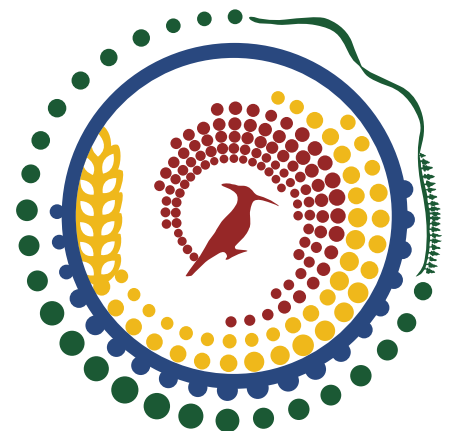


RHYTHMS *of the* LAND

Indigenous Knowledge, Science, and Thriving Together in a Changing Climate

by Karim-Aly S. Kassam, Daler Kaziev, Leo Louis, Morgan Ruelle, and Anna Ullmann

*In partnership with the communities of Sary Mogul (Kyrgyzstan), Savnob (Tajikistan),
Roshorv (Tajikistan), Oneida Lake (USA), and Standing Rock Sioux Nation (USA)*



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The creative drawings, design, photography, and other artwork related to the ecological calendars were largely undertaken by the research team and particularly the students involved. The design for this report was done in close collaboration with Gwen Ruelle, a graphic designer based in New York, with support from my research assistant, Thea Pradipta.

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As I express my gratitude to the communities, our research team, and particularly our students; it should be noted that any shortcomings in this organically developed work are entirely my responsibility.

Karim-Aly S. Kassam

Professor and Principal Investigator

Roshorv Community Members



Shozodalal
Ayomovich



Saidbek
Baktaolatov



Cholok Charorov



Sadonsho
Daoletmirov



Mobegim
Doutovna



Shomunir
Jamalov



Khudobek
Kazelov



Passor Kazelov



Zubujin
Kholmamadov



Komilsho
Khujanazarov



Zarinatsho
Khujanazarov



Madimar
Madimarov



Vatansho
Mirzoev



Bedillokhon
Mulloboboev



Karamsho
Mushkiev



Jamal
Nazarmamadova



Porshambey
Orshormamadov



Chinikhon Qizilov



Abdulrasul
Qurbonovich



Abdumamad
Sabzikov

**Roshorv
Community Members (cont.)**



Lalbek Sabzikov



Sultonmamad
Sainiev



Janob
Sangilichov



Navruzkhatur
Shaikhova



Khujanazar
Shugonovich



Saradbek
Tohirbekov

Savnob Community Members



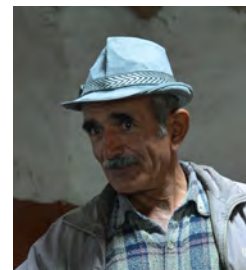
Mulkabek
Alifbekov



Mulomalek
Alifbekov



Munavvar
Ayubov



Odilkhon
Ayubov



Riswonova
Bakor



Topchibek
Bekov



Bakhtibek
Boshayev



Ekbolsho
Dustambuev



Gulzorkhon
Egamov



Ayubov
Gulayoz

**Savnob
Community Members (cont.)**



Otambek
Guldastashoev



Mamadsho
Guliev



Darwozi
Gulzarkhonov



Soatnazar
Gulzorkhonov



Kholmirozo
Jafarkuliev



Guldasteshoev
Kosembek



Marvori
Mamadbekova



Qandak
Mirshaibov



Zarbonu
Noyozova



Chilla
Nurmamadova



Sarkori
Rahmatbekov



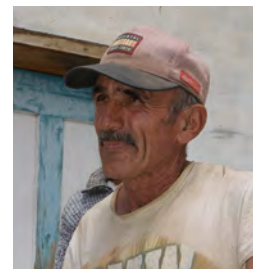
Shahlo
Saradbekova



Aslibegum
Sarkorieva



Schokoman
Schobozev



Qurbon
Shoguniev



Morodbegim
Solaymoshova



Mastale
Toshbekov



Olomali
Yormonov

Not Pictured: Gulbahor Ilchibekova

Sary Mogul Community Members



Kubanych
Aitmamatov



Mansur
Aliev



Ubaidylda
Jaanbaev



Mamatibraim Joldoshaev &
Tajikbai Syiymkulov



Sajida
Joldosnova



Aidaraly
Joljakshiev



Kuduret Jorobekov



Babanazar
Karimov



Toktomamat
Kenjebaev



Kanataly
Kenjeev



Altynbek
Kharybekov



Rafshan
Korgonbaeva



Karybek Kulatov



Abdilashym
Kurbanov



Zulaika Kyiasova



Ainura Adaham
Kyzy



Abdusamad
Mamatazimov



Ulcha Najimidinova &
Murat Satybaldiev

**Sary Mogul
Community Members (cont.)**



Mamatumar
Narmamatov



Baktygul
Narmamatova



Abdulashim
Nishanov



Danyar
Nurmamatov



Kudayar
Nurmamatov



Kadyrali
Orozaliev



Kochkonbai
Orozaliev



Muratbek
Orozaliev



Tokur
Orozbaev



Adalat
Rahimberdieva



Berdikul
Saitov



Altynbek
Tabanov



Abdilla
Tashbekov



Adalat
Tashkulova



Taalaibek
Tashtanov



Buunisa
Termechkova



Myrzakarim
Tilemishov



Bashir
Toktobaev



Kokonbek
Tokurov

Sary Mogul Community Members (cont.)



Sainazar
Turdiev



Mamatjuma
Uulu



Kharbek & Aynisa

Oneida Lake Community Members



Brenda Best



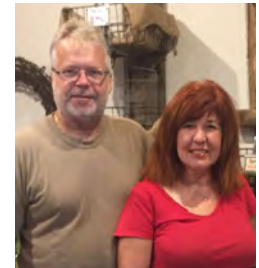
Linda Brosch



Jim Brownson



Tony Buffa



Ed & Deb
Canelli



Rip Colesante



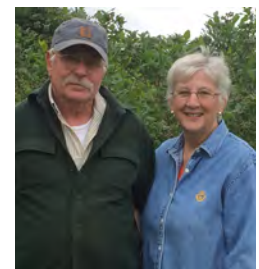
James Daher



Warren Darby



Ed Hogan



John & Carol
Holst



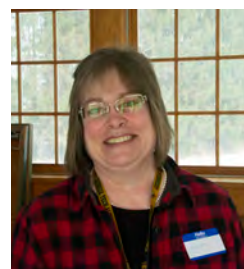
Elizabeth
McTavish



Frank Moses



George Nowack



Karen Noyes



Chuck Parker

**Oneida Lake
Community Members (cont.)**



James Schuyler



Steve Sherlock



Scott Shupe



David Simmons



Curt & Nancy
Snyder



David Steinbach



Suzi Taylor



David Taylor



Gary Will

Not Pictured

Linda Achimore
Joseph Bauer
Sue & Claude Braun
Rebecca Bray
Joe Chairvolotti
Mark Colesante
Carl Crittenden
Albert Daher
Wayne Dines
Dave Eichorn
Barb Elliot
Michael Fixler
Robert Goffredo
Kersten Hirsch
Patricia Jokajtys

Suzanne Jones
Maurice Kelsey
Kat Korba
Casey Landry
Dave Lemon
Susan Luchsinger
Andrew MacDuff
Bob McNamara
Les Monostory
Fred Neff
George Nowack
Jaqueline Orzell
Peter Pazer
Jim Petreszyn
Paul Pry

Bill Purcell
George Reck
Jennifer Roberts
Keith Schiebel
Richard Schuler
Gerry Smith
Matthew Snyder
Beverly Sutton
Don Therre
Peter Thompson
Bob & Bev Thorpe
Matthew Volz
Ronald & Judy Wagner
Martin Weiss
Brenda Wilder

Standing Rock Sioux Nation Community Members

Bullhead

Georgia Andre
Iyonne Bear Ribs
Alvina Long Chase
Michael Moore
Eileen Shoestring
Arbutus Steele

Cannon Ball

Tater Fool Bear
Sue Isbell
Charles McLaughlin
Elaine Brave Bull McLaughlin
Donnette Medicine Horse
Wanda Minor
Pete Red Tomahawk
Jeanette Two Shields
Delvin Uses Arrow
Lyle Uses Arrow
Noah Uses Arrow

Fort Yates

Geraldine Agard
Emma Jean Blue Earth
Grace Draskovic
Marilyn Keepseagle
Theresa Martin
Sharon Two Bears
Leonard Village Center

Kenel

Sidney Claymore
Germaine Demery
Shirley Poitra
Elaine St. John

Little Eagle

Eloise Castro
Roberta Follows the Road
Stella Guggolz
Blanche Lawrence
Helmina Makes Him First
Phyllis White

Porcupine

Harriet Black Hoop
Philomene Callous Leg
Mary Louise Defender Wilson
Ben Harrison
Luella Harrison
Mary Ann Krauser

Wakpala

Courtney Bliner
Nicholas Cadotte,
Ben Bone Club
Mary Brown
Charmayne Eagleman
Terry Fleury
Winona Flying Earth
Sharon Goodhouse
Gladys Hawk
Theo Iron Cloud
Kevin Locke
Melanie Thompson
Darren Tiger Sr.
LeGrand Wells
Robert White Mountain

Others

A.J. Agard
Mary Antell
Cynthia Antelope
David Archambault II
Loretta Bad Heart Bull
Etta Brave Crow
Jon Eagle
A. Ermere
Janet Frazier
Annette Goodreau
Linus Grey Eagle
Katlyn Gullickson
Mark Holman
Angeline Iron Road
George Keller
Margaret Knox
Cody Lenling
Gail Lenling
Marie Many Wounds
Shirley Marvin
Tim Mentz Sr.
Carol Nichols
Gladys See Walker
Aubrey Skye
Robert Taken Alive
Alma Thunder Hawk
Allyson Two Bears
Rosa Wilson

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Introduction

Why is Collaborative Research Important?

This is a narrative of collaboratively generated insights for the diverse communities where we undertook research. Therefore, the audience for this collection are these communities and those who seek to work with them. It shows the human-ecological relationships that underpin their food and livelihood systems. As a result of several decades of applied and participatory research, we have learned from many Indigenous and rural societies at high altitudes and latitudes that their food and livelihood systems are fundamentally dependent on their habitat. The relationships that arise from this connection to their respective environments inform their sense of self, cultural system, social structure, and even notions of the sacred. The ecosystem is the basis of these complex, sophisticated, and mutually beneficial interactions. Unlike the thinking that has informed the European Enlightenment and Industrial Culture, these societies do not perceive their existence outside their habitat. They live *within* the planet not just *on* it. Their sacred stories describe how they are *living through* the environment not *from* it. Although characterized by outsiders as remote locations, they see their habitat as a homeland in which to engage in the process of living. Indigenous and rural societies thrive in their habitats because of their connections with other living beings, human or otherwise. This dynamic and complex web of relations informs their identity and livelihoods and brings unity between their informational and physical environment. As such, there is no separation between mind and body because both exist because of and within an ecological space. Their homeland is not a frontier to be conquered and whose riches are to be extracted. This complex connectivity stands in stark contrast to the utilitarian or instrumental approach of industrial civilization, which views the land and waters teeming with life as *objects* for exploitation. Sadly, this dominant point of view has brought us to where we are today. The devastating impacts of anthropogenic climate change imperil the whole of humanity, including Indigenous and rural societies that have contributed least to its causes.

Over several years, as we have undertaken applied research in collaboration with Indigenous and rural societies, it has become clear that while their ecological professions may differ (such as hunters, fishers, farmers, herders, orchardists, and even tourism operators), the impacts of climate change bear similarly devastating effects on their overall food and livelihood systems. Whether it is late formation of sea-ice affecting hunting of marine mammals in the Arctic or unusual climatic variation impacting farming and herding communities of the Pamir Mountains, food security and livelihoods are increasingly being threatened.

The effects of anthropogenic climate change are causing debilitating anxieties because of the inability to anticipate so that communities can adapt. This anticipatory capacity to envision the next season or year and pragmatically consider future possibilities is essential for maintaining effective and sustainable food and livelihood systems. Furthermore, this instability will have immediate impacts on urban and sub-urban communities in the long-term owing to their dependency on the fruits of the lands and seas to sustain large

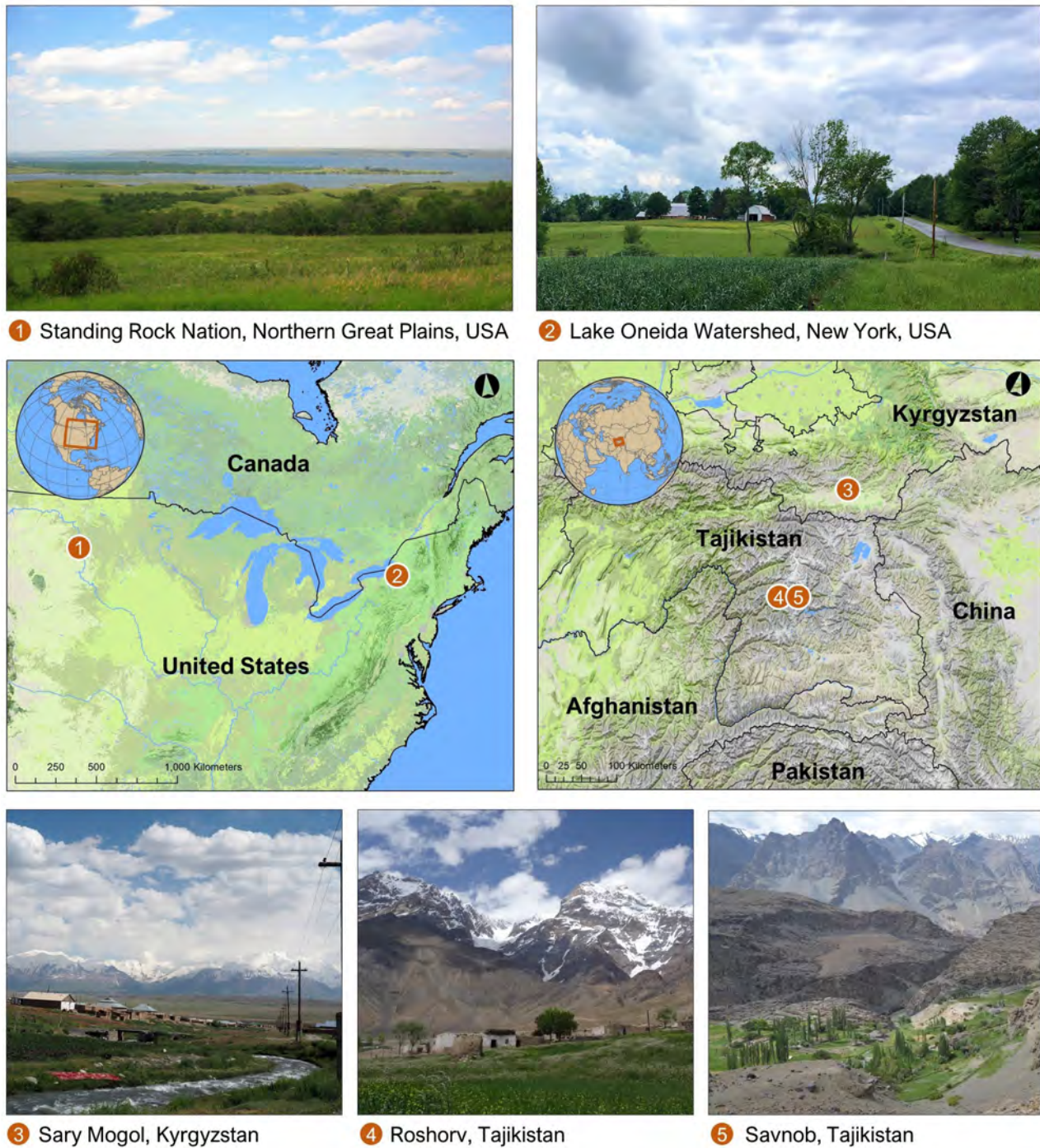


Figure 1.1: Research Context in Central Asia and North America

populations. Yet Indigenous and rural societies, which have faced the harmful impacts of colonization and now suffer the vagaries of global market and command economies, do not view themselves as mere victims. They recognize their own power and understand that while weakened by industrial domination of communist, socialist, or capitalist systems, their ecological knowledge and stewardship practices have enabled their survival for centuries if not millennia.

