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Wild Food Harvesting and Biodiversity in the Black Hills: Key Issues and Areas for Future Research

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Abstract

As we grapple with the complex and interrelated issues of widespread species extinction and global climate change, both largely driven by industrial agriculture, there is a need to investigate the relationship between food systems and conservation approaches to find solutions. Wild foods lie at the intersection of ecological and socio-cultural systems, bridge the wild and the domestic, and challenge the false dichotomy between production agriculture and conservation. Given the importance of biodiversity to the resilience of our food systems, both wild and domestic, this research serves as a scoping study to investigate key issues and areas in need of future research at the intersection of wild food harvesting and the conservation of biodiversity in the Black Hills of South Dakota. Eleven interviews were conducted with people who hunt, fish, or forage for mushrooms and plants in the Black Hills region. These interviews were analyzed utilizing a combination of inductive and deductive approaches, from which eight themes emerged. Harvesters were found to be in deep relationship with biodiversity in the Black Hills and harbored specific philosophies, values, and harvesting practices which intend to maintain or benefit the species they harvest. Harvesters are also noticing specific anthropogenic land uses as potentially threatening biodiversity and wild food harvesting in this region. Indigenous land rights and inclusion in management decisions and policy making was highlighted as a key issue at the intersection of wild food harvesting and biodiversity conservation. The loss of ecological knowledge, both held by indigenous and local people, was identified as another challenge at this intersect. Thus, the full and effective participation and collaboration with local harvesting and indigenous groups in land management planning and policymaking in the Black Hills were noted as important ways forward. Recognizing, researching, utilizing, and supporting the survival and transmission of traditional ecological knowledge held within indigenous and local wild food harvesting groups was also noted as vital to conserving both biodiversity and wild food harvesting traditions in the Black Hills.

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Introduction

Areas that show some of the longest and most significant histories of cultural use by humans are some of the most biodiversity rich areas on the planet (Ellis et al., 2021). Human subsistence behaviors have influenced the evolutionary biology of non-human species for perhaps 50,000 years or longer and well before the origins of agriculture (Boivin et al., 2016; Hunt et al., 2012; Stiner et al., 1999). Many wild species are thought to have coevolved from both direct harvesting pressures and indirect landscape modification practices such as broad-spectrum harvesting, predation, landscape burning, clearing practices, and translocation of species (Boivin et al., 2016; Sullivan et al., 2017). Furthermore, humans are known to exhibit various practices that actively maintain wild species they consume that might look like tending or cultivation, blurring the lines between domesticated and wild food systems (Bharucha & Pretty, 2010; Tremblay et al., 2020). Some of these practices include sowing wild seeds, irrigating stands of grass, burning to stimulate plant growth, selective culling of game animals and fish, replanting portions of roots, removing competing species, and enriching of trees (Charnley et al., 2018; Comberti et al., 2015; McLain et al., 2017; Tremblay et al., 2020). These subsistence strategies have created interdependent relationships to the extent that, in some cases, removing humans from the landscape can cause a simplification in the food web, loss of certain species, or even ecosystem collapse (Auffret & Cousins, 2013; Bird, 2015; Castilla, 1999). Thus, humans have been regarded as a keystone, and in some cases, a 'hyper-keystone,' species due to the impact their actions can have upon other species and the ecosystems they inhabit (Worm & Paine, 2016).

Humans also play a key role in species loss. The current dominant agri-food system – characterized by the globalization and industrialization of agriculture and food, single species production at scale, contamination of the environment, disintegration of cultural foodways, concentration of capital, unhindered growth of transnational corporations, and the exploitation of labor – is one of the primary drivers of species extinction globally, both directly through land use change for agriculture and indirectly as a primary driver of climate change (Wolf & Bonanno, 2013). The widespread and detrimental effects of the dominant agri-food system have been produced by the racialized and homogenizing forces of colonization and capitalism, rooted in plantation slavery, genocide, and indigenous land dispossession (H. Davis & Todd, 2017; J. Davis et al., 2019; Youdelis et al., 2021). Plantations served as the original model for the industrialized agricultural systems based on the growth of monocultures at scale through cheap labor for profit, which are now prevalent worldwide. The genocide of indigenous people and widespread indigenous land dispossession in the US also served as a primary source of natural capital necessary to commence the type of agri-food system that we see operating in the US today. Because of the homogenizing and ecologically destructive nature of these modes of production, these same forces have also created the necessity for the conventional approaches to conservation, which have been protectionist, market-based, dispossessed people of their territories, and created the need to further intensify agricultural production while largely failing to stave off severe biodiversity decline (Brockington & Igoe, 2006; Fletcher & Büscher, 2020; Holmes & Cavanagh, 2016; Lunstrum, 2016; Stevens, 2014). Thus, the conservation of biodiversity and food systems share a long and deeply entangled history with humans and must be addressed simultaneously and synergistically, alongside issues of social justice and equity, to produce the interdependent ecological, cultural, and individual wellbeing that many share as a collective goal.

Despite the homogenizing and ecologically and culturally destructive effects of the industrial food system, over 10,000 wild species are still currently utilized within the diets of one billion people, making the sustainable use of wild species crucial for global food security and adequate nutrition (IPBES, 2022). And although industrialized countries of the Global North are generally more distant from their immediate environments for subsistence, wild foods and the systems that surround them have been found to contribute to many culturally important functions in the US, including cultural identity, personal identity, cultural belonging, heritage, sense of place, food sovereignty, nutrition diversity, recreation, family time, spirituality, traditional ecological knowledge, and connection to the environment (Ahmed et al., 2022; Kuhnlein et al., 2013; Schulp et al., 2014; Smith et al., 2019; Turner et al., 2011). Additionally, cultivated food systems are equally dependent on a diversity of biological resources, both domesticated and wild, to contribute to its productiveness and resilience, especially in the context of climate change (Pilling et al., 2020). Thus, both domestic and wild food systems are dependent on diverse species on multiple levels, both directly and indirectly. In recognition of this necessity, the conservation of biodiversity has become of central concern globally and various policies have been set forth at both the international and national levels of governance to slow the rate of species extinction (Department of Interior, 2021; UN Environment Program, 2022). These policies recognize the role that indigenous and local people play as custodians of biodiversity and emphasize their full and effective participation in local and regional land management decision-making for the conservation of biodiversity (UN Environment Program, 2022).

Context within the Black Hills Region

The Black Hills region of South Dakota is known for its unique species richness, importance to indigenous tribes for cultural, subsistence, medicinal, and spiritual reasons, and as the place of one of the most blatant examples of treaty violations and indigenous land dispossession in US history. As a disjunct crossroads of Rocky Mountain, northern coniferous, eastern hardwood, and great plains ecosystems, the Black Hills harbors an especially unique and abundant assemblage of biological diversity (Albers, 2003; USFS, 2022). Due to the wide diversity of plants and animals not obtainable in the surrounding region, as well as for other cultural and spiritual reasons, the Black Hills have been central to various tribes throughout North America for food provisioning for at least 12,000 years and were regarded as a meat pack, safe, or ‘supermarket’ by the Lakota (Albers, 2003; Kornfeld, 1994; USFS, 2022). Some of the first Europeans to explore the Black Hills recorded many of the species important to local tribal diets as growing in profuse quantities throughout various locations (Albers, 2003). Ever since the US government brutally and illegally seized the Black Hills in 1877, it has been a hub for natural resource extraction, particularly timber and mining. For instance, in 2021 the Black Hills National Forest (BHNF) was assigned to produce one-third of the Rocky Mountain Region’s annual timber target, though it accounts for only about 5% of its overall forest (Steen-Adams et al., 2021). Studies have found that the emphasis on ponderosa production through particular logging techniques and fire exclusion in the BHNF have led to a more simplified, homogenous forest structure that is not as diverse as it was historically, with a drastic loss of diversity in its understories (Brown & Cook, 2006; USFS, 2022). Ultimately, this has resulted in reduced biological diversity and impacted the ecological integrity of the forest. Given the unique biodiversity native to the Black Hills, the central role it played in subsistence practices for thousands of years, and current threats to diversity through certain land use prioritizations, the

relationship of wild food harvesting and the conservation of biodiversity in the Black Hills is a relevant and important area lacking research.

Methodology

The intent of this research project was to serve as a scoping study to determine key issues and future research needs related to wild food harvesting and the conservation of biodiversity in the Black Hills Region of South Dakota. With no prior research having been conducted on this subject in the Black Hills, this information could be important for the public, harvesters, policymakers, and land managers to inform efforts to conserve biodiversity in a way that integrates important cultural, social, and economic dimensions into programming and policy.

