

Contribution of wild foods to diet, food security, and cultural values amidst climate change

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Abstract

Wild foods are recognized to contribute to diet and food security through enhancing the availability of

local, diverse, and nonmarket food sources. We investigated the contribution of wild foods to diet, food security, and cultural identity in a Native American¹ community in the context of climate

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Author Note

The research presented in the article reflects the masters-level work completed by Erin Smith, in accordance with the Graduate School and Department of Health and Human Development at Montana State University. The findings from this study have been presented at the 2018 annual meeting for the Societies of Ethnobotany and Ethnobiology in Madison, WI, as well as the 2018 Food Sovereignty Summit hosted by the Rocky Mountain Tribal Leaders Council in Billings, MT.

¹The term 'Native American' was determined to be the preferred term for referencing the Native American community in this study, based on consultation from our community advisory board.

change. Structured interviews were conducted with low-income residents of the Flathead Indian Reservation² in Northwestern Montana who participate in the federal Food Distribution Program on Indian Reservations, also known by participants as ‘Commodities.’ Responses to structured questions were analyzed for frequency, and open-ended responses were coded and analyzed to identify prevalent themes. Our analysis indicated that half of participants were food insecure. Approximately 28% of participants engaged in at least one wild food procurement activity, including hunting, fishing, and harvesting. On average, participants who engaged in one or more wild food procurement activities were more food secure than those who did not. Results highlight the multidimensional valuation of wild foods by participants including taste, freshness, nutritional quality, being a traditional community practice, and providing a sense of self-sufficiency. Climate change is perceived by participants to be adversely impacting wild food systems due to increased variability in seasonality and precipitation and increased incidences of wild fire. Findings point to the need for community-based strategies to strengthen wild food knowledge toward enhancing food sovereignty in Native American communities, in the context of climate change.

Keywords

Wild Foods, Food Environment, Food Security, Food Systems, Climate Change, Native American, Indigenous, Traditional Foods

Introduction

Food environments are the consumer interface of the food system and act as crucial determinants of food security by influencing the affordability, availability, desirability, and convenience of foods (Herforth & Ahmed, 2015). Natural food environments provide local access to wild and cultivated foods from nonmarket sources, while built food environments contribute to food security by providing foods for purchase in market settings (Ahmed & Herforth, 2017). Wild food environ-

ments persist as integral components of Indigenous and traditional food systems (Damman, Eide, & Kuhnlein, 2008). Indigenous and traditional food systems are place-based food systems comprising foods from the local environment that are obtained and prepared in ways that are culturally acceptable and reflect cultural heritage (Kuhnlein, 2013), including foods that are hunted, fished, and harvested (Lemke & Delormier, 2018). The Royal Commission on Aboriginal Peoples (RCAP) describes traditional food systems as “part of a cultural heritage. Thus, [traditional] food is holistically entwined with culture and personal identity, as well as with physical health” (RCAP, 1996, p. 194). Within communities, traditional foods promote sustainability by supporting food security and improve health by reducing critical micronutrient deficiencies (Samson & Pretty, 2006; Vincetti, Eyzaguirre, & Johns, 2008). Furthermore, traditional foods support the cultural, economic, and environmental sustainability of food systems (Ford, 2009; Kuhnlein & Receveur, 1996; Mason & Lang, 2017).

Colonization of Indigenous peoples has resulted in a dramatic shift away from wild food environments (Compher, 2006) and toward consumption of highly processed, store-bought foods that are high in refined sugars, saturated fats, and salts that are typical of the “Western diet” (Popkin, 2001; Satia, 2010). Evidence suggests that this nutrition transition is having a profound and disproportionate impact on the health of Indigenous peoples (Damman et al., 2008). Improving nutritional quality of foods available in the food environment, including increasing the availability of wild foods, has been identified as a strategy to mitigate the nutrition transition and improve diet and health outcomes (Chodur et al., 2016; Damman et al., 2008; Herforth & Ahmed, 2015).

In the United States, the nutrition transition is well-documented among Native American populations, with subsequent diet-related health disparities (Compher, 2006; Jernigan, Salvatore, Styne, & Winkleby, 2012; Kuhnlein, 2013; Story, Strauss, Zephier, & Broussard, 1998). Obesity rates among

² The term ‘Flathead Indian Reservation’ was determined to be the preferred term for referencing the location in which this study was held, based on consultation from our community advisory board.

Native Americans are 50% higher in adults and 30% higher in adolescents than Anglo-European Americans, and Native Americans are 2.5 times more likely to be diagnosed with diabetes (U.S. Department of Health & Human Services, 2017). One in four Native Americans is food insecure, twice the U.S. average (Jernigan, Huyser, Valdes, & Simonds, 2016).

Several federal assistance efforts have emerged to address health disparities among Native American communities, including the Food Distribution Program on Indian Reservations (FDPIR), commonly known in some reservation communities as ‘Commodities.’ The FDPIR provides a monthly food supply sufficient to meet basic nutrient needs to low-income Native and non-Native Americans living on or near reservations (U.S. Department of Agriculture [USDA], 2014). Participants in FDPIR travel to local food distribution centers (FDPIR centers) and self-select a limited number of food items from various food categories based on the number of family members in their household. Previous research has found that the FDPIR is the primary source of food for approximately 40% of participants nationwide (Pindus et al., 2016), and that 31% of FDPIR participants procure some amount of food from hunting, fishing, or gardening (Pindus et al., 2016). At the same time, previous research highlights that food offerings of the FDPIR fail to meet national dietary recommendations, including limited fresh fruit and vegetable offerings, which may exacerbate health challenges of Native American communities (Byker Shanks, Smith, Ahmed, & Hunts, 2015).

