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Author(s): Morgan L. Ruelle and Karim-Aly S. Kassam

Source: *Economic Botany*, Vol. 65, No. 3 (15 September 2011), pp. 295-307

Published by: Springer on behalf of New York Botanical Garden Press

Stable URL: https://www.jstor.org/stable/41408239

# Diversity of Plant Knowledge as an Adaptive Asset: A Case Study with Standing Rock Elders[1]

MORGAN L. RUELLE* AND KARIM–ALY S. KASSAM

Department of Natural Resources, Cornell University, Ithaca, NY, USA
*Corresponding author; e-mail: mlr245@cornell.edu

**Diversity of Plant Knowledge as an Adaptive Asset: A Case Study with Standing Rock Elders.** Indigenous knowledge is often represented as being homogeneous within cultural groups, and differences in knowledge within communities are interpreted as a lack of cultural consensus. Alternatively, differences in knowledge represent a range of possibilities for communities to respond to social and ecological change. This paper examines the diversity of plant knowledge among elders who live in the Standing Rock Nation of the northern Great Plains. Elders know how to use different plants, and also hold different knowledge about the same plants. Analysis indicates that elders each contribute unique, complementary, and seemingly contradictory plant knowledge to their community. Compiled seasonal rounds help visualize differences in knowledge about the temporal availability of plants. These differences are linked to variations in use, including references to specific gathering sites, strategies to harvest multiple species, and selection of plants at different stages of development. Elders' diverse knowledge about the seasonal availability of plants may facilitate community adaptation to climate change in the 21st century.

**Key Words:** Indigenous knowledge, Lakota, Dakota, intracultural diversity, food plants, Standing Rock Nation.

## Introduction

Indigenous knowledge systems are increasingly appreciated for their ability to anticipate, recognize, and respond to change (Berkes et al. 1995; Nyong et al. 2007; Turner and Clifton 2009). Some researchers have documented mechanisms within indigenous knowledge systems that facilitate adaptation and contribute to resilience (Berkes et al. 2000; Berkes and Turner 2006; Kassam 2010). Of particular interest are the contributions of biocultural diversity to adaptive processes. Biocultural diversity, which includes the diversity of life in all of its manifestations, is a source of adaptive capacity because it represents the range of possibilities for humans to sustain their communities in dynamic landscapes (Harmon 2002). Investigations of biocultural diversity have been conducted on global, regional, and national scales (Loh and Harmon 2005; Maffi 2005; Nabhan et al. 2002). However, there has been less attention focused on differences within cultural groups. Since biocultural diversity is critical to human adaptation, the survival of particular communities may rely on diversity at local scales (Kassam 2009).

By comparison, ecologists study biological diversity at a range of scales, from the genotypic variation within a population to the global diversity of ecosystems (Noss 1990). According to evolutionary theory, a population is able to adapt to selective pressures when it contains phenotypic variations that allow some individuals to survive changing conditions (Grant and Grant 1993). In a similar fashion, human communities may rely on variations in knowledge to adapt to social and ecological change. As indigenous communities respond to the multiple impacts of colonialism, globalization, violent conflict, and climate change, they draw on ecological knowledge to survive (Kassam 2010). Different ecological knowledge held by individuals within indigenous communities may be fundamental to community adaptation.

[1] Received 9 February 2011; accepted 1 August 2011; published online 4 September 2011.

*Economic Botany*, 65(3), 2011, pp. 295–307

Studies of indigenous knowledge often rely on interactions with a few community members to characterize knowledge held by entire communities. It is difficult to infer that the knowledge of "local experts" or "key informants" represents the broader knowledge of a community or cultural group (Davis and Wagner 2003; Vandebroek 2010). The cultural consensus model developed by Romney et al. (1986) and adopted by many ethnobotanists attempts to elucidate community knowledge as points of agreement among community members. The model equates culture with shared knowledge and therefore assumes that "correct cultural responses" are indicated when the most people provide the same answer to a question (Vandebroek 2010). While this model can accurately represent consensus, it may also devalue differences in knowledge, since those who disagree are assumed to be incorrect, at least with reference to a "cultural truth." Of particular concern is the implication that groups prefer consensus to plurality of know-how, when in fact communities may value variation in ecological knowledge. If indigenous knowledge systems survive by adaptation, then truth by consensus imposes limitations on knowledge systems that must function in dynamic ecological realities. Unique individual contributions to community knowledge may identify critical options for survival.

As an alternative to reliance on key informants and consensus analysis, indigenous communities might benefit from research that investigates the diversity of their knowledge and the range of opportunities that arise from that diversity. Engaging a broader range of knowledge holders in a participatory research process is an opportunity to explore the diversity of knowledge within communities and encourage knowledge holders to contribute to adaptation. In the case study that follows, a community of elders from the Standing Rock Nation in the northern Great Plains documented their knowledge about plants. Elders themselves challenged the notion that plant knowledge should be homogenous within their community. This paper examines the diversity of elders' knowledge and explores how that diversity might contribute to the adaptive capacity of their communities.

## Context

The Standing Rock Nation extends west from the Missouri River as it flows across the border of North and South Dakota (Fig. 1). The nation encompasses 2.3 million acres of grasslands, cultivated croplands, pastures, and hayfields. A small, but culturally significant portion (less than 2%) of the landscape is forested. In 2009, the population of Standing Rock was estimated at 8,290 people, of which 74.9% are Native American (U.S. Census Bureau 2009). 58% of elders (aged 60 and over) say they can speak Dakota or Lakota (NFE 2007). Fort Yates, North Dakota is the seat of the tribal government. The nation is divided into eight administrative districts, and elders in each district select a representative to the Elderly Advisory Council (EAC), a tribal non–profit organization that implements and monitors programs for elders. The EAC is convened by Nutrition for the Elderly and Caregiver Support (NFE), a tribal government agency that provides elders with food assistance and other services.