After reviewing existing literature on the subject from other regions, one overarching research question and two sub-questions were developed:

1. What is the relationship between wild food harvesting and the conservation of biodiversity in the Black Hills?
    a. What are wild food harvesters noticing in terms of ecological health and biodiversity shifts in response to perceived land-use and climate change in the Black Hills Region?
    b. What practices do wild food harvesters have which might promote or protect biodiversity in the Black Hills?

From these research questions, an interview guide was developed which asked questions about general harvesting practices, ecological observations, specific harvesting techniques, and land management considerations (See Appendix A). The researcher initially invited individuals they knew to hunt, fish or harvest plants and mushrooms in the region to take part in interviews. This was combined with a snowball sampling approach where interviewees had the opportunity to suggest additional interviewees (Polkinghorne, 2005). The researcher intentionally attempted to create a sample with diverse characteristics including gender, age, race, and type of wild food harvesting practiced (hunting, fishing, mushroom foraging, or plant foraging). Interviews were conducted by the researcher either online through Microsoft Teams or in person. Eleven interviews were conducted and recorded between June and November 2023. These were recorded and transcribed utilizing the Microsoft Teams transcription tool and cleaned by reviewing transcriptions alongside an audio recording of the interview.

Interviews were analyzed utilizing thematic analysis techniques in order to identify, describe, analyze, and report themes and patterns within data (Braun & Clarke, 2006). Codes were developed utilizing both deductive and inductive approaches. The researcher developed codes based on the interview questionnaire (and thus prior research) and developed additional codes utilizing an inductive approach after the first review of transcripts (Roberts et al., 2019). Applying the initial codes and secondary codes, the interviews were reviewed systematically, and additional concepts which emerged from the data were added as new codes (See Appendix B). After new codes were added, transcripts were reviewed again so that all interviews were reviewed in relation to every code. Once all codes were developed, they were reviewed and organized in relation to the research questions and overall intent of the study (Braun & Clarke, 2006, 2019). Themes were developed based on quantity and relevancy of codes that inform the

research questions (Braun & Clarke, 2006, 2019; Maguire & Delahunt, 2017). The most prevalent and relevant themes were analyzed in relation to existing research on the subject.

Results

Eleven people were interviewed for this project. Multiple participants practiced more than one harvesting type (i.e. fishing and hunting, fishing and mushroom foraging, etc.): seven hunted, eight fished, six foraged for plants, and six foraged for mushrooms. Participants embodied a wide range of reasons for harvesting, including for food agency, cultural or traditional reasons, social ties and bonds, enjoyment, challenge, medicinal purposes, nutritional purposes, spiritual purposes, ethics, and for deeper feelings of connection to nature.

"It's both a pastime for us, it allows us to interact with our environment, but it's a primary food source for us as well. We try and get most of our meat from hunting and fishing."
~ Interviewee 9, Hunter, fisher, mushroom and plant forager

"You feel a different connection to your food when you hunt it versus just going to the store to buy it." ~ Interviewee 6, Hunter and fisher

Research Question 1: What is the relationship between wild food harvesters and the conservation of biodiversity in the Black Hills?

Theme 1: Wild Food Harvesting is Dependent on Biodiversity

Wild food harvesters expressed their direct and indirect reliance on biodiversity richness. Although a systematic inventory of species harvested was not collected as part of the interviews, interviewees described actively harvesting and utilizing over 44 species in the Black Hills Region (see Table 1). In a direct way, these food species comprise a portion of the biological diversity present within the area. Every interviewee harvested more than one species; although the number of species varied greatly between interviewees; plant foragers tended to harvest the greatest variety of species. Additionally, interviewees consistently voiced the correlation between species rich ecosystems and the presence of food species.

Table 1.
Food Species Harvested by Interviewees

	Plants	Mushrooms	Animals	Fish
1	Fiddlehead Fern	Black Morel	Whitetail Deer	Walleye
2	Wild Asparagus	White Morel	Antelope	Croppie
3	Raspberry	Oyster	Elk	Carp
4	Thimbleberry	King Bolete	Mountain Lion	Perch
5	Chokecherry	Chanterelle	Mountain Goat	Rainbow Trout
6	Arnica	Lobster	Turkey	Brown Trout
7	Dandelion		Rabbit	Tiger Trout

8	Timpsula	Ruffed Grouse	Cutthroat Trout
9	Echinacea	Pheasant	Splake
10	Leadplant	Dove	Rock Bass
11	Mints	Mule Deer	Sunfish
12	Sages		Northern Pike
13	Yucca		
14	Mullein		
15	Wild Grape		

Harvesters also expressed awareness of their direct relationship with genetic diversity and ecological diversity, or diverse habitats. Foragers expressed the need to maintain a diverse gene pool to keep populations of food species healthy, resilient, and free from disease. Hunters seemed particularly aware of this relationship, noting harvesting practices they use to achieve this goal. Some of those include harvesting mature animals and avoiding the harvest of healthy younger animals to allow them to reproduce to maintain a healthy gene pool. They also expressed their role in managing populations, mainly deer, so that they don't overpopulate and cause other species to decline. Similarly, mushroom and plant foragers often noted restraint in the quantity of material that they harvest, as a way to leave enough for a healthy population to be able to reproduce.

Lastly, wild food harvesters mentioned a variety of ecosystems from which they harvest: from aspen groves to spruce forests, from small streams to large reservoirs, and from old growth forests to native grasslands. This diversity between habitats from which wild food harvesters utilize denotes the diversity of eco-types that they are in relationship with and depend on for the variety of species they are harvesting. Wild food harvesters expressed that they are looking for biodiverse ecosystems to harvest in, and in many cases, they are not finding as many as they'd like. Anthropogenic land use impacts, which are explored in greater depth later in this paper, are observed to have created more simplistic, homogenous habitats, making harvesting practices more difficult. This has, for the most part, either pushed food species to other areas, caused their habitats to shrink to smaller and smaller pockets, or erased them from the landscape all together. Thus, overall, foragers expressed awareness of their dependence on biodiversity at the genetic, species, and habitat levels.

Theme 2: Indigenous Intersections

At the intersection of wild food harvesting and the conservation of biodiversity, interviewees consistently talked about indigenous land rights and culture. First, some harvesters recognized indigenous tribes with ties to the Black Hills as the original harvesters and rightful stewards of the region. Secondly, they tied the impacts of current land uses and prioritizations, like cattle grazing and fire suppression, to the original dispossession of the Black Hills from indigenous tribes:

"I think a lot of that (loss of beneficial effects of fire) also includes removal of indigenous people from the landscape, pushing tribes off out of the Black Hills onto reservations. Traditionally, fire was a tool that was used by tribes. So you're losing that as a management tool."
~ Interviewee 3, Plant forager

Interviewees also acknowledged that some of the species they harvest hold deep cultural ties with indigenous groups, and they described learning some of their harvesting techniques and utilization of certain species from indigenous traditions. Traditional indigenous management techniques, especially the utilization of fire and grazing by bison, were noted to be potentially important to the maintenance of native species and food species in the Black Hills. Additionally, further loss of harvesting access for indigenous people, both in terms of accessing land and harvesting regulations, were noted as key issues that concern both wild harvesting and the conservation of species. Harvesters have observed development in the Black Hills shrinking areas where people used to harvest, forcing them to travel further to reach areas where intact ecosystems with native species are left. Permits for harvesting plants on US Forest Service land were also mentioned as an issue that impact indigenous harvesters. The types of information harvesters must share to obtain a permit was one hindrance that was expressed. Another issue is the irrationality of indigenous people needing to obtain a permit given the legal and social context of land rights in this region, and the understanding of this at some levels of enforcement but not at others.

Research Question 2: What are wild food harvesters noticing in terms of ecological health and biodiversity shifts in response to perceived land-use and climate change in the Black Hills Region?

Theme 3: Ecological Observations

Overall, wild food harvesters shared a wealth of observations about changes occurring in Black Hills ecosystems based on the ecological knowledge they have gleaned while harvesting. They seemed to be especially aware of the impacts that anthropogenic land use shifts are having on species they harvest. They are also noticing the decline of certain species and habitats and are concerned about further loss of certain species and habitats. Additionally, different types of harvesters (i.e., hunting, plant foraging, etc.) seem to hold different ecological knowledge. Unsurprisingly, plant foragers appeared to have more expertise in plant species, hunters in animals, fishers in fish species, etc. This data demonstrates how diverse harvesters might be able to provide useful information and feedback about anthropogenic impacts and species shifts to land managers who are managing for biodiversity in the Black Hills.

