you wouldn't harvest mushrooms?

You know, that's a really good question. I think we take it day by day and time by time. You know, time period by time period. But you know if it's too wet outside, we're usually not harvesting. And if it's too dry outside, we're usually not harvesting. So I would say with those extreme conditions, we try to let the mushrooms rest.

3. **Reciprocity Principles**

Do you follow any principles of reciprocity when foraging? For example, do you leave something behind, give back to the forest, or practice other forms of exchange?

I think I covered that pretty well earlier.

How do you perceive the relationship between foraging and the well-being of the forest ecosystem? What role do you think forgers play in maintaining ecosystem health?

I don't know how many I could give, but I could give you so many examples of plants that benefit from interaction with humans specifically. We are not separate from the ecosystem, and horrible things happen when we try to think of ourselves as, you know, having

dominion over the natural world or as being separate from the natural world. I really feel like terrible things happen when we have those behaviors, which I think are very individualistic and capitalist. I am a firm believer that we are a part of the system and that we can, as I said earlier, have a net positive impact on it. And so as I move through the world, I think about that constantly. I think about OK, you know, because I think of plants as my relatives, and I've tried to get to know them. Sweet grass for instance. Hierochloe odorata really actually likes to be thinned out. Like, really thinned out, you know? And if you let the roots just spread and spread and spread by their rhizomes, it can actually choke itself out of an area and it will stop growing there. And I think you know we can talk about wolves in Yellowstone and all kinds of stuff like whenever we have removed a species including ourselves from an area, bad things happen and things get overgrown.

You know, foragers are basically replicating that tradition since the beginning of time, checks and balances. Within the natural world, we also serve as agents of propagation and agents of dispersal. You know another plant that comes to mind is the camas, the edible blue camas up in the northwest. You know, I remember learning from some elders up there when they dig up the camas bulbs, which are corns, they will flick off the little baby corns around the bottom back into the holes where they're digging. And it actually keeps those stands very healthy. It helps to aerate the soil and loosen the soil up through their digging. I mean there are just so many benefits and there are cases and very visible cases where there used to be huge fields of camas but when people were forbidden from harvesting there, those fields died out.

A lot of elders will put it differently. They'll say the plants miss us when we're not around. And I think that that's very true. The plants and the mushrooms, I think miss us when we're not around because just as we have evolved, you know, in relationship with them, they've evolved in relationship with us and and you know we coexist. And so it would be just like taking someone important to you out of your life, you know. So yeah, I think foragers are, you know, serving as relatives to the plants and we're good to them 'cause, we want more of them next year.

Have you observed any changes in the forest or fungal populations as a result of your foraging practices? How do you think foraging, if done sustainably, could contribute to forest health?

This is a great question. We actually have a very good example of this. So this goes back to the chanakba, the elm oyster mushroom. So we were taught that basically people can serve as almost, I would say agents of propagation or maybe spore dispersal in that when you tap the trees for sap in the spring, you're actually creating a little place for the mushroom to take root. So it's almost like mushroom farming. The first year on the campus of United Tribes Technical College, the first year that we tapped trees. No, we actually got there in the fall and when we would normally be harvesting those mushrooms, we could not find a single one of those mushrooms on the United Tribes campus, even though there were like 100 boxelder maple trees. And we thought that was weird.

Well, the next spring we actually without even thinking about it, we thought, hey, we should do a sugarbush. It was the first sugarbush on the United Tribes campus ever. And so we did that. We tapped all those trees sustainably and got a really good harvest of sap. Cooked

it down into syrup and everyone was just, like, super thrilled. And that fall, we went back to those trees to look for mushrooms, and we got a massive harvest just in one season. So that was crazy to us because just from one year to the next, I think that we got like 60 lbs of mushrooms. And that was leaving a lot of them from those trees that year.

And then for many years after that, it was the same cycle, the same cycle of tapping those trees and then harvesting mushrooms in the fall. And so, you know, we were able to see that. And it also got the community so involved in this cycle. Which I think is so great.

So yeah, I think that we can have where the trees are super healthy as well because we made sure that they were healthy so that we could continue to get syrup, right. So, it's just that's one example where I feel like we had a positive impact on both.

4. **Anecdotal Evidence on the Impacts of Foragers**

From your perspective, how has foraging impacted the ecosystems you visited? Have you seen any positive or negative effects over time?

So, I have seen negative impacts in places. Honestly, I guess the way to put it is that I feel like people, when they are told they cannot forage in an area or they are not provided education on how to forage sustainably, they get, not greed so much as it's desperation, especially when we're talking about indigenous people who maybe have heard about a particular plant being important and they so desperately want to develop a relationship with that mushroom or that plant again, but and so they'll find some and they'll be like, "Oh my God, this is the mushroom my grandma picked. This is the one she talked about. Let's pick all of it." It's true of plants too. And they just, you know, they don't even know

what they're going to do with it. They just know that they need it. Like literally need it in their soul, but no one's talked to them about sustainability because so much of that knowledge was forcibly, you know, cut off because of boarding schools. Because colonization is suddenly colonialism. And so I have seen on private lands, on public lands, other places I have seen some negative impacts of foraging. But whenever people, in my experience, are educated on protocols and the spirit behind foraging, thinking of these plants as relatives instead of just things that we take, it changes. It totally changes the dynamic, I've seen damaged systems go to repaired systems through foraging.

