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Improving Indigenous Food Sovereignty through sustainable food production: a narrative review

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Indigenous communities in the United States (US) face substantial challenges including health disparities, food insecurity, and cultural disconnection. The Indigenous Food Sovereignty (IFS) movement seeks to address these hurdles through the restoration of traditional foodways in balance with the natural environment. Initiatives aimed at enhancing IFS have proliferated across the US in recent years and are receiving increasing attention from the federal government. While increasing community food production is an important component of IFS, initiatives centered around this goal have received relatively little attention in the literature. A better understanding of current efforts will elucidate the factors underlying their successes and challenges, supporting the development of effective future initiatives. This review characterizes IFS food production initiatives in the US and identifies topics for further research.

KEYWORDS

Indigenous, food sovereignty, food system, food security, agriculture

1 Introduction

Indigenous communities in the United States (US) face substantial disparities in chronic, diet-related diseases in comparison to white Americans (Office of Minority Health, 2020, 2021a,b,c). Indigenous individuals are up to 2 times more likely to develop conditions such as obesity (Office of Minority Health, 2020), diabetes (Office of Minority Health, 2021b), heart disease (Office of Minority Health, 2021c), and liver cancer (Office of Minority Health, 2021a), and are up to three times more likely to die from these conditions (Indian Health Service, 2019). After adjustment for age, sex, and energy intake, Indigenous individuals are 18% more likely to have poor diet quality (McCullough et al., 2022), which represents the largest modifiable risk factor for cardiometabolic mortality (Micha et al., 2017).

Additionally, rates of food insecurity have worsened during the COVID-19 pandemic (Hake et al., 2021). Nearly one-half of Indigenous households reported food insecurity at some time during the pandemic (Stanger-McLaughlin et al., 2021), compared to a national average of 38% (Kakaei et al., 2022). The pandemic has also disrupted the production of food by Indigenous food producers. A survey of Indigenous food producers across the US found that 84% were negatively impacted by the pandemic, with 54% fully or partially closing their operations (Mucioki et al., 2022). Consequently, nearly 80% of Tribal leaders said that their communities had limited access to food staples during the pandemic and nearly 40% indicated that hunger was exacerbated in their community (Mucioki et al., 2022).

These disparities originate from the history of western expansion and endure today due to structural, extractive, and industrial projects that continue to disproportionally impact Indigenous people (Scheidel et al., 2023). Indigenous communities were forced from their ancestral lands and dislocated from traditional food sources and economic opportunities, leading to rates of food insecurity as high as 90% in some communities (Sowerwine et al., 2019). However, food security may be too simplistic of a metric when applied to Tribal communities and should be replaced by the concept of native foods security, which encompasses not only caloric sufficiency but an entire framework of access to culturally significant foods through traditional means (Jarosz, 2014; Gurney et al., 2015; Sowerwine et al., 2019). This concept aligns with research showing a link between health disparities on Tribal reservations and the loss of traditional food systems (Conti, 2016).

Some federal efforts have tried to address these interconnected issues of food access, food security, and nutrition, but major oversights have plagued these programs. For example, the Commodity Supplemental Food Program provides a monthly food package to low-income seniors, and until 2014, women, children, and infants were also eligible (US Department of Agriculture, 2023a). However, many food items provided by this program are high in sodium and saturated fat, which are associated with diet-related chronic diseases (Chino et al., 2009). Although many people living in the United States benefit from supplemental food assistance provided by the Supplemental Nutrition Assistance Program (SNAP), people living on or near Indian reservations often lack access to participating retailers (USDA Food and Nutrition Service, 2018). In response, the federal government created the Food Distribution Program on Indian Reservations (FDPIR) to distribute food packages to these groups, yet traditional Indigenous food options are typically lacking (USDA Food and Nutrition Service, 2021). There is also an unmet opportunity to source these foods from Indigenous farmers, which would support tribal economies and strengthen local food systems (USDA Food and Nutrition Service, 2021). These shortfalls in federal policy are acknowledged in the White House National Strategy on Hunger, Nutrition, and Health, published by the Biden-Harris administration in 2022, which also presents opportunities to strengthen Indigenous Food Sovereignty (The White House, 2022).

The concept of Indigenous Food Sovereignty emerged in response to a food system that does not adequately serve Indigenous communities (Hipp and Shirl, 2015; Maudrie et al., 2021). The idea of food sovereignty was first articulated at the 1996 World Food Summit by the La Via Campesina movement, which put forth seven principles advocating for food systems that protect natural resources, local agriculture, the right to food, and community empowerment (Claeys, 2015). Food sovereignty protects the autonomy of individuals and communities to produce and access healthy and culturally appropriate food through environmentally sustainable methods. Rather than through corporations or market institutions, the control of food production lies within the communities which it supports (Maudrie et al., 2021). In an Indigenous context, food sovereignty encompasses broader ideas rooted in Indigenous values, including relationships of reciprocity and responsibility to the land (Miltenburg et al., 2022). Unlike food security, food sovereignty goes beyond the right to sufficient nutrients to emphasize the importance of culturally meaningful connections to the food system (Ruelle et al., 2011). Each community has the autonomy to define what is culturally relevant to them. In many cases, these are foods Indigenous to their traditional lands. In other cases, this becomes a bit more complex. For instance, while three sisters' agriculture has been a dominant agricultural system for many Indigenous communities throughout Central and North America for a millennium, corn and several varieties of beans were cultivated in Mexico and found their way into many communities through continental trade. In other cases, communities have been forcibly relocated from their traditional communities into regions with very different ecosystems. Their traditional foodways prior to colonization and forced removal may have difficulty flourishing in their new territories. Still others may have adopted foods during colonization that are deemed culturally important to them. Such is the case for the rapid adoption of the imported apple and Asian Persimmon replacing the Indigenous plants that were in different communities. The Senaca and Nottoway tribes were known to have apple and peach orchards as well at the end of the 17th century.

As this movement has grown, communities and organizations have developed Indigenous Food Sovereignty initiatives that target different parts of the food system from producers to retailers (Segrest, 2014) to consumers (Ruelle et al., 2011), in addition to projects focused on community education, school initiatives, and behavioral interventions (Dwyer, 2010; Sowerwine et al., 2019). However, initiatives that address food production have not been well characterized in the literature. Strengthening community food production is a key component of Indigenous Food Sovereignty, and a greater understanding of these initiatives in the US is crucial for supporting the success of this movement. Additionally, the majority of Indigenous Food Sovereignty research has occurred in the West and Midwest, with relatively few taking place in the east. The absence of Indigenous voices in East coast communities on how they define and engage in Indigenous Food Sovereignty initiatives could impact how we define and understand success. Characterizing food production initiatives being undertaken by a wide range of Indigenous groups will help identify the initiatives' strengths, challenges, and knowledge gaps, which can be leveraged to enhance existing programs and develop new ones.

This narrative review provides an overview of initiatives that aim to promote Indigenous Food Sovereignty in the US through food production as well as identifies further research needs. Because of the complexities of narrowing in on what is considered culturally important, and recognizing that there are 574 federally recognized tribes and hundreds of state and non-recognized communities, we adopt the approach of defining Indigenous Food Sovereignty based on each community's own definition. Additionally, because of the general absence of literature on Indigenous Food Sovereignty of eastern tribes, specifically mid-Atlantic and southeastern tribes, this review

includes food sovereignty projects from Indigenous organizations and tribes of these regions. This review is structured around seven themes: (1) Types of food production initiatives to promote food sovereignty, (2) Goals of food sovereignty initiatives, (3) Organizational structure of food sovereignty initiatives, (4) Evaluating outcomes, (5) Barriers to food sovereignty, (6) Food sovereignty among eastern tribes, and (7) The future of Indigenous Food Sovereignty.

2 Methods

2.1 Author positionality

When this manuscript was drafted, over 50% of the co-authors were enrolled members or documented descendants of a state or federally recognized US tribe. This includes co-authors TW, LJ, TP, JB, BR, and JP. TW, TP, JB, BR, and JP are from state and federally recognized tribes whose traditional and contemporary sovereign lands intersect with the colonial states of Maryland, North Carolina, and Virginia. LJ and TW Indigenous authors are academics at nationally ranked, predominantly white institutions. LJ is an enrolled member of the Pascua Yaqui Tribe, and TW is a documented descendant of the Chickahominy and Chickahominy Indian Tribe -Eastern Division. The other four authors are members of this research project's Indigenous Advisory Council (IAC). IAC member JP is employed by the Chickahominy Indian Tribe-Eastern Division and is directly involved with their tribal nation's food sovereignty initiatives. IAC member BR is a tribal councilperson of the Nottoway Indian Tribe and an Indigenous seed-keeper. The final two IAC members, TP and JB, both Indigenous, are board directors of the Baltimore American Indian Center (BAIC), which collaborates with several organizations to bring Indigenous Food Sovereignty initiatives to the Baltimore urban Indian community. For the five Indigenous authors who represent the eastern tribes in the manuscript, there is a recognized element of the absence of eastern communities, their beliefs, perspectives, and understanding of Indigenous Food Sovereignty in the context of Indigenous Food Sovereignty literature. Even among Indigenous scholars, sometimes the language used to represent Indigenous ideas and perspectives does not adequately represent the voice of eastern communities. For this reason, this paper uses a broad definition of Indigenous Food Sovereignty, allowing each community to define what it means to them.