A needs assessment of 91 elders conducted by NFE and the EAC revealed that the majority of Standing Rock elders are diagnosed with diet–related diseases, including diabetes, high blood pressure, and heart disease (NFE 2007). The incidence of diabetes among Standing Rock elders is approximately twice the rate for the rest of the United States (46% as compared to 23% nationally; NFE 2007; CDC 2007). Survey results indicate that most elders do not follow the dietary recommendations of their doctors. Several elders stated that recommended foods and dietary restrictions are unfamiliar or culturally unacceptable. Many elders state that traditional foods are preferable for the treatment and prevention of diet–related diseases.

Most of the traditional foods discussed by elders require plants from the Standing Rock landscape. Populations and distributions of plants have been impacted by social and ecological changes. In the memories of elders, the most dramatic changes resulted from the completion of the Oahe Dam on the Missouri River in 1959. Despite the protestations and legal actions of the Standing Rock tribal government, Congress authorized the U.S. Army Corps of Engineers to construct a dam that inundated 55,993 acres of Standing Rock land (Lawson 1994). The dam destroyed most of the nation's floodplain forests, which had been primary sources of food, medicine, fuel, fiber, and construction materials (Jones 1998; Kraft 1990; Lawson 1994).

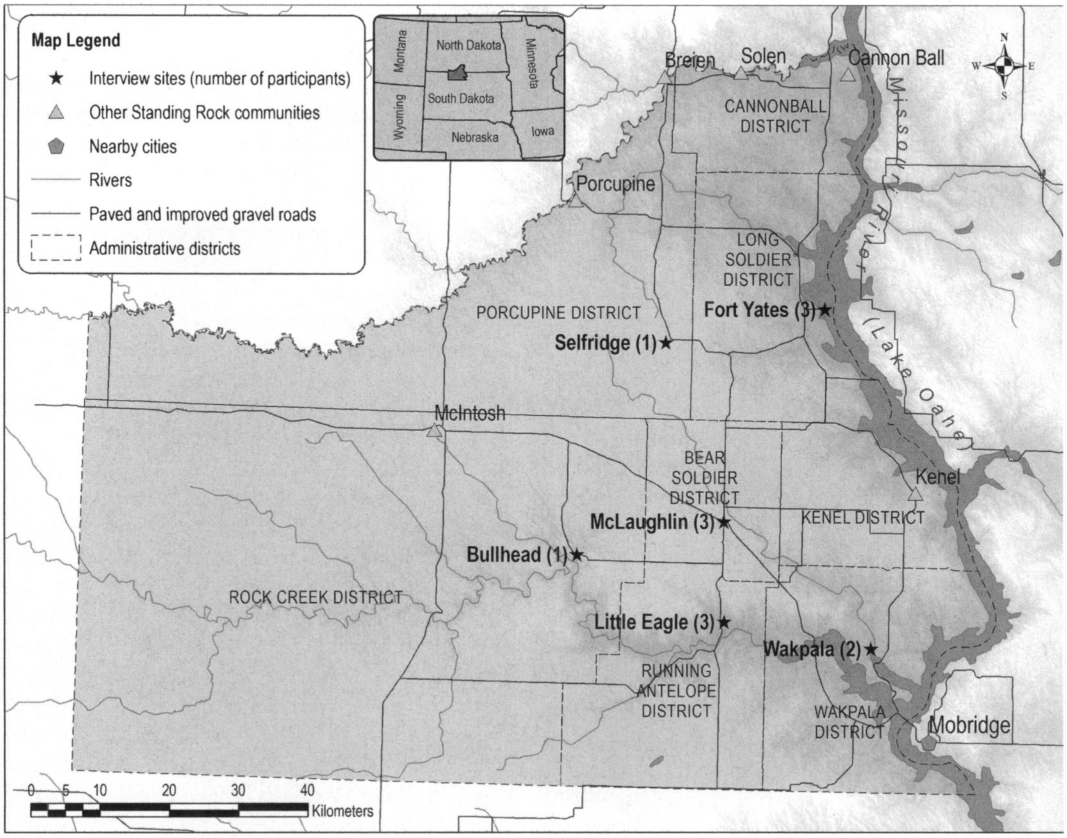


**Fig. 1.** Interview locations in the Standing Rock Nation.

Although the dam eliminated several important plants (Jones 1998), many forest food plants are still available in wooded ravines and the floodplains of the Missouri's main tributaries. In addition, prairie food plants can be accessed in hayfields and grasslands grazed by cattle and bison. 71% of elders say they still know how to gather non–cultivated plants for food (NFE 2007). Nonetheless, elders observe that consumption of non–cultivated plants has declined, and many express concern that younger people are not learning how to use plants. Elders often state that teaching young people how to gather non–cultivated plants is an important part of treating and preventing diet–related diseases in their communities. In addition, some elders are concerned that climate change will impact food plants and gathering practices.

The primary objectives of this research were to document plant knowledge held by Standing Rock elders and to develop research products that effectively communicate that knowledge within their communities. As interviews began, it became clear that elders knew about different plants and had different knowledge about the same plants. This paper therefore explores the diversity of elders' knowledge and proposes that diverse knowledge can contribute to the adaptive capacity of Standing Rock communities as they respond to environmental change.