Climate Change Impacting Species

Although foragers provided some data on their observations about how the climate may be affecting species present in the Black Hills, overall, there was less data provided and no clear themes or conclusions emerged. Some foragers noted an increase in volatility of storms causing increased erosion and flooding, downed forest swaths, or decreased snowpack leading to either more challenging harvesting conditions or decreased harvested species presence. Three foragers stated that they've noticed an overall decrease in moisture in the Black Hills region in recent decades, while four foragers noticed an increase in moisture. Additionally, many interviewees doubted their responses, and others chose not to comment because they weren't confident in their ability to speak on the subject. Several foragers mentioned that some of the changes that they are noticing could be a combination of anthropogenic and climactic factors. But given the lack of

consensus and seemingly contradictory observations provided on climatic impact observations alone, this did not seem to be a significant area for foragers in this region to provide feedback on.

Anthropogenic Land-use Change Impacting Food Species

In contrast to climactic observations, interviewees were observed to be highly attuned to the anthropogenic forces impacting species presence and dynamics throughout the Black Hills region. Development, off-road vehicle and utility task vehicle (UTV) use, logging, general disturbance, and grazing were the top five anthropogenic land-use change factors mentioned.

Increased development was the most commonly mentioned anthropogenic land use change impact, and foragers described this force as potentially affecting harvested species in multiple ways. First, foragers have noticed a decrease in access with an increase in development. For instance, many of the areas that interviewees once used for harvesting have been developed. Development has not only decreased access to harvesting in these areas, but, in most cases, harvesters note that it has changed the ecology of the area such that they do not support food species anymore. Secondly, multiple hunters pointed to development as changing patterns of behavior in deer and elk and, ultimately, making both more difficult to hunt. One pattern observed was that deer, which used to stay at higher elevations through the winter, are now congregating in developed areas, closer to domestic settings, or in the middle of towns. On the contrary, since elk are more sensitive to human presence and noise, they have been noticed to be moving further away from developed areas to escape interactions with humans. These dynamics, according to harvesters, are making hunting more challenging in this region.

Offroad vehicle and UTV use was the second most common anthropogenic impact discussed by foragers. Several hunters mentioned how UTV's are affecting hunting. Hunters have perceived that more trails and greater access for UTV's throughout the Black Hills have disturbed and pushed elk further into the Hills and away from areas where they used to be. One hunter told a story about how, on multiple occasions they have been close to a deer after waiting for hours and a sudden UTV in the distance disturbed the hunt. Another told a story about how a four-wheeler tore up a trail where they had noticed an elk wallow, thus, disrupting both the elk and the hunting opportunity.

> *"And I remember one time I was hunting elk in the Black Hills - archery - and I found a wallow where the elk were wallowing in the mud. "Oh boy, it's good place!" I'm gonna come back, and I kinda roughed in a little blind. And when I went there the next day, somebody had been in there with a four-wheeler or several of them, and they tore the heck out of it. That goofed that poor elk up." ~ Interviewee 11, Hunter, fisher, mushroom and plant forager*

Interviewee 7 (Hunter, fisher) mentioned how off-road vehicles are also increasing the ability and ease for people to poach animals. And interviewee 5 (Hunter, fisher) described how they have often seen UTV's disrupting riparian areas by driving destructively through creeks. They also noted how this has created more silt and erosion in these streams, affecting both the fisher and fish.

Logging is another human land use impact foragers discussed often and as having multiple impacts on various foraging practices. Mushroom and plant foragers seemed especially aware of these impacts. Several mushroom foragers voiced their observations of logging decreasing mushroom presence and diversity, due to the dry environment and disturbed understory created afterwards. Other foragers voiced discrepancies: interviewee 2 (Hunter,

fisher) noted an increase in plant species like lupine and various grasses after logging in an area, and interviewees 9 and 10 (Hunter, fisher, mushroom forager; hunter, fisher, mushroom and plant forager) have observed logged areas to be potentially good mushroom harvesting areas 10 years after an area has been logged. Another indirect impact that harvesters noted of logging and development is the suppression of fire. They perceive fire suppression as decreasing mushroom presence, as well as overall biodiversity richness. Lastly, plant foragers most often tied logged areas with an increase in invasive plant species and decrease in overall biodiversity on the landscape. While some plant foragers mentioned making use of some of the invasive species that follow logging operations, these environments were still described as suffering a loss in biodiversity and decline in habitat quality for plant foraging:

"I love walking around all the different parts of the Black Hills but a lot of the areas that are really dense with ponderosa, because they're logging areas, you know, sometimes there's a lack of biodiversity in that area. I mean, you can always find life everywhere …but a lot of times, in those big areas of ponderosa, you know what you're gonna find. You're gonna find pine, you're gonna find some juniper, you're gonna find some pine drop…" ~ Interviewee 4, Plant forager

Another commonly discussed anthropogenic impact is the increase in invasive species due to general human disturbances. This is linked to a decline in native plants and animals, which, ultimately, impact both foraging habitat and decrease biodiversity richness. Disturbances noted include logging, UTV and offroad vehicle use, development, grazing, an increase in road and trail use, and an increase in foot traffic. Interviewee 3 (Plant forager) noted how overuse in the grassland areas where they forage tends to create greater erosion which makes way for invasive plant species, which outcompete the native plant species. And that, *"the species that I'm looking for to harvest could also then be choked out and just really can shrink the habitat availability there."* An indirect effect of this observed pattern is the increase of herbicide use on the landscape. Plant foragers are aware of the use of herbicides to control invasive plant species on both private and public land. This has made them wary of harvesting in areas where there are signs of disturbance or where invasive plants are present or nearby because they are concerned about ingesting the chemicals utilized.

"When I see disturbances around that are a little extreme, so particularly with noxious weeds, I might be concerned that has this area has been sprayed with herbicide and if so, not only would that impact like the sages that I could be burning but the bulbs or the roots that I'm harvesting that have been absorbing the chemical." ~Interviewee 3, Plant forager

The last factor that harvesters have noticed as a major force on the landscape is grazing by cattle. Although grazing was often recognized as a necessary and potentially beneficial force on the landscape, interviewees often noted how the current impacts are largely detrimental to both food species and biodiversity levels. First of all, fishers noted how cows have been disturbing riparian habitat and fish reproduction by trampling and disturbing the banks of rivers and creeks. They have observed this to have created erosion, increased siltation and produced the potential harm to fish eggs and fish populations. Plant foragers also noted the high potential for cattle to overgraze areas, consuming many of the native food species while creating conditions for greater erosion and invasive species establishment. Additionally, cows are noted as dirtying habitats where there is potential for plant harvesting and several foragers note needing

to avoid areas which have clearly been "*bathroom areas for cattle*" for sanitary and health purposes.

Anthropogenic Land-use Change Impacts to Non-food Species

Foragers have noticed similar anthropogenic factors in the Black Hills affecting non-food species. Development, again, was noted as a key impact linked to observations in changes of bird species present near developed areas. Decreasing levels of forage diversity was also attributed to recently developed areas and, inevitably, a decrease in the quality of habitat for wildlife. Foragers tied this to a change in landscape, including managing the land for a green lawn, which is common in developed areas.

Another common anthropogenic impact affecting non-food species is logging. Again, plant and mushroom foragers in particular noticed logging being tied to greater instances of invasive plants, and a decrease of native plants. With this shift, these foragers note a significant reduction in species richness. Additionally, foragers have observed how logging is also tied to managing the land for ponderosa pine, which has become a homogenizing force on the landscape, pushing out other species and habitat types.

"You know how we manage our forests for timber harvest and timber production definitely seems problematic to me as someone who wants to forage and hunt. Because we're getting these large, you know, acres and acres and acres of area that are not really suitable habitat for anything other than a ponderosa tree." ~ Interviewee 9, Hunter, fisher, mushroom and plant forager

These forces combine to create what foragers, and especially plant foragers, describe as a major reduction in species richness, decrease in the variance of habitat types unique to the Black Hills region, and a reduction in native plant species present. And, although this was a common view of plant foragers, some hunters and fishers noted that they've observed an increase in grass, wildflowers, and lupine post logging. Thus, views on the effects of logging on overall biodiversity within the forest seemed varied, especially between different types of foragers.