2.2 Narrative review

This review was inspired by a narrative review of another element of Indigenous Food Sovereignty (Jernigan et al., 2021), and provides an overview of initiatives throughout the US that aim to promote Indigenous Food Sovereignty through food production and includes a comprehensive review of Indigenous Food Sovereignty initiatives across the US. These were the phases of the review: (1) article collection and exclusion; (2) content analysis; (3) inclusion of community projects; (4) face validity.

2.2.1 Phase 1: article collection and exclusion

Articles were identified through English language searches using Scopus, Google Scholar, and the United States Department of Agriculture Research, Education & Economics Information System. Searches were performed for articles that described food production initiatives in Indigenous communities, and additional articles were identified if they cited the original articles. Titles, abstracts, and keywords were reviewed for relevancy to programs initiated in Indigenous communities that were designed to, or had the effect of, supporting food production to improve food security and/or increase food sovereignty. These searches resulted in 140 articles, 65 of which were ultimately included after review of the full text.

2.2.2 Phase 2: content analysis

Two undergraduate research assistants led the article collection with the guidance of three faculty members. Over the period of January 2022 to July 2023, weekly meetings were held with the research team to explore the themes that emerged during the review and begin the writing process. Emerging themes were identified if they were key research objectives or outcomes, or key structural characteristics of food production initiatives, and appeared in multiple articles. Additional themes were identified if they were determined by the authors to represent barriers to achieving food sovereignty and their solutions. These themes were reviewed by an IAC that is associated with this project (described below), and ultimately led to the identification of seven primary themes.

2.2.3 Phase 3: inclusion of community projects

This review is associated with a three-year grant-funded project to build decision-support tools to support Indigenous Food Sovereignty initiatives in communities whose traditional and contemporary boundaries overlap with Maryland, North Caroline, and Virginia. The project includes an IAC comprised of six Indigenous community leaders who provide regular feedback on all parts of the project. Four of these IAC members were appointed by their respective tribal nations and two of these members were appointed by their organization's board. The literature is sparse with information on Indigenous Food Sovereignty initiatives for eastern tribes, especially mid-Atlantic first-contact tribes. During this phase, four of our IAC partners became co-authors and contributed commentary on Indigenous-led projects in their communities.

2.2.4 Phase 4: face validity

The key themes highlighted in the narrative review were reviewed independently by our IAC and co-authors. The co-authors and IAC have expertise in nutrition, epidemiology, biology, technology in sustainable food systems, Indigenous data sovereignty, food systems, Indigenous governance, and lived Indigenous experiences. Six of the authors are Indigenous to the US, and five are non-Indigenous to the US. The section on eastern tribes results from the lived experience of the five Indigenous members of eastern communities who feel excluded from the body of Indigenous research and want to contribute their voices.

3 Types of food production initiatives to promote food sovereignty

Food production initiatives to promote Indigenous Food Sovereignty have been implemented in all regions of the US, with the greatest number identified by this review in the West and Midwest

(Figure 1). While this pattern generally follows the distribution of Indigenous populations across the US, very few initiatives were identified in Alaska, the state where the highest proportion of Indigenous individuals reside (National Congress of American Indians, 2020). A possible explanation is that subsistence hunting and fishing are more important than agriculture in this region. Here we review initiative types in three broad categories: (1) farming, (2) ranching, and (3) fishing and whaling. We define farming as any activity involving growing plants, ranching involving animal husbandry, and fisheries and whaling involving fishing and hunting of aquatic vertebrates, respectively.

3.1 Farming

3.1.1 Gardens

Gardens are among the most common types of food sovereignty-related food production initiative in the US, which can range from backyard plots in single family homes to larger community gardens that are collectively managed. An example of a backyard garden initiative is Growing Resilience, a project that supports Northern Arapaho and Eastern Shoshone families living on the Wind River Reservation in Wyoming in installing and maintaining home gardens (Budowle et al., 2019). In Iowa, the Santee Sioux Reservation takes a multi-pronged approach to encouraging more families to garden, from skill demonstrations to nutrition classes, cooking workshops, and gifts of starter plants (Landholm, 2016). This holistic approach is typical, and many garden initiatives also teach skills to community members, encourage youth participation in the food system, and revitalize traditional growing practices (Carlson, 2015; Ho-Lastimosa et al., 2019; Maunakea-Forth and Maunakea-Forth, 2020).

3.1.2 Farms

Farms are larger in scale than gardens, yet many of these evolve out of smaller gardens as their operation grows. For example, Micmac Farms in Maine began as a garden that sought to help alleviate food insecurity and health issues arising from poverty in the region by growing healthy, low-cost food for local consumption (Caulfield, 2011). Today, the 18-acre farm produces a variety of fruits, vegetables, and Christmas trees while also developing additional facilities such as a trout hatchery and greenhouse. The hatchery has particular significance to Indigenous food culture because trout are a key traditional food of the Micmac people. The growing of traditional foods is also a key objective of Tesuque Pueblo Farm in New Mexico (McKenna, 2013). Although

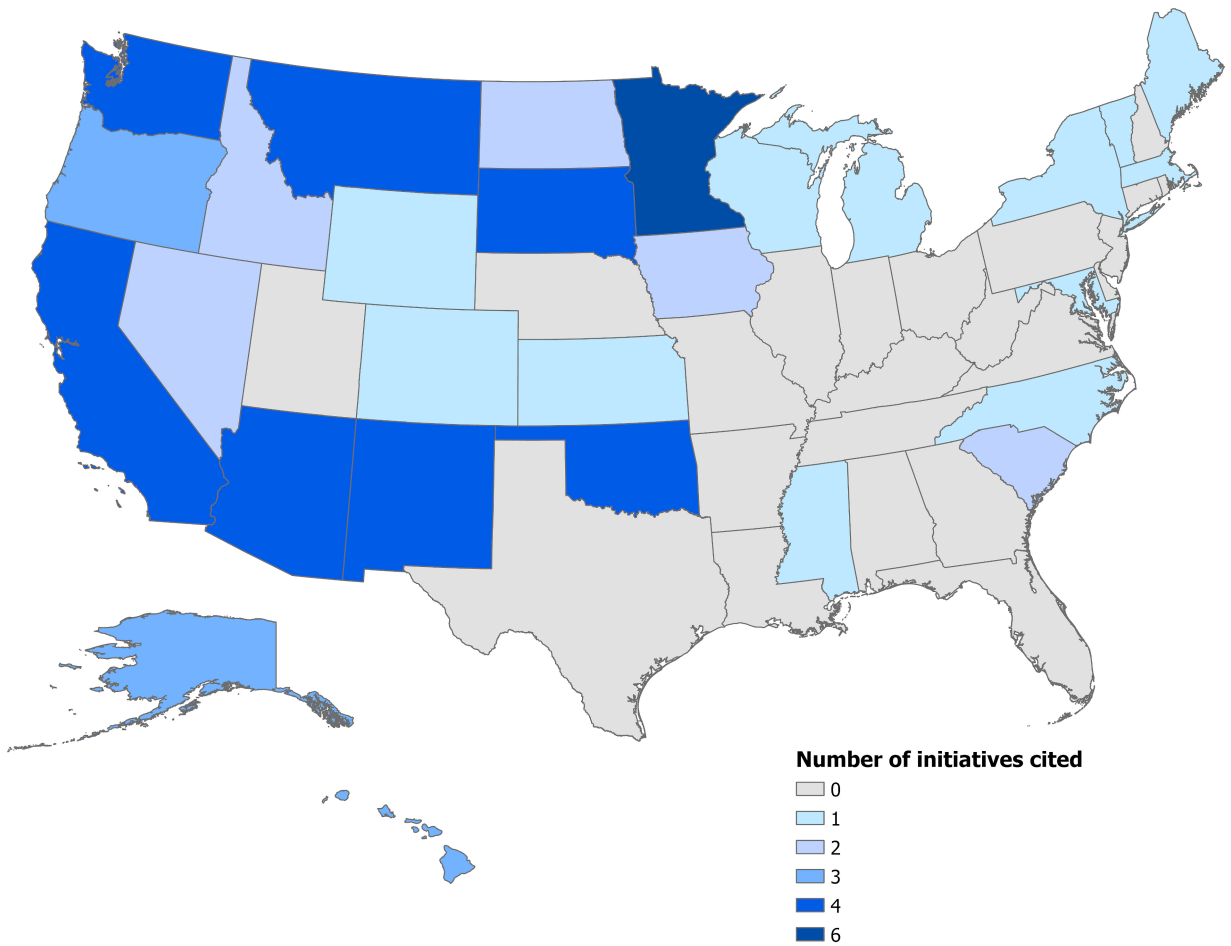

FIGURE 1
Geographic distribution of referenced food production initiatives to promote Indigenous Food Sovereignty in the United States.

the farm initially focused on crops for commercial sale such as alfalfa, it has transformed into a community-focused enterprise that uses sustainable agriculture methods to grow traditional foods and medicinal plants. The farm encourages community involvement through volunteer programs as well as assisting members of the community in preparing fields on the farm to grow their own food. In Hawai'i, MA'O Organic Farms runs a Youth Leadership Training program that teaches young Indigenous Hawaiians traditional agricultural skills in addition to mentoring them for future academic and career success (Maunakea-Forth and Maunakea-Forth, 2020). Those who participated in the program reported being more likely to grow their own food, choose healthy and locally grown food options, and value local and environmentally sustainable agriculture. In 2020, MA'O harvested 71,477 pounds of organic produce and secured over $11 million in funding to continue their operations.