## Methods

Ethnobotanical research was conducted in June through December of 2009. Before research began, a research plan was approved by resolution of the Standing Rock Tribal Council and a Memorandum of Understanding was signed with NFE as the primary project partner. Initial interviews were requested with members of the EAC because they represented a cohesive community of elders with ties to a broad social network extending throughout Standing Rock. Additional participants were selected based on recommendations from EAC members and the

NFE director. Because the EAC members who agreed to participate were women, a concerted effort was made to include men. All participants were at least 60 years old and had grown up in Standing Rock or lived within the nation for at least 50 years. Although most participants resided in larger towns, many had lived in more remote parts of Standing Rock, including seven of the eight administrative districts.

Interviews were conducted with 3 men and 10 women in their homes or community centers (Fig. 1). Seven interviews were conducted individually and three were conducted in pairs. Interviews focused on the seasonal availability of non–cultivated food plants, with the explicit goal of creating a seasonal round to visualize the availability of those plants throughout the year. Participants examined an example of a seasonal round published by Kassam and The Wainwright Traditional Council (2001) and discussed how a seasonal round could be used as a practical planning and educational tool. Specific interview questions focused on the seasonality of food plants, but elders shared knowledge about many other aspects of plant ecology and use.

Interviews were documented with detailed field notes rather than video or audio recordings. All plant knowledge was recorded in a Microsoft Excel spreadsheet including the name of the elder, the name of each plant he or she mentioned, and notes on knowledge pertaining to that plant. Knowledge about the seasonal availability of plants was digitized as seasonal rounds using Inkscape 0.48. Individual seasonal rounds were generated based on the knowledge of each elder. A compiled seasonal round was created by overlaying all individual rounds as transparent layers with 25% opacity. Tables of notes and seasonal rounds, including individual and compiled rounds, were validated during a second meeting with each participant. Participants were provided an opportunity to revise their individual seasonal rounds based on the contributions of others; this allowed elders to confirm differences in their knowledge. Validated notes were analyzed to identify 25 knowledge domains, or distinct topics related to the ecology and use of plants (see Table 1). Local plant names and knowledge domains were used to code and compile all validated notes into a knowledge base. The complete knowledge base was provided to research participants for review.

The knowledge base and this publication refer directly to participants by first and last name. During the interviews, all participants provided written informed consent for the use of their names in this and other publications. The use of participant names is a sign of gratitude and honors personal contributions of participants to the research process. The use of names also strengthens the internal validity of this work; Standing Rock community members who read the knowledge base often know about the life experiences of the research participants, so the knowledge of each elder is understood with reference to its source.

## Results and Discussion

During 20 interviews with 13 individuals, elders named 32 categories of non–cultivated plants and fungi. These include 16 local names associated with Western botanical genera and 12 with species (Table 2). Since voucher specimens were not collected, decisions to associate local names with Western botanical nomenclature were conservative. Local plant names were linked to botanical genera based on previous ethnobotanical research conducted in Standing Rock (Gilmore 1991; Jones 1998; Kraft 1990). Species names were assigned in cases where use is well documented (Gilmore 1991; Jones 1998; Kraft 1990) or only a single member of the genus is known to occur in the study area (USDA–NRCS 2010). In some cases, elders' descriptions indicated that local names are used interchangeably for multiple species in the same genus, so gooseberry and currant (*Ribes* sp.) were combined for analysis, as were juniper and cedar (*Juniperus* sp.). Three local names could not be linked to Western botanical taxa. In addition, wild mushrooms (*čhaŋnákpa*, "tree ears") were discussed by elders and included in our analyses. Elders stated that only one type of fungus is used for food, but further research is necessary to determine its Latin name (Gilmore 1991; Jones 1998; Kraft 1990).

Some elders differentiated between plants within the same category. For example, "sage" (*Artemisia* sp.) was usually described as a single plant, but some elders referred to "man's sage," "woman's sage," and "prairie sage," names that likely correspond to species within the genus *Artemisia*. A similar pattern was observed for *čheyáka* (wild mint), which can refer to both *Mentha* sp. and *Nepeta cataria* L. (Jones 1998). Some elders described various kinds of *čheyáka*, indicating that they recognize differences between these two genera.

**Table 1.** Names and descriptions of knowledge domain categories developed to analyze interview data and organize the knowledge base.