Rhythms of the Land Displayed Through Ecological Calendars

It is here that this work begins. It is grounded in the ecology and culture of the peoples with whom we are working. Historically, Indigenous and rural societies have developed and utilized *ecological calendars* to anticipate and then adapt to the changing rhythms of the seasons. Ecological calendars are knowledge systems to measure and give meaning to time based on close observations of one's habitat. They reveal seasonal indicators that integrate ecological phenomena (such as the first snowfall, the last frost, the flowering of a tree species, the sound of ice breaking, the appearance of an insect, or the arrival of a migratory bird) with cultural systems. Understanding these relationships has enabled Indigenous and rural societies to anticipate weather and other seasonal processes and thereby, adapt and coordinate their livelihood activities appropriately. These communities use ecological indicators to guide their actions to inform not only their food systems but also cultural events because these activities are fundamentally integrated into and are mutually reinforced through their daily lives.

We present our findings from five diverse geographical regions, ecological contexts, and cultural milieus (Figure 1.1) of Indigenous and rural societies in the Pamir Mountains of Kyrgyzstan and Tajikistan, as well as the Standing Rock Sioux Nation and Oneida Lake Watershed in the United States of America.

The communities that participated in this project have long-standing collaborative relations with researchers, which allowed for the mutual development of trust and understanding. This also enabled honesty during challenging moments. Given the geopolitical history where each of these communities is located, collective trust was fundamental to any research undertaken by us and key to addressing their priorities and concerns. In addition, these communities are at the forefront of anthropogenic climate change thus creating a sense of urgency for very practical and ethical reasons.

Our Collaborative Research Approach

The research problem guides the process of how we undertake research. In this case, we are seeking to build anticipatory and adaptive capacity to the effects of anthropogenic climate change at the level of specific communities. Therefore, an effective strategy must involve those affected by engaging their particular cultural and ecological systems and collaborating with their social institutions. In other words, the question of how to build anticipatory capacity and develop adaptive strategies drives the methodological approach. An adaptation strategy for any kind of change must be grounded within the local ecological and cultural contexts if it is to be effective in the long-term. An outside fix is neither relevant nor sustainable, and therefore, not appropriate.

Such an approach confounds single disciplinary expertise and demands collaboration among individuals with diverse expertise including the social, physical, and ecological sciences as well as the humanities. Collaboration is foundational because locally-grounded insights are achieved through participation of relevant professions such as farming, fishing, gathering, herding, hunting, tending to orchards and so on.

To achieve this, we undertook a participatory research process that facilitated the cogeneration of insights. The first step was partnership formation through the use of local workshops (Figure 1.2). Except for the Oneida Lake Watershed, which encompasses rural Euro-American settler communities, we approached both the secular leadership (such as a tribal leader or village organization president) and spiritual leaders (such as Elders or *Khalifas*) to establish a partnership. Once there was an agreement to work together, we invited various participants who represented the different and wide-ranging knowledge found across the community based on advice of the leaders. However, partnerships with communities are not formed in a vacuum. Collaborative activities through workshops grounded in the reality of the community, anchor and cultivate this relationship. As a part of a community gathering involving a meal, our first collaborative research action was to develop a seasonal round. It forged our partnership.

Iterative Research Process

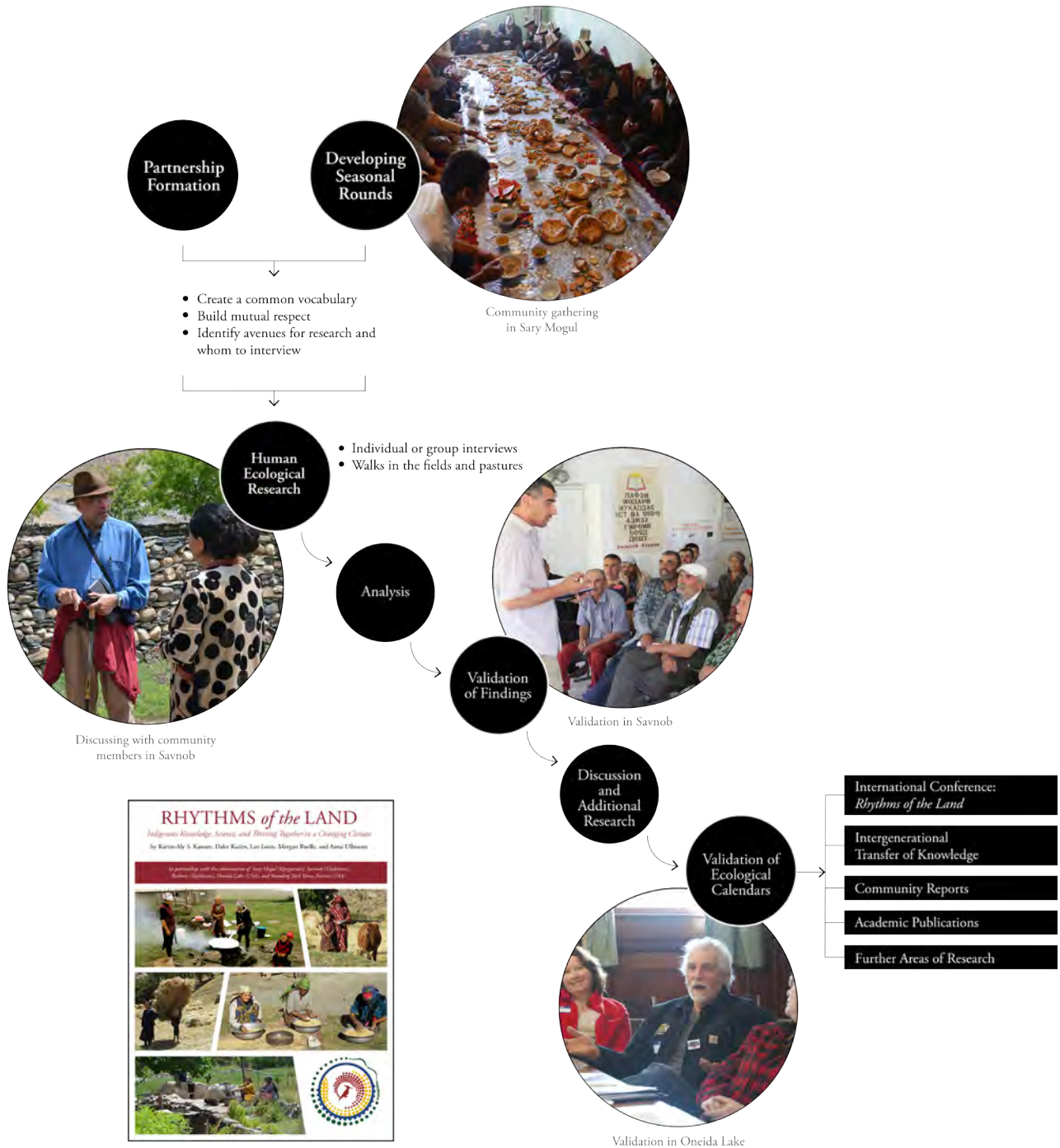


Figure 1.2: Steps in the Iterative Research Process

Seasonal rounds are verbal articulations and visual representations of a community’s sociocultural relations with their habitat. They express knowledge from engagement with spatial and temporal aspects of ecological cycles through the seasons. The spatial dimension speaks to the occupancy of landscapes used by the community. Movement across their habitat such as moving herds to summer pastures, ploughing farmland in the spring, or undertaking ice-fishing in the winter, convey the spatial dimension of the seasonal round. The temporal dimension is expressed through seasonal indicators that inform the timing of these activities, including herding, farming, or fishing. Articulation of a

seasonal round begins with broad questions such as ‘How do you know that winter has ended and the next season has begun?’, ‘How many seasons are there?’, and ‘What are the names of those seasons?’ As the discussion flows and deepens, the researcher serving as a facilitator gears their questions toward the specific ecological professions in the community, taking into account their distinct sociocultural and ecological contexts.

The process of articulation and physical representation of a seasonal round creates a common vocabulary and understanding among those participating in the research process. It builds mutual respect for different ways of knowing between those who are engaging in the inquiry and those who are engaging in the practice; namely, the researchers and the communities. In addition, it identifies specific avenues for further research and identifies topics to be explored through semi-structured interviews.

Finally, as seasonal variation is a reality upon which food and livelihood systems depend, this participatory process generates initial insights into: (1) a specific community’s relationships with their habitat; (2) the divergent impacts of climate change upon them; and (3) locally appropriate adaptation strategies to respond to the emergent climate crisis.

After the seasonal rounds were developed, the research team lived within the communities to undertake semi-structured interviews and observe livelihood activities. This research on human ecological relations was undertaken through individual or group interviews as well as observation of livelihood activities in agricultural fields, pastures lands, fishing sites, and homes of community members.

Having compiled and analyzed the information gathered during workshops, interviews, and field observations the research team returned to each community to undertake validation of human ecological research findings at a second community workshop (Figure 1.2). Again, the secular and spiritual leadership were involved in gathering individuals to share a meal while discussing and developing a much more detailed and precise seasonal round. The researchers would ask general and specific questions to ensure an accurate understanding of the seasonal livelihood processes, examine the accuracy of the analysis, engender further discussion, add new insights, and as necessary, identify further research.

This iterative process tests the credibility of the cogenerated knowledge. It also sets the stage for identifying specific seasonal indicators for use in ecological calendars to anticipate climatic variation. Once this process was completed, the research team would analyze the information gathered for insights and indicators to be used to develop ecological calendars (Figure 1.3).

A final series of validation workshops to review each ecological calendar was planned as part of the iterative research process (Figure 1.2). However, due to the COVID-19 global pandemic these workshops were delayed. Nonetheless, under strict public health guidelines, a validation workshop was carried in July 2021 with community members in the Oneida Lake Watershed. Again, a meal was served while the draft ecological calendar was reviewed in detail and modifications made based on in-depth discussion.

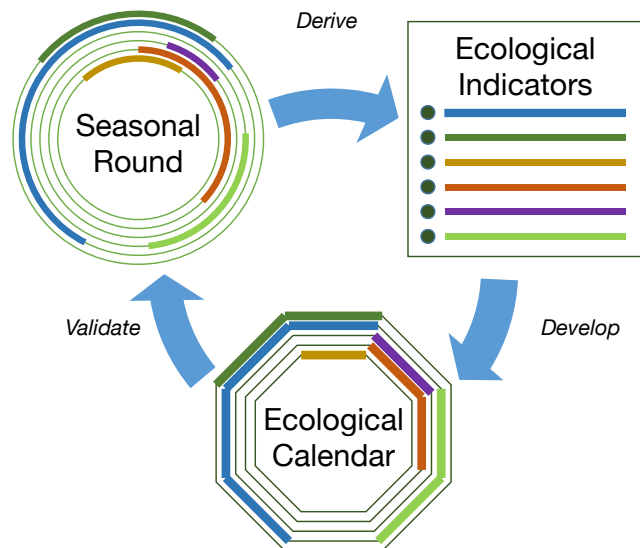


Figure 1.3: Collaborative Process of Developing Indicators for Ecological Calendars

This report is an organic outcome of the interaction between the research team and respective communities. Therefore, we have built-in flexibility – the electronic version of this report can be updated and changed after validation of the ecological calendars by the remaining communities and new insights may be added. Therefore, the long-term impacts of COVID-19 on our research process are mitigated by the strength of our collaborative relationship and the use of technology.

Diversity of Ecological Calendars

In the next sections, collaborative insights and ecological calendars are provided for the villages of Roshorv and Savnob in the Bartang Valley of Tajikistan; the village of Sary Mogul in the Alai Valley of Kyrgyzstan; the Oneida Lake Watershed in upstate New York, USA; and the communities of Bullhead, Cannon Ball, Fort Yates, Kenel, Little Eagle, Porcupine, and Wakpala in the Standing Rock Sioux Nation in North and South Dakota, USA.

The notion of an ecological calendar is universal and simultaneously particular. These calendars are diverse for obvious reasons. The first is tragic, reflecting the historical injustice of colonialism, war, and cultural genocide facilitated by dominant communist and capitalist colonial ventures that these various Indigenous and rural communities have experienced. In fact, anthropogenic climate change is, arguably, a result of instrumental industrialism across the entire planet and its peoples. In the Pamir Mountains as well as in the Standing Rock Sioux Nation, the impacts of the colonial legacy have been felt on the application, transmission, and utilization of Indigenous knowledge.

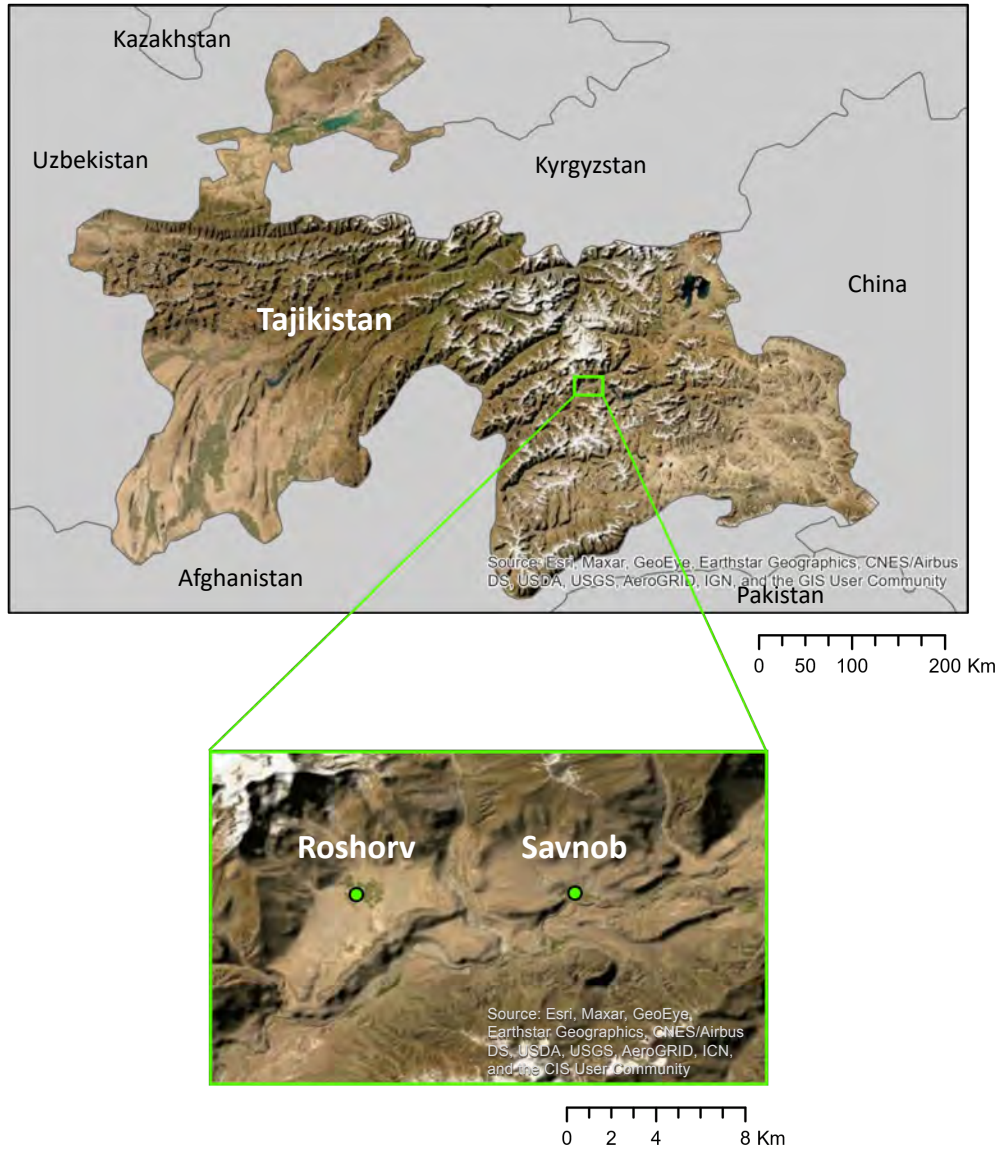
The second is that these calendars reflect the diversity of ecological professions, cultural systems, and ecological contexts. As described above, communities who see their habitat as a homeland in which to engage in the process of living share the notion of ecological calendars. However, the power and efficacy of these calendars are derived from their context-specificity because they facilitate anticipatory and adaptive capacity in a distinct sociocultural and ecological setting.