3.1.3 Greenhouses

Greenhouses are often constructed in tandem with farms or gardens, particularly in the West where the arid climate makes it challenging to cultivate certain plants. For example, the Tesuque Pueblo Farm in New Mexico utilizes a greenhouse to shelter vulnerable plants (McKenna, 2013), while the Blackfeet Community College Greenhouse Project uses a greenhouse and a garden for teaching plant-growing skills to the community (Landry, 2014). Particularly in areas with harsh weather, greenhouses are an invaluable tool for protecting immature plants and extending the growing season. These benefits are crucial for restoring control of the food system to local communities, as many localities may be unable to grow sufficient food to feed themselves without the support of greenhouse technology. One particular structure that has been growing in popularity is the hoop house, which consists of arched supports with a plastic covering, allowing for natural temperature regulation within. Their basic design makes them relatively inexpensive and simple to construct, and many food sovereignty programs have found success in expanding the capacity for food production through building hoop houses in community gardens as well as individuals' yards (McKenna, 2013; US Department of Agriculture, 2013; University of Nevada, 2017).

3.1.4 Aquaponics

Aquaponics combines hydroponic growing techniques with aquaculture in contained systems that yield both fish and produce for harvest. This method of food production has been utilized in Indigenous Food Sovereignty programs in Hawai'i because of its resemblance to the traditional food system known as ahupua'a (Beebe et al., 2020). Ahupua'a are tracts that stretch from terrestrial to aquatic ecosystems, whose mutual influence is recognized and cultivated in balance. To improve food security among Indigenous Hawaiians, the organization God's Country Waimanolo in Hawai'i hosts aquaponics workshops that enable families to mirror the principles of ahupua'a in their own backyards (Ho-Lastimosa et al., 2019; Beebe et al., 2020). More than 70 families in the rural town of Waimanolo built backyard aquaponics systems between 2010 and 2016 with the help of these workshops. In interviews about their experience, these participants reported benefits such as improved nutrition, economic savings, stronger familial and community bonds, and a greater sense of cultural connection (Beebe et al., 2020). After witnessing the success of these workshops, God's Country Waimanolo developed a new, 3-month workshop series integrating aquaponics skill-building, nutrition programming, cooking classes, and traditional medicine (Ho-Lastimosa et al., 2019). In the future, the Mini Ahupua'a for Lifestyle and Mea'ai through Aquaponics initiative intends to create an aquaponics certification program and a system to train youth to teach aquaponics to others in turn, expanding the reach of this program (Ho-Lastimosa et al., 2019).

3.1.5 Orchards

Orchards are another key avenue of food production for many Tribes, with the majority located in the Midwest. In Wisconsin, the Bad River Band cultivates apple orchards, while the Shakopee Mdewakanton Sioux Community in Minnesota grows 14 apple varieties in their orchards (Carlson, 2015). As part of their commitment to agriculture in harmony with the land, the Shakopee Mdewakanton Sioux integrate poultry production into their operation to control pests in their orchards. Both of these Tribal initiatives were launched as ways to remedy community health disparities and displacement from historical food traditions. The desire to preserve traditional foods also guides the efforts of the Karuk, Yurok, and Klamath Indian Tribes in California as they collaborate with the University of California at Berkeley (UC Berkeley) to preserve heirloom fruit trees that currently grow in the region but are at risk of dying out ('Securing Our Fruit Trees', 2017).

Maple syrup production has been a popular initiative in the Midwest (Dwyer, 2010; Carlson, 2015; Meskwaki Nation, 2018; Calvert, 2023). Harvesting maple sap to boil into syrup and mold into sweet cakes is a re-emerging Meskwaki tradition being led by tribal youth (Meskwaki Nation, 2018).

3.1.6 Heirloom seeds

Many traditional plants used by Indigenous communities are heirloom varieties, and their seeds may not be readily accessible on the commercial market. To help those wishing to grow traditional foods, many organizations gift or sell seeds. For example, Native Seeds/SEARCH (NS/S) conserves and distributes seed varieties that are native to the Southwest and adapted to the arid climate (Native Seeds SEARCH, 2020). The resounding success of NS/S demonstrates the high demand for seeds as a resource for revitalizing Indigenous cultural foods, with over $1 million in annual gross income from seed sales, donations, and membership subscriptions. NS/S subsequently reinvests this revenue into offering free seed packets to Indigenous farmers as well as conserving over 100 heirloom seed varieties. Another group striving to preserve native seed varieties is Seeds of Renewal in Vermont (Vermont Indigenous Heritage Center, 2023). Initially founded to unearth the history of the Abenaki Tribes in order to gain state recognition, the project has expanded into an effort to restore traditional horticultural practices through gardening classes, agricultural ceremonies, and the creation of a seed bank containing over 50 varieties of traditional crops. In New Mexico, the Tesuque Pueblo Farm specifically dedicates a portion of its land to producing seeds, which it grows on behalf of organizations such as NS/S or for its own seed bank (McKenna, 2013). The farm is especially concerned with protecting Indigenous seeds from cross-fertilization with genetically engineered plants.

3.2 Ranching

Ranching includes food sovereignty initiatives that involve animal husbandry, such as the rearing of livestock. A review of efforts by four Northern Great Plains Tribes to restore historical bison herds revealed a variety of economic and cultural approaches (Shamon et al., 2022). Often Tribes possess both a conservation herd, intended to preserve the bison population in the region, and a commercial herd that can be a source of revenue. Revenue is generated by selling hunting licenses (often at a discount for Tribal members), calves, or mature bison that need to be culled to maintain a sustainable population size. These programs are accompanied by efforts to promote the cultural importance of bison, which may include ceremonies, educational opportunities, and donations of meat to local schools. However, bison restoration also faces major challenges such as fragmented land holdings that makes it challenging to maintain large herds, lack of funding, and lack of meat affordability for Tribal members (Shamon et al., 2022). The Thunder Valley Community Development Corporation in South Dakota helps reduce these barriers by training farmers and ranchers in developing bison herds, while also supporting the community by raising chickens for local consumption (Long, 2023).

3.3 Fishing and whaling

3.3.1 Fishing

Fishing-related food sovereignty initiatives are also taking place, whether in the form of fisheries (U.S. Department of the Interior, 2018), hatcheries (Caulfield, 2011), or campaigns to reclaim fishing rights (Nulhegan Abenaki Tribe, 2020). The Aroostook Band of Micmacs established a successful hatchery to revive the dying brook trout population in Maine, which are culturally and nutritionally significant to their Tribe. The hatchery produces over 50,000 brook trout each year, which are sold to consumers and regional retailers or released into Tribal waters as fishing stock. The wastewater from the hatchery is recycled for agricultural use on the Tribe's farm (Micmac Farms, 2023).

3.3.2 Whaling

Many Alaska Indigenous Tribes have directed their efforts in recent decades towards obtaining subsistence whaling rights, with a major victory at the 2018 meeting of the International Whaling Commission (Ikuta, 2021). However, the Makah Tribe in Washington State is still fighting for their sovereign right to subsistence gray whale hunting, which was guaranteed to them in the 1855 Treaty of Neah Bay (International Whaling Commission, 2023). Whaling is a cornerstone of Makah culture and provides an essential food source in a community where 99% of households depend on subsistence hunting and fishing. In a 2018 survey of those living on the Makah Reservation, 80–88% of respondents reported the desire for regularly available whale oil, meat, or bone, and over 95% expressed support for their community whaling traditions (International Whaling Commission, 2023). Currently, the Makah are forbidden from whaling under the United States Marine Mammal Protection Act. The National Oceanic and Atmospheric Administration is processing the Makah's request for a waiver and expects to make a final decision this year (NOAA Fisheries, 2023).

4 Goals of Indigenous Food Sovereignty initiatives

While food sovereignty initiatives often consist of concrete actions such as constructing a garden, they typically describe the larger purpose that these actions are intended to serve. Based on the initiatives reviewed, the primary goals of many initiatives are cultural preservation, health promotion, and cultural food security. Economic development and environmental stewardship are also prioritized, although less frequently, while disaster preparedness is a newer motivation that is gaining increasing attention.

4.1 Cultural preservation

The preservation of traditional food culture is a primary goal of many initiatives. This can involve educating the community on traditional horticultural techniques, reintroducing traditional foods into the local diet, and organizing cultural ceremonies around important phases of the growing cycle such as harvest time. For example, the agroecology stewardship program of United Tribes Technical College in North Dakota educates the community in techniques for all levels of food production, from beginning a garden to harvesting and preserving produce (Burke, 2015). At each stage, traditional methods and plants of the affiliated Tribes are emphasized. The Technical College's gardens host over 80 heirloom corn varieties, ceremonial plants such as sweetgrass, and plants used in the sacred medicine wheel.

Another important method of preserving cultural practices is the intergenerational transfer of knowledge from elders to youth. This priority was identified in a survey of innovative Tribal food system projects across the US, in which youth engagement stood out as a key theme across initiatives (Hipp and Shirl, 2015). For example, Seneca Nation's Food is Our Medicine project partners with an early childhood learning center to teach young children how to grow traditional plants and hosts children's events at the local farmers market (Robert Wood Johnson Foundation, 2018).