| Domain name | Brief description |
|---|---|
| D/Lakota name | Elders use or mention the Dakota or Lakota name of the plant. |
| Varieties | Elders distinguish between different types of a plant, e.g., "man's sage" and "woman's sage." Types may or may not correspond to Western botanical taxa. |
| Regional distribution | Elders describe the geographical range in which a plant can be found. |
| Habitat requirements | Elders describe the features of places in the landscape where a plant can be found, e.g., rocky hay fields or ravines. |
| Specific locations | Elders mention particular sites where a plant can be found. |
| Ecological relations | Elders describe connections between a plant and other plants or animals, e.g., squirrels eat burr oak acorns. Ecological relations with humans are implied and not included here. |
| Life history | Elders refer to the stages of development of a plant, e.g., *čheyáka* is tall by August. |
| Calendar availability | Elders refer to the Gregorian solar calendar or Dakota/Lakota lunar calendars in describing the times of year when a plant is typically available to gather. |
| Seasonal cues | Elders refer to variable seasonal events that signal when a plant is ready to gather, e.g., wild grapes are sweet after the first frost. Alternatively, elders describe the use of plants as seasonal cues themselves, e.g., it is safe to swim when goldenrod blooms. |
| How to locate | Elders describe methods for finding a plant in the landscape, e.g., walk into the sun so that *thiŋpsiŋla* blossoms will be lit up from behind. |
| How to identify | Elders mention characteristics that can be used to distinguish a plant from other plants, e.g., *thiŋpsiŋla* has fuzzy leaves, whereas *wanáǧi thiŋpsiŋla* does not. |
| How to evaluate readiness | Elders describe methods to determine if a plant is ready to gather for a specific purpose, e.g., jelly should be made from chokecherries when some are still red. |
| How to gather | Elders describe methods for gathering a plant, e.g. buffaloberries are gathered by placing a blanket under the bush and hitting it with a stick. |
| How to conserve | Elders describe practices intended to sustain populations of a plant, e.g., *thiŋpsiŋla* are gathered in such a way that flower stalks remain in place to disperse seeds. |
| How to honor | Elders describe practices intended to express gratitude for a plant. |
| How to prepare | Elders describe methods for using a plant to prepare a food for consumption. |
| How to store/preserve | Elders describe methods to prepare a plant so that it can be saved for use at a later time. |
| Medicinal uses | Elders describe the use of a plant to treat or prevent disease. The medicinal uses in this category are only those that are distinct from the uses of plants as food (Kassam et al. 2010). |
| Ceremonial uses | Elders mention the use of a plant in activities that the elder identifies as spiritual or religious. |
| Other uses | Elders describe the use of a plant for purposes other than food, medicine, fiber, or ceremony. |
| Precautions | Elders describe the impacts of using a plant improperly. |
| Trade/Exchange | Elders mention the trade opportunities for a plant or note the market value of a plant. |
| Changes in population | Elders describe an increase or decrease in the size of a population of a plant. |
| Technology | Elders describe technologies associated with the use of a plant. |
| Changes in practice | Elders describe changes in the ways their communities use a plant. |

The diversity of plant knowledge among elders is evident in two ways. First, elders demonstrated knowledge about different plants (Table 2). No elder discussed all of the non–cultivated plants known by their community. Each elder discussed between 6 and 20 non–cultivated plants, an average of 12 plants (±4.5 st. dev.). The number of plants discussed by elders did not correspond to their reputation as a local expert or their own confidence in their knowledge. Elders who initially lacked confidence in their plant knowledge often expressed surprise at the number of plants they had been able to discuss during interviews.

Of the 32 plants and fungi described, only two species were mentioned by all participants: chokecherries (*Padus virginiana* (L.) M. Roem. [syn. *Prunus virginiana* L.]) and *thiŋpsiŋla* (prairie turnip, *Psoralea esculenta* Pursh). These two species have been important foods for Dakota and Lakota people for centuries and are used to prepare a number of traditional foods, as well as for medicine and ceremony (Gilmore 1991; Kindscher 1987; Phillips 2003). By contrast, most plants (23 of 32) were discussed by less than half of participants, and 13 plants were mentioned by only one or two elders.

**Table 2.** Non-cultivated plants discussed by Standing Rock elders during interviews conducted in 2009.

| Plant name(s) used by elders | Latin name of associated botanical taxon[a] | Family[a] | Elder 1 | Elder 2 | Elder 3 | Elder 4 | Elder 5 | Elder 6 | Elder 7 | Elder 8 | Elder 9 | Elder 10 | Elder 11 | Elder 12 | Elder 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bitterroot | *Acorus* sp. | Acoraceae | x | | x | x | | | x | x | | x | x | x | x |
| Buffaloberry | *Lepargyrea argentea* (Pursh) Greene | Elaeagnaceae | x | x | x | x | x | | x | x | | | x | x | |
| Burr oak, acorn | *Quercus macrocarpa* Michx. | Fagaceae | | | | | | | x | x | | | | | |
| Cattails | *Typha* sp. | Typhaceae | | | | | | | | | | x | x | | |
| Cedar, juniper | *Juniperus* sp. | Cupressaceae | | x | | x | | | | | | | | x | |
| *Čheyáka*, wild mint | *Mentha* sp. and *Nepeta cataria* (L.) | Lamiaceae | x | x | | | x | x | x | x | | | | x | |
| Chokecherry | *Padus virginiana* (L.) M. Roem. | Rosaceae | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Crabapple | *Malus* sp. | Rosaceae | | | | | | | | | | | | x | |
| Dandelion | *Taraxacum officinale* Webb | Asteraceae | | | | | | | | | | | | x | |
| Elm | *Ulmus* sp. | Ulmaceae | | | | | | | | | | | | x | |
| Goldenrod | *Solidago* sp. | Asteraceae | | x | | | | | | | | | | | |
| Gooseberry, currants | *Ribes* sp. | Grossulariaceae | x | x | | x | | | x | x | | | | x | |
| Horsetail | *Equisetum* sp. | Equisetaceae | | x | | | | | | | | | | | |
| Juneberry | *Amelanchier* sp. | Rosaceae | x | | | | | x | x | x | x | | x | | x |
| Milkweed | *Asclepias* sp. | Asclepiadaceae | | | | | | | | | | | x | | |
| Mouse beans | *Amphicarpaea bracteata* (L.) Fernald | Fabaceae | | | x | | | | | | x | x | | x | |
| Poison ivy | *Toxicodendron radicans* (L.) Kuntze | Anacardiaceae | | x | | | | | | | | | | x | |
| Prickly pear | *Opuntia* sp. | Cactaceae | | | | | | | | | | | | x | |
| Sage | *Artemisia* sp. | Asteraceae | | x | x | x | x | x | x | x | | | | x | x |
| Sandcherry | *Prunus pumila* (L.) | Rosaceae | x | x | | | x | | x | x | | | | x | |
| Soapweed | *Yucca glauca* Nutt. | Agavaceae | | x | | | | | | | | x | | | |
| Sore medicine | unknown | unknown | | | | | | | x | x | | | | | |
| Sweetgrass | *Hierochloe odorata* (L.) P.Beauv. | Poaceae | | | x | x | | | | | | | | x | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Thiŋpsiŋla*, prairie turnip | *Psoralea esculenta* Pursh | Fabaceae | × | × | × | × | × | × | × | × | × | × | × | × | × |
| Toothache medicine, *poipi* | unknown | unknown | × | | | | × | × | × | × | | | | | |
| Wild grape | *Vitis riparia* Michx. | Vitaceae | × | × | | | | × | × | × | | | × | × | |
| Wild mushroom, *čhaŋnákpa* | unknown | Fungus kingdom | × | | | × | × | × | × | × | × | × | | × | |
| Wild onion | *Allium* sp. | Alliaceae | × | × | | | × | × | | | | | × | × | |
| Wild plum | *Prunus americana* Marshall | Rosaceae | × | × | × | × | × | × | × | × | | | × | × | × |
| Wild rose, *unzinzintka* | *Rosa* sp. | Rosaceae | × | × | | × | | | × | | | | | | |
| Wild strawberry | *Fragaria* sp. | Rosaceae | | | × | | | | × | × | | | | | |
| Willow | *Salix* sp. | Salicaceae | | | | | | | | | | × | | | |