It was noted that some anthropogenic land-use changes were linked to an increase in biodiversity. These practices included a decrease in helicopter use over the Black Elk wilderness area tied to an increase in mountain goat population. An increase in raptor presence due to humans increasing the fish stocked in reservoirs. Lastly, forest thinning was linked to increasing the amount of wildlife present in certain forested areas of the Black Hills. As opposed to logging which generally takes medium to large trees from an area, forest thinning aims to decrease the amount of smaller trees or "doghair" in an area.

Theme 4: Biodiversity Loss & Concern

Interviewees were directly asked about observed loss, or concern for loss, of food species from the Black Hills Region. Due to other anthropogenic land use pressures such as logging, development, and fire suppression, harvesters are concerned about the loss in aspen forest habitat, lodgepole pine, and potential future loss in spruce forest habitat. All of these ecosystems are important areas of biodiversity and tied to specific food species. Though no specific plant, mushroom, or fish species were denoted to be of particular concern by foragers, several animal species have been observed by hunters to have experienced significant decline in population over

the past 3-4 decades. This has ultimately affected their hunting practices and the food they consume. Species mentioned include ruffed grouse, antelope, and porcupine.

The ruffed grouse were described by hunters to have been in far greater populations decades ago, but now are much more rare.

"When I was younger, I would see ruffed grouse every time I was in the woods. Every single time. They were prolific. They were everywhere. The last ruffed grouse I've seen was probably six or eight years ago. One or two a year if, if you're lucky and that has been the most startling change in biodiversity that I've seen." ~ Interviewee 10, Hunter, fisher, mushroom forager

The decrease in ruffed grouse populations were thought to be tied to habitat loss, specifically of aspen habitat linked to fire suppression, propagation of ponderosa, and development. Multiple hunters voiced that they personally have chosen to stop hunting grouse due to the current state of their populations, and they believe that the Game, Fish, & Parks (GFP) shouldn't allow them to be hunted by others either.

Hunters have also observed antelope to be in decline, potentially because more fragmented landscapes and development may be pushing them further out of the Black Hills Region. And although this is a species reported to be a favorite meal in several households, hunters have decreased their harvest levels significantly, and some even believe there should be a multi-year moratorium on hunting antelope to allow their population to rebound.

Although not seen a major food source, porcupines were also reported as having drastically declined in recent decades. Because they are so rarely seen, one hunter recounted abstaining from hunting them altogether now:

"I mean, you could see 15 or 20 porcupines in one night of driving around the Black Hills. And now I go years in between seeing one. I mean, it's not like a slight, it's startling the difference in the population of porcupines." ~ Interviewee 10, Hunter, fisher, mushroom forager

Wild food harvesters who participated in this study also described the loss of ecological knowledge as a key social element that is both affected by and could be contributing to biodiversity loss in the Black Hills. Without the knowledge to inform cultural values to prioritize managing these landscapes for diverse species and habitats, other management prioritizations that are not reliant on biodiverse ecosystems may and in many ways already have prevailed. Additionally, without the knowledge of how to harvest sustainably, often termed "best practices," foragers are concerned that food species will suffer and the potential for negative harvesting impacts will only increase. This has negative consequences for both the diversity that food species comprise within an ecosystem, as well as the non-food species that are in relationship with them.

"We're losing all that information [traditional ecological knowledge]. And we're losing the ability to care about it. Because right now, you know, why go out, pick a bunch of berries, when I can walk across the street and buy it. I think we're losing it."
~Interviewee 11, Hunter, fisher, mushroom and plant forager

All in all, interviewees directly and indirectly expressed how harvesting has become more difficult in recent years due to the increased pressure of other uses in the Black Hills.

Drops in the populations of some species, increased presence of invasive species, and loss of certain types of habitats due to logging pressure and development have all affected foragers in some way. Similarly, the expansion of offroad vehicle trails and increased use paired with the effects of the expansion of development in the Black Hills, and the change of culture that has accompanied it, have coalesced into make harvesting much more challenging in this region.

Research Question 3: What practices do wild food harvesters have which might promote or protect biodiversity in the Black Hills?

Theme 5: Symbiotic Harvesting Techniques

Another way wild food harvesters are in relationship with biodiversity richness is through their harvesting practices. Interview participants described two types of harvesting techniques that could support the conservation of biodiversity. First, interviewees described harvesting practices aimed to sustain or promote *food* species (see Table 2).

Table 2.
Harvesting Techniques to Sustain or Promote Food Species

	Practices to Sustain Food Species	**Practices to Promote Food Species**
Mushrooms	• Harvesting a certain percent of population • Not harvesting immature mushrooms • Only harvesting if abundant	• Carrying harvested mushrooms in a porous bag to spread spores
Plants	• Harvesting a certain percent of population • Focusing harvests on vegetative portions (rather than roots) so they can grow back • Root and bulb harvest used sparingly and with great care; allow plant to go to seed first	• Harvesting to stimulate growth • Spreading seeds by spitting or excretion • Pruning to promote abundance for humans and wildlife
Animals	• Harvesting older or younger animals; avoiding best age group for reproduction • Not harvesting does with fawns	
Fish	• Only harvesting males when fish species is breeding • Not harvesting larger female walleye • Harvest smaller fish in areas of dense populations to create better spread of age groups • Avoid fishing in areas rainbow trout reproduce on their own • Avoid fishing on hottest days and hottest times of the year • Avoid harvesting large trout in small streams in Black Hills	

Fish harvesting practices differed from other harvesting practices due to the artificial nature of fish populations in the Black Hills. Every fisher interviewed expressed their awareness of the put-and-take stocking system that the Game, Fish & Parks (GFP) maintains throughout the Black Hills. For the most part, fishers continued to take careful measures to maintain fish populations, even though they knew they were artificially stocked. But interviewees expressed how these sustainable harvesting practices were not as important as they would be if the GFP didn't stock them. Additionally, many fishers expressed a sense of harvesting with more ease or in greater abundance than they otherwise would, simply because they knew that it's what the system is designed for. However, even though fisherfolk know that they are in relationship with an artificial stocking system, they still maintain some specific harvesting techniques to benefit and protect the species that they are harvesting, such as harvesting in accordance to breeding cycles (see Table 2).

Wild food harvesters also noted harvesting practices they have which may impact species outside of those utilized for food, although these were less common (see Table 3).

Table 3.
Harvesting Techniques to Sustain or Promote Non-food Species

Practices to Promote Non-food Species	Practices to Promote Native Species
• Leaving enough harvested flowers for other pollinators in area • Hunting as a way to regulate deer populations to allow other species to maintain their populations	• Intentional unsustainable harvest of invasive species to promote or protect native species • Spreading native seeds • Transplanting native plants to new areas • Harvesting non-native fish to provide more food for native aquatic species • Picking invasive plants (not always for food but sometimes just for management) while out hunting, mushroom foraging, or plant foraging

Theme 6: Harvesting Ethics & Philosophies

Among the sample interviewed, harvesting ethics and philosophies seemed to be linked to the conservation of biodiversity by way of influencing why people harvest, the practices they utilize to harvest, and the quantity of material they choose to harvest. These all, in turn, might affect the overall impacts that harvesters have on species throughout this region. Two prevalent sub-themes emerged from this section. First, while talking about their harvesting practices, the notion of self-regulation and self-restraint emerged with great prevalence. Harvesters talked about leaving mushrooms or throwing fish back if they did not need them. They often

emphasized only harvesting if they are going to eat the species, and only harvesting what they can eat. Attention was given to perceived population levels and reproduction cycles of a species.