4.2 Health promotion

Concerned by high rates of chronic disease, mental health struggles, and other health issues, many communities have turned to food sovereignty initiatives as a way to restore their health. Because Indigenous communities often understand health in a far broader sense than physical wellness, this goal can encompass a variety of outcomes such as cultural connection, emotional well-being, connection to the land, and reciprocity among people, communities, and their environment (Donatuto et al., 2011, 2016; Lines et al., 2019). For example, the Mini Ahupuaʻa for Lifestyle and Meaʻai through Aquaponics program in Hawai'i aims to fight nutrition-related disease through backyard aquaponics systems that produce fish, fruits, and vegetables for Indigenous Hawaiian families. At the same time, this program prioritizes the health benefits that arise naturally from traditional land stewardship practices (Ho-Lastimosa et al., 2019). In Minnesota, the White Earth Land Recovery Project emphasizes intellectual, emotional, spiritual, and physical well-being, the four parts of the medicine

wheel, in their food sovereignty programming ('White Earth Land Recovery Project', 2020).

The Food Is Our Medicine project, a collaboration between the Seneca Nation of Indians and the Seneca Diabetes Foundation in New York, was created to address high rates of metabolic disorders through growing healthy, traditional foods (Pietrorazio, 2021). The Shakopee Mdewakanton Sioux Community in Minnesota has implemented a continuously expanding community garden alongside a health foods store, Tribally Supported Agriculture program, and other projects in order to improve health on the reservation (Carlson, 2015). Another example is MA'O Organic Farms in Hawai'i, which trains youth interns in the principles of traditional horticulture. Program alumni reported greater frequency and variety of vegetable intake than their peers, and after completing the program, both alumni and their families reported they were more likely to choose healthy food options and that they felt more strongly about the community importance of land and water. Many interns and staff also reported feelings of hope, community connection, and healing associated with their time in the program (Maunakea-Forth and Maunakea-Forth, 2020). Additionally, a study is being conducted on a cohort of the interns to compare their physical health before and after participation in the program. Preliminary results show that the percentage of interns who were diabetic or pre-diabetic fell from 62% to 30% over the course of a year in the program (Mauli Ola Study, 2024).

The close relationship between restoring traditional foodways and restoring health was universally expressed in the Traditional Foods Project conducted by the Centers for Disease Control and Prevention (DeBruyn et al., 2020). This project evaluated the food sovereignty initiatives of 17 Tribal partners and identified improving community health as a key motivation, with several initiatives explicitly targeting outcomes such as weight loss, increased exercise, and nutritious diet choices. As that analysis shows, even when health issues are not the primary focus of a project, they are still given consideration. For example, the Osage Nation intentionally selects fruits and nuts with high nutrient density for their community orchard in Oklahoma (Lovell et al., 2021). Initiatives like these seek to increase local production of nutritious foods in the hope that community members will benefit from healthier diets and from reconnecting with traditional practices, although they rarely directly measure the effects on health outcomes.

4.3 Cultural food security

Lack of consistent access to healthy food in Indigenous communities is associated with increased consumption of nutrient-poor food items (Jernigan et al., 2012). This arises from the long history of displacement of Indigenous populations from their ancestral lands, which has interrupted traditional methods of food procurement and exacerbated poverty in Indigenous communities across the US. In an Indigenous context, solutions to hunger must expand beyond addressing insufficient quantities of food, but also address insufficient access to traditional foods, known as cultural food security (Blanchet et al., 2021).

Many initiatives use food sovereignty as a prism through which to address cultural food insecurity. For example, a research collaboration with the Round Valley community in Northern California identified key barriers to food security such as lack of community involvement in local agriculture and poor availability and affordability of traditional foods (Jernigan et al., 2012). To remedy these problems, the project worked to implement policy changes such as creating a Community Supported Agriculture (CSA) program, supplying school cafeterias with local produce, and increasing the amount of fresh produce available at the local grocery store. The Round Valley Indian Health Center also began to distribute additional local produce to 25% of families receiving FDPIR food assistance (Jernigan et al., 2012). In Mississippi, the Choctaw Fresh Produce initiative has implemented a CSA program as well, which is supplemented by a mobile produce market to ensure that remote areas of the reservation have equal access to these foods (Carlson, 2021). A collaboration between several Tribes and UC Berkeley identified food security as the focal point of a broader project to transform the regional food system (Sowerwine et al., 2019). Wide-ranging initiatives were undertaken, from workshops on traditional food preparation to the creation of an herbarium and new grade-school curricula on Indigenous food systems. More than 17,000 people participated in these initiatives, with 65% of those surveyed reporting that the programming made the community more food secure and 81% reporting that it had other positive impacts.

4.4 Environmental stewardship

Although environmental stewardship is a key principle of Indigenous Food Sovereignty, it is rarely the primary goal of food production initiatives. Rather, it is often incorporated into these initiatives as a value that guides their implementation. For example, the FRTEP at the University of Arizona works with the Hopi Tribe to develop regenerative agricultural practices that improve rather than deplete the land (Sekaquaptewa, 2021). One technique is rotational grazing, which is intended to maintain soil health and mitigate climate change by increasing carbon sequestration in the pastures. Similarly, the Salish Kootenai College Extension Programming in Ecological and Human Health Restoration in Montana implemented techniques in its community gardens to increase carbon sequestration and reduce the use of pesticides and water, while also working to eliminate invasive plant species on Tribal lands (Dupuis, 2021). Utilizing these sustainable methods, a 15-week community gardening educational series produced sufficient amounts of fruits and vegetables for all 50 participants in addition to more than 10,000 lbs. of surfeit produce for those in need in the community. Both of these initiatives prioritize environmental stewardship by choosing sustainable agricultural practices.

In a specifically Indigenous context, these practices are often passed down through generations as traditional ecological knowledge (TEK). TEK is the accumulated cultural wisdom of Indigenous communities in regard to living in harmony with the environment (Lovell et al., 2021). In New Mexico, the Cochiti Youth Experience seeks to restore traditional farming practices by facilitating the exchange of TEK between elders and young people (Blauvelt, 2016). Integrating TEK into food sovereignty initiatives ensures that these projects respect the Indigenous values of relationality, responsibility, and reciprocity (Miltenburg et al., 2022). A survey of individuals involved in Indigenous Food Sovereignty initiatives found that these principles are central to their attitudes towards food and the land; rather than viewing nature as an exploitable resource, these individuals

feel a duty to be respectful stewards of the environment (Miltenburg et al., 2022). In return for this stewardship, communities benefit from the sustained abundance of the ecosystem, which supports the longevity of food sovereignty initiatives.

4.5 Economic development

Through selling produce, employing Tribal members, and making local food more affordable, these initiatives can stimulate local economies. For example, Micmac Farms in Maine has expanded from a small garden into a formal business operation with a general store, kitchen, and online interface for streamlining produce delivery and shipping (Caulfield, 2011). Vouchers distributed by the Bureau of Indian Affairs enable members of the Micmac Tribe to purchase the fresh produce that the farm grows. The operation also benefits from USDA funding to support operational infrastructure, including training in marketing and management, as well as electronic systems to facilitate participation in food assistance programs for lower income households (Caulfield, 2011). In Montana, where the Blackfeet Reservation relies on 1.5 million acres of agricultural properties as the basis of its economy, the Federally Recognized Tribes Extension Program (FRTEP) helps youth overcome financial obstacles to becoming farmers and ranchers (Billedeaux, 2023). For example, FRTEP helps young people obtain funds from the Montana Junior Agriculture Loan Program to develop agricultural projects, helping them to build their vocational skills, credit, and equity.

4.6 Disaster preparedness

Disaster preparedness is an emerging theme in Indigenous Food Sovereignty, and often takes the form of improving self-sufficiency to reduce the risk of disruptions to the food supply. Most recently this occurred as a result of the COVID-19 pandemic, which exposed vulnerabilities in the food system that included insecure supply chains and increased reliance on food imports. For example, labor shortages in meat processing facilities left many Indigenous communities with limited access to meat products despite a sufficient supply of livestock (Mucioki et al., 2022). However, while the COVID-19 pandemic exacerbated existing challenges for accessing traditional and store-bought foods, it also revealed the resilience of these communities, which experienced a growth of Indigenous cultural and economic practices, such as food sharing networks and other programming to support access to traditional foods. These efforts during this time of need strengthened the ability of individuals and communities to respond to significant events that might occur in the future (Johnson et al., 2021).

Climate change also poses challenges to the food system. As the frequency of extreme weather events such as hurricanes and wildfires is expected to increase in coming years, communities are increasingly concerned about developing the ability to supply their own food and securing food access in extreme situations (New Entry Sustainable Farming Project, 2019; Mucioki et al., 2021). For example, the Hawaiian Islands rely on imports for 80–90% of their food consumption, leaving the residents vulnerable in the event of natural disasters (McGregor, 2020). Stakeholders including the State of Hawai'i Emergency Management Agency, universities, private schools, and nonprofits are seeking to improve the islands' disaster resilience by strengthening Indigenous Food Sovereignty in the local food system. For example, Kamehameha Schools seeks to restore Indigenous agricultural and land stewardship practices, which were estimated to produce over 1 million metric tons of food per year before colonial European contact in contrast to the islands' current production of approximately 150,000 metric tons of food per year (McGregor, 2020). The use of Indigenous Health Indicators to predict the impact of climate change on community health has been pioneered in Coast Salish communities in Washington and could be a valuable tool for developing priorities for climate change adaptation (Donatuto et al., 2014).