The food sovereignty movement has emerged in response to the detrimental nutrition and health outcomes associated with the nutrition transition (Patel, 2009). Specifically, the food sovereignty movement advocates for the protection and ownership of built, wild, and cultivated food environments to enhance food security and human health for all peoples (Patel, 2009). Food sovereignty movements are increasingly manifest in Native American communities, calling for the strengthening of Indigenous food systems including promotion of wild foods (Patel, 2009).

At the same time, climate change threatens wild food environments and Indigenous food sys-

tems (Bharucha & Pretty, 2010; Doyle et al., 2013; Ericksen, 2008; Ford, 2009; Raiten & Aimone, 2017). Wild food environments are experiencing regional climate variability, including changes in temperature and seasonal patterns (Lynn et al., 2013), which threatens wild food availability, accessibility, and quality (Ford, 2009; Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007). For example, thinning and reduced arctic and subarctic sea ice shortens the hunting season for Inuit populations in the Canadian Arctic (Ford, 2009). In Montana, members of the Crow Nation have observed migrations and reductions in freshwater fish populations attributable to warming waters (Doyle, Redsteer, & Eggers, 2013).

The mutualistic concepts of enhancing resilience and food sovereignty are recognized as approaches for mitigating the negative impacts of climate change and other challenges of the Anthropocene that threaten Indigenous food systems (Ford, 2009; Patel, 2009; Shumsky, Hickery, Pelletier, & Johns, 2014; Tendall et al., 2015). Building food system resilience, or “the capacity over time of a food system and its units, at multiple levels, to provide sufficient, appropriate, and accessible food to all in the face of various and even unforeseen disturbances” (Tendall et al., 2015, p. 19), involves identifying and reducing existing vulnerabilities while increasing capacity to adapt to change (Shumsky et al., 2014). Increased utilization of wild foods can enhance food system resilience by incorporating local biodiversity and alternative modes of food procurement into diets, thus reducing omnidependence on built food environments (Ford, 2009).

The purpose of this research was to investigate the contribution of wild foods to diet, food security, and cultural values in the context of climate change among FDPIR participants on the Flathead Indian Reservation in northwestern Montana. We addressed our study objective through implementation of semi-structured interviews with Native American and non-Native American residents enrolled in the FDPIR.

Materials and Methods

Study Site

There are seven federally recognized tribes and one

state-recognized tribe in Montana. Approximately 70,000 Native Americans live in Montana, of whom 63% reside in urban centers across the state (U.S. Census Bureau, 2016). This research was carried out on the Flathead Indian Reservation (FIR), the remaining homeland of the Confederated Salish, Kootenai, and Pend d'Oreille Tribes. The FIR is the fourth largest reservation in Montana, comprising 1.3 million acres (526,000 hectares) situated within intermountain valleys in the Rocky Mountains and including Flathead Lake (Confederated Salish & Kootenai Tribes [CSKT], 2013). Flathead Lake is the largest freshwater lake west of the Continental Divide, drawing both tourists and non-native residents to the region. The current population of the FIR is 28,938, and less than one-third (28.3%) are of Native American heritage (U.S. Census Bureau, 2016). Among the Native American population, 5,333 individuals are tribally enrolled members of the Confederated Salish and Kootenai Tribes (CSKT, 2015). CSKT members have year-round access to open lands of the reservation, with some limitations, under the Hell Gate Treaty of 1855, for hunting, fishing, and gathering of wild foods (Kappler, 1855). Vegetation on the FIR is dominated by conifer forest and grasslands. (Arno, 1979; Montana Fish, Wildlife, and Parks, 2015). The FIR has a mild climate that is dominated by Pacific Ocean activity, and its forests are drier relative to surrounding forests (Arno, 1979).

The subsistence patterns of the Salish, Kootenai, and Pend d'Oreille tribes remain a central component of tribal cultural identity (CSKT, 2017). The CSKT tribal government has made efforts to preserve their food traditions by establishing cultural committees and a Natural Resources Department (CSKT, 2017). In addition, the CSKT have developed a Climate Strategic Plan “to develop potential programmatic and/or regulatory actions and changes ... appropriate to addressing the effects of climate change” (CSKT, 2013, p. ii).

The poverty rate for both Native and non-Native residents of the FIR was 23.6% in 2015, according to a report by Montana State University Extension (2017), nearly twice the national average (Proctor, Semega, & Kollar, 2015). Food insecurity is considered a major health risk factor for all

residents of the FIR (Administration for Children & Families, 2016), with 17.9% of the population participating in the Supplemental Nutrition Assistance Program, and 70.6% of students receiving free or reduced price school lunch in 2015 (Montana State University Extension, 2017). In addition to these programs, an average of 513 low-income households relies on FDPIR for a monthly provision of foods (Petet, 2017). This study was specifically focused on FDPIR participants.

The number of extremely cold days ($\leq -18^{\circ}\text{C}$ or 0°F) in Montana has declined, and ends an average of 20 days earlier than a century ago (Pederson, Graumlich, Fagre, Kipler, & Muhfield, 2010). At the same time, the number of extremely hot days ($\geq 32^{\circ}\text{C}$ or 90°F) has tripled, and the warm season lasts on average 24 days longer than a century ago (Pederson et al., 2010). Annual average temperatures have risen by 1.1° to 1.7°C (2 to 3°F) across the state since 1950, and changes in precipitation patterns have resulted in an overall decline in snowpack, accumulated layers of snow which act as an important water resource in high-altitude regions with extended winters (Whitlock, Cross, Maxwell, Silverman, & Wade, 2017). Additionally, Montana is experiencing an increase in the frequency and intensity of wildfires during the late summer months through September (Whitlock et al., 2017).