[a] IPNI (International Plant Names Index) 2011; The Plant List 2010.

Secondly, elders have different knowledge about the same plants. To understand how individuals contribute to community knowledge, it is helpful to examine a typical entry from the knowledge base. The entry for wild grapes (*Vitis riparia* Michx.) is one of the shortest, but a good example of the diversity of knowledge each entry contains:

**Wild grapes – *čhuŋwíyapehe* – *Vitis riparia* Michx.**

The elders who described these plants called them "grapes" or "wild grapes." The Lakota name (*čhuŋwíyapehe*) is from the *New Lakota Dictionary* (Ullrich 2008).

Mary Jane Tiokasin said that the wild grapes hang just like "real grapes."

Iyonne Bear Ribs said that they grow along the Grand River. She said she had some relatives who lived down there and they grew around their place. She said her uncle picked them.

Mary Jane said that grapes are harvested in August and September.

Florence McLaughlin said that grapes are harvested just before the buffaloberries, so just before the first frost.

Iyonne said they are ripe in fall, so people bring them in with the mushrooms.

Vernon Iron Cloud and Pearl Day said that if you eat them after the first frost they are juicier and sweeter.

Helmina Makes Him First and Blanche Lawrence said that they are ready in September.

Helmina and Blanche said that they seem to hide under the vines. They said you don't see them at first until you walk under the tree. They said they use a long stick with a hook on it to pull down vines, but later they put the vines back up at least halfway so that they can grow back.

Iyonne said that the grapes taste really bitter, but you can make something out of them.

Helmina and Blanche said that nobody seemed to gather grapes this year even though there were a lot of them according to some people. They said the Hutterites didn't come to buy them this year either. They said that one time someone was selling them for $10 a bushel and that ruined it for everyone else (it was too little money for the work involved).

Each of the elders who discussed wild grapes contributed different knowledge to this documentation. Much of the knowledge contributed is unique, including the knowledge contributed by Helmina Makes Him First and Blanche Lawrence, sisters from the community of Little Eagle who were interviewed together. There are a few places in the entry where participants confirm each other's knowledge, as where Pearl Day and Vernon Iron Cloud (interviewed separately) each state that grapes are sweeter after the first frost. There are also important points of disagreement, including the appropriate time to harvest grapes in relation to the first frost (McLaughlin harvests before, Iron Cloud and Day after).

In order to generate a systematic comparison of elders' additions to the knowledge base, we counted the number of elders contributing knowledge about each plant within the 25 knowledge domains (Table 3). First, elders often imparted unique knowledge. Knowledge pertaining to a plant within a specific knowledge domain was often contributed by only one elder, as indicated by a matrix value of 1 in 38% of all cells with matrix values. Second, whenever multiple elders revealed knowledge about the same plant within the same knowledge domain (i.e., all matrix values greater than 1), elders' contributions were most often complementary (49%), as represented by dark grey cells in Table 3. By comparison, multiple elders contributed the same knowledge in fewer cases (37%), as represented by light grey cells. Elders' knowledge was therefore more often complementary than redundant.