Even with its concomitant elements of historical colonial and environmental injustice, this diversity bears witness to Indigenous and local knowledge, and the agency of these respective communities in the third millennium to continue to demonstrate the relevance of their ontology or way of living. While reflecting the unique knowledge and strength of each community, this collection also puts into conversation the diversity of challenges these communities face. For instance, in the ethnic Bartangi villages of Roshorv and Savnob in the Pamir mountains of Tajikistan, where we first learned about the use of ecological calendars, the community engages in subsistence tilling of the land and orcharding at high altitudes and have some animals that they take to pastures. In contrast, the ethnic Kyrgyz village of Sary Mogul in the Pamir Mountains of Kyrgyzstan is primarily a herding culture with some cropping activities mainly potatoes for food and barley for fodder. At Oneida Lake, residents are settled in five counties within the Watershed pursuing a variety of livelihoods including farming and dairy production. In addition to their daily employment, many residents engage in fishing, gathering, hunting, orcharding, trapping and so on. However, these activities are not primarily subsistence activities as in the villages of the Pamir Mountains of Kyrgyzstan or Tajikistan. Finally, the Standing Rock Sioux Nation in North and South Dakota emerges from a painful history of cultural genocide and forced migration. The construction of the Oahe Dam destroyed the region's floodplain forests. The remaining lands in the Standing Rock encompass cultivated croplands, grasslands, hayfields, and pastures. As such, the differences among these communities are not a point of departure but rather a moment for mutual engagement to identify common options and to learn from each other.



Bartang Valley, Tajikistan

Savnob & Roshorv



Roshorv



Savnob

Figure 2.1: Maps and Images of the Two Villages in the Bartang Valley of Tajikistan, Roshorv and Savnob.

Roshorv & Savnob

Bartang Valley, Tajikistan

Context

The impetus for research on ecological calendars was inspired by insights and information provided by the villagers of the Bartang Valley in the Pamir Mountains of Tajikistan during fieldwork by the lead Principal Investigator of the *Ecological Calendars and Climate Adaptation Project* (ECCAP), Professor Karim-Aly Kassam, in 2006. Gorno-Badakhshan Autonomous Oblast (GBAO), the name of the mountainous region of Tajikistan where the Bartang Valley is situated, is a remnant of Soviet colonial rule in the region. According to villagers, during Soviet presence in the region, cultivation and herding practices were altered from sustainable self-sufficiency to production at an industrial scale through forced migration and collectivization, mechanization of agriculture, and sedentarization of peoples of the Bartang Valley to the lowlands to produce cotton. The impact was devastating on the communities of the valley as many died of malaria and starvation. This also resulted in loss of knowledge concerning how to cultivate local seed varieties of grains and fruits in their own homelands. Thus, diminishing food sovereignty and security. Indigenous knowledge, like the know-how for use of ecological calendars, was actively suppressed and denigrated under Soviet industrial development. Eventually some community members returned to their homelands but not after significant disruption to their cultural and social systems as Soviet style rule was established.

From 2006 to 2010, communities in the Bartang Valley reported the following impacts of climatic variation ([Kassam, 2009](#); [Kassam, Bulbulshoev, & Ruelle, 2011: 148](#)):

- Increasing water levels in rivers and lakes due to more rapid snow and glacial melt;
- Villages at lower elevations report the loss of valuable agricultural land to higher water levels and changing river-ways;
- Villages at higher elevations report increasing size of glacier-fed lakes;
- Increased intensity of rainfall in the spring, which is now concentrated within a few days rather than spread over a longer period, is affecting the physical integrity of structures;
- Villagers also identified growing problems with avalanches and rockslides due to rains;
- In some villages, ploughing and sowing begins 15 to 30 days earlier than a decade ago, and harvesting also takes place 15 to 30 days earlier;
- It became possible to grow regular crops of wheat without the risk of frost damage in villages at higher elevations;
- Villagers at lower elevations report change in the quality of, or inability to grow certain fruits because they require cold days in spring to produce fruit in the summer (i.e. vernalization); and
- Nomadic communities report that the spring season seems like a continuation of winter and in the summer, fodder in high altitude pastures is “burnt,” resulting in animals not gaining the necessary weight to sustain them through the winter.

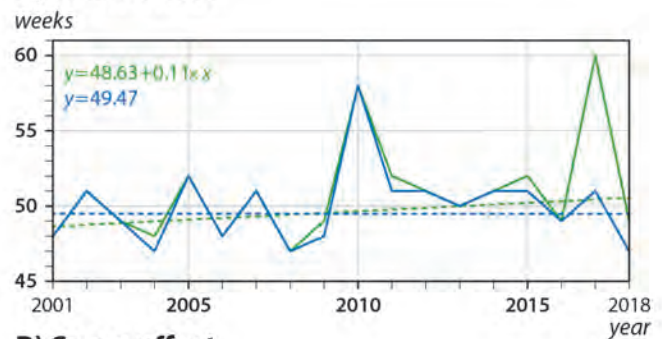
Unusual weather events are a key feature of the anxiety caused by the impacts of anthropogenic climate change. Therefore, when the ECCAP research team undertook interviews in 2017, their results were different from their findings between 2006-2010. The unusual weather patterns of 2017 were evident in community members' comments as they described abnormal weather such as increased snow levels. However, the research team returned the following year and undertook validation of the 2017 observations. The information collected in 2017 was relayed back to the community members of Roshorv and Savnob to ensure accuracy, make adjustments, update observations where relevant, and add new insights. In contrast to 2017, 2018 was more characteristic of the impacts described earlier (2006-2010), illustrating the variable effects of annual weather patterns associated with climate change. As illustrated below, findings by the climate science members of our research team for the winter snow period reinforced observations from individuals living in both communities (Haag et al., 2021).

Climate Data from 2001-2018

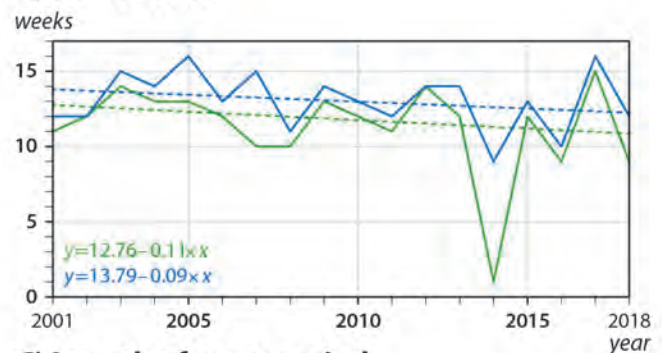
Figure 2.2 illustrates the change in snow cover in Roshorv and Savnob over time. Data were collected on snow onset (A), snow offset (B), and length of the snow period (C). Snow onset is defined as the first week where the number of days with snow cover is above 50%, while snow offset refers to the first week where the number of days with snow cover is below 50%. From 2001 to 2018, results showed a shortening of the season due to the onset occurring later as well as the snow offset occurring earlier. This was particularly evident in Savnob where the snow period decreased by 5.4 weeks.

In conjunction with the climate data, interviews were also collected to consider community observations. Based on these observations, a moderate level of consent was reached in Savnob for declining snow levels. In comparison, community members in Roshorv were strongly in consensus about the decreasing levels of snow over time.

A) Snow onset



B) Snow offset



C) Length of snow period

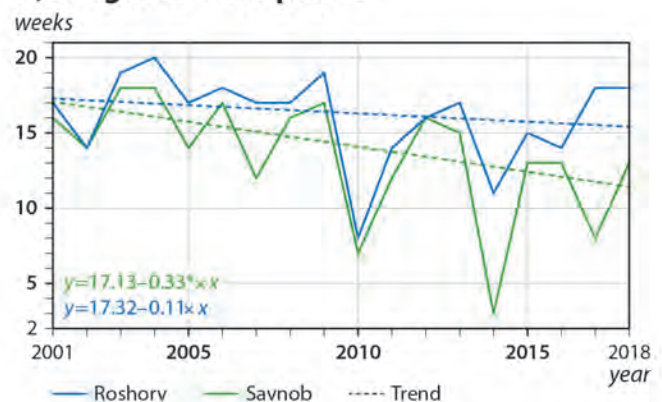


Figure 1: Changes in the timing of snow onset, snow offset, and in the duration of the snow period in weeks for the villages Savnob and Roshorv (Haag et al., 2021).

Voices of the People

Village of Roshorv

Calendar of the Human Body

- How do we know it is time for *Boj Ayom*?

“We use the varmoi to count where the sun is in the body: three days in the nail, three days in the knee, and so on, until it meets the head” (Mushkiev Karamsho Qurbonovich, 2017 Workshop).

Irregular/extreme weather events

- In the past ten years, have you noticed that hazards are more frequent than before? Are there any new climate events that you have not seen before?

“This year there was much snow, and as a result, many avalanches and rockfalls. They destroyed some homes here. This is the first time an avalanche came to this place in ten years. On November 20th, there was a strong and terrible wind that blew for a day and night and destroyed the roof of the first aid station/doctor’s office. There was also an earthquake in December 2015. No one died, but they had to close the road” (Vatansho Mirzoev, Charorov Cholok Sufovich, and Shozodalal Ayomovich 2017 project initialization workshop while developing seasonal round).

- Impact of receding glacier:

“According to my experience, the weather is becoming warmer. In the past, we would harvest wheat and barley in October, and some people couldn’t harvest before it began to snow. Now we harvest in August. Also, the Fedchenko glacier is becoming smaller” (Porshambey Orshormamadov, 2017).

- Changes in weather:

“I remember that last year (2016) on November 25, we had a very heavy wind. It picked up the clay from the land... it only happened last year. These heavy winds are unusual. We always have a light wind in March and April, but this is the first wind like this that I have ever seen” (Mushkiev Karamsho Qurbonovich, 2017).

- Changes in wildlife behavior:

*“After tsatsao, when the land becomes all green in the village, the babub (Eurasian hoopoe, *Upupa epops*) appears, which is another sign of spring. The babub comes after ploughing. Nowadays, they come near the beginning of June. When I was younger, the babub would come at the same time. When the wheat and barley become green from the land, at that time the babub comes”* (Barotov Abdulrasul Qurbonovich, 2017).

Context Specificity

- *“If you planted 10 hectares of land here and 10 hectares in Savnob, the harvest in Savnob would be more than in Roshorv. This is because the water in Savnob is warmer water (spring water)”* (Sabzikov Lalbek Shakarshoevich, 2017).

Village of Savnob

Calendar of the Human Body

- Do you think that this calendar could be useful today for timing events?

“It is useful, but we didn’t pay attention to it. Our grandparents started their work with this calendar” (Aslibegum Sarkorieva, 2017).

Irregular/extreme weather events

- What unusual weather have you noticed in your lifetime?
“1995 was a dry year with no snow. This year 2016-2017 there was too much snow. If I’m not mistaken, in 2010 it was about minus 40-50 in winter in Aktash” (Qandak Mirshaibov Yusefshuevich, 2017).
- Can you remember when you saw this steam coming from the ground this year?
“It usually comes on the 21st of March, when the day and night become equal. But this year, it did not happen until April 10th when the snow melted” (Riswonova Bakor, 2017).
- Changing climate impacting crop yields:
“It has a lot of influence. When we sleep inside, we make a tent inside of the home because of the bugs. It also influences the crops. Now there are more insects that destroy onions and other vegetables. The cold has not been killing the insects” (Odilkhon Ayubov, 2017).
“The rust appears when it is warmer. The warm weather causes the water to become warmer and hurts the plants. The plants don’t grow well then. When we gather hay, there is also not as much” (Mulomalek Alifbekov, 2017).
- Impact of receding glacier:
“Now the summers are warmer than when I was young. When I was younger, in the nearby valley called Ruj Dara, there was a glacier. When we used to go when I was young, one pasture was a glacier. Nowadays, a few years ago I went, and the glacier has melted back 1-2 kilometers” (Guldasteshoev Kosembek, 2017).
“When we used to take oxen to Ruj in past years, we would go over the glacier. But now the glacier is retreating, and we do not cross over it. Usually there is no snow in the mountains when we take our animals to pasture, but this year there was snow. In August the snow melts and more grass grows. When there is more snow in the autumn, we cannot feed our animals on the mountain” (Odilkhon Ayubov, 2017).

Context Specificity

- Between Roshorv and Savnob:¹
 What makes the agriculture of Savnob unique?
“Every family tries to plant wheat first because wheat is the most important. In Savnob and other poytakht villages, we can grow apples and apricots” (Ekbolsho Dustambuev, 2017).
 What makes Savnob poytakht?
“Poytakht villages are warmer than other villages. The snow melts very early here, right after Navruz. We plow 20 to 25 days earlier than other villages like Roshorv. It is possible to grow cucumbers and tomatoes here. The sarad villages are very high above sea level. For example, Savnob is only 2,500 m above sea level, while sarad villages are 3,000 m above sea level. The elevation is what makes Savnob poytakht” (Ekbolsho Dustambuev, 2017).

1 Villages are categorized as either *sarad* or *poytakht* according to their geographic location and climatic conditions. *Sarad* villages are located at higher altitude and therefore commonly have colder temperatures and lower land productivity than *poytakht* villages. *Poytakht*, being the center or capital, and *sarad*, translated to border or periphery, describe locations comparatively. This relationship is conditional as the village of Savnob could be considered *sarad* relative to villages at lower elevations (Bulbulshoev, 2021).

- Within Savnob²

“In some place, the land is called wombi zamin (downstream), and the other is called sai zamin (dry soil). People in sai zamin plant and harvest earlier than wombi zamin (around 4-5 days). Wombi zamin has a better harvest than sai zamin” (Ilchibekova Gulbahor, 2017).

Working with the Ecological Calendar

Introduction

Ecological calendars capture key events across space and time. Individually tailored to the communities of Roshorv and Savnob, their calendars are an illustration of important events that were discussed during interviews with the *Ecological Calendars and Climate Adaptation in the Pamirs* research team in 2017 and 2018. [Roshorv’s and Savnob’s ecological calendars](#) are attached at the end of this chapter. Please read the subsequent sections along with the ecological calendars for Roshorv and Savnob (Figures 2.10 and 2.11). Both of their calendars engage all the senses as they highlight the villagers’ agropastoral relationship with their habitat, speaking to their farming and herding practices. They feature weather phenomena, movement of local animal and plant life, spiritual aspects, and cultural festivities (Figure 2.3). The diversity of perspectives among individuals as well as the nuances in their approaches have added to the complexity of their ecological calendars. Therefore, these calendars have the ability to speak to every individual in the Bartang Valley.



Image A: Roshorv
Apricot Harvest



Image B: Savnob
Flooding Road



Image C: Bartang
Ibex Kidding



Image D: Bartang
Pamiri Ceiling

Figure 2.3: Images A-D are icons present in both Roshorv’s and Savnob’s ecological calendars representing agropastoral activities (e.g., Image A of apricot harvest), abiotic and weather events (e.g., Image B of the river flooding), local animal and plant life (e.g., Image C of ibex kidding), and reference to their spirituality (e.g., Image D depicting a Pamiri ceiling).