Tribal Partnership

This study was developed based on ongoing research by the study team beginning in 2012. The study team is made up of Native American and non-Native American researchers from Montana State University and Salish Kootenai College. The study team was advised by a community advisory board consisting of Native and non-Native residents of the FIR with expertise in food and health issues, as well as a Tribal Council member.

Participants

An initial 42 residents of the FIR were recruited as participants through flyers and word of mouth. Approval for the participation of human subjects in research was obtained from the Institutional Review Boards of the affiliated tribal college and

state university. Participants were considered eligible for the study if they were FDPIR recipients over 18 years of age and were residents of the reservation for at least five years. Given the diversity of FDPIR recipients and FIR residents, participants were recruited regardless of tribal affiliation. Participants received US\$50 Visa gift card incentives for participating in the study.

Survey and Interview Tools

We utilized a mixed-methods approach for this study, with participants completing a combination of a structured survey and semistructured interviews. Participants were requested to complete a structured survey at the start of the study, which included the USDA Six-Item Short Form of the Food Security Survey Module (USDA, 2012) as well as sociodemographic information including age, gender, and Native heritage. The USDA Six-Item Short Form Food Security Module is a validated tool that measures household food security status.

The study team developed and administered a series of four semistructured interviews. The interview instrument was developed collaboratively by the study team, our community advisory board, and a panel of five experts in the fields of cultural anthropology, ethnobotany, nutrition, and environmental sciences. The interviews comprised structured and open-ended questions to characterize the frequency of wild food consumption, Wild Food Procurement, Wild Food Dietary Diversity, wild food valuation, perceptions and observations of climate change on wild foods, and environmental concerns (Appendix A). Wild Food Procurement is defined as the number and type of wild food procurement activities (hunting, fishing, and harvesting of edible plant foods) that participants engaged in. Wild Food Dietary Diversity is defined as the number and type of species of wild foods reported to be consumed in the community. Wild Food Valuation was further measured using a set of five Likert scale response questions.

Data collection began in August 2017 and ended in January 2018. Interviews were conducted by members of the study team who were trained by observing and practicing interviews with a Native American community member who has worked in

the health field on the FIR for the last five years. Interviews were recorded using a digital recorder and transcribed by members of the study team.

Data Analysis

Food security scores were calculated by totaling the number of affirmative responses to the USDA Food Security Survey Module. An affirmative response indicates that the participant agreed that over the last 12 months due to financial constraints they either lacked access to food, skipped meals, or reduced the size and quality of meals (USDA, 2012). The USDA Food Security Module is reported on an inverse scale where lower scores indicate high food security, and higher scores indicate low food security. A score of 0 or 1 indicates high or marginal food security, 2 to 4 indicates low food security, and 5 or 6 indicates very low food security.

Recorded interview responses were transcribed and coded to identify prevalent themes (Saldana, 2016) using a grounded theory approach (Glaser & Strauss, 1967). A qualitative, thematic codebook (Saldana, 2016) was created to code interview responses by identifying four to five prevalent meaning units (sentences or phrases which highlight specific research themes or responses). The codebook was developed by reviewing 10 randomly identified interview transcripts. The research team reviewed and revised the codebook after practice coding multiple interviews. All interview responses were coded by two separate coders for inter-rater reliability, and discrepancies were resolved. Coded responses to each interview question were compiled to determine frequencies of prevalent themes. Responses were compared between Native American and non-Native American participants.

A score for Wild Food Procurement was calculated on a scale of zero to three, with zero indicating that the participant did not engage in wild food procurement, one indicating that the participant engaged in at least one form of wild food procurement (hunting, fishing, or harvesting wild plants), two indicating that the participant engaged in two forms of wild food procurement (e.g., hunting and fishing or hunting and harvesting edible plants or fishing and harvesting edible plants), and three

indicating that the participant engaged in all three food procurement activities (hunting, fishing, and harvesting wild plants). A score for Wild Food Dietary Diversity was calculated by summing the total number of wild food species that participants reported consuming.

JMP statistical software (version 12.0 SAS Institute Inc., Cary, NC) was used to carry out analysis of co-variance (ANCOVA) to understand the relationships between gender, age, Native heritage, and food security. Bivariate fit analyses were conducted to examine relationships between food security status and Wild Food Dietary Diversity scores, as well as with Wild Food Procurement scores. Significance level was set at $p=0.05$.

Results

Food Security and Demographic Data

A total of 42 participants completed the first interview, 32 completed the second interview, and 31 completed both the third and fourth interviews. Participants attributed their decision to drop out to participation barriers of time and transportation. The numbers reported in the results section are thus based on the total number of participants completing each interview. Participants consisted of CSKT Tribal members and descendants ($n=22$), Native non-CSKT members ($n=5$), and non-Native residents ($n=15$); 31% were male ($n=13$) and 69% were female ($n=29$). The average participant age was 54.45 years ($SD=14.9$).

Mean food security score was 2.05 ($SD=2.04$), indicating low food security. A share of 33% of participants experienced low food security, and 17% experienced very low food security. Men experienced higher food security on average than women ($p=0.0437$), and middle-aged participants (46–58 years) experienced lower food security than all other age groups ($p=0.0026$; Table 1). There were no significant differences in food security between Native American and non-Native American participants.

Wild Food Consumption and Dietary Diversity

Between a quarter and one-third of the participants engaged in at least one Wild Food

Procurement activity, with 26.8% engaging in hunting, 24.4% in fishing, and 34.1% in harvesting wild plant foods. Additionally, 38.1% reported having one or more members of the household who hunt, fish, or forage wild plant foods. Just over one-quarter (26.2%) of participants stated that wild foods are shared within the community among friends, family, and at community gatherings. Wild Food Procurement varied by gender but not by age, with men ($M=1.54$) engaging in an average of one more food procurement activity than women ($M=0.54$, $p=0.0028$).