A lot of times I'll see nice morels that just sitting there waiting to be picked. But if I'm not ready to use them at the moment, then I'll often just leave the mushrooms."
~ Interviewee 3, Plant forager

The second sub-theme that emerged was the concept of interconnectivity that foragers described while talking about their harvesting practices. In some instances, foragers spoke to this as they described the reasons why they hunt or fish: the things they get to see while in nature for long periods of time, the depth of understanding of species they glean while being in close proximity with them for extended periods of time, and their feelings of belonging within the environment while harvesting. One hunter described it as such:

"You're in what's happening and you're a part of what's happening. And when we did shoot a deer, it makes you think about how you're taking away from that group…You feel a different connection to your food." ~ Interviewee 6, Hunter, fisher

Others spoke to this interconnectivity in terms of spiritual experiences, in realizing that through consuming species from their environment, the molecules of that place literally becomes them:

"Yeah, that connection of, you know, this thing has lived and now it's energy is part of me."
~ Interviewee 2, Hunter, fisher

Interconnectivity was also integrated into the ways foragers spoke about the roles of humans in the environment and in the conservation of species. While one harvester voiced that the only way to conserve biodiversity is to keep humans separate from the environment, others expressed the opposite. They see humans as interconnected with the species in their direct environment, whether they are aware of it or not, and it's how humans choose to enter into that relationship that determines the survival and wellbeing of other species:

"We shouldn't be scared of touching the environment, because we are it, and we need to connect with it in order to heal each other. So, you know, don't be afraid but don't take everything, don't take it all, just take 1/3." ~ Interviewee 4, Plant forager

"They're [local species] all interconnected somehow, and people don't pay attention to that anymore like they used to. There's a reason things are here, and sadly we're the reason they're gone." ~Interviewee 11, Hunter, fisher, plant and mushroom forager

Theme 7: Negative Harvest Impacts

Interviewees were asked directly about negative harvesting impacts that they have observed which might be impacting species richness throughout the region. The response of interviewee 5 (Hunter, fisher) sums up most foragers' responses about their own foraging

practices well: "*I've worked pretty hard to not have that happen*." But interviewees were concerned about patterns they've observed in certain parts of the harvesting community throughout the Black Hills, including a lack of education and a shift in harvesting culture.

Most interviewees didn't see foraging as a threat to species richness if harvesters are educated on sustainable harvesting techniques, though some did express that this might only be true given a particular number of people harvesting in this region. But interviewees did express a wariness about uneducated foragers, those unfamiliar with "best practices" or sustainable harvesting practices, those unfamiliar with the ecosystem, or those who are not mindful of others who may also be harvesting. Many foragers also indicated noticing an increase in foraging popularity, more people wanting to learn, and an influx of people who are new to the area wanting to forage. This is why plant foragers, mushroom foragers, and hunters alike, all viewed education as key for sustainable harvesting in the Black Hills.

> *"Yeah, like that's the only thing that could be detrimental to foraging is if people aren't educated and they just go out and they are just ripping stuff out of the ground."*
> *~ Interviewee 1, Plant and mushroom forager*

Additionally, some foragers expressed concern about a shift they have observed taking place in harvesting culture. Multiple harvesters have observed an increase in harvesting which isn't done for food as much as it is for sport or commercial use. These individuals talked about motives for harvesting moving towards "feeding" one's ego instead of their family:

> *"Now they want the biggest one they could get, or the most they could get. The biggest fish, the biggest buck and they're…instead of a hunter gatherer, they're more gathering information for their ego. It's an ego thing. It has nothing to do with the with food."*
> *~ Interviewee 11, Hunter, fisher, mushroom and plant forager*

Harvesters also tied their observance of an increase in poaching and head hunting to the expansion of offroad vehicle trails, making illegal and non-food harvesting easier and more accessible. Also, interviewees viewed harvesting for personal use and a few gifts as a sustainable level, but once a commercial aspect is introduced, their concern about the negative impacts of harvesting increases.

Next Steps

Theme 8: Management Considerations

Interviewees were asked about land management changes that they think should be considered to benefit both food and non-food species with the overarching goal of conserving biodiversity throughout the Black Hills. Through the interviews, several themes emerged including prioritizing the conservation of biodiversity, greater indigenous inclusion in management, more prescribed burns, expanding ecological educational opportunities, and prioritizing management of native species.

Prioritizing the Conservation of Biodiversity

Harvesters described many of the current prioritizations of land use in the Black Hills as leading towards the creation of homogenous environments which are ultimately degrading to wild food environments and lead to species loss. Therefore, to benefit wild harvesting and the conservation of biodiversity at large, some foragers would like to see the conservation of biodiversity become a conscious and collective priority within land management in the region.

"It seems very problematic to me as someone who is trying to harvest elk and make a living in the outdoors, so to speak, that we don't really start to see the deer and the elk and the songbirds until we get into these areas of more heterogeneity on the landscape where you have that mosaic habitat. And we're not managing our forests for mosaic habitat right now. And I think that is a disservice to everyone else who's not cutting trees down." ~ Interviewee 9, Hunter, fisher, mushroom and plant forager

Indigenous Inclusion

Several interview participants voiced the need for greater involvement and collaboration with indigenous tribes and people in the formation of policy and decision making for land management in the Black Hills, especially that which centers around the conservation of species. Foragers recognize that indigenous groups with ties to the region often have had long standing relationships with native and food species there. Paired with land rights issues, foragers consistently noted that greater involvement and collaboration with indigenous groups could be a good step towards addressing social justice issues and prioritizing the conservation of biodiversity in the Black Hills. Ideas on ways to accomplish this ranged from LandBack, or the global movement to reestablish indigenous political authority on lands designated as theirs by treaty, to the co-management of public lands, giving indigenous people the primary opportunity to lead fishing and hunting guiding services throughout the region, and amending harvesting permits for indigenous groups on public lands in the Black Hills.

"So that would be a great place to start. Is for that [conservation of biodiversity] to be a collective priority, and for it to be done in a way that is equitable and inclusive and representative of not just the public, like hunters and foragers, but also of indigenous communities and traditional ecological knowledge…co-stewardship would be a great way to see some of these changes, I think. And to recognize the rights and the significance of the Black Hills for the Lakota people and indigenous communities more broadly, as the rightful stewards of the land." ~ Anonymous

Prescribed Burns

Foragers highlighted a need for more prescribed burns throughout the Black Hills to support the conservation of biodiversity and to promote particular food species, non-food species, and habitats. Fire was noted by foragers as a traditional management technique utilized by indigenous people before white settlers arrived in the area. The observed effects of fire suppression were noted by foragers as affecting harvested species and environments negatively, often decreasing biodiversity. This loss of diversity was particularly connected to loss of aspen groves, which oftentimes are an early successional after fire in this region. Half of all interviewees noted aspen habitat as lacking in the Black Hills, having been lost gradually since the arrival of Europeans. Aspen groves are seen as necessary habitat for ruffed grouse, many

mushrooms, and several other species. Thus, plant foragers, mushroom foragers, and hunters alike called for more prescribed burns:

"I know my dad was having a fit because he got an elk tag and then they decided to do a prescribed burn in the area he wanted to hunt and he was sure that just took care of all that. And when we were going through there, there were deer, deer eating right by the burn piles. So, I don't think that really hurt anything and it really helps get the forage back... I think that those really help with biodiversity." ~ Interviewee 5, Hunter, fisher

Ecological Education

Foragers also highlighted education as essential for both sustainable foraging and the prioritization of the conservation of biodiversity in the Black Hills. Plant foragers, mushroom foragers, fishers and hunters alike, noted how important ecological knowledge is to inform best harvesting practices, which serve to avoid harm of harvest to both harvested and non-harvested species. They also noted that one of the main threats of harvesting comes from uneducated or under-educated harvesters. Additionally, harvesters noted that foraging is a good way to raise awareness about and kindle interest in other non-food species in the area. Once a bond is formed with a species through foraging, it can become a gateway towards realizing, valuing, and working to protect biodiversity at large in the local environment. Foragers noted that the public, as well as certain industries like developers and loggers operating in the area, should have better access to educational opportunities about the species of this area. Amidst observations of widespread loss of ecological knowledge within society, greater ecological education opportunities could be beneficial for the conservation of biodiversity in the Black Hills.

"I just think that even if they don't want to forage or anything, just knowing like, hey, we live in a place like, look at all the stuff that's native to here and it's here whether you want it here or not. And you should know what it is." ~Interviewee 1, Plant and mushroom forager

Prioritizing Native Species Management

Native species were noted as important to harvesters and biodiversity richness in the area. Harvesters called for less overall disturbance of the environment, more effective and precise grazing management, logging practices which create less disturbance and contribute to heterogenous habitats, and less expansion of UTV and offroad vehicle roads as important initial strategies to help prioritize native species in land management of the Black Hills.