Calendar Description & Symbolism

Inspired by the villagers’ cultural spirituality, both Roshorv’s and Savnob’s Ecological Calendars incorporate vast amounts of symbolism (Figure 2.4). Their octagonal shape considers the community’s complexity and the interconnectivity woven throughout their activities and the land with which they engage. The octagon represents the material, cyclical, and spiritual nature of the communities’ relationship with their habitat. It references their cosmology and architectural style. Furthermore, the octagonal shape can assist in visualizing changes occurring overtime. As the calendar is divided into four seasons, green for spring, yellow for summer, red for fall, and blue for winter, alterations in the climate could be revealed through the fluctuating length of seasons. For example, if the cold winter

² *Wombi zamin* and *sai zamin* can be geographic descriptions relating to water sources such as rivers, channels, and streams. Upstream, or the top half, is referred to *sai/say zamin* while downstream is identified by *ghumbi/wombi zamin*. However, *sai/say zamin* not only describes land lacking water supply upstream, but this term is also used to describe unfertile land irrespective of its location. Similarly, *wambi/ghumbi zamin* primarily indicates productive soils (Bulbulshoev, 2021).

months are prolonged, this would clearly be displayed in the area dedicated to the color blue (Image A in Figure 2.4). Given villagers of the Bartang Valley incorporate multiple calendars into their everyday life, one of which being the Gregorian solar calendar, the names of months are fixed within the calendar's octagon outline as another point of reference. Similar to the octagon, the months provide orientation to illuminate variation in shifting events that occur overtime.

This ecological calendar also refers to the historical use of the calendar of the human body. This calendar was first revealed to the ECCAP research team in Savnob. Although the use of the calendar of the human body is no longer ubiquitous, it remains linguistically active and resonant (Image B in Figure 2.4). Comparable to the internal separation of a traditional Pamiri house, with a feminine and masculine side, a man and women dressed in traditional Pamiri clothing are placed with their heads aligning at the summer *chilla* and feet at the winter *chilla*. Despite the division, they remain united and equal. The *chillas* refer to periods when community members can regain energy and reflect. These *chillas* are therefore built into the calendar of the human body as well as into the ecological calendars of Roshorv and Savnob.

The centers of the Bartang Valley ecological calendars hold a depiction of the sun entering through the skylight of a traditional Pamiri home (Image D in Figure 2.3). As the sun shines through, its rays mark the passing of time through their movement around the inside of the house. The year begins with *Navruz*, the vernal equinox, occurring nine days before the sun rises over the *varmoi*, a marker or sign made of rocks in the mountains visible from the village (Image C in Figure 2.4). Although there are multiple calendars and cultural qualities at play, the sun ties each of these elements together. Its movement through the human body, appearance across the mountain tops of the Bartang Valley, and entrance through the skylight into one's household are simultaneously linked to the sun's travel through their ecological calendar. The sun is an essential element of culture and necessary for survival.

Each event or activity is represented by an icon situated on a tapered brown line within the ecological calendar. This line symbolizes the span of time over which the event occurs. For example, in Savnob, the line associated with yaks calving extends from April to July and has its respective icon resting in the middle. This relays that yaks generally calve from April to July in Savnob. Similarly, the line associated with cows calving in Roshorv extends from December to February, has its respective icon resting in the middle, and conveys calving from December to February. Some Roshorv villagers have additional land in Yapshorv therefore dividing their labor between these two villages. Events in these locations inform each other, influencing the sequence of livelihood activities. To distinguish events that occur in Yapshorv, Roshorv's ecological calendar employs two shades of brown. Dark brown denotes Yapshorv while the light brown represents Roshorv. When events take place in both locations, such as the river flooding in July, the line is evenly divided into both colors.

Every icon in the calendar represents a unique event, such as the celebration of a festival, the arrival of a migratory bird, or snowfall. These encompass everything occurring in the surrounding environment as well as human activities. Therefore, the categories of icons include references to livestock management, agricultural practices, crops, crop pests, birds, amphibians, undomesticated animals, hunting, gathering, abiotic events, celebrations, and potentially threatening events.

The representations of these icons act in accordance with particular themes. Icons that symbolize the planting of crops are expressed through an illustration of their life stages (Image D in Figure 2.4). Similarly, hands holding a crop always depict the action of harvesting (Image A in Figure 2.3). Any incidents that may pose a threat to the community and their sustenance are highlighted with a red circle around the icon. Identified by the community, these include natural disasters, extreme temperatures, or possible predation and conflict with undomesticated species (Image B in Figure 2.3). Additionally, key species that inform livelihood activities, indicator species, are also emphasized in the ecological calendars. Each indicator species icon is placed into a light-green filled circle (Image C in Figure 2.3).

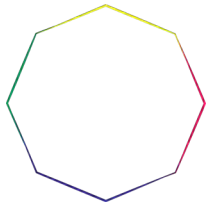


Image A: Bartang

Ecological Calendar Octagon



Image B: Savnob

Calendar of the Human Body



Image C: Savnob

Varmoi in the Mountains



Image D: Bartang

Planting Potatoes

Figure 2.4: Images representative of Savnob’s and Roshorv’s ecological calendars. Image A and D correspond to both ecological calendars while Image B and C pertains to the village of Savnob. Image A presents the octogonal shape and seasonal colors of the ecological calendars, Image B appears in Savnob’s calendar with reference to the calendar of the human body, Image C represents Savnob’s varmoi in the moutains, and Image D symbolizes the planting of potatoes.

Engaging these calendars requires noticing how each of the icons are interacting, both in terms of the events that occur together in time as well as those dispersed. As organisms are connected to each other and the local environment, their behaviors influence the livelihood activities of villagers. This is a matter of survival. Therefore, it is these complex relations that provide the foundation of the ecological calendar and life in the Bartang Valley.

Each ecological calendar is accompanied by an icon legend which contains descriptions of icons and their respective relations. This document is intended to be referenced by the local *Hisobdon*, an individual devoted to monitoring seasonal events. As the ‘keeper of time’, they are responsible for overseeing the passing of time (Kassam et al., 2011; 2018). The top left corner of the legend addresses consistent elements found within their calendars such as how seasons, timeframes, indicators, and dangerous events are represented. All the content populating the ecological calendar and icon legend are derived from the 2017 interviews and 2018 validation with the research team. This ensures precise portrayal of every event, and therefore, includes the diversity of perspectives found amongst individuals of the community.

Sequences

The Bartang Valley ecological calendars are designed to show sequences, the order in which events occur across time. From left to right, the first icon on the left of a line represents the initial event that arises. For example, in Roshorv, the order in which specific crops are planted begins with wheat and is followed by chickpeas, barley, potatoes, and then other vegetables (see Image A in Figure 2.5). In other scenarios, the first icon may initiate a sequence such as the appearance of dandelions. In this sequence of events at the end of March and beginning of April, snowmelt always initiates the arrival of dandelions. This also applies to Savnob as the temperatures dropping in November influence migratory birds leaving for the winter.

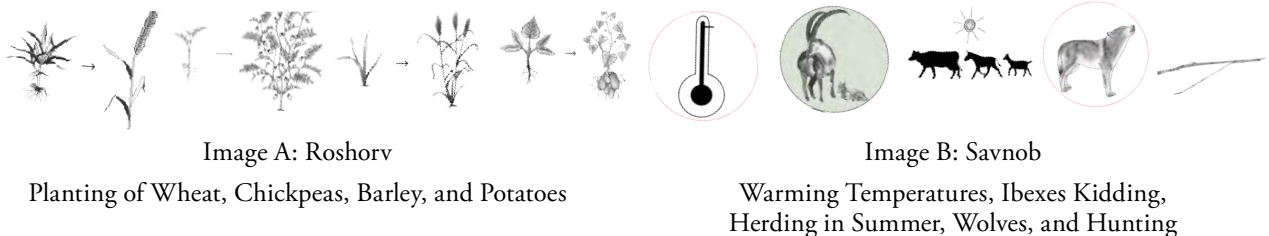


Image A: Roshorv

Planting of Wheat, Chickpeas, Barley, and Potatoes

Image B: Savnob

Warming Temperatures, Ibexes Kidding, Herding in Summer, Wolves, and Hunting

Figure 2.5: Illustrations of sequences in the Bartang Valley’s ecological calendars. Image A depicts the order of planting in Roshorv regarding three crops from April to May. Wheat is planted first, followed by chickpeas, barley and then potatoes. Image B includes five icons, the longest sequence in Savnob’s ecological calendar. When weather warms in the beginning of June the ibexes begin kidding. These events are related to herding activities, wolf behavior, and prevalence of hunting.

The majority of the Bartang Valley's ecological calendars are composed of clearly depicted sequences. Despite initial appearance, the standalone icons are also connected to other elements of the calendar. This holds true for situations such as the birthing of livestock as this is a result of mating earlier in the year. It is important to keep in mind that other external factors such as weather, availability of fodder, or absence of disease each influence the success of such events and tie biophysical and physical processes to human livelihoods.

The longest sequence in Roshorv's ecological calendar includes six icons, occurring throughout September. The first cue to initiate the sequence is a change in temperature. At the beginning of September, the temperature drops causing streams to freeze. The grasses turn yellow as a sign that autumn has arrived and meanwhile, the marmots begin to disappear. In turn, this causes the wolves to apply more pressure on the livestock in pasture. These five events are an indication for herders to bring their livestock back to lower pastures and the village.

Juxtaposed to Roshorv's calendar, the longest sequence in Savnob's ecological calendar includes five icons, occurring throughout June. The first cue, which initiates the sequence, is a change in temperature. At the beginning of June, when the weather warms, the ibexes begin kidding. This corresponds to the herders moving to higher pastures in *Aqtash* as the wolves are increasingly threatening the livestock as well as greener pastures are available at higher elevations. These events initiate hunting (Image B in Figure 2.5).

Cues

Cues are signals that notify the community of upcoming events. They encompass celestial, physical, and biophysical events (Figure 2.6). Cues can exist in the beginning of a sequence as well as within a sequence. For instance, in Roshorv, the temperature of the soil at a depth of 10 cm is a cue to plant vegetables in mid-April. If the soil is warm to the touch, then planting can occur (Image A in Figure 2.6). The avalanches in July are also a cue. They inform the community to harvest apricots in Yapshorv.

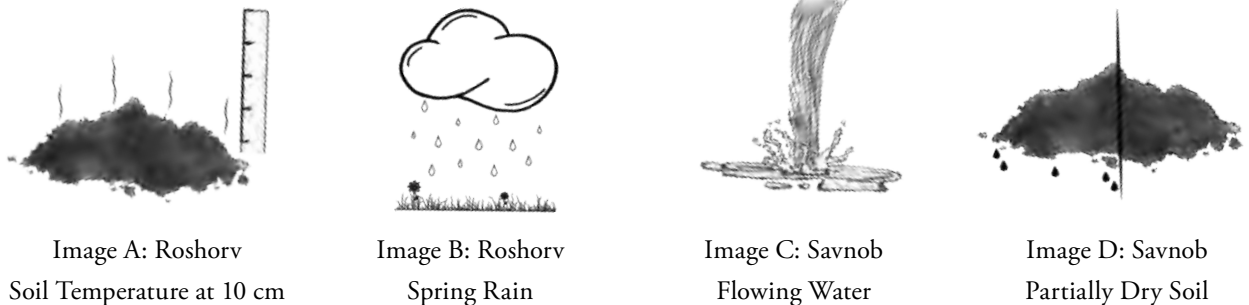


Figure 2.6: Examples of cues in the Bartang Valley's ecological calendars. Cues notify the villagers of approaching events. These icons include, but are not limited to, soil characteristics (Image A and D), weather events (Image B), and flowing water (Image C).

Concerning Savnob, steam rising from the ground is a cue for some villagers to spread sand on the snow encouraging it to melt faster. Similarly, partially dry soils (Image D in Figure 2.6) are a cue to begin plowing in April. It is common for cues to be followed by indicator species before the livelihood activities take place. This is evident in two sequences in Roshorv relating to plowing time in April as well as a sequence in September regarding livestock herding. In Savnob, this is also apparent in multiple sequences throughout June regarding hunting as well as harvesting of wild and cultivated plants.

Indicator Species

Indicator species, a form of cue, are a crucial aspect of the ecological calendars as their behaviors inform livelihood activities. As previously mentioned, their icons are distinguished in the calendar by a light-green background (Figure 2.7). Each time an indicator species appears in the calendar it is highlighted, irrespective if it is performing as an indicator in that instance. This is intended to emphasize the importance of their life stages and relevant behaviors.



Image A: Roshorv
Wurj



Image B: Roshorv
Zarez



Image C: Savnob
Akhar

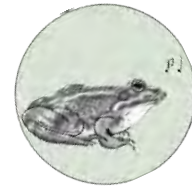


Image D: Savnob
Kharbirj

Figure 2.7: A sample of two indicator species from each village, Roshorv and Savnob, in the Bartang Valley of Tajikistan. Indicator species are highlighted in the ecological calendars with a green circle and inform community members when to carry out livelihood activities. They include mammals, birds, plants, and amphibians. Further information on the 11 indicator species is detailed in Tables 2.1 and 2.2.

Roshorv Indicator Species

The village of Roshorv has a total of eight indicator species consisting of four birds, three mammals, and one plant family. These include the *mandozak* (barn swallow, *Hirundo rastica*), *torwathich* (brown dipper, *cinclus pallasi*), *tsatsao* (Himalayan snowcock, *Tetraogallus himalayensis*), *zarez* (chukar, *Alectoris chukar*), *wurj* (grey wolf, *Canis lupus*), *khuchirf* (long-tailed marmot, *Marmota caudata*), *nakhcheer* (Siberian ibex, *Capra sibirica*) and *wokh* (term for grasses in the Monocotyledons class). As previously mentioned, these indicators are completely unique to Roshorv, aside from the Siberian ibex. See Table 2.1 for their respective icons, associated sequences, and seasons in which they appear in Roshorv's ecological calendar.

The grasses are a very important indicator species, appearing in the ecological calendar a total of four times, more than any other icon. At the end of March and beginning of April the temperatures warm and the grass begins to turn green. Although it is not performing as an indicator in this instance, the grass icon reappears in the beginning of May because the greening color is inviting the ibexes to move to lower pastures. Once the ibexes have arrived at lower elevations, they become easier to hunt. In June, grass is the first icon of a sequence as it is an important food source for the ibex who are kidding. This time period also coincides with the hatching of the chukar, another indicator species, as it is followed by the blossoming and harvest of alfalfa. Both the ibexes' behavior and the greening of grass in higher pastures initiate hunting in June. Arguably, the best time to hunt is not until autumn when the wildlife is well satiated from their summer diets. Commonly hunted animals include ibex, Marco Polo sheep, marmots, Himalayan snowcock, and chukar.

The Himalayan snowcock is an indicator that generally arrives after the appearance of grass in the beginning of spring. This takes place following the melting of snow and first rain. The call of the Himalayan snowcock is important because it initiates plowing. The arrival of barn swallows and brown dippers, two other indicator species, arrive in mid-April following the Himalayan snowcock. These birds are indicators for the second and third plowing sessions, corresponding to the thawing of the land. This time of year, a stone can be dropped as a cue to determine if the land has softened. If this stone does not bounce once it hits the ground, then the soil has thawed enough to plow. The barn swallows reappear in the ecological calendar towards the end of September. Their arrival in autumn is an indication for herders to bring their livestock back from pasture.
















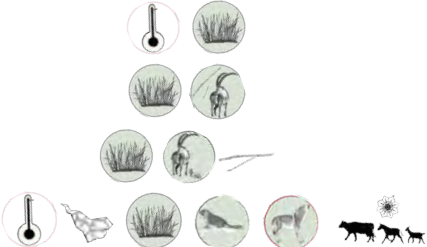
Icon	Indicator Species	Respective Sequence	Months
	Mandozak Barn Swallow <i>Hirundo rastica</i>		April (Spring – Green) September (Autumn – Red)
	Torwathich Brown Dipper <i>Cinclus pallasii</i>		April (Spring – Green)
	Tsatsao Himalayan Snowcock <i>Tetraogallus himalayensis</i>		April (Spring – Green)
	Zarez Chukar <i>Alectoris chukar</i>		June (Summer – Yellow)
	Wurj Grey Wolf <i>Canis lupus</i>		September (Autumn – Red)
	Khuchirf Long-tailed Marmot <i>Marmota caudata</i>		September (Autumn – Red)
	Nakhcheer Siberian Ibex <i>Capra sibirica</i>		May (Spring – Green) June & August (Summer – Yellow)
	Wokh Grasses		April & May (Spring – Green) June (Summer – Yellow) September (Autumn – Red)

Table 2.1: Table of Roshorv’s indicator species including the (1) icon illustrations, (2) species according to the Bartangi, English, and scientific name, (3) depiction of the respective sequences in which the indicator appears in the ecological calendar, as well as (4) the time of year the indicator species emerge and how it is represented in the ecological calendar. These species include *mandozak*, *torwathich*, *tsatsao*, *zarez*, *wurj*, *khuchirf*, *nakhcheer*, and *wokh*.