Individual reporting of Wild Food Dietary Diversity ranged from zero to eight wild food species, with an average of 3.34 wild foods reported per household. The most commonly reported wild game species consumed were deer (*Odocoileus spp.*, $n=22$), elk (*Cervus canadensis*, $n=17$), moose (*Alces alces*, $n=5$), and bison (*Bison*, $n=4$). The most commonly consumed wild fish reported were trout (*Salmo spp.*, $n=11$), bass (*Morone chrysops*, $n=6$), and pike (*Esox lucius*, $n=4$). Huckleberries were the most commonly reported wild edible plant consumed (*Vaccinium membranaceum*, $n=23$). Others included bitterroot (*Lewisia rediviva*, $n=4$), chokecherries (*Prunus virginiana*, $n=3$), serviceberries (*Amelanchier alnifolia*, $n=2$), wild mushrooms (not specified, $n=2$), and wild greens (not specified, $n=1$). See Figure 1 for the most commonly consumed wild foods among participants.

Rates of wild food consumption varied by

Table 1. Mean Food Security Score by Gender, Age, and Native Heritage

Scores of 0–1=high or marginal food security, 2–4=low food security, 5–6=very low food security.

Demographic Parameter		Mean Food Security Status	Standard Deviation
Gender	Male ($n=13$)	1	2.0
	Female ($n=29$)	2.5	1.8
Age by Quartile	Q1 (21–45 yrs)	2.1	1.4
	Q2 (46–58 yrs)	3.6	2.3
	Q3 (59–65 yrs)	1.7	1.9
	Q4 (66–79 yrs)	0.3	0.5
Native Heritage	Native ($n=27$)	2.1	2.1
	Non-Native ($n=15$)	1.9	1.8

food type (game, fish, and plants). Game was the most commonly consumed wild food, with 26.8% of participants consuming wild meat at least once per week, followed by 26.8% of participants consuming wild fish at least once per month. Wild edible plants were consumed seasonally by participants (31.7%) with 19.5% of participants consuming wild food plants once or twice a year on special occasions such as holidays and ceremonies.

Bivariate fit analyses revealed linear relationships between food security, Wild Food Procurement, and Wild Food Dietary Diversity (Figure 2). Participants who engaged in a greater number of food procurement activities were more food secure

on average than those who engaged in fewer food procurement activities. For example, participants who engaged in two procurement activities such as hunting *and* fishing had a mean food security score of 1.1 (marginal food security), while participants who engaged in only one procurement activity had a mean food security of 2.3 (low food security).

Similarly, participants with greater Wild Food Dietary Diversity scores were more food secure than those with lower Wild Food Dietary Diversity scores. For example, food security scores were improved by 0.33 points for every additional wild food incorporated into the diet. Participants consuming four wild food species had a mean food

security score of 1.83 (marginal food security), while participants consuming two wild food species had a mean food security score of 2.49 (low food security).

Wild Food Valuation

While wild foods were not consumed by all participants, wild foods were valued by 90% of participants. The most common themes regarding Wild Food Valuation include (1) quality ($n=26$), (2) tradition ($n=12$), and (3) self-sufficiency ($n=9$). Wild foods were highly valued for various aspects of quality, including taste, freshness, health, and nutritional value (63.4%). Many participants perceived wild foods as being healthier than food from grocery stores or the FDPIR center. Wild foods were further perceived to be of higher quality for not being raised or processed commercially. A share of 21.9% of participants reported that they valued wild edible plants for being pesticide-free and wild game and fish because they do not contain commercially

Figure 1. Commonly Reported Wild Foods Consumed By Participants

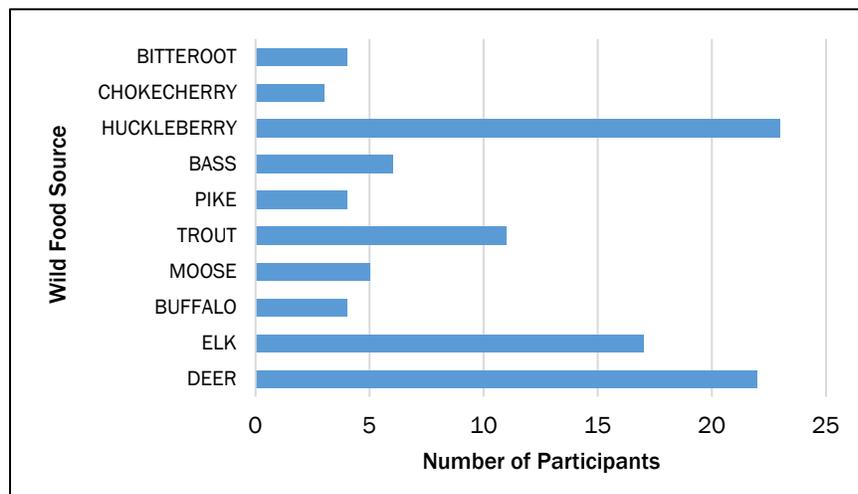
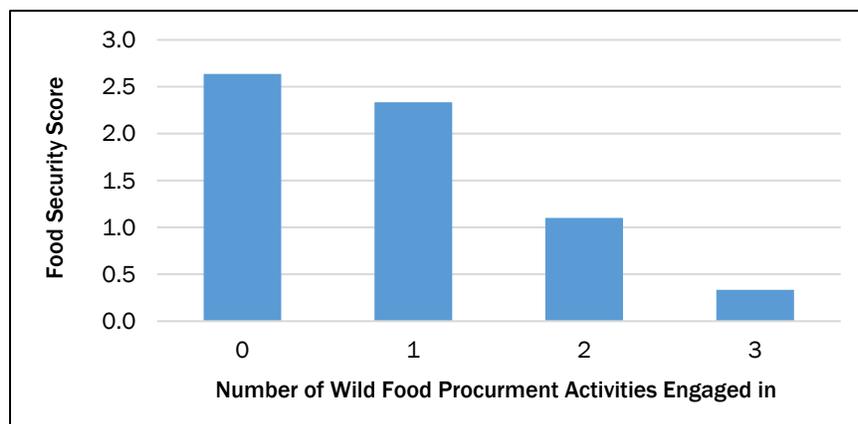