"I think more management by the Forest Service to keep the cows where they're supposed to be. Because we ended up doing a lot of fence fixing where they were getting into places where they were then mucking up the riparian area. But they needed water too. But there's places where I fish that are fenced so that there is a place that cattle can come to water, but then they don't trash the rest of the banks and the meadows." ~ Interviewee 5, Hunter, fisher

Discussion

The intention of this study was to investigate the current relationships between wild food harvesting and the conservation of biodiversity in the Black Hills Region. Six key findings emerged: (i) wild food harvesting and biodiversity may be interdependent, (ii) issues of social justice are central to this topic in this region, (iii) foragers are noticing specific anthropogenic land-uses negatively impacting native species, native habitats, and food species, (iv) sustainable harvesting techniques and values which seek to sustain or benefit harvested species are common amongst harvesters interviewed and could contribute to the conservation of biodiversity, (v) ecological education may be a vital bridge to sustain both wild food harvesting traditions and the conservation of biodiversity in this region, and (vi) wild food harvesters and indigenous groups could be important stakeholders to include in land management planning and decision making.

This scoping study supports research from around the world which has found wild food harvesting to exhibit interdependent relationships with biodiversity richness (Armstrong et al., 2021; Bharucha & Pretty, 2010; Ellis et al., 2021; Tremblay et al., 2020; Turner et al., 2011). These interdependencies have been described as reciprocal and co-evolutionary relationships that knit the health and wellbeing of the ecosystem to the wellbeing of humans (Teixidor-Toneu et al., 2023). The diverse reasons why participants harvest suggest that wild food systems could be linked to social and cultural wellbeing. Thus, further loss of species, lack of access to harvesting areas, and loss of ecological knowledge could negatively impact socio-cultural wellbeing throughout the region (Ahmed et al., 2022). Simultaneously, harvesting, has been found to be compatible with the maintenance of, and in some cases even beneficial for, certain species (Landor-Yamagata et al., 2018; Teixidor-Toneu et al., 2023; Turner et al., 2000). This could be the case for some of the harvesting practices listed above, although more research is needed to determine the actual impacts of these harvesting practices in this region, both on harvested and non-harvested species. Although not all harvesting is ultimately beneficial to species conservation, recognizing the potential roles humans have in the ecosystem could have profound implications for human and cultural wellbeing tied to wild food systems, as well as the effectiveness, sustainability, and equitability of species conservation initiatives moving forward (Ahmed et al., 2022; Bliege Bird & Nimmo, 2018; Ellis et al., 2021; Gavin et al., 2015; Tauli-Corpuz et al., 2020). This data aligns with concepts found in other studies including "conservation through use," "conservation for nutrition," and the "One Health Approach" which contend that biodiversity depends on specific human relationships with other species and their environments through food, while human health, cultural wellbeing, and more domesticated food systems simultaneously rely on biodiversity richness (Ahmed et al., 2022; Singh et al., 2013; Vasquez & Sunderland, 2023).

Issues of social justice including land rights were another central topic that arose at the intersection of wild food harvesting and the conservation of biodiversity in the Black Hills. It is well recognized that indigenous groups steward much of the world's biodiversity (Garnett et al., 2018; Sobrevila, 2008). And indigenous management and harvesting techniques, embedded within traditional ecological knowledge and indigenous knowledge, have been highlighted as important to incorporate into policies and plans to conserve biodiversity (Tauli-Corpuz et al., 2020; Turner et al., 2000). Simultaneously, indigenous land dispossession in the US has been described as foundational for the forces of colonization, industrialism, and capitalism, which may contribute to the anthropogenic and climate-induced biodiversity loss observed today (J. Davis et al., 2019). Additionally, traditional conservation models were often created by the

removal of indigenous people, have been "fortress-based," negatively impacted traditional food ways, and have been largely ineffective; future calls for the expansion of protected areas for the conservation of biodiversity risk exacerbating these injustices, eroding traditional ecological knowledge, and negatively impacting traditional food systems (Barthel et al., 2013; Reyes-García et al., 2019; Tauli-Corpuz et al., 2020; Vasquez & Sunderland, 2023).

Thus, issues of power, access and control have been found to be central to the social dimensions of harvesting in the US, with people of color disproportionately facing barriers to access and inclusion in land management decision-making (USFS, 2018). Recent national and international policies call for indigenous leadership and collaboration in the planning and decision making for species conservation initiatives (Department of Interior, 2021; UN Environment Program, 2022). This study further strengthens those calls in the context of the Black Hills region by showing how the conservation of biodiversity is linked to wild food harvesting, and how harvesters note indigenous leadership as an important aspect of managing for both. This issue takes on greater gravity given the history of land dispossession, legal implications of the Fort Laramie Treaty of 1868, and sustained calls for LandBack in the Black Hills. Additionally, the recent Joint Secretarial Order 3403 reasserted the US's Trust Responsibility to manage federal lands and waters in a way that "protects the treaty, religious, subsistence, and cultural interests of federally recognized Indian Tribes" (USDA, 2023). One project of co-stewardship at the Pactola/He Sapa Visitor Center has recently begun between the USFS and multiple tribes to jointly develop a natural and cultural interpretation program at a central location in the Black Hills (USDA, 2023). Given the amount of land the federal government stewards throughout the Black Hills, the international and national policy context, and the potential implications for successful biodiversity conservation and sustained wild food harvesting, indigenous leadership in land management and collaboration in policymaking seems to be an essential area of focus and prioritization for maintaining a healthy, biodiverse ecosystem and a thriving wild food system in this region.

The third finding suggests that wild food harvesters have important feedback about anthropogenic land use impacts to species in the region. Interviewees expressed compatible observations about the types of land uses impacting species. Development, logging, offroad vehicle and UTV use, general disturbance, and cattle grazing were the top five most prevalently mentioned anthropogenic land-use changes noted by interviewees, and they were associated with observations of decreased habitat heterogeneity, decreased native species, and decreased access to wild food species. This supports the findings of other research from around the globe, which confirms the vulnerability of biodiversity and wild food environments to land-use change (Ahmed et al., 2022; IPBES, 2019; Mcconnell & Viña, 2018). This research also aligns with other studies which have highlighted harvesters as effective monitors for particular species throughout this region (USFS 2018). This could be especially true on public land whose managers are struggling to fund monitoring for the conservation of biodiversity (Wearn et al., 2020). Additionally, given the interest some harvesters have in harvesting invasive species, this is a potentially symbiotic relationship that land managers working to remove invasive species from the landscape could explore as an alternative management technique.

Interviewees expressed their intent to contribute to the conservation of biodiversity both through their sustainable harvesting techniques as well as their harvesting ethics and philosophies. Interviewees conveyed an awareness of reproductive cycles and population levels of the species they harvest and an intent to adjust their harvesting practices accordingly to support the wellbeing of those species. Negative harvesting impacts were mentioned but were

less common and associated with a lack of ecological education or were driven by markets or non-food related motives. Other studies have also shown wild harvesting as either a driver of biodiversity loss or contributors of their protection, depending on the type of system utilized (Berkes et al., 2000; Fa et al., 2002; Gadgil et al., 1993; Tremblay et al., 2020). Other studies have also found that wild food harvesting can be supportive of the conservation of biodiversity through specific harvesting and stewardship practices (Armstrong et al., 2021; Landor-Yamagata et al., 2018; McLain et al., 2017; Teixidor-Toneu et al., 2023; Turner et al., 2011). This could be the case for some of the harvesting practices listed above, although more research is needed to determine the actual impacts of these harvesting practices, both on harvested and non-harvested species. This scoping study also suggested that sustainable or symbiotic harvesting techniques could be in relationship with harvesting philosophies and ethics, including self-restraint and perspectives on the interconnectedness of humans, other species, and their environments. Like other studies suggest, these ethics, values, and worldviews might have an indirect but critical relationship with harvesters' overall impacts on the biodiversity richness of the region (McLain et al., 2017; Singh et al., 2013).

The depth of ecological observations, specific harvesting and management practices, and underlying belief systems described by interviewees suggest the presence of traditional and local ecological knowledge within wild food harvesting cultures in the Black Hills. It has been well recognized that traditional ecological knowledge, especially that which is held and practiced by indigenous people globally, has and continues to play a crucial role in the creation and maintenance of the world's biodiversity (Turner et al., 2000). Traditional ecological knowledge is also highly vulnerable to loss due to global land-use shifts, insensitive economic development, and shifts toward market economies (Ahmed et al., 2022; Turner et al., 2000). Threats to traditional and local ecological knowledge were suggested through the concerns that interviewees had about the negative impacts of the lack of ecological education, as well as the emphasis that interviewees placed on the role of and need for greater education around harvesting practices, values, and ecological understanding. Additionally, continued knowledge and use of edible wild species keeps humans connected to their environments and promotes ecological awareness and ecological integrity (Turner et al., 2011). The ecological knowledge associated with harvesting could be a vital bridge that contributes to the conservation of biodiversity by investing local communities in their environments and the diverse species that inhabit them. Given the embeddedness of much of this ecological knowledge in particular local and indigenous cultures, other studies have noted the importance of recognizing and integrating this ecological knowledge into local land management structure and policy in a fully participatory and collaborative way (Brondízio et al., 2021). Additionally, more opportunities for ecological knowledge sharing around harvested and non-harvested species could be an important consideration for land managers and community members organizing around the conservation of biodiversity in the Black Hills.