Savnob Indicator Species

The village of Savnob has a total of four indicator species consisting of a plant, bird, mammal, and amphibian. These include the *akhar* (dog rose, *Rosa canina*), *qargha* (Red- and Yellow-billed Chough, *Pyrrhocorax pyrrhocorax* and *Pyrrhocorax graculus* respectively), *nakhcheer* (Siberian Ibex, *Capra sibirica*), and *kharbirj* (referring to the frogs and toads of the region). Relative to Roshorv, and aside from the Siberian Ibex, these indicators are completely unique to Savnob. See Table 2.2 below for their respective icons, associated sequences, and seasons in which they appear in Savnob’s ecological calendar.









Icon	Indicator Species	Respective Sequence	Months
	Akhar Dog rose <i>Rosa canina</i>		June (Summer – Yellow)
	Qargha Red/Yellow- billed Chough <i>Pyrrhocorax pyrrhocorax/graculus</i>		March (Spring – Green) June (Summer – Yellow)
	Nakhcheer Siberian Ibex <i>Capra sibirica</i>		June (Summer – Yellow)
	Kharbirj Frog The order Anura		February (Winter – Blue)

Table 2.2: Table of Savnob’s indicator species including the (1) icon illustrations, (2) species according to the Bartangi, English, and scientific name, (3) depiction of the respective sequences in which the indicator appears in the ecological calendar, as well as (4) the time of year the indicator species emerge and how it is represented in the ecological calendar. These species include *akhar*, *qargha*, *nakhcheer*, and *kharbirj*.

The croaking of frogs, likely the lake frog (*Rana ridibunda*) and green toad (*Bufo viridis*), are the first sign winter is coming to an end. Their calls are an indicator initiating the celebration of *Boj Ayom* in February. This event is a chance for villagers visit each other’s homes to wish *Shogun Bahor* (a happy new year and happy spring). Many prepare *kochi* during this time. *Kochi* is a dish similar to porridge made from red wheat flour, milk, and water. After the croaking of frogs, the subsequent indicator species in Savnob’s ecological calendar is the chough. The chough arrives with other migratory birds around *Navruz*, the vernal equinox. Although not an indicator in this first scenario, the chough reappears in the calendar around *Joth*, the summer solstice. Through the dusty weather, the chough’s calls can be heard coming from their nests during their mating season. This is an indicator to collect mint.

June holds the most indicator species. Generally appearing slightly earlier than the chough indicator, when the weather has warmed, the ibexes are kidding. This informs herders to move their livestock to their highest pastures. This time period also corresponds to wolves threatening the livestock, which initiates hunting. But come mid-summer, the wolves shift to feeding on the abundant marmots. The final indicator, appearing at

the end of June, is the dog rose. This species simultaneously flowers when water flows into the Ruj pastures. The flowering of dog rose indicates turnips are ready to be harvested and planted for the second time.

Livelihood Activities

The narratives in the Bartang Valley ecological calendars are guided by multiple practices such as that of the farmer, herder, hunter, and gatherer. The calendar therefore provides adaptive capacity outlining what agropastoralists, among others, may experience throughout the year. Activities include, but are not limited to, the planting of chickpeas and the hunting of ibex in Roshorv as well as mating of goats and harvesting apples in Savnob (Figure 2.8).

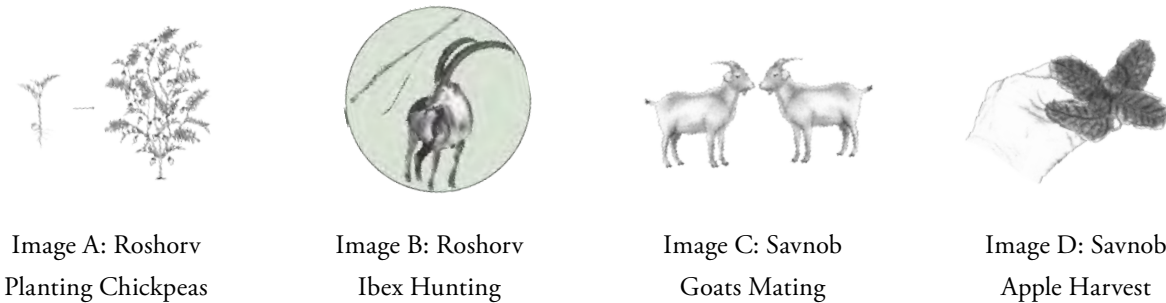


Figure 2.8: Icons of livelihood activities in the Bartang Valley. Images A and B, planting chickpeas and ibex hunting respectively, are icons present in Roshorv's ecological calendar. Images C and D, goats mating and apple harvest, appear in Savnob's ecological calendar.

Focusing on the herder's experience in Roshorv, livestock generally give birth throughout winter as a result of mating during the warmer season. Specifically, livestock keepers are focused on sheep, cows, and goats delivering young between December and February. Come February, some oxen need to be taken down to Yapshorv. This is necessary for their land to be plowed. Throughout March and April, the yaks require extra attention while they are calving. Additionally, plowing begins in April once the *zamin* (the land) becomes alive. In May, after planting is complete, sheep need to be sheared before they leave Roshorv for pasture. It takes from the end of May until early June to drive the livestock to Aqtash³ and Gudhara pastures. Between July and August, it is common for cows to calve in the summer pastures before the temperatures drop. In response to cues and indicators in September, the shepherds bring their livestock back to the village. Community members will ensure the crops are harvested before the livestock return and then will assist in the herding process. Once again, as the sheep have returned to Roshorv, shearing occurs. It is only the cold and windy month of November, while winter is arriving, where the herders are not occupied with tasks noted on the ecological calendar. However, their livestock still need tending and it is time to settle in for another cold winter before the cycle continues.

In contrast, focusing on the herder's experience in Savnob, they are occupied with their goats kidding from March into May. After plowing the land in March and April, the yaks and cattle also need to be taken to the forest. This is generally only necessary if the snow has melted but there is not enough grass. However, if a fence is available, some livestock can be kept away from the crops until the middle of May. Furthermore, the beginning of May entails the oxen and donkeys need to be taken to pasture in Ruj. Once planting is completed around the end of May, livestock are moved to an Aqtash pasture, which is also used by yaks.

² Aqtash pasture, also referred to as Aktash, is commonly used by various herders. Similar to other pastures, they are identified by several names (Kaziev, 2021).

Similarly, the goats and sheep are brought to pasture before the arrival of insects in Savnob. In June, when the weather is warm and the ibexes are kidding, herders move their livestock to Aqtash's top pastures.

Throughout this process, additional attention needs to be given to the cows, yaks, chickens, and sheep in Savnob. Overlapping with the goats, the cows are calving between April and May, the chickens from May to June, and the yaks from April through July. Additionally, it is common for sheep mating to occur in the summer, generally through June and July. The mating of goats, yaks, and cows typically begins at the end of August and lasts into October. The declining temperatures in September and October are a cue for herders to move their livestock to lower pastures. Rather than bringing them back to the village right away, they remain in this location until Savnob's harvests are complete. However, if their herds are under pressure from wolves, or the conditions are too wet, then this exception would encourage the herders to bring their livestock back earlier. When available, fences are used for the animals coming back from pasture, especially if harvest is not complete.

The winter months in Savnob, from the end of November into March, are spent tending to the livestock as it is time to settle in for another cold winter before the cycle continues. They are fed fodder collected over the summer months. During the coldest winter days, the animals are either fed three times a day or taken to winter pastures. However, pastures are only accessible if there is not too much snow, preventing some villagers from being able to feed their livestock if the roads are blocked. This is less of an issue for yaks that feed well during the summer (they eat about 60-70 kg of grass per day) as they will be able to keep on their weight during the winter.

Similar to the herder, this extrapolation can also be conducted for the farmer or hunter. The Bartang Valley's ecological calendars include the relative timing of seeding, tending, and harvesting crops as well as why those actions take place at their respective times. Furthermore, the calendar captures intricacies that indicate specifics such as when the evenings are warm enough for hunters to spend the night outdoors or when it is the best time to hunt. As displayed above, although these professions are discussed separately, there is incredible overlap and interconnectivity between these livelihood activities and the local habitat in which they reside. Each experience may be different, yet success is achieved through direct and indirect collaboration.

Potentially Threatening Events

In addition to sequences, cues, indicator species, and livelihoods events, the Bartang Valley ecological calendars include periods of recurring hardships relating to crops, temperature, livestock, and natural disasters. Emphasized by a red circle, these icons provide warnings of potentially dangerous or threatening events to the villagers and their livelihoods (Figure 2.9).



Image A: Roshorv
Floods



Image B: Roshorv
Crops Covered by Clay



Image C: Savnob
Frost

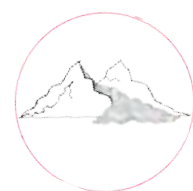


Image D: Savnob
Avalanche

Figure 2.9: Icons of potentially threatening events in Roshorv and Savnob, highlighted by a red circle in their ecological calendars. Images A-D depict floods, damage to crops, frost, and avalanches respectively.

Recent history shows spring to be the most troubling season in the Bartang Valley. The winter food storage runs low affecting both the villagers and their livestock. Illness is simultaneously becoming more prevalent with increasing temperatures and anxiety is growing. Preparation for the new season needs to occur however crop production will not begin until summer. Nonetheless, according to both Roshorv's and Savnob's ecological calendars, summer has the highest frequency of threatening events relative to the other seasons.

In Roshorv, crop related concerns begin in June as it is common for rust to affect the wheat yield. Across June and July, a variety of pests appear consuming crops. For example, it is common for caterpillars to arrive and feed on sorrel, apple, and apricot leaves. The month of July also commonly entails avalanches and floods (Image A in Figure 2.9) while August tends to have exceptionally high temperatures. These heat waves can harm the wheat and barley crops while causing glaciers to melt rapidly. The resulting increase in runoff sequentially covers the crops down river with clay (image B in Figure 2.9). Cherry trees also ripen in Yapshorv in August, enticing the Eurasian tree sparrows to their red fruits. In September, during the harvest season, the crimson winged finch arrives for the wheat and barley grains. September is also the month when wolves begin to threaten the livestock. This is due to the declining autumn temperatures, as marmots move into hibernation leaving the wolves with less food supply. Come winter, the end of November occasionally has very strong winds capable of picking up clay from the land. When transitioning into the coldest time of year, December, it is important that ample firewood was collected in October before the temperatures dramatically drop and snow appears. Although the snow begins to melt during the daytime in February, it ultimately covers the ground until the end of April.

In contrast to Roshorv, the first reasons for concern arrive in June as wolves begin threatening Savnob's livestock and strong winds blow through the village. Although these winds are occasional, they can damage roofs, cause injuries, and knock down large trees, including fruit trees. July commonly presents floods and the highest level of crop pests. It is specifically during *Nosh boz*, in Mid-July, when the rivers begin to flood and wash out the roads. Among many other pests, the caterpillar arrives in dry, warm years. Other common pests include mosquitoes, grubs, aphids, and grasshoppers.

In August, when harvesting occurs, migratory birds return to eat the ripe grains and fruit. Generally, these species include the hill pigeon, crimson winged finch, spotted great rosefinch, and the barn swallow. September corresponds to the first frosts, *khitsoom* (Image C in Figure 2.9). This frost arrives during the autumnal equinox, when the length of the day and night become equal. In order to protect their vegetables, it is important for Savnob villagers to harvest before *khitsoom*. Although the temperatures decline in September; they drop dramatically between October and November. The end of November also corresponds to the period of *Bolo Gordon*. This represents the return of bad tidings (i.e., weather events) such as avalanches, blocked roads, and other dangers (Image D in Figure 2.9). To avoid these hazards, the villages are precisely located outside of areas where avalanches occur. A tradition that predates Islam includes burning *strakhm* (immortelle, *Anaphalis virgata*), a medicinal plant, to ward off evil. Others choose to recite "balo-rad-sa, balo-rad-sa" and sacrifice an animal as a cleansing ritual. The coldest time of year arises between mid-December and mid-February. The migratory birds have already departed in November to avoid these temperatures and they will not return until the land begins to thaw at the end of March.

Updating the Ecological Calendar

The Bartang Valley's ecological calendars were designed to be organic and dynamic as an evolving and updateable record. The calendar's flexible design is easily adaptable, responding to fluctuations as it captures the nuances of varying experiential knowledge. However, as larger changes occur overtime, especially under conditions of climate change, the intention is for the community members to update their ecological calendar as was historically done with the calendar of the human body.

Once an understanding of the calendar's organization and contents have been achieved, observations of changes in the local environment, as well as impacts on the community members, can be introduced into the calendar. This is envisioned to provide anticipatory capacity; and therefore, assist in informing future decisions. However, this cycle of updating the calendar is continuous. The outcomes of actions, those which were influenced by the calendar, are also a form of necessary feedback with which to revise the calendar. Not only does this ensure Savnob's and Roshorv's ecological calendars remain effective with current conditions, but it also becomes a record of the local transformations taking place. Like the historical calendar of the human body, these ecological calendars are therefore evidence of the communities' adaptive capacity as it demonstrates human response to changes occurring in the environment.

Planning and Risk Management

Considering the circumstances of climate change, it would be beneficial to determine the vulnerability of Savnob's and Roshorv's key indicator and livelihood species to climate change. Such an assessment predicts how threatened a species is by the changing environment based on significant characteristics. This meaningful evaluation not only sheds light on whether the species is particularly sensitive to the varying environment, but it also would highlight cascading effects on the community.

Simply making this distinction by defining an indicator as vulnerable does not capture the level of detail needed for this to be a useful assessment. For example, a vulnerable species could be beneficial to the community if its behaviors are noticeably influenced by the local environment. The act of being responsive to external stimuli would be revealing for agropastoralists as indicator species dictate the timing of their activities. As this affects the probability of a successful harvest, it is a matter of livelihoods. However, an extremely sensitive species may no longer be able to survive under the new conditions. Irrespective of whether the species is capable of relocating, members of the Bartang Valley would be warned of the demise of this indicator in their village. This allows them to have more time to adapt to the new circumstances. Alternatively, if the vulnerability assessment determined the indicator to be incredibly insensitive, this species would not be in tune to subtle changes in the environment. Although the species will likely remain in the village, these sensitive characteristics are precisely what is needed to be an effective indicator. It is therefore the detail and precision of a vulnerability assessment that is essential to providing meaningful results.

Data from the International Union for Conservation of Nature (IUCN), thus far, recognizes two of Savnob's indicator species to have stable global populations. These include dog rose and the red- and yellow-billed chough. As for Roshorv, the grey wolf, long-tailed marmot, chukar, brown dipper, barn swallow and Himalayan snowcock have also been acknowledged to have stable global populations by the IUCN. However, specifics about the subspecies, when relevant, to Savnob and Roshorv are needed for an accurate vulnerability assessment. This is particularly critical for the Siberian ibex, although it has a stable population in the region, as their global population is threatened. Similarly, although the red-billed chough is currently not listed as a species of concern, their global population is declining. Climatic impacts are difficult to predict in mountainous ranges, therefore data collected in the village would be the most reliable. If such an assessment is of interest to the villagers in Savnob and Roshorv, thorough studies of these species specific to the Bartang Valley would be needed.