Figure 2. Mean Food Security for Participants Engaging in 0, 1, 2, or 3 Wild Food Procurement Activities

Food Security scores between 0 and 1=high or marginal food security, 2 and 4=low food security, 5 and 6=very low food security.



produced hormones and/or antibiotics. Several participants stated that their health could be improved if they consumed more wild foods. Additionally, some participants expressed dissatisfaction with the quality of foods offered at the FDPIR center and asserted that FDPIR foods negatively impacted their health.

Nearly three-fourths (72%) of participants shared that wild foods were a part of their cultural identity. Both Native and non-Native participants reflected on the contribution of wild foods to their upbringing and shared stories about procuring wild foods with parents and grandparents. In addition, Native participants shared teachings on wild foods that they had learned from elders, such as respecting wild foods by praying before harvesting, 'paying' for food by offering tobacco or other gifts as an act of reciprocity, expressing gratitude, and taking only what you need.

Just over a fifth of participants (21.4%) expressed that hunting, fishing, and foraging provided a sense of self-sufficiency. For example,

having knowledge of wild foods was seen as a resource for maintaining food security. Participants discussed the importance of knowing how to acquire wild foods, particularly in times of hardship, and of being able to feed their family if necessary to do so (see Table 2).

Participants' responses to Likert-scale questions regarding Wild Food Valuation further support the themes identified in Table 2, as 88% of participants agreed that consuming wild foods lowers out-of-pocket food costs, 80% agreed that wild foods contribute to dietary diversity, and 72% agreed that wild foods contribute to dietary quality. Both Native (86%) and non-Native (80%) participants expressed concern that younger generations were losing the knowledge and desire to harvest wild foods.

Observations and Concerns Regarding Environmental Change

A share of 81% of participants reported observing changes in temperature, precipitation, and overall

Table 2. Summary of Wild Food Valuation Themes, Subthemes, and Sample Quotations from Participants

Wild Food Valuation		
Research Theme	Subthemes	Sample Quotations
Theme 1: Quality	Subthemes include aspects of taste, freshness, nutritional quality and health, and knowing where your food comes from.	<p><i>"Well I think it's just healthier for us to eat off the land. I would at least say that would be the most valuable is just eating unprocessed foods that are not full of chemicals."</i></p> <p><i>"You know I was raised- my parents we hunted, and I went with them and stuff. So, being raised that way with berries and fruits- we used to go berry picking every summer and my family grew a big garden and, I've seen my health take a big nose dive now having those commodities and processed foods and things like that and I think it's- I really think it's part of it."</i></p>
Theme 2: Self-sufficiency	Subthemes include having knowledge of wild foods for food security and expressing pride for being able to feed oneself and family.	<p><i>"I think for me it's the knowledge of knowing how to do it. Because I know how to gather berries and preserve them and, I could survive if I had to."</i></p> <p><i>"My family does not go hungry. Yeah- and it tastes excellent."</i></p>
Theme 3: Tradition	Subthemes include stories about procuring wild foods with family, practicing respect and reciprocity for wild foods.	<p><i>"I think it's important to do it because my elders taught me to pray for each food that I harvest, the first one that you get, and pray that you'll be back next year harvesting again."</i></p> <p><i>"I always pay for my food, whether that's with tobacco or something else. And I always pray over it and ask it to bring me to the next year, so that I can eat that food again next year, so I'm still here on this earth."</i></p>

weather patterns during their lifetime, changes in the prevalence of pests and disease (71%), and changes in the prevalence of wildfires (87%). Participants were concerned that changes in climate and land use coupled with overpopulation could decrease the availability of wild foods. Sixty percent of participants noticed changes in the overall availability of wild game, fish, and plants ($n=11$), and some participants found wild foods harder to find ($n=2$). Conversely, some participants perceived an increase in the deer population on the reservation ($n=4$). A share of 30% of participants reported observing changes in wild plant quality or productivity, and 26% reported observing changes in the timing of the harvest season and duration of availability of wild plants.

Open-ended questions regarding climate-related observations and concerns revealed the following themes (Table 3): changes in temperature and timing of seasons (seasonality) and precipitation patterns, increases in wildfire frequency and severity, and a decline in wild food availability.

Participants reported that summers were warmer, started earlier, and lasted longer, while winters were ‘disappearing,’ and that the spring and fall seasons seemed shorter. Participants also expressed observing that weather characteristics were becoming more variable and extreme, and harder to predict from year to year. Participants shared that rainfall was occurring at times throughout the year that were different from usual patterns, with less rain in the summer when it is needed most.