Finally, the results of this study suggest that the incorporation and participation of wild food harvesters and indigenous groups in land management decision-making, planning, and policymaking in the Black Hills could help conserve regional biodiversity in a way that is also beneficial for the socio-cultural wellbeing of the surrounding region (Reyes-García et al., 2019; Turner et al., 2000; UN Environment Program, 2022; USFS, 2018). Since current land-use prioritizations seem to be largely at odds with both the conservation of biodiversity and interests of wild food harvesters, this study supports the idea that this is a particularly important stakeholder group to include in land management because of their depth of ecological knowledge

and inherent investment in diverse, often native, species. This mirrors national and international policy goals to incorporate indigenous and local people into biodiversity conservation policy and planning, and furthers this by highlighting wild food harvesters as a potentially important subset group to include in land management policymaking and planning. This study illuminates a few particular ways that this could begin to be implemented at the regional level in the Black Hills, but needs further research.

Future Research

Several directions of future research have emerged from this scoping study. First, because of the longstanding relationships that indigenous people have had with the native ecosystems and traditional foodways of this region, more research needs to be conducted on culturally important species, traditional management techniques, potential impacts of species loss on cultural wellbeing, and observances of land-use change impacts specific to the indigenous foraging community throughout the region. Given the historical context of land dispossession and social injustices that have incurred in the Black Hills, this type of research should be conducted in a fully collaborative and participatory manner. It should also be paired with research on social justice aspects of land management planning and policymaking in the Black Hills, and investigate ways where transition to indigenous management, co-management, and greater inclusion of indigenous people and perspectives can be realized.

Also, given the implications that sustainable harvesting practices and traditional management techniques may have to aid in the conservation of biodiversity in this region, future studies should investigate these specific techniques in greater depth and measure their actual and longstanding impacts on the ecosystem, native plants, harvested and non-harvested species.

This study found that interviewees harvested for diverse reasons, some of which were connected to various aspects of individual, social, and cultural wellbeing. This is another area that could be investigated in greater depth to better understand the importance of wild food harvesting to people in this region.

The last area of future research should investigate threats to local and traditional ecological knowledge loss and discern what types and to what extent ecological knowledge is being lost, how this may be impacting local and indigenous cultures tied to the region, and specific reasons why the loss might be occurring. Simultaneously, educational opportunities where this knowledge could be supported and expanded should also be investigated in a way that sustains the cultural integrity and respects the historical context of the knowledge. Additionally, researchers should explore how the ecological knowledge involved in wild food harvesting may contribute to the biodiversity conservation by expanding awareness of and creating shared values around local, native, and diverse species in the region.

Limitations

The findings of this project are subject to limitations. With eleven interviewees, it is difficult to discern the extent to which the findings reflect the experiences of the general population of wild food harvesters in the Black Hills region. Additionally, because experts were targeted for these interviews, their perspectives cannot be extrapolated to represent that of the general harvesting community. However, since this was a scoping study and only general context and directions for future research was sought, the number of interviewees was sufficient for the intent. Additionally, without demographic questions, it is impossible to note any comparisons or differences in terms of views between different groups of people or to determine

whether a truly diverse sample was created. Since indigeneity is a central aspect to this topic, knowledge about this key demographic piece would have been especially helpful to discern between indigenous and non-indigenous perspectives. However, the lack of inclusion of demographic questions could contribute to interviewees expressing viewpoints that aren't necessarily in alignment with the demographic groups they belong to. Also, without them, we are able to look at the foraging community as a whole, and, with the size and scope of the study, breaking down interviewees into smaller groups wouldn't be especially necessary or helpful.

Conclusion

Wild food harvesting is an important way humans interact with their immediate environment and form reciprocal relationships with the diverse species there. As prior research suggests, there seems to be an inherent and intimate relationship between wild food harvesters and the conservation of biodiversity in the Black Hills Region. This relationship has the potential to support species richness or harm it, depending on the harvesting techniques employed, harvesting ethics and philosophies, and ecological education present. Additionally, foragers show the potential to hold vast amounts of knowledge about certain species, both in terms of feedback about land-use impacts on species and specific management techniques to benefit species. Indigenous groups may be particularly knowledgeable on this subject, and traditional ecological knowledge, along with land management rights should be explored to address issues of equity, justice, nutrition, food security, and species loss simultaneously and synergistically (Vasquez & Sunderland, 2023). More ecological educational opportunities and research is needed to investigate and maintain sustainable harvesting practices, better integrate socio-cultural practices into land management, and re-embed the valuation of diverse species into regional culture. Lastly, indigenous people and local harvesters need to be included in shaping land management policies in the Black Hills to better prioritize the conservation of biodiversity in a way that builds synergies between humans and nature through food.

"And when we lose that biodiversity, we lose the opportunity to even experience or interact with plants that are unknown to us. And then vice versa, we also lose that knowledge of those plants as well, because if they don't exist five years from now then we lose that entire relationship."

~ Interviewee 9 (Hunter, fisher, mushroom and plant forager)

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Appendix A

Interview Guide

(General Questions)

1. Can you tell me about the types of wild food harvesting, gathering, foraging, hunting, or fishing practices that you engage in?

2. What animals/plants/fish/mushrooms do you harvest?
    a. Are there any particular species that are especially important to you? Why?

3. Can you tell me about the reasons why you forage/hunt/fish?
    a. Probes: food security, tradition, enjoyment, social ties, connection with the environment, health, etc.?

4. What types of habitat do you most often forage/hunt/fish in? For example, Ponderosa pine forests, deciduous forests, open meadows, riparian areas, etc.? (Not specific places)
    a. Is there a particular type of habitat associated with the species you most often harvest?

(Ecological observations)
The next set of questions explores the environments where you forage/hunt/fish.

5. In the last decade, have you noticed any ecological changes in the areas where you harvest that you think could be attributed to climatic shifts?
    a. Probes: Changes in precipitation patterns? Seasonal timing? Intensity of weather events?

6. In the last decade, have you noticed any ecological changes in the areas where you harvest that you think could be attributed to changes in how the land is being used by humans?
    a. Probes: Logging practices, disturbance, increased use, encroachment, recreation, fire suppression, etc.?

If yes to 6 and/or 7:

7. Have you observed either of these changes (climatic or land-use) affecting biodiversity in the environments where you're noticing the shifts?
    a. Types of species present?
    b. Species richness or the number of different species present?
    c. Population size of species present?
    d. Quality or health of the species present?
    e. Distribution patterns or species shifting habitats?

8. Have you noticed any of these environmental changes (climatic or land-use) affecting the quantity or quality of the foods that you harvest?
   If yes:
   a. How are these changes impacting the foods you harvest?
      i. Which ones?
      ii. How does this impact your life?
   b. What types of habitats are associated with these species?
   c. Have you changed your harvesting practices in response to these shifts? How?

9. Are there any food species that you used to harvest that you can't anymore?
   Probes, if yes:
   a. What species?
   b. What is the type of environment that you associate with this species?
   c. Why do you think this is the case?
   d. Are there any species that you are concerned that you won't be able to harvest anymore in the near future? Which ones?

(Specific Techniques)
The final set of questions relates to the specific practices that you use to harvest.

10. Do you have any harvesting practices that you believe help promote the availability or quality of the wild foods that you harvest?
    Can you tell me about those?
    a. Probes: Spreading seeds, spreading rhizomes, weeding out other species, burning, etc.

11. Do you have any harvesting practices that you believe help promote biodiversity at large in the places where you harvest?
    a. Can you tell me about those?

12. Are there certain land management practices that you think would better promote the quantity and quality of the wild foods you harvest?

13. Are there certain land management practices that you think would better support biodiversity in the Black Hills?

14. Are there any foraging practices that you or others practice that you are concerned might negatively impact biodiversity in the Black Hills?
    a. Of the wild food species that you harvest?