Additionally, to improve Tribes' ability to access food during disasters, the organization Partnership with Native Americans is partnering with the organization Feeding America to facilitate disaster preparedness plans between Tribes and local food banks (Partnership with Native Americans, 2023). Adopting sustainable farming practices may also be a strategy to mitigate the effects of climate change in turn. Likely with these considerations in mind, the Federal Emergency Management Agency is planning to incorporate food security as a priority in its disaster preparedness strategy for Tribes (The White House, 2022).

5 Organizational structure of food sovereignty initiatives

Food sovereignty initiatives are launched at three levels of Tribal organization: Tribal affiliations, reservations, and urban areas, which tend to differ from rural areas in key ways. Additionally, instances of inter-Tribal initiatives are emerging.

5.1 Tribal affiliation

Indigenous Food Sovereignty initiatives are typically developed by a particular Tribe for the purpose of serving its members. For example, Micmac Farms is run by and for the Aroostook Band of Micmacs in Maine (Caulfield, 2011), while the Wozupi project in Minnesota is run by members of the Shakopee Mdewakanton Sioux Community (Carlson, 2015). At the same time, there are instances of inter-Tribal cooperation such as the Growing Resilience project, which supports the creation of home gardens for both Eastern Shoshone and Northern Arapaho families living on the Wind River Reservation in Wyoming (Budowle et al., 2019).

5.2 Reservations

As reservations are more common in the Midwest and West compared to other regions of the US, they are also a more common locus for food sovereignty initiatives in those areas. For example, the Santee Sioux Reservation in Iowa assists residents in starting gardens (Landholm, 2016), while the Shakopee Mdewakanton Sioux Community in Minnesota has introduced a variety of projects including gardens and cooking classes to their reservation (Carlson, 2015). In contrast, initiatives in Alaska and much of the southern and northeastern regions of the US tend to serve Indigenous individuals

that do not live on reservations. The WISEFAMILIES Through Customary and Traditional Living program at the Southeast Alaska Regional Health Care Consortium, for example, is being implemented in several Alaskan towns with significant Indigenous populations (Bingham, 2009). The Seeds of Renewal initiative is based in Burlington, Vermont, and their programming is dedicated towards all members of the Abenaki Tribe throughout the Northeast US and Southeast Canada (Vermont Indigenous Heritage Center, 2023).

5.3 Urban initiatives vs. rural initiatives

Many Indigenous Food Sovereignty initiatives are implemented in rural areas (Caulfield, 2011; McKenna, 2013; Chollett, 2014; Hipp and Shirl, 2015; Landholm, 2016; Hayden et al., 2019; Beebe et al., 2020; Lovell et al., 2021; Pietrorazio, 2021; Calvert, 2023; Sićaŋǧu Co, 2023), while fewer take place in urban areas (Kokua Kalihi Valley Comprehensive Family Services, 2011; Hipp and Shirl, 2015; Women's Environmental Institute, 2015; Miltenburg et al., 2022). Here we define rural areas according to information from the Rural Health Information Hub, which utilizes information about an area from census data, designation by the Federal Office of Rural Health Policy, and the USDA Economic Research Service's Urban Influence Codes (Am I Rural? Tool, 2023). This disparity may be partly attributed to the fact that reservations are a common site for initiatives and tend to be rural. Another possible contributing factor is that rural areas provide more land resources for food production in comparison to more densely populated and developed urban areas. As a result, urban initiatives tend to be more limited in size and scope. While rural initiatives can encompass farms (Caulfield, 2011), animal rearing (Shamon et al., 2022), and orchards (Lovell et al., 2021), these projects are not typically possible in urban areas, where initiatives tend to be limited to household and community gardens (Women's Environmental Institute, 2015; Miltenburg et al., 2022). For example, working within the confines of limited land availability, the Kalihi Valley `Aina to Table Initiative was able to establish a community garden and planter boxes in an urban area in Hawai'i (Kokua Kalihi Valley Comprehensive Family Services, 2011). In contrast, the Rosebud Farm Company in rural South Dakota manages a nearly 2000-acre farm as well as large bison herds (Sićaŋǧu Co, 2023). South Carolina's Building Capacity for Tribal Food Sovereignty Project focuses on revitalizing traditional fishing and hunting practices, establishing farms, and promoting gardening in primarily rural areas of the state (Hayden et al., 2019). Interestingly, although urban initiatives are less common, rates of food insecurity for Indigenous individuals are higher in urban areas (Jernigan et al., 2016), suggesting an unmet need for food production initiatives in these locations.

5.4 Inter-tribal food knowledge exchanges

Recognizing that Indigenous communities are often underserved and underrepresented in scientific research, in addition to being amongst the poorest and most food insecure due to structural inequities, some Indigenous communities are coming together to engage in cross-regional knowledge exchanges. For example, the Indigenous Food Knowledges Network connects Indigenous and non-Indigenous scholars, community members, and leaders from the US Arctic and the US Southwest to co-produce food sovereignty solutions (Jäger et al., 2019). The research coordination network was created in 2017 by the University of Colorado and the University of Arizona and is driven primarily by Indigenous community leaders and scholars, in addition to guidance from an all-Indigenous steering committee. Members of the network exchange knowledge about ways to maintain traditional ways of life, from river restoration, community gardens, housing infrastructure, and farming practices to culture camps in which Indigenous knowledge is shared with younger generations. This work, primarily driven by Indigenous community leaders and scholars, emphasizes community-driven research that addresses Indigenous peoples' interests, foregrounds Indigenous knowledge systems, and both respects and asserts Indigenous sovereignty (Jäger et al., 2019). Outcomes from these gatherings resulted in the Arctic Report Card's first inclusion of Indigenous Knowledges (Johnson et al., 2021) with recognition that Indigenous Food Knowledges can be quite broad, ranging from seed sovereignty and language revitalization to ecosystem protection.

6 Evaluating outcomes

Many Indigenous Food Sovereignty initiatives are grassroots efforts with a diversity of metrics used to measure success. While some initiatives collect quantitative data on program outputs, others emphasize qualitative methods that demonstrate personal and community impacts. In either case, community engagement and consent in data collection processes is of paramount importance in order to prevent exploitation and to embody the collective nature of food sovereignty.

6.1 Quantitative outcomes

Some initiatives measure agricultural output such as the mass quantity or number of fruits and vegetables harvested (Dream of Wild Health, 2019; New Entry Sustainable Farming Project, 2019; Maunakea-Forth and Maunakea-Forth, 2020) or sold (Maunakea-Forth and Maunakea-Forth, 2020; Land to Hand Montana, 2021). Other projects quantify the expansion of their operations. For example, MA'O Organic Farms in Hawai'i reported the addition of 15 fields to rotation, the installation of over 20,000 feet of irrigation, and the acquisition of over 250 acres of land in 2020, in addition to 260,000 pounds of harvested produce (Maunakea-Forth and Maunakea-Forth, 2020). Because community ownership is key to food sovereignty, another common metric is community participation, which can be expressed in terms of number of program participants (Dream of Wild Health, 2019; Maunakea-Forth and Maunakea-Forth, 2020; Thunder Valley Community Development Corporation, 2020) or volunteers assisting in operations such as farmwork (New Entry Sustainable Farming Project, 2019; Native Seeds SEARCH, 2020; Land to Hand Montana, 2021; Mashpee Wampanoag Tribe, 2022). For example, the Mashpee Wampanoag Tribe's Community Food Project reported that 12 volunteers dedicated nearly 1,300 h to food production efforts in one year (Mashpee Wampanoag Tribe, 2022). These volunteers were recruited through postings in the Tribal newsletter, the Tribal website, and the Community Government

Building, although the COVID-19 pandemic made recruitment challenging. Another example is the Land to Hand Montana initiative, where 390 people volunteered in the community garden in 2021 and 1,150 young people participated in gardening and nutrition education programs (Land to Hand Montana, 2021).

A promising method for measuring health outcomes in a specifically Indigenous context has been developed in recent years by the Native Coast Salish communities in Washington State, who piloted the use of Indigenous Health Indicators in health assessments (Donatuto et al., 2016). These indicators assess community-level components of health that are important to many Indigenous individuals but that are rarely included in traditional physical health assessments, such as community connection, natural resources security, cultural use, education, self-determination, and resilience. Future food sovereignty initiatives could utilize these indicators to assess their holistic health benefits.