Wildfires were observed to be increasing in frequency and severity in the late summers. Participants attributed an increase in wildfire to the hotter and drier summers. More intense fire seasons were perceived to affect community health due to negative effects on air quality, wild food habitat, and wild food availability. The loss of wild food availability concerned 80% of participants. Many participants noted that wild fish and plants were increasingly hard to find, and some shared stories about the loss of specific foods that they used to harvest. The loss of wild food was

Table 3. Research Themes, Subthemes, and Sample Quotations Regarding Observations of Environmental Change and Wild Foods

Observations of Environmental Change		
Research Theme	Subtheme	Sample Quotations
Seasonality and Precipitation	Subthemes include warmer and longer summers, increased variability, and changes in rainfall patterns.	<p><i>“The concern of the weather pattern is that we are having less moisture in one time of the year and way too much in another time of the year but not too evenly through the whole year.”</i></p> <p><i>“I’ve noticed that we get hotter summers with way more heat and periods with no rainfall.”</i></p>
Increase in Fires	Subthemes include an increase in the frequency and severity of fires with negative implications for community health.	<p><i>“They’re [fires] bigger and burning hotter. They’re more out of control than they used to be.”</i></p> <p><i>“The fires were horrible this year. Breathing was horrible this year. Our health was horrible this year. So hopefully next year will be better but this year was not good.”</i></p>
Loss of wild foods	Subthemes include changes in the availability of wild plants, issues of land use change and overpopulation and tourism.	<p><i>“I don’t know why but there’s a lot less [wild plants] than there used to be... Like down by the river, Jocko river. Used to be like blackberries, they’re black caps actually, and all the berries were along there. And now, nobody’s really messed with it- why would they- but, [there’s] just a lot less.”</i></p> <p><i>“Because there’s so many people going farther out into the footlands and taking up space that normally would be used for food production. You know, there’s so many more houses going in on agricultural ground and that all impacts the wild food.”</i></p>

predominately attributed to overpopulation leading to pollution, land-use change, decrease in wildlife habitat, and overharvesting.

Participants expressed multiple concerns, about chronic wasting disease and pine beetle (*Dendroctonus ponderosae*) outbreak. Chronic wasting disease is a transmissible spongiform encephalopathy that causes chronic weight loss and death in members of the deer family, with the first case in Montana occurring in October 2017 (Almberg, Ramsey, Carson & Gude, 2018). Mountain pine beetle is a bark beetle that feeds on various species of pine, and outbreaks are causing widespread tree mortality throughout forests in western North America (Gibson, Kegley, & Bentz, 2009). Some participants were concerned about general environmental toxins and their impact on the health of wildlife; these participants stated that they only hunt in areas where they know the animals are not ill. Participants also noted issues related to water quality linked to environmental contaminants ($n=12$). A few participants stated they discovered arsenic or lead in their well water.

Discussion

Our study findings highlight the contribution of wild foods to food sovereignty and sustainable food systems through diet, food security, and cultural identity among low-income and food-insecure FDPIR participants on the FIR. The results point to the vulnerability of wild food environments in the face of climate change and other challenges of the Anthropocene, including overharvesting and agricultural encroachment, which are threatening Indigenous food systems. Our findings indicate that wild foods can contribute to strengthening food security and should be promoted through research, education, interventions, and policy changes. No significant differences were found in food security status, wild food valuation, and observations of environmental change between Native American and non-Native American participants. Future research is called for to examine food security, wild food valuation, and climate change observations and concerns between both Native and non-Native residents in other reservation communities.

The consumption of wild foods by residents of the FIR is likely to have positive implications for health given that wild game, fish, and plants are sources of micronutrients and essential fatty acids (Bharucha & Pretty 2010). However, research on micro- and macronutritional properties of wild plant foods lags notably behind research on cultivated species (Vincetti et al., 2008). Further research is thus needed on the nutrient and phytochemical profiles of wild plant foods in order to support their role in diet and health.

Our findings of higher Wild Food Procurement and Wild Food Dietary Diversity scores being associated with lower food security scores are consistent with the literature (Luckett, DeClerck, Fanzo, Mundorf, & Rose, 2015; Powell, Thilsted, Ickowitz, Termonte, Sunderland, & Herforth, 2015). However, Wild Food Dietary Diversity was notably lower in this study than in rural communities in other parts of the world, including Asia, Africa, and South America (Bharucha & Pretty 2010; Cruz-Garcia, Caffi, Zans, & Sanchez-Choy, 2018; Shumsky et al., 2014). The relatively lower wild food dietary diversity among study subjects was expected as market foods make up a substantial portion of the diet in Indigenous communities in North America as compared to Indigenous communities in Asia, Africa, and South America (Compher, 2006). In addition, regional climate and ecosystem type determine the overall availability of wild food dietary diversity. However, research is needed to understand how availability along with other socio-ecological factors influence consumption and utilization of wild foods.

Wild Food Dietary Diversity reported by participants was not representative of wild food diversity available on the FIR, which suggests a loss of knowledge of wild food utilization. For example, recently produced field guides on the FIR provide information on 25 wild plant foods historically utilized by the Bitterroot Salish peoples (Salish Language Revitalization Institute, 2012); however, in this study, only six wild plant foods were identified by participants. Comprehensive documentation and dissemination of wild food identification, uses, and preparation techniques are needed to prevent the loss of knowledge of wild foods on the FIR (Bortolotto et al., 2017).

The multidimensional valuation of wild foods for quality, self-sufficiency, and tradition touches upon multiple aspects of sustainable food systems and is consistent with value systems reported in the literature associated with traditional foods among Native Americans (Cozzetto et al., 2013). Our findings suggest that there is a need for culturally appropriate and nutritious wild food offerings in FDPIR settings. Perceptions of diminished health resulting from consumption of FDPIR foods is consistent with previous studies that note that the FDPIR historically has provided culturally inappropriate food to Native peoples (Compher, 2006; Kuhnlein & Receveur, 1996) as well as nutritionally inadequate food (Byker Shanks et al., 2015). Examination using the Healthy Eating Index 2010 (HEI-2010) of foods offered by FDPIR found that the mean offerings of fruit, vegetable, greens and beans, protein, and refined grains did not adhere to recommendations by the U.S. Dietary Guidelines (Byker Shanks, 2015). U.S. federal policy efforts to promote food security among tribal communities are seen as undervaluing the contribution of wild foods to wellbeing (Olson, 2002). Future evidence-based interventions should focus on enhancing the availability of culturally appropriate and nutritious food in the FDPIR.