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Ecological Calendar for Roshorv, Tajikistan 2018

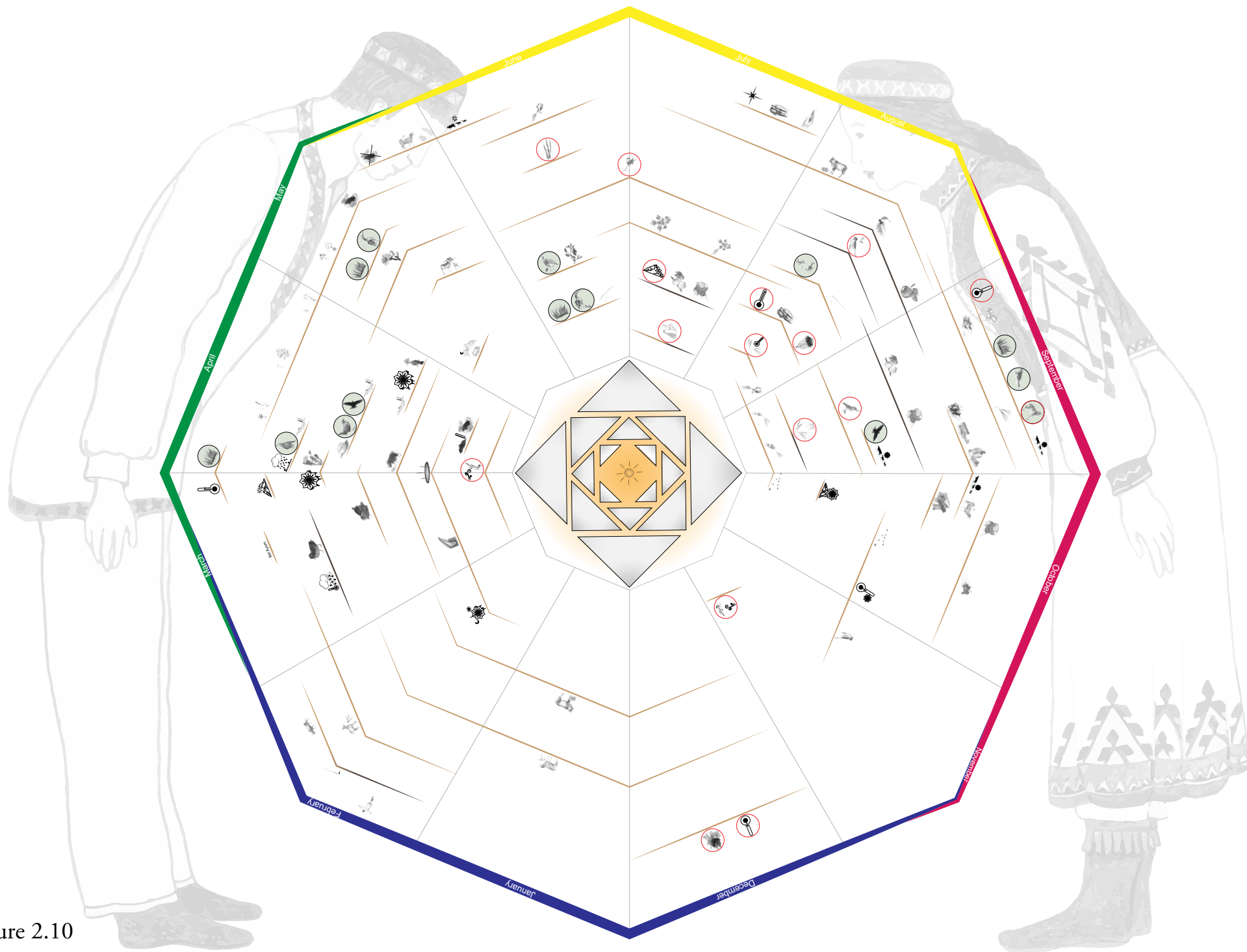


Figure 2.10

Legend for Ecological Calendar

Roshor, 2018

<p>Events that take place in the village of Roshor can be distinguished by the light brown colored lines that accompany icons. The length of the lines corresponds to the time of the respective event within the calendar year.</p>	<p>The temperature of the soil at 10-15 centimeters deep, which is the length of a soil, can help determine if it is time to plant. The soil is ready if it is warm.</p>	<p>When the weather warms in June, the zarez (chukar, <i>Alectoris chukar</i>) begin nesting in the valley near Roshor. This coincides with the rakhoev (red wheat, <i>Triticum aestivum</i>) in the mountains. The blossoming of ghar (alfalfa, <i>Medicago sativa</i>) usually coincides with zarez hatching. Zarez are hunted at the same time as bees, mehak (Marco Polo sheep, <i>Ovis ammon polii</i>), chush (barley, <i>Hordeum vulgare</i>), Marmota caudata, and tsafsoo (Himalayan snowcock, <i>Tetraogallus himalayensis</i>) in the beginning of autumn.</p>	<p>Planting kilik Bartangi (wheat, <i>Triticum aestivum</i>) occurs when the weather becomes warm. Rushtar (red wheat, <i>Triticum aestivum</i>) is planted in the valley near Roshor. The rakhoev (red wheat, <i>Triticum aestivum</i>) and chush (barley, <i>Hordeum vulgare</i>) are planted in the mountains. The rakhoev (red wheat, <i>Triticum aestivum</i>) is planted in the valley near Roshor. The rakhoev (red wheat, <i>Triticum aestivum</i>) is planted in the valley near Roshor.</p>	<p>Every two to three years, there are about ten days in August when rapid warming causes the glacier to melt quickly and push clay down the river. If the clay is not carried down the river, then the black clay runoff covers the farmland like plastic. This prevents the water from permeating, thereby affecting the crop yields. During these years, it is important to water the lands early in the morning, before the clay enters the water.</p>
<p>Events that take place in the village of Roshor can be distinguished by the lines that fade from dark to light brown and accompany icons. The length of the lines corresponds to the time of each respective event within the calendar year.</p>	<p>During Amal, zamin (land) becomes alive and everything begins to grow because the snow has melted, the winter cold has left, and spring has arrived. Fowling can begin to plow the land.</p>	<p>Mendocosa (rain swallow, <i>Hirundo rustica</i>) arrive in spring as an indicator for the second plowing as well as the fall as an indicator to bring the livestock back from pasture. They are seen after the moving season, sitting on the steeply rising lines and in the beginning of autumn.</p>	<p>Common varieties of karkotka (potato, <i>Solanum tuberosum</i>) include kardinal (red), jodor (a local variety), and jrgatol (a larger variety brought from Jirgatal, in northern Tajikistan). All of these varieties grow well and there is no difference between growing them. They are all planted at the same time before the beginning of June. The potatoes are planted in conditions of 8°C at a soil depth of 12 centimeters. Once the potatoes are planted, it is time to plant other vegetables.</p>	<p>There can be a cold spell in September called Kitzoven. Although Kitzoven is rare, the frost lasts for three days and it can harm the kilik Bartangi (wheat, <i>Triticum aestivum</i>) and chush (barley, <i>Hordeum vulgare</i>) crop. This is more common in Yaphosh.</p>
<p>Green corresponds to the season of spring.</p>	<p>This icon represents the movement of livestock to the summer pasture at the end of spring. Once the plowing and seeding the land is complete at the end of May, the livestock need to be moved, not including makhshob (donkey, <i>Equus asinus</i>), to the green summer pastures before they destroy the land. Weather permitting, as the snow cannot be too deep for the animals, it takes from the end of May to early June to drive the animals to pasture in Aqtash and Gudhara.</p>	<p>The zhabib (Eurasian hoopoe, <i>Upupa epops</i>), a symbol for spring, arrives when the land is free from snow. It appears after <i>Navruz</i>, when the plowing is finished, and the kilik Bartangi (wheat, <i>Triticum aestivum</i>) and chush (barley, <i>Hordeum vulgare</i>) are turning green. It stays until the end of summer, sometimes later. The eagles stay in Roshor all year including throughout the winter and make their nests in the spring. It is impossible to see the eagle nests because they are at the top of the mountains. Other birds that stay in Roshor throughout the year are the gargal (red-billed chough and yellow-billed cuckoo), <i>Pyrrhoxoxa pyrrhoxoxa</i> and <i>Pyrrhoxoxa graculus</i> respectively as well as the raven, and crow.</p>	<p>Common varieties of karkotka (potato, <i>Solanum tuberosum</i>) include kardinal (red), jodor (a local variety), and jrgatol (a larger variety brought from Jirgatal, in northern Tajikistan). All of these varieties grow well and there is no difference between growing them. They are all planted at the same time before the beginning of June. The potatoes are planted in conditions of 8°C at a soil depth of 12 centimeters. Once the potatoes are planted, it is time to plant other vegetables.</p>	<p>Occasional very hot weather in August impacts the crops for a couple of days. The kilik Bartangi (wheat, <i>Triticum aestivum</i>) begins to wilt, turn yellow and fall over. The heat also misadvisingly whitens the wheat as if it is ripe. Although this is unusual, it causes a very poor harvest because it dries the crop.</p>
<p>Yellow corresponds to the season of summer.</p>	<p>At the end of summer, after everything has been harvested and the weather becomes cold, the shepherds bring the livestock back to the village in order to protect them from the wuj (wolf, <i>Canis lupus</i>). While the grass turns yellow and the khuchir (long-tailed marmot, <i>Marmota caudata</i>) disappear, the herdsmen move the livestock (cattle, <i>Bos taurus</i>) to lower pastures. Additional community members arrive at the pastures and assist moving the livestock to the village and the streams freeze and the temperatures drop.</p>	<p>The arrival and call of the tsafsoo (Himalayan snowcock, <i>Tetraogallus himalayensis</i>) indicates that it is time to begin plowing as spring has arrived. Tsafsoo arrive with the first spring rains once the snow has melted, a period described as khushk (dry) in the winter. The tsafsoo feeds on the pastures, where the rakhoev (red wheat, <i>Triticum aestivum</i>) and chush (barley, <i>Hordeum vulgare</i>) are planted in the previous year, then the land does not need plowing the following year.</p>	<p>Chush (barley, <i>Hordeum vulgare</i>) is sown when the spike turns white and the seeds become too hard to bite. Chush (barley, <i>Hordeum vulgare</i>) is sown when the spike turns white and the seeds become too hard to bite.</p>	<p>In October and November, the cold temperatures and snow begin to stay for the winter. At this point the migratory birds have left but a few species remain in Roshor including the chafchoch (Eurasian tree sparrow, <i>Passer montanus</i>).</p>
<p>Red corresponds to the season of autumn.</p>	<p>The best time to hunt is in August when the animals are well satiated from their summer feeds. Common animals hunted during this time include nakhchoer (alta ibex, <i>Capra ibex</i>), mehak (Marco Polo sheep, <i>Ovis ammon polii</i>), khuchir (long-tailed marmot, <i>Marmota caudata</i>), tsafsoo (Himalayan snowcock, <i>Tetraogallus himalayensis</i>), and zarez (chukar, <i>Alectoris chukar</i>). Hunting usually begins in June when the higher pastures turn green. This coincides with the bees going into hibernation.</p>	<p>The towanchoh (brown dipper, <i>Cinclus pallasi</i>) is a small, dark colored bird that stays in Roshor in the spring as an indicator for the second plowing. They stay in Roshor during the summer and leave at the end of September.</p>	<p>Chush (barley, <i>Hordeum vulgare</i>) is ripe when the spike turns white and the seeds become too hard to bite.</p>	<p>After winter the warmer temperatures are an indication that it is time to plow and plant crops.</p>
<p>Blue corresponds to the season of winter.</p>	<p>The varmlo is used to count where the sun is in the human body. In the calendar of human body, the sun enters through the toe and when it is in the shins, it corresponds to the time the villagers celebrate <i>Boj Ayom</i> in Roshor and then go down to Yaphosh to plow the land.</p>	<p>The arrival and call of the tsafsoo (Himalayan snowcock, <i>Tetraogallus himalayensis</i>) indicates that it is time to begin plowing as spring has arrived. Tsafsoo arrive with the first spring rains once the snow has melted, a period described as khushk (dry) in the winter. The tsafsoo feeds on the pastures, where the rakhoev (red wheat, <i>Triticum aestivum</i>) and chush (barley, <i>Hordeum vulgare</i>) are planted in the previous year, then the land does not need plowing the following year.</p>	<p>Chush (barley, <i>Hordeum vulgare</i>) is often planted with revard (chickpea, <i>Cicer arietinum</i>) following the seeding of kilik Bartangi (wheat, <i>Triticum aestivum</i>). Planting barley requires harvest (karkotka, <i>Solanum tuberosum</i>) to plow the land. This is not the case for wheat and barley is planted in the previous year, then the land does not need plowing the following year.</p>	<p>The streams freezing is an indication that the temperatures are dropping and that it is time to bring the livestock back from the summer pastures to the village.</p>
<p>A light green circle is placed around each of the indicator species.</p>	<p>The varmlo is used to count where the sun is in the human body. In the calendar of human body, the sun enters through the toe and when it is in the shins, it corresponds to the time the villagers celebrate <i>Boj Ayom</i> in Roshor and then go down to Yaphosh to plow the land.</p>	<p>The towanchoh (brown dipper, <i>Cinclus pallasi</i>) is a small, dark colored bird that stays in Roshor in the spring as an indicator for the second plowing. They stay in Roshor during the summer and leave at the end of September.</p>	<p>Chush (barley, <i>Hordeum vulgare</i>) is ripe when the spike turns white and the seeds become too hard to bite.</p>	<p>Every two to three years in August there is rapid warming. This causes the glacier to melt quickly and push clay down the river. The black clay runoff can cover the farmland like plastic.</p>
<p>A red circle is placed around events that require additional warning.</p>	<p>The varmlo is used to count where the sun is in the human body. In the calendar of human body, the sun enters through the toe and when it is in the shins, it corresponds to the time the villagers celebrate <i>Boj Ayom</i> in Roshor and then go down to Yaphosh to plow the land.</p>	<p>The towanchoh (brown dipper, <i>Cinclus pallasi</i>) is a small, dark colored bird that stays in Roshor in the spring as an indicator for the second plowing. They stay in Roshor during the summer and leave at the end of September.</p>	<p>Chush (barley, <i>Hordeum vulgare</i>) is ripe when the spike turns white and the seeds become too hard to bite.</p>	<p>Every two to three years in August there is rapid warming. This causes the glacier to melt quickly and push clay down the river. The black clay runoff can cover the farmland like plastic.</p>
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Ecological Calendar for Savnob, Tajikistan 2018

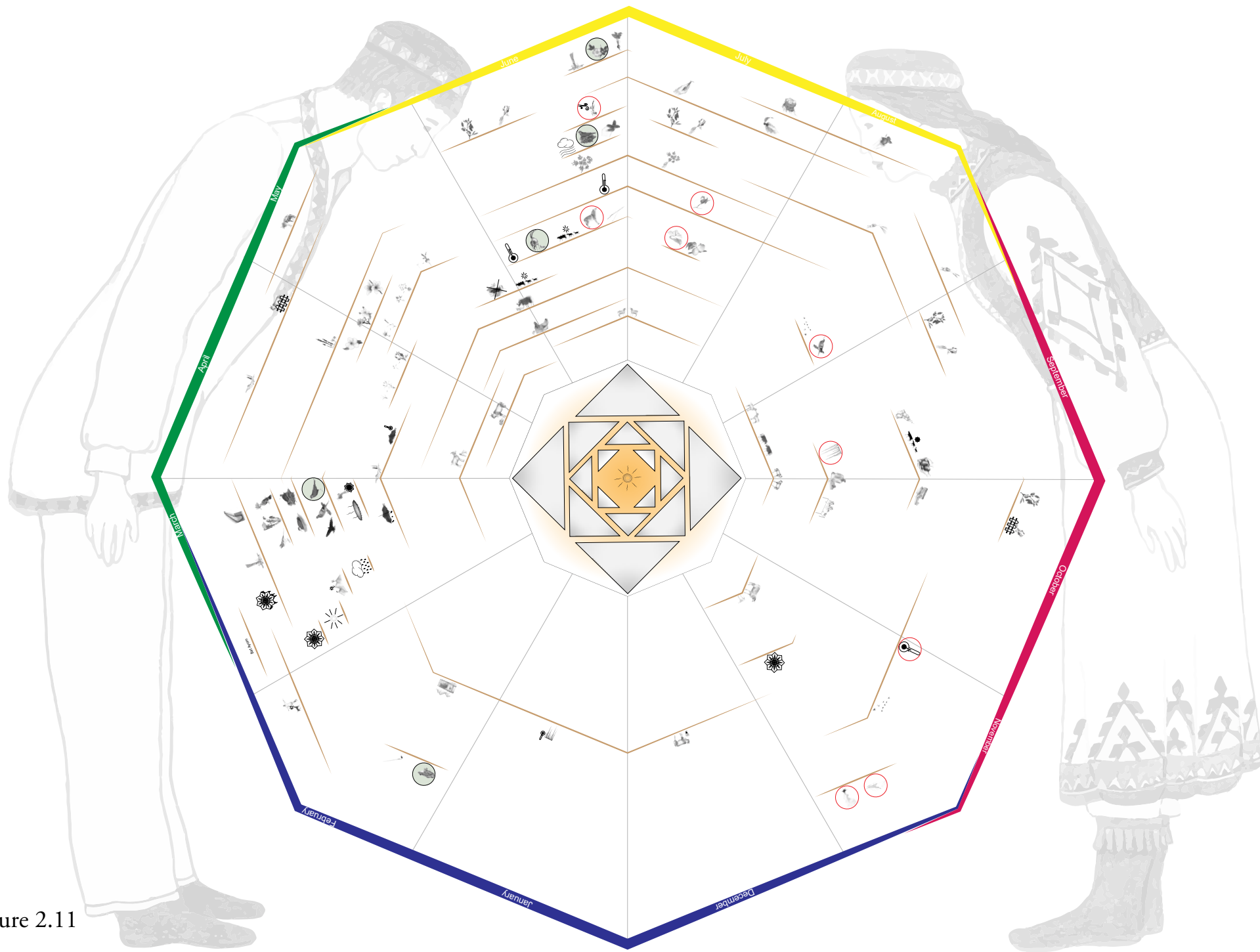


Figure 2.11

Legend for Ecological Calendar Savnib, 2018

Events that take place in the village of Savnib can be distinguished by the light brown colored lines that accompany icons. The length of the line corresponds to the timeframe of each respective event within the calendar year.