In addition to offering unique and complementary knowledge, elders' contributions were sometimes contradictory. The knowledge communicated by multiple elders within the same domain for the same plant is contradictory in 14% of cells with matrix values greater than 1 (represented by black cells). Contradictory knowl-

**TABLE 3.** STANDING ROCK ELDERS' KNOWLEDGE ABOUT NON-CULTIVATED FOOD PLANTS WITHIN DISTINCT KNOWLEDGE DOMAINS (SEE TABLE 1 FOR DESCRIPTIONS OF DOMAINS). NUMBERS IN THIS MATRIX INDICATE THE NUMBER OF ELDERS WHO COMMUNICATED KNOWLEDGE WITHIN THAT PARTICULAR KNOWLEDGE DOMAIN. SHADING INDICATES WHETHER KNOWLEDGE PROVIDED BY MULTIPLE ELDERS WAS THE SAME (LIGHT GREY), DIFFERENT YET COMPLEMENTARY (DARK GREY), OR CONTRADICTORY (BLACK).

| Common name(s) of plant used by elders | Latin name of associated botanical taxon | D/Lakota name | Varieties | Regional distribution | Habitat requirements | Specific locations | Ecological relations | Life history | Calendar availability | Seasonal cues | How to locate | How to identify | How to evaluate readiness | How to gather | How to conserve | How to honor | How to prepare | How to store/preserve | Medicinal uses | Ceremonial uses | Other uses | Precautions | Trade/Exchange | Changes in population | Technology | Changes in practice |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Buffaloberry | *Lepargyrea argentea* (Pursh) Greene | | | 2 | 1 | 2 | | | 7 | 3 | | 2 | | 3 | 1 | | 1 | 1 | | | | 1 | | 1 | 2 | |
| Burr oak, acorn | *Quercus macrocarpa* Michx. | | | | | | 2 | | | | | | | | | | 2 | | | | | | | 2 | | |
| *Čheyáka*, wild mint | *Mentha* sp. and *Nepeta cataria* L. | 7 | 4 | | 4 | | | 1 | 4 | | 2 | 5 | 1 | 2 | 2 | | 2 | 1 | | | | | | | | |
| Chokecherry | *Padus virginiana* (L.) M. Roem. | | | | 2 | 2 | 2 | 1 | 8 | 1 | 2 | | 2 | | | | 7 | 6 | | 1 | | | | | 6 | 2 |
| Crabapple | *Malus* sp. | | | | | | | 1 | | | | | | | | | 1 | | | | | | | | | |
| Dandelion | *Taraxacum officinale* Webb | | | | | | | | | | | | | | | | 1 | | | | | | | | | |
| Elm | *Ulmus* sp. | | | | | | | | 1 | | | | | 1 | | | 1 | | | | | | | | | |
| Gooseberry, currant | *Ribes* sp. | | | | | 3 | | | 4 | | | 3 | 2 | | | | 1 | | | | | | | 1 | | |
| Juneberry | *Amelanchier* sp. | | | | | 1 | 2 | 1 | 7 | | 1 | | | | | | 1 | 1 | | | | | | | | |
| Mouse beans | *Amphicarpaea bracteata* (L.) Fernald | 1 | | | 2 | 2 | 4 | 2 | 2 | 1 | | | | 4 | | 3 | | | | | | | | 4 | | |
| Prickly pear | *Opuntia* sp. | | | | | | | | 1 | | | | | | | | 1 | | | | | | | | | |
| Sage | *Artemisia* sp. | 3 | 5 | | 1 | 2 | | 2 | 5 | 1 | | 6 | 1 | | | 1 | 1 | 1 | 1 | 3 | 4 | | | | 2 | |
| Sandcherry | *Prunus pumila* (L.) | | | | 2 | 1 | | 1 | | | | 3 | | 5 | | | | | | | | 6 | | 1 | | |
| *Thiŋpsiŋla* | *Psoralea esculenta* Pursh | 11 | | 1 | 2 | 1 | | | 9 | 4 | 3 | 3 | 6 | 2 | 3 | | 3 | | 1 | 1 | 2 | 3 | 3 | 2 | | |
| Wild grape | *Vitis riparia* Michx. | | | | | 1 | | | 3 | 4 | 2 | 1 | | | 2 | | 1 | | | | | | 2 | | 2 | 2 |
| Wild mushroom | Fungus | 3 | | | 4 | 5 | 5 | | 7 | 4 | | 3 | | 1 | | | 4 | 1 | 1 | | | 2 | 1 | | | 3 |
| Wild onion | *Allium* sp. | | | | 1 | 1 | 1 | | 5 | | | | | | | | | 1 | | | | | | | | |
| Wild plum | *Prunus americana* Marshall | | | | 1 | 1 | 1 | 3 | 8 | 3 | | | | | | | 4 | 4 | | | | | | | | |
| Wild rose, *unzinzintka* | *Rosa* sp. | 1 | | | 2 | | | | | 1 | | | | | | | 1 | | 2 | | | 2 | | | | |
| Wild strawberry | *Fragaria* sp. | | | | 2 | | | | 1 | | | 2 | | | | | | | | | | | | | | |

edge was most frequent pertaining to the seasonal availability of plants (both calendar availability and seasonal cues). Since seasonal availability was the primary focus of interviews, these are the knowledge domains with the highest number of contributions and therefore the most likely domains to accumulate contradictions.

Seasonal rounds (Fig. 2) were generated for the 12 non–cultivated food plants that were discussed by the greatest number of participants. The compiled seasonal round represents the combination of 10 seasonal rounds produced by seven individuals and three pairs of elders. Individual seasonal rounds were overlaid as transparent layers so that viewers can identify periods of time where knowledge of seasonal availability corresponds (seen as darker shades) and periods of time where knowledge differs (seen as lighter shades). This compiled seasonal round helps to visualize the diversity of knowledge pertaining to seasonal availability.

## Differences in Knowledge Linked to Differences in Use

Differences in knowledge may be due to use of the same local name for different plants. For example, elders' contradictory descriptions of the habitat requirements for *čheyáka* may be explained by the fact that this name can refer to different plants with distinct ecologies. However, in most other cases, differences in knowledge are linked to differences in use.