Have you noticed changes in the availability of certain mushroom species in areas where foraging is frequent?

Yes, absolutely. And so the elm oyster touched on that some but also we noticed that. Give two quick examples: One is like some of our morel spots where we will go and harvest and then we will take some of the older ones and we will put them in some water and then pour the water around everywhere. We have actually been able to increase our harvest by doing that, like big-time, like double and triple year after year. Because we put some of the older mushrooms into water and then dispersed the spores that way. That has worked wonders for us, and that was the tip that we actually got from an elder out east, a Cherokee elder. So that is amazing.

So that's one. And then the other one is- I didn't know this was true, but field mushrooms like the Pink Gilled field mushrooms, we really like those and we found a whole bunch of them in a particular spot. We talked to an elder about it and he was from Cheyenne River.

His last name was Brown Wolf, but I can't remember his first name. And he said, whenever you find those, you should take a few of them and step on them and then smear them into the ground. And we thought, oh, that's kind of interesting, you know. But it was just something that he had been taught and we started doing that and noticing that you know it like they increased big-time in those areas.

Do you think other foragers are generally mindful of sustainability, or have you noticed patterns of overharvesting?

Anyone that I would personally call a forager is incredibly mindful. I can't state that enough. People who I would call actual foragers, gatherers even, are so mindful and so conscientious and almost paranoid about having a positive impact. Now that is not to say that there are not people out there who I probably would not call foragers or gatherers who have a negative impact based on, you know, there are some business people who I think go out and overharvest and don't think about the future of the plant. They just think about maybe how much money they can make at a particular time and they get sort of worried that, hey, these mushrooms might not be here for next year. Self-fulfilling prophecy 'cause then they'll take everything and they'll be really disrespectful and then there won't be any mushrooms there next time. But I don't think I would call them foragers. I think I might call them business people.

Have you observed any changes in biodiversity in the areas where you forage as a result of human activity or natural changes?

Hmm. I mean, I have plenty of examples that are not about mushrooms. But I don't know if I can specifically say that about mushrooms. You know 'cause, when you prune or pull up certain plants or you know, maybe even take off part of the canopy so that the sun shines through to the ground, to the soil, you get a different profile next time because you have allowed you know the seed bank to release to receive some sunlight, right? I don't know if I can really think of that being true like that, I've observed that with mushrooms, but I would assume that it's true. I would assume that through my activities of foraging sustainably and practicing reciprocity and aerating the soil, but also gently compacting the soil in some areas, I'm probably making changes and I believe that they are positive changes because my feet are really no different than the hooves of animals that have been there for millennia, for forever. You know, my harvesting is really no different than grazing by animals. So yeah, I haven't observed that specifically with mushrooms, but I believe it's true.

How do you think the presence of multiple foragers in a forest or prairie could affect its ecosystem health? Do you think there's a threshold for sustainable foraging in a certain area?

I think there's probably a threshold and it's probably a lot because you know again, I have to go back to the fact that people do not. My husband and I watch that show "Alone" sometimes and we think it's so funny that people think that show is about man-versus-nature. It is not man-versus-nature. It's like man-versus-self, you know that show is called "Alone" for a reason. Because we are not meant to forage alone. We are not meant to survive alone. We're not meant to build the shelter and try to feed ourselves at

the same time. We're supposed to be doing that as a community or part of the community is helping us build the shelter while the other part is gathering food so that we can build our shelter.

It's amazing how important that is and the plants and the mushrooms have adapted along with us as they are their own communities. And so you know that like I said, that threshold is pretty high because there have historically been so many people out there gathering and foraging. And I really think that's honestly better because it also means that there's some people who will be gathering the morels, but there are other people who will be gathering [other things]. But look, I found this huge stand of, you know, some other spring mushroom that they'll be gathering, you know, so that sort of takes the pressure off of the morels. So yeah, like gathering, harvesting, foraging in community, I think, is more sustainable than harvesting as individuals.

APPENDIX B

MINNESOTA FORAGING ALLIANCE (MNFA) MISSION, VISION, VALUES

Minnesota Foraging Alliance

Mission:

To protect access to public lands for responsible and sustainable foraging by all Minnesotans.

To educate and advocate for responsible foraging practices that are preserved in shared knowledge, protected in legislation, and stewarded by us all.

Vision:

Working towards a future where responsible foraging practices are widely recognized as valuable and beneficial, protected by law, to deeply connect us to the lands we share.

Values:

Conservation: Foraging and sustainable land management are not at odds with each other, but rather complement each other. This has been modeled by the millenia that Dakota and Ojibwe people have been stewarding the land of Minnesota. The land evolved with human interaction, and cannot restore itself without that same reciprocal relationship. Not just in Minnesota but across the world, these traditional practices continue to deeply connect all of us to the land and its nourishment.

Connection: Gathering wild food brings a deep connection to land and people. Food brings people together in seeing year after year how the land provides nutrition for families and inspires care for future generations of humans and protection of the land.

Equality: Every person has the right to responsibly access wild foods on public lands.

Tradition: Practicing the ancient land stewardship practices of foraging is essential in respecting and modeling the original land stewards, the Dakota and Ojibwe people. Further, the traditional hunting, fishing, and foraging practices of many migrants both recent and generational should be supported for future generations.

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Minnesota Foraging Alliance