Green corresponds to the season of spring.

Yellow corresponds to the season of summer.

Red corresponds to the season of autumn.

Blue corresponds to the season of winter.

A light green circle is placed around each of the indicator species.

A red circle is placed around events that require additional warning.

When the snow reaches the varnii, it indicates the start of spring. This is indicated for various species of plants in the fall.

After the sun enters the female dog (ofob ba bō), it then goes through the female dog (ofob ba mardir/ba mar) around February when the land becomes alive.

In winter the primary tasks are housework and feeding the livestock. Common household includes cooking, cleaning, and removing snow that has collected on the roof.

The irrigation channels are cleaned, repaired and opened for the first time in March. This is celebrated by sacrificing an animal and performing a Khudoj where blessings are given, and food is shared.

The period of Bolo Gordon represents the return of bad things such as avalanches, blocked roads and other dangers. A tradition that predates Islam includes burning stralham (immortelle, *Anaphalis virgata*) to ward off evil. Others choose to sacrifice 'balo-radisa, balo-rad-sar' and sacrifice an animal as a cleansing ritual.

In June, when the weather begins to warm, the nahcheer (altaf bee, *Capra sibirica*) give birth and the herdsmen move to high pastures in Aqtash. When wuzj (grey wolf, *Canis lupus*) start attacking the livestock, hunting begins.

Bog Ayom marks the period of preparations from 8th to 12th of February. It is the beginning of a small Navruz. People bring the farmer's tools, their horses and use them in the fields. This is a sign that spring work has begun.

Bat Ayom is similar to Bog Ayom but it occurs one month later from the 8th to 12th of March. People visit each other's homes to wish them Shogun Bahor (a happy new year and happy spring). Many cook koldj during this time which is similar to a porridge made from rushtak (red wheat, *Triticum spp.*), flour, milk and water.

The celebration of Sol Poinkha marks the completion of the harvest season in Savnib, often accompanied by a frost that lasts two to four days at low elevations. This Bantingyay festival is celebrated by beating sticks together (thos-ithd) while singing, "We will bear seed next year". This is accompanied by games, music, and kikklov, the sacrifice of an animal for the celebration.

Harvesting marks the season of autumn. Everyone tries to harvest their crops before the frost and avoid days with rain. The birds (in) and eat the kikas Barlangi (wheat, *Triticum aestivum*). The sequence in which crops are harvested begins with chush (barley, *Hordeum vulgare*) and is followed by safedak (white wheat, *Triticum spp.*), rushtak (red wheat, *Triticum spp.*), kartoshka (potato, *Solanum tuberosum*), and other vegetables. This must occur before the animals return from their summer pasture. If the livestock are fenced in, they do not pose a threat to the crops and harvesting can occur later.

All the crops have to be harvested before the livestock return from summer pasture. The celebration of Sol Poinkha marks the completion of the harvest season. There is often a frost that occurs at the same time in Savnib lasting two to four days at low elevations.

From mid-March until mid-April the soil is partially dry referring to sahe-zamin (the land above the canal). Plowing begins around April first.

At the end of March, the weather is warming, the snow is melting, and steam is rising from the ground. This is the period of taf-zamin, at the end of tance, where the length of the day and night are becoming equal and the snow is melting on both the earth and in the sky. When the steam rises, plowing begins to start on the ground because the snow melts at a faster rate and therefore the land is dry at higher elevations. The melting of snow influences when the soil can be seeded.

If the soil is above ten degrees Celsius, planting can occur. The soil is warm to its touch.

Navruz represents the vernal equinox on March 21st. Afterwards, the oxen come out for plowing from April to May while various bird species arrive. The snow must be melted, and the land has to be tilled by *Aray*. Arayplowing will delay this process. The livestock are kept in a fenced area, so they are not able to disturb the land. Once the plowing is finished, the oxen and markabkhar (donkey, *Equus asinus*) are taken to pasture in Ru.

If there is less snow, livestock can be taken to pasture which is used by some quotas (domestic yak, *Bos grunniens*) all year. Other yaks may return to Savnib if needed. These larger animals as well as cows are first taken to the forest (yod-booth or kanabon) when the snow has melted in April before they are taken to the Aqtash pasture in May. Once plowing is finished, the oxen and markabkhar (donkey, *Equus asinus*) are taken to pasture in Ru.

The smaller animals such as vaz (domestic goat, *Capra aegagrus hircus*) and msv (sheep, *Ovis aries*) are taken to pasture when there is less snow and before the arrival of the insects in Savnib. Moving the livestock to Aqtash indicates summer. In June, when the weather warms and nahcheer (altaf bee, *Capra sibirica*) give birth, the herdsmen move the livestock to its top pastures.

In late September to early October the temperatures begin to drop, streams freeze, and ice forms in the water bodies. The livestock are now moved to lower pastures and chush (barley, *Hordeum vulgare*) and kartoshka (potato, *Solanum tuberosum*) crops are harvested. Winter is about to arrive. The livestock do not come back to the forest to harvest unless the climate is too wet or wuzj (grey wolf, *Canis lupus*) are threatening their animals.

Once plowing is finished, the oxen and markabkhar (donkey, *Equus asinus*) are taken to pasture in Ru.

Although chash (chicken, *Gallus gallus domesticus*) are rare in Savnib, ducks hatch between May and June, especially if they are kept in a well-tended chicken coop protected from foxes.

The larger animals such as quotas (domestic yak, *Bos grunniens*) and hivanat (cattle, *Bos taurus*) are first taken to the forest (yod-booth or kanabon) when the snow has melted in April. They are later brought to the pasture in Aqtash in May. Moving the animals from forest to pasture in Aqtash is referred to as kuch'yaf. The livestock are only taken to the forest if there is not enough grass, but before the insects arrive.

When harvesting occurs, the migratory birds return to eat the ripe grain. These include the khotta (hill pigeon, *Columba rupestris*), mestron (crimson winged finch, *Rhipidopychia sanguinea*), rashahtkhnat (spotted great reosfinch, *Capropodys severtzovi*), and mandozak (barn swallow, *Hirundo rustica*). They sometimes also eat nozh (apricot, *Prunus americana*) that ripen later in the year.

The arrival of ducks from the south marks the end of winter. The churag (European coot, *Fulica arca*), sholarafakablor (mallard, *Anas platyrhynchos*) frequent the river. While the churag is completely black, the sholarafak is brown with a red crest, and the abtibor is a red-brown. They nest in Savnib and leave in autumn depending on the weather. These birds used to be hunted as a source of food.

The khotta (hill pigeon, *Columba rupestris*) appears in Savnib around Navruz accompanied by the mandozak (barn swallow, *Hirundo rustica*) and qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively). The khotta is sometimes hunted for food.

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The ghl (white wagtail, *Motacilla alba*) is the first bird to arrive in March once winter has ended. This small bird has black on top and is white underneath. Its arrival in Savnib, which is weather dependent, marks the season of plowing and planting. During colder temperatures it will appear later.

The babub (European hoopoe, *Upupa epops*) is one of the first birds to arrive in March once winter has ended. This small bird has black on top and is white underneath. Its arrival in Savnib, which is weather dependent, marks the season of plowing and planting. During colder temperatures it will appear later.

The arrival of ducks from the south is an indication that winter has ended. Many other migratory bird species arrive after the ducks including the ghl (white wagtail, *Motacilla alba*), qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively), mandozak (barn swallow, *Hirundo rustica*), khotta (hill pigeon, *Columba rupestris*) and babub (European hoopoe, *Upupa epops*). In autumn, the migratory birds, mestron (crimson winged finch, *Rhipidopychia sanguinea*), rashahtkhnat (spotted great reosfinch, *Capropodys severtzovi*), mandozak, and khotts, return to eat the ripe grain. The chertchoh (Eurasian tree sparrow, *Passer montanus*) and karhopos (magpie) stay in the village all year.

Gilas (cherry, *Prunus avium*) bloom in April before becoming ripe and ready to harvest in late June through early August. The soft (white mulberry, *Morus alba*) ripen at the same time as cherries in July.

The tubt (white mulberry, *Morus alba*) ripen and are harvested at the same time as gilas (cherry, *Prunus avium*) in July.

Msv (apple, *Malus spp.*) become ripe and ready to harvest in late July through August. They blossom in late April to early May, but if there is a lot of snow, they begin later.

Nozh (apricot, *Prunus americana*) trees blossom in late April and then ripen for harvest between July and August.

The first nozh (apricot, *Prunus americana*) become ripe during Nozh boz in mid-July. This is the same time the rivers begin to flood and wash out the roads.

The nozh (apricot, *Prunus americana*) and mun (apple, *Malus spp.*) trees blossom in late April and early May, producing fruit in July and August. If there is a lot of snow, they begin to blossom later, however if the weather is dry, it occurs earlier. They generally blossom just after the gilas (cherry, *Prunus avium*) trees and before the tubt (white mulberry, *Morus alba*).

The wuzj (grey wolf, *Canis lupus*) are a threat to livestock. In June, during the beginning of summer, they threaten quotas (domestic yak, *Bos grunniens*), hivanat (ox, *Bos taurus*), msv (sheep, *Ovis aries*), and markabkhar (donkey, *Equus asinus*). The nahcheer (altaf bee, *Capra sibirica*) are giving birth while the herdsmen move their livestock to the top pastures in Aqtash. In midsummer the wolves feed on the abundant khushif (long-tailed marmot, *Marmota flaviventris*). In autumn, the wolves arrive in Savnib when the shepherds are coming back from pasture.

Nahcheer (altaf bee, *Capra sibirica*) kick when the weather warms and the herdsmen move to the top of the pastures in Aqtash.

The crossing of khayrib (late frog, *Rana ridibunda* and green toad, *Bufo viridis*) is the first indication that winter is over, initiating the celebration of Bog Ayom in February.

The beginning of spring is marked by the zhon (golden eagle, *Aquila chrysaetos*) nesting and calling from the tops of the mountains. It occurs around Navruz, the vernal equinox, and corresponds to the time of plowing.

Around Jofh, summer solstice, you can hear the qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively) calling in their nests during their mating season. Mint is also being collected, but during this time of year, the mestron (duky, and trees should not be planted (afghankaj).

The qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively) arrive in Savnib around Navruz with the khotta (hill pigeon, *Columba rupestris*) and mandozak (barn swallow, *Hirundo rustica*).

The mandozak (barn swallow, *Hirundo rustica*) are a small black bird with a forked tail. They arrive around the same time as the khotta (hill pigeon, *Columba rupestris*) and qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively), usually during plowing, and return in August at the time of harvest. Some use the mandozak's nest for medicine.

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Nozh (apricot, *Prunus americana*) trees blossom in late April and then ripen for harvest between July and August.

The first nozh (apricot, *Prunus americana*) become ripe during Nozh boz in mid-July. This is the same time the rivers begin to flood and wash out the roads.

The nozh (apricot, *Prunus americana*) and mun (apple, *Malus spp.*) trees blossom in late April and early May, producing fruit in July and August. If there is a lot of snow, they begin to blossom later, however if the weather is dry, it occurs earlier. They generally blossom just after the gilas (cherry, *Prunus avium*) trees and before the tubt (white mulberry, *Morus alba*).

The wuzj (grey wolf, *Canis lupus*) are a threat to livestock. In June, during the beginning of summer, they threaten quotas (domestic yak, *Bos grunniens*), hivanat (ox, *Bos taurus*), msv (sheep, *Ovis aries*), and markabkhar (donkey, *Equus asinus*). The nahcheer (altaf bee, *Capra sibirica*) are giving birth while the herdsmen move their livestock to the top pastures in Aqtash. In midsummer the wolves feed on the abundant khushif (long-tailed marmot, *Marmota flaviventris*). In autumn, the wolves arrive in Savnib when the shepherds are coming back from pasture.

Gilas (cherry, *Prunus avium*) trees blossom in late April and are ready to be harvested in July to early August. They usually blossom just before msv (apple, *Malus spp.*), nozh (apricot, *Prunus americana*), and tubt (white mulberry, *Morus alba*).

Chieghifalifa (peach, *Prunus persica*) blossom in late April to early May and are ready to be harvested in July to early August. If there is a lot of snow, they blossom later. Although peaches can be grown in Savnib, they usually come from Ruzhan or Khoroj.

Klax Barlangi (wheat, *Triticum aestivum*) harvest occurs from August to September. Safedak (white wheat, *Triticum spp.*) is harvested at the same time as klax (soft wheat), which is about ten days before rushtak (red wheat, *Triticum spp.*), but rushtak is less common because it struggles with the warmer water and disease. The wheat is used for human consumption, often to make bread, yet the sparrows also enjoy eating both varieties.

Klax Barlangi (wheat, *Triticum aestivum*) is planted between April and May. People look for steam coming from the ground as a sign for planting. Rushtak (red wheat, *Triticum spp.*) is usually planted before safedak (white wheat, *Triticum spp.*) and generally, Klax (soft wheat, *Triticum spp.*) is planted first, followed by wheat, kartoshka (potato, *Solanum tuberosum*), and other vegetables such as onions, carrots, cabbage, and radiska (turnip, *Brassica rapa rapa*).

Chush (barley, *Hordeum vulgare*) is harvested in July to early September. It is cut with hivanat (ox, *Bos taurus*) and then stored to dry. It is primarily used as fodder today, but historically it was a staple food made into bread.

Chush (barley, *Hordeum vulgare*) is planted around April. If there is a lot of snow, then planting will occur later. Some also look for the steam coming from the ground (taf-zamin) to indicate that it is time to plant.

The time to plant jidore potatoes (*Solanum tuberosum*) is between April and the beginning of May after chush (barley, *Hordeum vulgare*), ghar (alfalfa, *Medicago sativa*) and klax Barlangi (wheat, *Triticum aestivum*), but before other vegetables such as onions, carrots, cabbage, and radiska (turnip, *Brassica rapa rapa*).

Kartoshka (potato, *Solanum tuberosum*) are harvested between the end of September and the beginning of October because, shortly after, the hivanat (cattle, *Bos taurus*) come back from summer pasture. The timing usually follows the movement of livestock to the lower pastures. The temperatures begin to drop during this time, forming ice in streams and buckets.

The harvest and planting of radiska (turnip, *Brassica rapa rapa*) for the second time in late June coincides with the planting of klax Barlangi (wheat, *Triticum aestivum*) and klax Barlangi (wheat, *Triticum aestivum*) in the field. At the same time, water flows into the pastures in Ru.