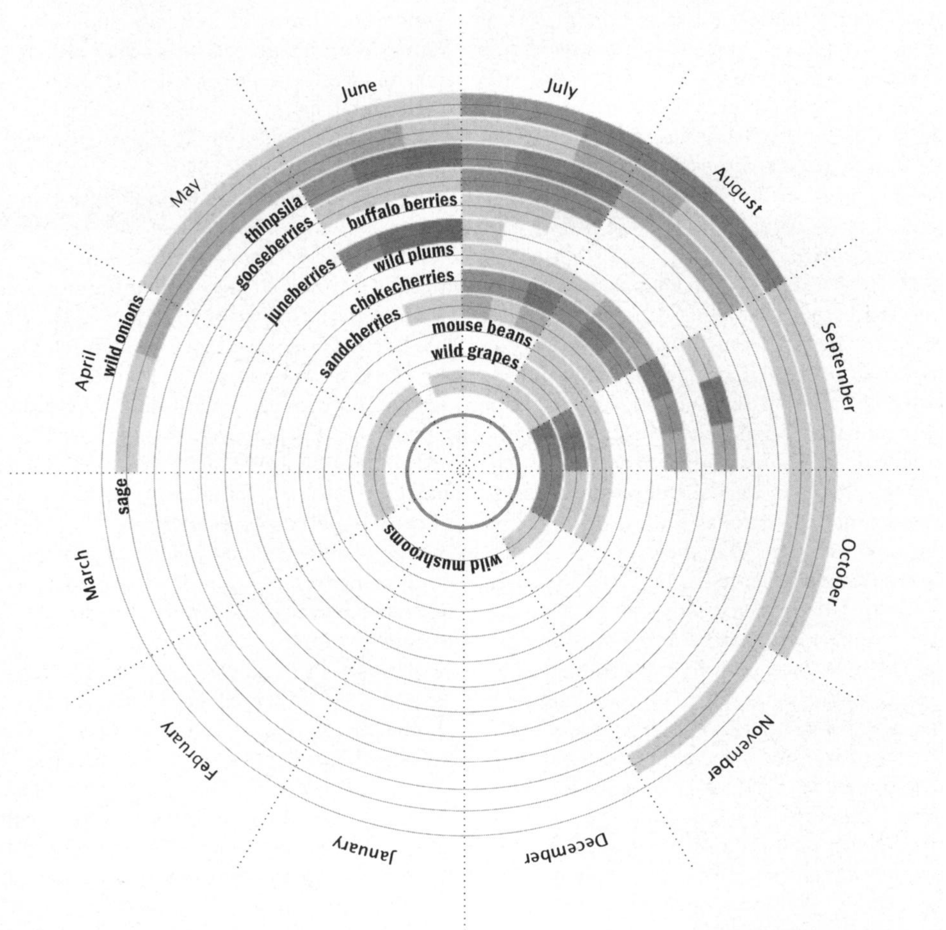


**Fig. 2.** Seasonal round of elders' knowledge about the seasonal availability of non–cultivated food plants. Ten individual seasonal rounds are layered with 25% opacity. Darker areas represent periods of increasingly frequent knowledge and/or use. Plants located in wetter parts of the landscape (floodplain forests) are located near the center of the round, while plants found in prairies and other dry areas are located at the periphery.

Elders gather food plants from different parts of the landscape and speak about seasonal availability with reference to plants in particular locations. For example, when elders talked about the availability of currants, Blanche Lawrence and Helmina Makes Him First referred to bushes behind their school in Little Eagle, whereas Pearl Day spoke about a single currant bush in the Porcupine cemetery. The Standing Rock landscape is remarkably heterogeneous due to its rugged relief, localized patterns of precipitation, range of soil types, and divergent land–use histories. Phenologies of the same plants likely differ according to this environmental variability. Hence elders' knowledge of seasonal availability is necessarily site specific and therefore differs among elders who gather the same plants in different locations.

Elders' plant knowledge is also linked to their gathering strategies. A compelling example comes from Sidney Eagleshield, Sr., who says that chokecherries, wild plums (*Prunus americana* Marshall), Juneberries (*Amelanchier* sp.), buffaloberries (*Lepargyrea argentea* (Pursh) Greene [syn. *Shepherdia argentea* (Pursh) Nutt.]), and *thiŋpsiŋla* are all ready to harvest after the 5th of July. When other elders reviewed his contributions to the compiled seasonal round, they were surprised that he had reported that Juneberries were available so late and buffaloberries so early in the year. One explanation for Eagleshield's knowledge is that he has focused his gathering efforts on a time of year when he can maximize the variety of plants he might gather in a single trip. If we remove Eagleshield's contributions from the compiled seasonal round, other elders' contributions indicate that the greatest diversity of plants are available in early July, so Eagleshield's knowledge makes sense given a certain gathering strategy. Over the course of his lifetime, Eagleshield may have found Juneberries available later or buffaloberries earlier than usual, and these experiences inform his knowledge and practice.

Differences in knowledge about seasonal availability may be due to elders' preference for plants at various stages of development. For example, the compiled seasonal round shows that wild plums are gathered in July through September, but each elder identified a specific time period within those months that they gather plums at different stages of maturation. Elders spoke about eating hard, tart plums as children, using slightly ripened plums to make jelly, boiling ripened plums into plum butter and jam, or sun drying well–ripened plums to store for *wóžapi* (fruit or berry pudding) in the winter. Differences in knowledge about seasonal availability therefore reflect the variety of foods elders know how to prepare from plants.