6.2 Qualitative outcomes

In addition to quantitative measures, food sovereignty also encompasses concepts such as community empowerment and cultural revitalization that are often better captured using qualitative evaluation (Maudrie et al., 2021). Many of these measures ask participants to directly report their experiences with an initiative and the impacts they received. For example, the organization God's Country Waimanolo in Hawai'i worked with faculty and students from the University of Hawai'i at Manoa to conduct interviews with those who took part in an aquaponics program (Beebe et al., 2020). Two researchers collaborated to identify themes in the transcripts and then shared their findings with the participants, God's Country Waimanolo, and the broader community for validation. Themes were categorized as benefits, challenges, and suggestions; benefits included improved diet, sustainability, financial savings, family strengthening, community building, and cultural connection. Challenges included limited support, managing organisms (such as maintaining proper environmental conditions for fish and plant growth), and inclement weather. Suggestions included further opportunities for communal learning, shared community aquaponics systems, and additional training (Beebe et al., 2020). Another Hawai'i initiative, MA'O Organic Farms, conducted a survey of former Youth Leadership Training interns to assess outcomes related to diet, nutrition, and food sovereignty; outcomes included greater reports of growing one's own produce, knowledge of local agriculture, and valuing community resources (Maunakea-Forth and Maunakea-Forth, 2020).

6.3 Participatory research

Indigenous communities have been historically exploited by academic institutions (Budowle et al., 2019). To address issues of power inequities and the exclusion of communities from the benefits of research involving them, Indigenous Food Sovereignty studies often adopt participatory methodologies that empower communities within the research process (Sowerwine et al., 2019). Methodologies that engage the target population at all stages of the process are known as community-based participatory research (CBPR) (DeBruyn et al., 2020). An example of CBPR is the Traditional Foods Project conducted by the Centers for Disease Control and Prevention, which provided funding and support to Tribal partners who were otherwise autonomous in designing and implementing initiatives in their local communities (DeBruyn et al., 2020). These partners worked with community stakeholders such as Tribal councils and local schools to develop goals that were culturally specific, such as the restoration of traditional farming and foraging methods. Local coordinators were responsible for data collection, utilizing methods such as storytelling to understand how participants' perspectives influenced quantitative outcomes such as health-related behavior changes.

Another example is the Growing Resilience project, which sought to decolonize the research process by granting autonomy to the community. Before beginning data collection related to its gardening initiative, the project secured approval for its research from the Eastern Shoshone and Northern Arapaho Tribal Business Councils (Budowle et al., 2019). Participants were able to share their thoughts in talking circles, a method of turn-based discussion rooted in local customs. The talking sticks, which are passed around to indicate whose turn it is to speak, were crafted and blessed by community elders. These talking circles then developed into a broader focus on sovereign storytelling, which provides a voice to research participants in the representation of their experiences. Common ways in which participants chose to tell their stories about their experiences with the initiative included interviews, talking circles, informal conversations, photography, garden journals, garden-related artwork, and videos. Stories were then coded for common themes such as family and togetherness, revealing the personal and community impacts of gardening initiatives.

7 Barriers to food sovereignty

Although the Indigenous Food Sovereignty movement has enjoyed many successes, communities trying to regain autonomy over their food system still face substantial barriers. The historical and ongoing colonization in the US has severely disrupted Indigenous homelands and traditional foodways, often displacing Indigenous peoples far from their traditional lands. Reservations were often established on low-quality, marginal lands where environmental conditions were not compatible with a group's ecological knowledge (Shamon et al., 2022). Other policies such as assimilation intentionally deprived Indigenous individuals of cultural knowledge, including that concerning traditional foods and agricultural practices (Sowerwine et al., 2019). These factors combine to form major obstacles to restoring culturally informed, community-based control of food production. To overcome these challenges, many initiatives are seeking to restore their community's agricultural traditions, which present powerful opportunities to revive cultural practices as well as the quality of depleted soil (Burke, 2015; Budowle et al., 2019; Pietrorazio, 2021).

This history has also contributed to a distrust of the US government and its institutions. Past exploitation of Indigenous communities makes many Indigenous individuals wary of participating in non-Tribal programs or research, including those relating to food sovereignty. These issues took a central focus during a collaborative food security project between UC Berkeley and the

Klamath, Karuk, and Yurok Tribes (Sowerwine et al., 2019). Because of the university's history of appropriating the culture of these Tribes, the initiative began with extensive work to develop policies that would decolonize the research process and protect the Tribes' interests. The Karuk Tribe developed a document to assert their sovereignty and outline protections for all cultural and intellectual property, which included extensive review processes by the Karuk Advisory Board, Review Committee, and Tribal Council (Karuk Tribal Council, 2015). The Karuk Tribe and UC Berkeley also produced another document to provide guiding principles for the research process, including community engagement, benefit to the Tribal community, educational opportunities for Tribal youth, and confidentiality, among others (Karuk-UC Berkeley Collaborative, 2013). Establishing such protections may encourage more Tribal communities to participate in food sovereignty initiatives while simultaneously preventing exploitative practices.

Another obstacle for food production initiatives is acquiring and distributing seeds. Many heirloom plant varieties have been selected over generations to suit local environmental conditions and possess rich cultural significance for Indigenous Tribes (Cherokee Nation, 2023; Native Seeds SEARCH, 2023). However, knowledge of this significance has been lost in some cases, and heirloom seeds can also be challenging to acquire (Vermont Indigenous Heritage Center, 2023). Many efforts have emerged to address these problems, including seed libraries and exchanges. These organizations identify, collect, and sell or distribute seeds to those who wish to grow native plants, ensuring the longevity of heirloom varieties that may not be available from commercial retailers (McKenna, 2013; Cherokee Nation, 2023; Native Seeds SEARCH, 2023). However, the rarity of many varieties can make it challenging to accumulate large stocks of seeds. Supply may be unable to meet demand (Cherokee Nation, 2023), and state restrictions can negatively impact small-scale seedbanks (Women's Environmental Institute, 2015). Despite these challenges, organizations such as Native Seeds/SEARCH in the Southwest and Seeds of Renewal in Vermont are successfully conserving dozens of heirloom seed varieties and integrating them back into Tribal farms and gardens (Native Seeds SEARCH, 2020; Vermont Indigenous Heritage Center, 2023).

Another risk to heirloom plants is cross-fertilization, leading to hybridization that alters the plant's genetics (Cherokee Nation, 2023). While cross-fertilization is always a risk in natural environments, some Tribes are particularly concerned by the rise of genetically engineered plants. Offspring of genetically engineered plants are subject to patents that can lead to costly lawsuits; furthermore, many crops have value that goes beyond sustenance to encompass kinship relationships and spiritual meaning (Raster and Hill, 2016). The modification of these plants through cross-fertilization threatens these relational systems and threatens Indigenous Food Sovereignty. For these reasons, many Tribes have campaigned against the use of genetically engineered seeds and pledged not to plant them (McKenna, 2013; Native Seeds SEARCH, 2023). The Native American Seeds Protection Act of 2019 had the potential to become a major milestone in this effort but did not progress to a floor vote in the US Senate (BillTrack50, 2020). For now, local rights disputes continue, such as the fight of the Ojibwe people in Minnesota to resist commercial appropriation of traditional wild rice (Raster and Hill, 2016).

As the food sovereignty movement grows, finding creative solutions to common obstacles will be essential. Improving soil quality, restoring traditional ecological knowledge, enhancing cooperation among Tribes and funding institutions, and protecting Indigenous plant varieties are some of the major efforts facing Indigenous communities in their work to reclaim traditional foodways.

8 Indigenous Food Sovereignty among eastern tribes

8.1 Challenges facing eastern tribes

The majority of Indigenous Food Sovereignty initiatives that focus on food production have occurred in the West and Midwest, with relatively few taking place in the East. Eastern Tribes have had the longest sustained contact with settler colonialism in the territory now known as the continental US. Through encroachment on sovereign lands, loss of reservation land, treaties predating the creation of the US federal government, and racist policies such as blood quantum, many Tribes were later deprived of the right to be acknowledged by the US federal government as sovereign nations. Many exist as federally non-recognized Tribes, some are recognized by states, and fewer have recently become federally recognized in the past two decades.

For example, the Virginia Tribes that are federally recognized only recently won that battle in the last 5–10 years. In 2015, through the Bureau of Indian Affairs federal acknowledgment process, the Pamunkey Tribe was acknowledged as sovereign. In 2018, through an act of Congress, Chickahominy, Eastern Chickahominy, Monacan, Nansemond, Rappahannock, and Upper Mattaponi were acknowledged as sovereign nations. Like many other Tribal nations, most Tribal members and Tribal descendants live in urban settings and do not have access to large areas of agricultural land. As newly recognized sovereigns with limited access to resources, many first-contact Tribes are trying to catch up with the rest of Indian country in terms of governance structure and institutional capacity. Many Tribes have prioritized establishing healthcare access, land reacquisition, conservation efforts, and to a lesser degree, education initiatives. As a result, scalable food sovereignty initiatives have not been prioritized.

Many Tribes, particularly those in the East, do not have the institutional capacity to manage grants or projects beyond what they are currently doing. Despite there being many highly educated and qualified Tribal descendants, many cannot enroll in their Tribe due to institutional challenges that prevent them from bolstering their Tribe's human capital. For example, some Tribes have restricted their citizenship through blood quantum laws or incomplete base citizenship rolls, and changing those laws may help improve their human capital shortage problem. When other sovereigns such as Canada (Nation-State) or Maryland (US State) face human capital issues to address critical infrastructure, security, health needs, and others, they attract new talent from abroad to help address the human capital shortage, which is not an option for Tribal nations.