Participant observations of climate change are consistent with the Montana Climate Assessment (Whitlock et al., 2017). Observations of shifts in precipitation patterns are in line with the assessment, which demonstrates that changes in precipitation patterns are affecting snowpack and water availability and increasing the severity of wildfires in the region (Whitlock et al., 2017). However, participants generally attributed the observed decrease in wild food availability to increased population, agricultural encroachment, overharvesting, and land-use change, and less so to climate change. Agricultural encroachment on wildlife habitat and overharvesting by humans are recognized as key drivers of wild food system change (Bharucha & Pretty, 2010).

Participants' observations of increasing pests and diseases, including chronic wasting disease (CWD) and mountain pine beetle, were interpreted as presenting a threat to wild game populations. This is particularly concerning given

that wild game is the most commonly consumed wild food among participants. While there are no documented cases of CWD being contracted by humans, similar diseases exist in cattle and other food species (Almberg et al., 2018). Public health, wildlife management, and agriculture agencies all recommend testing animals harvested in areas of known prevalence, which requires driving to a state surveillance check area (Almberg et al., 2018). While there are no known cases of CWD on the FIR, infected deer have been found about 200 miles (320 km) away (Montana Fish, Wildlife, and Parks, 2018). Recommendations for dealing with CWD-positive animals include not eating them, which could result in reductions in both wild game consumption and food security. Additionally, the loss of canopy cover due to mountain pine beetle outbreak reduces the ideal habitat for large-bodied ungulates who use forest cover to regulate their body temperature (Gibson et al., 2009). Reductions in elk and moose populations could occur if their habitat is limited to forests with prevalent pine beetle outbreak (Gibson et al., 2009).

This study highlights the need for future research, education, evidence-based interventions and policies to enhance wild food environments in the face of climate change, particularly among vulnerable communities (Bharucha & Pretty, 2010; Cordalis & Suagee, 2008; Lynn et al., 2013). Research is needed to determine the ecological carrying capacity for supporting wild food harvest on the FIR, as well as the effects of increased wild food consumption on supporting health outcomes. Identifying areas where encroachment and overharvesting are occurring, coupled with wild food harvesting policies and education initiatives, could mitigate the negative impacts of unsustainable resource use. Wild food education initiatives are needed to enhance knowledge of wild foods while promoting their sustainable harvest. Policy support is further called for to promote and monitor sustainable harvest of wild foods, including efforts that prohibit wild food collection in areas that have experienced overharvesting, particularly in locations where tourists harvest on public lands. Monitoring of wild food environments over time coupled with

local meteorological data can provide insight into the effects of climate change on wild food systems that are currently unknown.

Conclusions and Recommendations

Wild foods were found to contribute to resilient and sustainable food systems on the FIR by supporting health, cultural, economic, and environmental well-being. Wild foods were associated with improved food security among low-income FDPIR recipients and valued for taste, nutritional quality, empowering self-sufficiency, and for being a food practice linked to cultural heritage for both Native and non-Native study participants. Participants perceive that variation in precipitation, seasonality, extreme weather events, and wildfires is threatening wild food environments, along with other challenges of the Anthropocene that include overpopulation, pests and disease, and land-use change such as agricultural encroachment.

Wild food environments have the potential to facilitate strengthening food system resilience, especially during times when incomes or access to market foods is limited. At the same time, wild foods are more vulnerable than market foods to local environmental disturbances. Local govern-

ments can play a crucial role in promoting and protecting wild foods through conservation and monitoring initiatives along with resilience planning for wild food environments. In support of sustainable food systems, these efforts should be fortified by enhancing community knowledge about wild foods, wild food carrying capacity, sustainable harvesting, and the effects of environmental change.

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Appendix A: Food Environment Interviews

Researcher Introduction: Hello. My name is [facilitator's name] and I'm part of a team of researchers from [blinded for review]. In these interviews, we are trying to better understand how wild foods and the natural food environment are part of the local food system. There is no right or wrong answer to the questions I'll ask, and you don't have to respond to any question that makes you feel uncomfortable. Please say what you think, we are respectful of your opinion. The interview will be audio recorded and transcribed. No one's name or personal identifying information will appear on any reports that we write about this project. Do you have any questions before we start?

Interview Part 1: Wild Foods

In this interview, we will ask about your practices, values, and perceptions regarding wild foods including hunting, fishing, and wild edible plants.

A. Wild Food Practices

(1) *Hunting*

- a. Do you hunt?
 - i. *If the informant does not hunt:* Does anybody in your household hunt?
 - ii. *If the informant hunts:* Who taught you how to hunt, or where did you learn how to hunt?
- b. **Free-listing:** What are all the type of animals that [you or someone in your household] hunt?
Prompt: Do [you or someone in your household] hunt anything else?
- c. Which animals do you hunt the most?
- d. Approximately how often do you consume the meat that you or somebody else in your community hunted?
 - i. *Prompt:* Once a week? More than once a week? Once a month? In a certain season of the year?

(2) *Fishing*

- a. Do you fish?
 - i. *If the informant does not fish:* Does anybody in your household go fishing?

ii. *If the informant fishes:* Who taught [you or someone in your household] how to fish, or where did you learn how to fish?

b. **Free-listing:** What are all the type of fish that [you or someone in your household] harvest?