15. Is there anything you would like to add about the interrelationship between biodiversity and wild food harvesting in the Black Hills?

16. That's all my questions pertaining to wild foods and biodiversity, but before we wrap up, I want to ask you if there are there any other wild food harvesters that you would consider to be an expert in the region that you would recommend I reach out to?

Appendix B

Code Book

Theme	Code	Definition	Examples
Harvesting Dependent on Biodiversity	Species Harvested	Interviewee lists a species that they harvest for food	"But for the most part, game meat and all kinds of small game, I do a lot of rabbit and squirrel hunting"
	Genetic Diversity	Interviewee discusses how their harvesting practices impact or rely on genetic diversity	"I'm just talking healthy that they're kind of like late teens, early 20s beer, they're healthy they got more vigor they're more able to sustain harsh weather. I think I try to protect those for carrying on, you know, for perpetuating the population. I think that leaving the age class of critters that are most resistant to whether it be disease or weather makes the most sense."
	Habitats	Interviewee explains the type of ecological environment in which they harvest food	"So definitely the most common habitat that I find myself foraging in would be the full sun meadow kind of grassy meadow type of habitat."
Indigenous Intersections	Indigeneity and Biodiversity	Interviewee notes a relationship between indigenous culture, knowledge, land management practices, or foodways and diversity richness	"So definitely removal of fire and ungulates from the landscape, but then yeah, overuse of ungulates and other cases, you know, I think a lot of that also includes removal of indigenous people from the landscape, pushing tribes off out of the Black Hills onto reservations."

	Indigenous Management	Interviewee talks about specific indigenous land management techniques or traditional harvesting techniques	“Traditionally, fire was a tool that was used by tribes. So you're losing that as a management tool.”
	Indigenous Land Rights	Interviewee discusses the rights of indigenous people to access, manage, or make decisions regarding land in the Black Hills	“Depends on the area and who you're talking to, there could be some flexibility there, whether that's like truly in the policy to allow for indigenous people to harvest without a permit, or it could be kind of a unwritten rule that an agency follows and allows, or it could be really hard line and if you were to be observed harvesting without a permit, there could be some repercussions there.”
Ecological Observations	Climate Impacts	Interviewee observes an ecological change that they attribute to a change in the climate	“It seems that our new weather patterns have shifted this area to, you know, increase a lot of the moisture.”
	Anthro + Climate Impacts	Interviewee observes an ecological change they attribute to a combination of changes in climatic and anthropogenic factors	“I think that winter storms where antelope historically could navigate storm systems, they’d just move to avoid super deep snow and inability to forage. Now with a super broken landscape with tons of fences and roads, I think it's harder for them to avoid these climatic, you know, impacts like huge blizzards.”
	Anthro Impacts	Interviewee observes an ecological change that they attribute to a change in land use by humans (anthropogenic impacts)	“Especially like if they're like clear cutting if say I was finding arnica there, it'll be gone.”

	Climate & Anthro Impact Food Species	Interviewee describes how the ecological change they observed, due to either climatic or anthropogenic factors, is impacting the species that they harvest for food	"Sometimes areas that have been logged, not super recently but within the past 10 years will be productive mushroom areas because there's that nutrient and carbon turnover in the soil."
	Climate & Anthro Impact Biodiversity	Interviewee describes how the ecological change they observed, due to either climatic or anthropogenic factors, is impacting species that they do not harvest for food	"I got a mowed lawn, they could eat anywhere they want. But they don't, they pick I think. And so I think that's goofing them up a bit…The squirrels, chipmunks and all that stuff, in my opinion, have changed. I don't see the squirrels like I used to."
Biodiversity Loss and Concern	Observed Loss	Species the interviewee has directly observed to have had a loss in population	"Rough grouse and porcupine as both are something that we're just common and you saw them constantly and now it's a real anomaly to see either one."
	Concern for Loss	Species the interviewee hasn't observed a major loss in population yet, but due to current practices or impact, the interviewee is concerned that there will be loss of this species in the future	"So I will say that this hasn't happened yet, but there is the proposal to basically clear cut our spruce stands so that we can replace them with Ponderosa, which we take out an entire habitat type out of the Black Hills."
	Social Loss	Interviewee describes a loss in societal social or cultural practice or phenomenon that they describe as tied to a loss in or a concern for loss in a species	"We're losing all that information. And we're losing the ability to care about it. Because right now, you know, why go out, pick a bunch of berries, when I can walk across the street and buy it. I think we're losing it."

Symbiotic Harvesting Techniques	Harvesting Benefit Food Species	Interviewee describes harvesting practices they utilize that they perceive as being beneficial to the species that they are harvesting for food	"Hunting I think, helps keep the healthy herd, helps keep it down to a manageable level. They don't overpopulate."
	Harvesting Benefit Biodiversity	Interviewee describes harvesting practices they utilize that they perceive as being beneficial to species outside of the species they are harvesting for food	"So I feel like if people keep more fish in the Canyon that they are increasing the biodiversity of wild native species that are terrestrial in the area, and so it's counterintuitive to, you know, fisheries conservation, but none of the fish in the Canyon are wild from native sources."
Harvesting Ethics and Philosophies	Why Harvest	Interviewee describes the internal motivations they have for harvesting	"So that's really what drives it at this point. I think is just a sense of a clearer conscience in taking other critters lives to support mine and my families."
	Self-regulation	Interviewee describes internal restraints that they put upon themselves voluntarily to harvest species sustainably	"Rough grouse, right? I don't mess with them, even though they're you can legally take them."
	Interconnect-edness	Interviewees describe how harvesting contributes to or allows them to perceive the relationships between seemingly separate entities or disparate phenomenon within an ecosystem	"Understanding that spirituality is the connection that we all have with the actual molecules that are never lost or gained that are continuously cycled through our system and consuming that energy is, just so vital to health of all living things that are part of that and just having that connection together is something that just found to be a spiritual connection."

Negative Harvest Impacts	Too many mushrooms	Interviewees share that they believe that too many mushrooms are being harvested from this ecosystem	“I was often concerned with seeing uh people are removing bags and bags of bogus (mushrooms) out of the forest.”
	Poaching	Interviewees observe illegal harvesting techniques of fish or animals which are impacting biodiversity and harvesting	“I've seen a lot of poaching for heads because people do go further in than they’re supposed to in their vehicles or lots of poaching because of that.”
	Under-educated	Interviewee draws a relationship between lack of education around ecology or harvesting techniques to a loss in biodiversity	“The biodiversity will stay there with your harvesting it correctly. I don't see it like it, it can't disappear. That's the only way I think that things would go bad as that people started just like pulling things from the roots, not realizing what they're doing otherwise.”
	Sport	Harvesting without the intention to consume that which is killed; hunting or fishing for recreation	“A lot of people go hunting and they wonder what they're gonna do with it if they get one.”
	Commercial	Harvesting species for profit	“It's I really don't see a lot of impact, but once you start adding more people on the landscape, which is where we're trending towards in the Black Hills and having people maybe start introducing that commercial aspect, then not only do you have the potential for over harvest.”
Management Considerations	Prioritize Biodiversity	Interviewee notes that they believe the conservation of biodiversity should be prioritized more than it is currently	“So unless biodiversity is like the top or a top priority for management, it's going to be really hard for management decisions to in improve things or trend in that direction.”

Indigenous Inclusion	Interviewee describes how indigenous people and/or groups should or could be better included decision-making or planning for land management	"Co-stewardship would be a great way to see some of these changes, I think. And to recognize the rights and the significance of the Black Hills for the Lakota people and indigenous communities more broadly, as the rightful stewards of the land."
Fire	Interviewee notes how fire is, needs to, or could be utilized as a management tool	"We're a fire adapted landscape and we continue to not prioritize putting fire back on the landscape and a lot of our mushroom and plant species need fire to thrive."
Education	Interviewee notes education as key in land management for both biodiversity and wild harvesting	"So yeah, education, because I think the more that people realize too, like, woah, this place is special, we need this diversity are the more people that are gonna be the people voting for things."
Native Species	Interviewees emphasize a need to prioritize managing for species that are endemic to the Black Hills region	"That uh rock snot algae got bad in Rapid Creek for few years and that had a huge effect on them, on populations, cause that lessened the aquatic insects for the fish to eat so then we lost whole age classes of fish at that time. So I guess invasive species too."