For Indigenous people who live outside of Tribal lands and reside in urban areas, their lack of access to healthy, affordable, culturally relevant, and sustainable foods is similar to other disenfranchised communities. Increased membership and access to resources in their traditional communities could benefit many if they are willing to move back to their traditional territories,

which may not be feasible or desirable for many. Tribal nations will also have to invest in supply chain infrastructure to deliver food from rural agricultural areas to densely populated urban areas. However, the eastern Tribes occupy lands that cover a diversity of plant hardiness zones with commensurate diversity in the types of agricultural products that can be produced. Additionally, the proximity to other Tribal nations raises the potential for inter-Tribal food trading and supply chains.

In areas where high quality land, resources, and supply chain coordination are lacking, urban Indigenous communities could benefit from alliances with other disenfranchised communities to establish food networks. Black and Indigenous alliances are emerging throughout the US to address critical issues affecting these communities. Technological innovation will also play an important role as vertical and shipping container farming becomes more efficient, cost-effective, and available.

The following subsections on the food sovereignty initiatives of eastern Tribes were, respectively, contributed by four of this paper's authors who are all enrolled or documented descendants of state and federally recognized tribes from mid-Atlantic and Southeast tribes. They are also personally involved in the efforts described.

8.2 Urban Indigenous Food Sovereignty: Baltimore American Indian Center

The Baltimore American Indian Center (BAIC) is an urban Indian cultural and resource center serving the greater Baltimore area and beyond. The challenges of food sovereignty in urban communities are the consequences of a general lack of economic resources, a lack of availability of food retail establishments near residential areas, and the reality that most major food chains which would offer a wider variety of healthy foods will not open stores in poorer urban districts. Residents also face a lack of accessible areas to grow produce near their homes. Much of the Indigenous urban population only has direct access to small convenience stores that prioritize the sale of low-quality food. Some potential solutions include local government incentives to encourage large food chains to establish stores in poorer neighborhoods, community gardens in areas with healthy and safe soil, government-sponsored farmers' markets in poorer neighborhoods, and healthy eating instruction in public schools.

The BAIC is addressing these urban food sovereignty issues through several initiatives. First, the BAIC partnered with Pearlstone Retreat Center to name a river on their site in honor of the Indigenous people of this area. The river was being blocked which was hindering the rebirth of aquatic life with cultural importance such as sunfish, crawfish, and trout. That river was unblocked in 2022 and now it leads into the Patuxent River. Second, in summer 2023, the BAIC expanded their Baltimore City Public School Indian Education Title VI grant to include elements of food sovereignty education. Students are able to attend a 4-day summer camp at another Maryland nonprofit organization which centers around restorative agriculture, The REED Center, to learn about ecosystem farming. It is an opportunity to get urban Indigenous children reconnected with nature and to understand the impacts of different food systems. The retreat will also highlight Indigenous food as many of these children, like their families, have been disconnected from Indigenous food pathways. Finally, a new Indigenous food program was established in December 2022. This program includes bi-monthly food drives and quarterly Indigenous cooking classes. The Indigenous cooking class operates as a knowledge co-creation and sharing program where urban Indigenous residents can reconnect with Indigenous foods and learn how to cook fresh produce provided during the food drive. Several hundred people have attended at least one of the events to date.

8.3 Eastern Chickahominy and USDA local purchasing program

The Chickahominy Indian Tribe – Eastern Division views food sovereignty as a vital part of cultural preservation and independence as a nation. Food sovereignty involves re-learning the traditional knowledge of ancestors in a way that is sustainable and sharable for future generations. The Indigenous community has a deep connection with the earth and the resources she has given them to steward. The food and water needed for survival and nourishment are seen as gifts to be cared for, shared, and then given back. Incorporating environmental sustainability into food sovereignty initiatives is integral to increasing health and reducing food scarcity in the Indigenous community.

In 2021 the Tribe was awarded a new sustainable materials management grant by the EPA for a community compost and gardening program. The grant's goal was to support efforts to eliminate food insecurity in the Tribal community and raise awareness of traditional and sustainable food management practices. A community garden was planted and cared for by the Tribal community and school, with education, outreach, and fresh produce being offered to Tribal citizens. The grant ended in 2022 and was not renewed by the EPA due to lack of progress by other grant recipients.

In September 2022, the Tribe was awarded the USDA Local Food Purchase Assistance grant. The grant is aimed at strengthening the relationship between the local farm community and the underserved Indigenous community. As a rurally dispersed environmental justice community, there is a lack of education and access regarding locally grown, healthy foods. The USDA grant allows the Tribe to purchase produce and meat from local farms, which is then distributed throughout the Tribal community. Hot meals are prepared and delivered to elders. Fresh produce is utilized in the Tribal school and summer camp program, and there are designated pantry box pick-up days for citizens.

There are future projects that the Tribe hopes to implement to support food sovereignty. A native food forest is in the planning phase, which will incorporate traditional knowledge of food management through cultural classes and Tribal citizen volunteers. There is hope that this could lead to economic development, furthering the Tribe's goal of developing capacity as a sovereign nation. Land acquisition will allow for hunting and gathering, traditional agriculture, and conservation practices. Learning from Tribal elders and other Tribal nations is an important part of reaching these goals, as well as working with organizations, research and educational institutions, and government agencies. As with most goals of underserved communities, lack of capacity, technical assistance, and funding are barriers in reaching many food sovereignty goals.

9 The future of Indigenous Food Sovereignty

As the Indigenous Food Sovereignty movement continues to grow, it will be critical to understand the evolving characteristics of the movement and the approaches that can be most effectively leveraged to generate progress. Trends such as federal support, refined research methods, and harnessing big data could potentially have major impacts on the scale and effectiveness of future food production initiatives.

9.1 Role of the federal government

In addition to motivating grassroots efforts, Indigenous Food Sovereignty is gaining attention on the national stage. The 2022 White House National Strategy on Hunger, Nutrition, and Health outlines explicit strategies to better support the food sovereignty of Tribes with federal programming (The White House, 2022). For example, the USDA has committed to devoting more resources to the FDPIR Self-Determination projects, which grant greater autonomy to Tribes in curating the contents of their government food packages. Through these projects, Tribes are able to advocate for the inclusion of healthier, traditional foods in their packages in place of highly processed commodities (The White House, 2022). The USDA will also provide more traditional food offerings in its Child Nutrition Programs and facilitate the inclusion of traditional foods in school meal programs. In order to create the economic infrastructure to sustain local food systems, another USDA initiative is the creation of Regional Food Business Centers in underserved communities, including Tribal lands. Additionally, the USDA has made recent announcements regarding the nomination period for a Tribal Advisory Committee which will provide greater support and inclusion of Indigenous communities within USDA programs and policy and to include subject matter experts to provide key advice to advance USDA's work within Indian Country and to support Indigenous food security and sovereignty (US Department of Agriculture, 2023b). Much of the work of USDA is funded by the Farm Bill, which is currently under revision. This piece of legislation has the potential to significantly expand federal Indigenous Food Sovereignty programming, as expressed by the Native Farm Bill Coalition, an organization which develops policy priorities in support of Indigenous peoples in the US (Parker and Hotvedt, 2022).

Other government agencies will be instrumental to the federal government's food sovereignty efforts as well. The Bureau of Indian Affairs and the Bureau of Indian Education will seek to increase the availability of healthy and culturally relevant foods at certain schools and detention centers through the creation of Indigenous Food Hubs. The Department of Health and Human Services will also increase its efforts to reduce inequities in Tribal communities by providing greater guidance on the resources related to food security, food sovereignty, and physical activity that are available from the Administration for Children and Families. Finally, the Department of Housing and Urban Development will devote more of its funds to create infrastructure and behavioral programs dedicated to improving food access and health outcomes in Tribal communities. In order to track the outcomes of these diverse projects, the National Strategy on Hunger, Nutrition, and Health also recommends that all levels of government form data sharing agreements with any institutions and stakeholders that collect relevant data. The federal government's interest in promoting Indigenous Food Sovereignty demonstrates the growing strength of this movement in the US. As this trend continues to spread, the identification of effective and sustainable initiatives will be increasingly important.

9.2 Outcome measures

There is limited data on the direct impact of initiatives towards achieving Indigenous Food Sovereignty goals. Many projects rely on indirect measures such as the quantity of produce harvested or the number of skills workshops offered, but individual and community outcomes are rarely measured. For example, initiatives designed to improve community health often report increased availability of fresh produce but do not directly measure outcomes such as rates of chronic disease, making it challenging to assess the initiatives' effectiveness. Future research should collect data on outcome measures related to the goals of food sovereignty initiatives. However, because many of these initiatives are grassroots efforts, they may have limited capacity to expand the breadth of their data collection or to disseminate their findings to a broader audience. Additionally, even when these activities are prioritized, peer reviewed literature is often made inaccessible by paywalls. To ensure that Indigenous Food Sovereignty initiatives can produce impactful data, resources for data collection should be prioritized in the planning and funding stages, and researchers should seek to publish their findings in open access journals, if possible.

When deciding which data to collect, both qualitative and quantitative methods have value. Qualitative methods can shed light on a project's successes and challenges by accounting for intangible factors such as cultural and personal impacts. However, these approaches often lack standardization, making comparisons across initiatives challenging. On the other hand, quantitative measures provide more objective data about an initiative's outputs but may not adequately capture important contextual information. Approaches that synthesize both objective and subjective data could provide a more thorough understanding of an initiative's impacts, supporting the development of more effective and sustainable Indigenous Food Sovereignty initiatives. Additionally, because of the historic exploitation of Indigenous communities by academic institutions, including the misuse of health data, empowering and building trust with these communities must be prioritized throughout the research process (NCAI Policy Research Center and MSU Center for Native Health Partnerships, 2012).