Prompt: Do [you or someone in your household] harvest any other types of fish?

c. Approximately how often do you consume the fish that [you or someone in your household] harvest?

i. *Prompt:* Once a week? More than once a week? Once a month? In a certain season of the year?

(3) *Wild edible plants*

a. Do you harvest wild plant foods (wild edible plants)?

i. *If the informant does not harvest wild plant foods:* Does anybody in your household harvest wild plant foods?

ii. *If the informant fishes:* Who taught [you or someone in your household] about wild edible plants, or where did you learn about wild edible plants?

b. **Free-listing:** What are all the types of wild plant foods that [you or someone in your household] harvest? *Prompt:* Do [you or someone else in your household] harvest any other types of wild plant foods?

c. Which wild plant foods do [you or someone else in your household] harvest the most?

d. Approximately how often do [you or someone else in your household] consume the wild foods that you harvest?

i. *Prompt:* Once a week? More than once a week? Once a month? In a certain season of the year?

B. **Wild Food Valuation**

(1) **Free-listing:** What are all the things that you value about *hunting*? *Prompt:* Do you value anything else?

- (2) **Free-listing:** What are all the things that you value about fishing? *Prompt:* Do you value anything else?
- (3) **Free-listing:** What are all the things that you value about harvesting wild plant foods? *Prompt:* Do you value anything else?
- (4) **Free-listing:** What are all the things that you value about eating wild foods? *Prompt:* Do you value anything else?
- (5) **Free-listing:** Are harvested wild foods shared among the community?
a. *Prompt:* At events? Among neighbors, co-workers, or friends?
- (6) **Free-listing:** Who prepares different types of wild foods? Do [you or someone in your household] have specific recipes that you use to prepare these wild foods? Where did the recipes come from?

Thank you for your time and sharing your experiences. We are interviewing several community members and will make the results available to you, if you are interested. If you would like to see the results, please provide your e-mail address or home address where we can send them to. Please follow up with any questions you may have.

Interview Part 2: Wild Food Perceptions

In this interview, I will present several statements about wild foods. For each statement, you are requested to share how strongly you agree or disagree with each statement.

(1) “Eating wild foods contributes to the overall *quality* of my diet.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

(2) “Eating wild foods contributes to the overall *diversity* of my diet.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

(3) “Collecting and/or eating wild foods is part of my cultural identity. It connects me to my ancestors and our stories.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

(4) “I am concerned that the younger generations of our community are losing the traditional knowledge about wild foods.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

(5) “I am concerned that the younger generations of our community are losing the desire to collect and/or consume wild foods.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

(6) “Consuming wild foods lowers the cost of my diet.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why do you feel this way?

Thank you for your time and sharing your experiences. As we mentioned earlier, if you would like to see the results, please provide your e-mail address or home address where we can send them to. Please follow up with any questions you may have.

Interview Part 3: Environmental Change

In this interview, I will ask about your observations and perceptions regarding your surroundings and observed changes.

A. Environmental Observations

In the past decade, have you *observed* any changes in the following:

(1) Overall *availability* of wild game, fish, or wild plant foods

Prompts: [If the informant responds yes] What changes have you observed? Do you have to travel further to go hunting or to harvest wild foods?

(2) The *harvest times and / or harvest duration* of wild edible plants

Prompt: [If the informant responds yes] What changes have you observed?

(3) The *quality and / or productivity* of wild edible plants

Prompt: [If the informant responds yes] What changes have you observed?

(4) Temperatures, precipitation, and overall weather patterns (i.e., rainfall and snowfall)

Prompt: [If the informant responds yes] What changes have you observed?

(5) The prevalence of *fires*

Prompt: [If the informant responds yes] What changes have you observed?

(6) The prevalence of *pests and disease*

Prompt: [If the informant responds yes] What changes have you observed?

B. Environmental Perceptions: *You are requested to share how strongly you agree or disagree with the following statements.*

(1) “I am concerned about land-use changes in and around our community.”

- a. Strongly agree
- b. Somewhat agree

- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: Why are you concerned?

(2) “I am concerned that in the future there may be decreasing availability of wild foods.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: [If the informant agrees] Why are you concerned?

(3) “I am concerned with the water quality in our community.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompts: [If the informant agrees] Why are you concerned? What is your water source? Do you trust your water source? Does your water have a pleasant or unpleasant smell? Is your water discolored?

(4) “I am concerned with the water rights in our community.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral

- d. Disagree
- e. Strongly disagree

Prompt: [If the informant agrees] Why are you concerned?

(5) “Changes in weather patterns are impacting the well-being of our community.”

- a. Strongly agree
- b. Somewhat agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

Prompt: [If the informant agrees] Why are you concerned?

Thank you for your time and sharing your experiences. As we mentioned earlier, if you would like to see the results, please provide your e-mail address or home address where we can send them to. Please follow up with any questions you may have.

Interview Part 4: Protecting Tribal Resources

- (1) What are your suggestions for protecting tribal *food* resources?
- (2) What are your suggestions for protecting tribal *water* resources?
- (3) What are your suggestions for protecting tribal *land* resources?
- (4) Do you have any special practices, rituals, or stories associated with hunting?
- (5) Do you have any special practices, rituals, or stories associated with fishing?
- (6) Do you have any special practices, rituals, or stories associated with harvesting wild foods?
- (7) Is there anything you would like to add about wild foods or your environment such as water resources?

Thank you for your time and sharing your experiences. As we mentioned earlier, if you would like to see the results, please provide your e-mail address or home address where we can send them to. Please follow up with any questions you may have.