## Adaptation to Climate Change

Differences in plant knowledge may be an asset that contributes to the adaptability of community knowledge in response to change. Of particular interest are elders' strategies to anticipate the temporal availability of food plants given highly variable weather patterns observed in their region. These strategies may be relevant given the predicted impacts of climate change on the northern Great Plains, which include warmer mean temperatures in winter and spring, higher daily minimum temperatures throughout the year, increases in annual precipitation, and decreased soil moisture due to increased evaporation (Joyce et al. 2001).

Elders were asked to describe their use of plants in terms of the fixed Gregorian or Lakota calendars, but in many cases elders referred instead to variable seasonal events and phenological cues. The seasonal development of plants might be more accurately predicted with reference to temperature and precipitation patterns than to fixed solar or lunar calendars. For example, many elders referred to the first frost as the end of the plum and mushroom season and the date when wild grapes and buffaloberries sweeten. By watching for the frost rather than following a calendar, elders will change their gathering dates in unusually hot or cold years. Elders' knowledge can therefore help their communities anticipate new climate variability.

In other cases, the developmental stages of plants themselves are cues for other seasonal events. As long as signals and events remain in synchrony, this knowledge can help communities respond to climate change. For example, Shirley Marvin remembered that the release of cottonwood (*Populus* sp.) seeds along the river signals that *thiŋpsiŋla* are ready to dig on the prairie. Marvin links the timing of events in different parts of the landscape. If cottonwoods and *thiŋpsiŋla* respond similarly to the same changing weather patterns, this knowledge reduces the likelihood that gatherers will make unsuccessful trips to the prairie to dig *thiŋpsiŋla*. Elders' knowledge of the temporal relationship between cottonwoods and *thiŋpsiŋla* may remain relevant despite new climate uncertainty.

Several elders described the seasonal availability of food plants within a narrative following the months or seasons of harvest for particular plants. Iyonne Bear Ribs, for example, described the appearance and disappearance of Juneberries, gooseberries, chokecherries, plums, and wild grapes over the course of the summer and fall. This narrative conveys knowledge of the sequential availability of plants. The use of a relational phenology is adaptive because gathering activities can be planned whether or not plants are available on a specific date. In 2009, for example, Bear Ribs observed that gathering times were delayed and shortened due to a cold, wet spring, but still followed the pattern indicated by her seasonal narrative. Seasonal narratives therefore communicate temporal relationships among plants that help community members understand their availability within a flexible time frame.

Specific knowledge about seasonal cues and relative schedules of plants differs among elders. Much of the knowledge about calendar availability and seasonal cues is either complementary or contradictory (Table 3). In the context of climate change, elders with different knowledge may propose different responses to unusual weather patterns as they emerge. Changes in seasonal availability will likely vary based on microhabitat variables, so adaptation cannot be uniform. Different knowledge about seasonal availabilities leads elders and their families into different parts of the landscape at different times, and this constitutes a form of monitoring as the developmental stages of plants are reported back to communities. In these ways the diversity of knowledge about plants continues to evolve and present effective responses to uncertainty.

Finally, participants often attributed their own knowledge to other elders. This indicates that elders have access to others' knowledge when they need to respond to new realities. Elders are already aware of differences in knowledge within their community and know how to draw on those differences when necessary. The awareness of knowledge available through social relations allows individuals to engage others' knowledge when personal knowledge is rendered ineffective. "Knowing who knows" means that when new knowledge is required, elders can bypass time–consuming or precarious processes of personal experimentation by drawing on each other's knowledge. The diversity of knowledge held by elders and the social relations through which elders access this diversity may be critical to their adaptive capacity.

## Conclusions

Differences in ecological knowledge can reflect personal experiences in specific contexts. If research products highlight differences in knowledge instead of attempting to resolve them, they demonstrate the value of diverse experiences. By acknowledging the individual contributions of participants, research can effectively integrate information that is applicable in a variety of contexts. In order to communicate ecological knowledge to younger generations, research products can illustrate the range of experience within communities and identify local sources of practical wisdom.

For community participants, a meaningful research process may be as significant as the research products, especially if that process honors differences in knowledge. Research is an opportunity to reexamine experience and consider its implications. Ideally this process results in specific actions; in this case, discussions revealed the value of unique knowledge about food plants and key contributions each elder can make to prevention of diet–related diseases in their communities.

Biocultural diversity is increasingly appreciated as the source of possibilities. By investigating the myriad ways that we inhabit our landscapes, we identify options to survive the consequences of industrialization. Diversity is vital at a range of scales, including the various ways that people in the same community relate to other beings in their landscape. Generalized representations of community knowledge might obscure intricate patterns of experience and knowledge. As we develop adaptive systems for the uncertainty of climate change, we cannot ignore the diversity of knowledge we generate within our communities.

## Acknowledgements

The authors would like to thank the director of NFE, Luella Harrison, for her guidance throughout the research process. We are indebted to the Standing Rock Elder Advisory Council for their enthusiasm and support. Thanks to all of the elders who shared their knowledge, including Therese Martin, Leonard Village Center, Stella Whitesell Guggolz, Theo Iron Cloud, and those named earlier in the text. We would also like to thank Timothy Fahey, Kurt Jordan, Stephen Morreale, the editors, and the anonymous reviewers for valuable insights that strengthened this work. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-0707428.

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