9.3 Data-driven approaches to Indigenous Food Sovereignty

Initiatives to improve Indigenous Food Sovereignty can be complex and must carefully balance many components such as adequate nutrition for community members, cultural norms of food consumption, support for the livelihood of food producers, and stewardship that supports a resilient ecosystem. These diverse objectives can sometimes result in a competition of priorities, such as deciding whether to produce food in ways that favor high yield, enrich

the environment, or provide greater income to farmers. When a community is not able to balance the needs of the community, needs of the producers, and needs of the ecosystem, then it may lack the capacity for food sovereignty. One framework introduced in the Indigenous Food Sovereignty literature highlights seven indicators that address an Indigenous community's capacity for food sovereignty. These indicators include: (1) access to resources, (2) production, (3) trade, (4) food consumption, (5) policy, (6) community involvement, and (7) culture (Jernigan et al., 2021).

According to this framework, access to resources is both a physical and knowledge-based indicator. Communities that are largely fishing communities must have access to their traditional waterways as well as culturally relevant knowledge to sustainably harvest and respect their food source. The production indicator highlights the importance of an equitable distribution of food to the community, which will meet its needs and allow food producers longevity in operation. The trade indicator highlights the importance of balancing affordable food prices for the community with profitability for farmers. The food consumption indicator highlights the importance of healthy and sustainable foods available to the community. The policy indicator highlights the importance of policies that support fair access to resources. The community involvement indicator highlights the importance of community input in food system management, as communities may have the requisite traditional knowledge to ensure the lifecycle of foods is managed in a culturally relevant and sustainable way. Finally, the culture indicator highlights the cultural relevance of the foods consumed.

To use these indicators to measure a community's capacity for Indigenous Food Sovereignty, data is needed to quantify concepts like access to resources, market prices, number of farmers, and ecosystem health. Computing technology could support the collection of these data. Additionally, data science and computing technologies can help measure a community's current capacity for sovereignty and help define pivotal areas to focus efforts for capacity growth.

Many Tribes in the West and Midwest lack access to resources such as productive soil and water for agriculture (Shamon et al., 2022), while many urban Indigenous populations experience a lack of land and limited food availability (Burki, 2021). Innovations in technology can help address these issues. At the agricultural level, data science, artificial intelligence (AI), and blockchain technology has already been used to support soil, crop, disease, and weed management, which can promote increased agricultural productivity and reduced environmental impacts (Eli-Chukwu, 2019). For example, distributed network approaches can be used to better understand the interrelatedness between water scarcity issues across and among agricultural areas, which may lead to better scarcity pattern identification (Lin et al., 2018). Intelligent built-in irrigation systems for precision scheduling may also lead to greater efficiency in water use on Indigenous lands (Nikolaou et al., 2020). The Agriculture Improvement Act of 2018 directed the Federal Communications Commission to improve broadband access on agricultural land with the aim of facilitating precision agriculture in the US. The task force created around this objective has devised specific strategies for implementing the program on Tribal lands, such as collaborating with Tribal colleges to identify unserved and underserved agricultural areas and collaborating with other government agencies to update land use data (Federal Communications Commission, 2021). Additionally, technologies that perform land suitability analyses, such as geographic information systems (GIS), can be a valuable asset to Indigenous farmers (Bandyopadhyay et al., 2009). GIS could also help identify suitable horticultural locations in urban areas (Kazemi and Hosseinpour, 2022) where Indigenous individuals experience high rates of food insecurity (Jernigan et al., 2016).

The production indicator includes disease control, product monitoring, and storage management, which can be implemented and monitored through computing technologies. These processes ensure that food is healthy and resilient from farm to table by (a) operating as an early detection system, safeguarding against potential loss of yield due to disease or other pressures, (b) analyzing crop health and recommending when additional inputs and management are needed, and (c) automating commodity storage systems to preserve food safety and minimize waste. The trade indicator can be supported by AI-assisted forecast crop commodity pricing for farmers (Akkem et al., 2023) which can help determine whether market prices support farmer profitability and community affordability.

The food consumption, policy, community involvement, and culture indicators can be supported by data science and AI technologies that assist with supply chain traceability, sentiment analysis of the community food system, monitoring of the health of food throughout the supply chain (Misra et al., 2022), and promoting healthy food recommendations to consumers (Marvin et al., 2022). Additionally, recommender systems, which are computing systems that explore vast information spaces and make task-specific recommendations relevant to a user's inquiry, can have built-in features that promote sustainable food choices by identifying culturally relevant foods that minimize environmental impacts. Sentiment analysis of online reviews of Indigenous suppliers or forums to discuss community food policy can provide decision-makers with aggregated opinions of the community, thereby creating a feedback loop between the community and decision-makers. Crowd-sourcing as a data acquisition and management strategy can also be useful in transferring traditional knowledge (Papadopoulou and Giaoutzi, 2014). AI can also be used to increase workers' productivity or replace workers where there may be a labor shortage (Ryan et al., 2023).

9.4 Indigenous data sovereignty

Although Indigenous communities have been participating in agriculture practices since precolonial times, Indigenous data has often been viewed through a colonial lens that fails to recognize and value Indigenous approaches and perspectives that may differ from Western norms. In order to better support the involvement of Indigenous peoples in the agricultural sector, greater efforts are needed to engage with these communities to collect accurate data about their farm and ranch operations to identify unmet needs. Fortunately, this process is now underway. In 2002, Montana, North Dakota and South Dakota initiated pilot programs to collect state-level data on agricultural activity on American Indian reservations (US Department of Agriculture, 2007), which was expanded to include all states in the 2007 Census of Agriculture administered by the USDA. If producers did not respond to the mailed report, census employees—many of whom were Tribal members that were

able to bridge language and cultural barriers (United States Department of Agriculture, 2019)—followed up in person to help them complete their forms. These data collection efforts represent a promising first step toward greater inclusion of Indigenous peoples in the US agricultural sector. Importantly, clear agreements on the handling of data collected during research with Indigenous communities are necessary to prevent infringements on Tribal sovereignty and misappropriation of community information (Harding et al., 2011; NCAI Policy Research Center and MSU Center for Native Health Partnerships, 2012).

10 Conclusion

The Indigenous Food Sovereignty movement in the US has emerged in response to the legacy of large-scale displacement, marginalization, and erasure of Indigenous peoples and culture over the centuries since European colonization. The Indigenous Food Sovereignty movement asserts the right of communities to ownership of their own food systems in ways that are culturally meaningful and empowering (Maudrie et al., 2021). Restoring these food systems offers a powerful approach to addressing food insecurity, health inequities, and cultural disconnectedness by dismantling their common roots of unequal access to healthy, traditional foods and a lack of community-controlled food production (Sowerwine et al., 2019).

Recognizing the interconnectedness of these issues, effective Indigenous Food Sovereignty initiatives often take a holistic approach that encompasses several goals and food production methods in addition to programming such as cooking classes (Karuk – UC Berkeley Collaborative, 2012), horticultural demonstrations (Burke, 2015), or youth skills training (Maunakea-Forth and Maunakea-Forth, 2020). By diversifying their efforts, organizations are able to address many prongs of food sovereignty at once, including production, sustainability, and access. However, most literature pertains to gardens and farms rather than less conventional types of initiatives. Future research should seek to characterize lesser-known practices, including those such as hunting and foraging that may occur on an individual scale or through informal channels. These means of food production may be better suited to certain traditional foods and may also provide solutions for unconventional environments. For example, restoring Indigenous fishing rights for a local river could simultaneously amend a historical injustice and provide urban residents with a means of acquiring their own food.

Although the Indigenous Food Sovereignty movement faces challenges such as loss of cultural knowledge, low quality land, and lack of seed access, initiatives continue to make progress towards their goals of cultural preservation, health promotion, cultural food security, economic development, environmental stewardship, and disaster preparedness. Supporting Indigenous Food Sovereignty is an emerging goal of the federal government, which will likely bring greater attention and resources to this movement. To maximize the success of future initiatives, further research should be conducted on the characteristics of current initiatives and the factors influencing their effectiveness. This review contributes to this goal by characterizing food production initiatives that strengthen Indigenous Food Sovereignty and identifying gaps in the literature. This information can advise the development of future food production initiatives and help identify potent research questions, supporting the ongoing and accelerating success of the Indigenous Food Sovereignty movement.

Author contributions

SR: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing, Writing – original draft. CB: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. RS: Data curation, Investigation, Writing – original draft, Writing – review & editing. TW: Writing – original draft, Writing – review & editing, Funding acquisition. ML: Funding acquisition, Writing – review & editing. LJ: Writing – review & editing. TP: Writing – review & editing, Writing – original draft. JB: Writing – original draft, Writing – review & editing. BR: Writing – review & editing. JP: Writing – review & editing. ZC: Writing – review & editing, Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision.

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Conflict of interest

BR was employed by Nottoway Indian Tribe. JP was employed by Chickahominy Tribe – Eastern Division.

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

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