Radiska (turnip, *Brassica rapa rapa*) are planted after chush (barley, *Hordeum vulgare*). They prefer cool weather, so this crop occasionally struggles in Savnib due to the warmer temperature and insect pests. The season of plowing and planting. During colder temperatures it will appear later.

In Savnib, there are four ghar (alfalfa, *Medicago sativa*) harvests. The first harvest is in the beginning of July, the second in mid-July, the third at the beginning of September, and the fourth at the beginning of October. Ghar is used to feed the livestock, the fourth harvest to protect it from livestock.

There are four ghar (alfalfa, *Medicago sativa*) harvests in Savnib, but the fourth harvest can only occur if the ghar is fenced. It would take place in the beginning of October when the livestock have returned from their summer pastures.

In Savnib are four ghar (alfalfa, *Medicago sativa*) harvests. Once the alfalfa begins to flower from 30 to 70 percent, it is time to harvest.

Ghar (alfalfa, *Medicago sativa*) is planted as fodder for livestock at the same time as chush (barley, *Hordeum vulgare*) and it thrives when the soil is saturated.

The icon depicting the gathering of the zira (black cumin, *Bunium persicum*) plant represents the collection of wild and medicinal plants that usually takes place during June and July. Common plants that are collected include zira, which is used for blood pressure regulation, chaber (caper, *Caparris spinosa*) for tuberculosis, yag-voitak (broadleaf plantain, *Plantago major*) for stomach problems, yobratrakim (immortelle, *Anaphalis virgata*) a diuretic, wotrovim (wild mint, *Mentha asiatica*) as a tea, khonkhorth/qayzarula (catnip, *Nepeta glifozosa*) applied to areas with injured bones, and tsakh (wild onion, *Allium spp.*) used as food.

The icon of zira (black cumin, *Bunium persicum*) represents the flowering of wild and medicinal plants. Usually the flowering and gathering of wild plants is best in June and July. Common plants that are collected include zira, which is used for blood pressure regulation, chaber (caper, *Caparris spinosa*) for tuberculosis, yag-voitak (broadleaf plantain, *Plantago major*) for stomach problems, yobratrakim (immortelle, *Anaphalis virgata*) a diuretic, wotrovim (wild mint, *Mentha asiatica*) as a tea, khonkhorth/qayzarula (catnip, *Nepeta glifozosa*) applied to areas with injured bones, and tsakh (wild onion, *Allium spp.*) used as food.

Witrovim (wild mint, *Mentha asiatica*) is harvested during Jofh, summer solstice. It has green flowers and is used in tea, soup, and for animal fodder. It is believed to be good for all ailments including the stomach.

When akhar (dogrose, *Rosa canina*) begins to flower in the village, water simultaneously comes to the pastures in Ru. This is similar to the time when the churag (European coot, *Fulica arca*) and chush (barley, *Hordeum vulgare*) are planted for the second time around late June.

Zerd guta/khinguvak (standalone, *Taraxacum officinale*) blossoms in late spring, coinciding with the first appearance of ducks. If there is a lot of snow, its arrival can be delayed. Zerd guta can be used as stomach medicine.

The mv (caterpillar, *Pieris brassicae*) icon is a placeholder for all common insect pests in Savnib, as there are level (moquito, *Culexidae* spp.), chum (grey grub), shakara (green aphids, *Sappaphis pin*), and zafetsh/zhdzshk (grasshopper, *Caerillera* spp.). The mv does not appear every year but prefers warm and dry weather.

Vegetables are planted in spring after steam comes from the ground (taf-zamin) and the land is warm. After chush (barley, *Hordeum vulgare*), klax Barlangi (wheat, *Triticum aestivum*), ghar (alfalfa, *Medicago sativa*), and kartoshka (potato, *Solanum tuberosum*) are planted, then it becomes time to seed the remaining crops.

Planting is finished in late May when the msv (sheep, *Ovis aries*) and vaz (domestic goat, *Capra aegagrus hircus*) are taken to the summer pasture.

Khnoson, frost, occurs when the days become equally long during the autumnal equinox. In order to protect all vegetables, they need to be harvested before khnoson.

The darkest and coldest time of year is when the land is frozen. The days are shorter than the nights during the chita-ekolon in early December. This lasts for approximately 40 days. The chita-ekolon follows for another 20 days. As the days are slowly lengthening, qid arrives and everything becomes alive again after having died during winter.

The coldest time of year is between mid-December and mid-February. The migratory birds have left before winter when the temperature begins to drop.

Avalanches are common during Bolo Gordon, the return of bad things. Often roads and pathways between villages become blocked and hazardous. To avoid danger, the villages are located outside of these areas. This is similar to a Khudoj where blessings are given, and food is shared.

Freezing streams in the Aqtash pasture is an indication to move the livestock to lower grounds. Aqtash is at a higher elevation than Savnib so if herdsmen walk in the morning the ice in water buckets, they know it is time to return. This cold weather arrives in late September and early October.

During taf-zamin, at the end of March, the weather is warming, the snow is melting, and steam can be seen coming from the ground. Some villagers choose to spread straw on the snow to help it melt faster.

Snowfall indicates the arrival of winter. It provides needed moisture to the crops and wild plants. If there is too much snow, the land remains wet and cold in the spring. This can be very dangerous for the livestock in April. The animals quickly lose weight and they have to travel far to find food. Planting will have to occur later, likely resulting in a poor harvest. Additionally, a winter with heavy snow can cause the wuzj (grey wolf, *Canis lupus*), nahcheer (altaf bee, *Capra sibirica*), foxes, and leopards to come down from the mountain to the village. Alternatively, in a dry year with little snow, the plants face early in the spring which also has an impact on the animals.

Winter has ended when the warm sun is shining brightly, and the snow is melting. The snowflakes are filled with water, called palak, and the land is in namrom, meaning it is wet soil. When the snow melts in the gorge, water begins to run making streams. It has possible to see the steam coming (taf-zamin) out of the land indicating that the soil is drying and now ready to plow and plant. This is an indication of spring.

When the first rain appears, it means winter has ended. Most of the rainfall occurs in spring, yet heavy rain in July and the beginning of August can damage klax Barlangi (wheat, *Triticum aestivum*) and chush (barley, *Hordeum vulgare*).

Dust is very common around Jofh, the summer solstice. This dust is also called afghanka and occurs when the qargha (red-billed and yellow-billed chough, *Pyrrhocorax pyrrhocorax* and *graculus* respectively) are calling in their nests and mint is being gathered. It is advised not to plant trees during afghanka.

The sun shining brightly indicates heat.

Warm temperatures in Savnib occur between June and August. In June, the nahcheer (altaf bee, *Capra sibirica*) give birth, herdsmen move to the highest of the pastures in Aqtash, wuzj (grey wolf, *Canis lupus*) attack the animals, and hunting takes place. It is also common for pests to appear during this warm period between June to July.

Water runs into the pastures in Ru at the same time the akhar (dogrose, *Rosa canina*) begins to flower. This also occurs during the second harvest and planting of radiska (turnip, *Brassica rapa rapa*). The source of water in Savnib comes from glaciers and snow. It is available in both the dry and in the wet years. With rain, temperatures in the summer, the glacier melts more rapidly. In July and August, the water from the spring is too warm and can kill the crops. Cooler weather and cooler water are needed for Aqtash boz.

During Nozh boz, in mid-July, the rivers begin to flood and wash out the roads at the same time the first nozh (apricot, *Prunus americana*) ripen.

There are occasional strong winds in late June which can damage roofs, causing injury and knock down large trees, including fruit trees.

Alai Valley, Kyrgyzstan

Sary Mogul

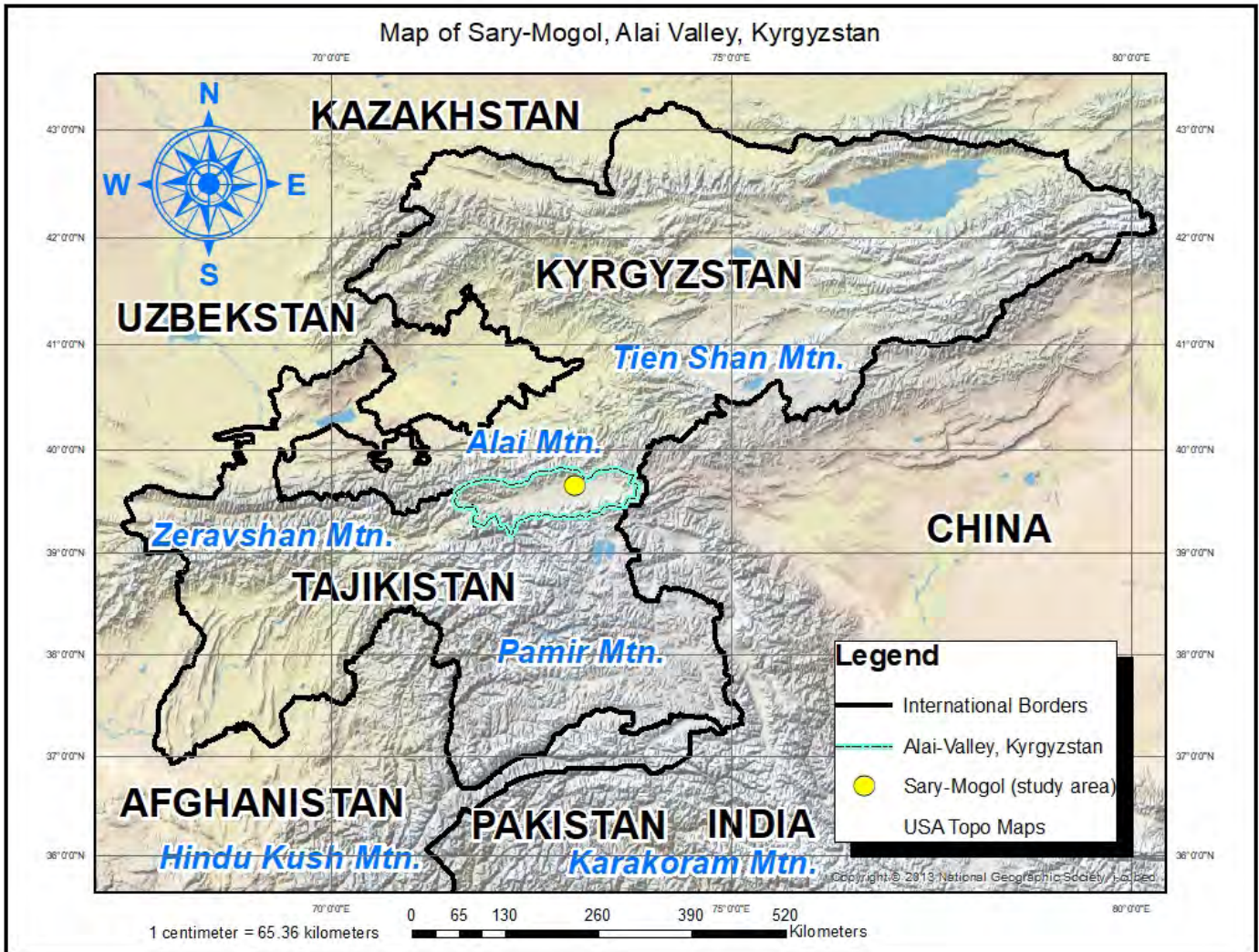


Figure 3.1: Sary Mogul in the Alai Valley

Sary Mogul

Alai Valley, Kyrgyzstan

Context

The village of Sary Mogul is in the Alai Valley of southern Kyrgyzstan at an elevation of around 3100 meters above sea level (Figure 3.1). The local livelihoods depend predominantly on herding and some farming practices. Community members engage in animal husbandry raising yaks, sheep, goats, and cows as well as grow crops like barley as fodder and potatoes for human consumption. Throughout the year, villagers are engaged in making livestock and crop related decisions. However, changes in the timing and severity of snow cover, and other shifts in seasonal weather patterns influence their livelihood activities.

It is commonly believed that Sary Mogul is a community of Kyrgyz from Tajikistan, who recently settled in the Alai Valley. However, the Alai Valley had been pastureland for several tribes before Soviet colonization of the region. Sary Mogul is not a homogenous village. Historically the village is formed of tribes from many ecological zones. For example, tribes arriving from lower part of Alai Valley, where barley and potatoes have long histories of cultivation, are experimenting with alternative crop cultivation in upper Alai. The inhabitants have various professions such as teachers, doctors, drivers, entrepreneurs, and veterinarians which supplement their income and support their activities on the land. Thus, Sary Mogul represents the ecological knowledge of those who arrived from surrounding areas and have adapted their knowledge to the climatic conditions in the Alai Valley.

Following the collapse of the Soviet Union, communities in the Pamirs of Central Asia faced food shortages. After the fall of the integrated Soviet planned system, which included state provisioned food systems, communities faced challenges in terms of self-reliant food production. Communities also faced uncertainties about decision making due to a shift from top-down decision-making systems in the Soviet times to bottom-up decision-making systems in the absence of governance structures and an emerging civil society. In the aftermath of the food crisis in the Alai Valley region (1998-2000), the Aga-Khan Development Network (AKDN) piloted several potato projects. Seed was brought from Chelpek Village farm, near Yssyk Kul Lake of Kyrgyzstan. Chelpek Village is located at a similar elevation, and it was hoped that these potatoes would grow in Sary Mogul. Some seed potatoes were brought from Jar-Bashy (at the western end of the Chon Alai Valley), Kyrgyzstan, and others from Suusamy, a 3000-meter-high valley between Osh City and Bishkek City. Seeds were also brought from Ishakshim (Wakhan Valley) in Tajikistan and planted in Sary Mogul. Some of these potatoes mature in 60 days, others in 90 days. Successful potato growth depends on sunlight, soil quality, and use of livestock manure. These local experiments with seed potato varieties informed adaptation strategies for the community. The ecological calendars project seeks to build on these and other projects, by focusing on the development of anticipatory capacity, further supporting adaptation strategies.

Ecological Calendar for Sary Mogul

The Ecological Calendars and Climate Adaptation Project (ECCAP) to help build anticipatory capacity to climate change began in 2016 with the initialization workshop described in the Introduction (Figure 3.2).



Figure 3.2: Developing the Seasonal Round in Sary Mogul Village, 2016

The ecological calendar of Sary Mogul contains an enormous amount of local knowledge. This community report highlights two essential uses of ecological calendars: seasonal livestock management and crop harvest which will be discussed below. The ecological calendar supports seasonal livestock herding and crop related decisions by contextualizing the timing of livelihood activities within the local ecology and season. Changes in the timing of snow fall, and the duration of snow cover are critical for herding activities as it determines when to move livestock between grazing pastures. Due to changes in the timing and duration of winter weather, the availability of fodder in spring has become an issue. Herders rely on fodder to sustain livestock through the winter. For example, people reported that in some years the grass is not growing as high as it did in the past, especially during the summer rainy season. People associate the low productivity of grass with more snow in winter and lack of favorable weather conditions in summer. In addition, shifting times of snowmelt is creating pressure on the availability of fodder grass. If snowmelt occurs late, the community is at risk of running out of the stored fodder, especially during the lambing season. This was the case in 2016. Therefore, the ecological calendar may help to secure lambing in the spring. The revitalized ecological calendar aids in deciding when to plant potatoes and when to harvest them based on the local knowledge of appropriate biophysical conditions. The ecological calendar, thus, points out existing uncertainties and helps to anticipate changes related to crop harvesting. This community report includes a description of the

revitalized ecological calendar for Sary Mogul. It describes how the calendar can contribute to herders' decisions and seasonal mobility, which is dependent on the duration of snow cover in winter, snow melt in spring, snow free times in summer and accumulation of snow in autumn. [Sary Mogul's ecological calendar](#) is attached at the end of this chapter. Please read the subsequent sections along with the ecological calendar for Sary Mogul (Figure 3.10).

Seasonal Livestock Cycle

Keeping livestock is an essential livelihood represented in the calendar of Sary Mogul village. There are four distinct seasonal migration patterns such as *baarloo* spring, *jailoo* summer, autumn *kyzdoo*, and *kyshtoo* winter in the ecological calendar. Temperature related events such as snow cover change is a vital cue that informs seasonal rotation of livestock. For the herders, these migration patterns, and events such as snow accumulation (autumn), snow cover (winter), snowmelt (spring), and snow free (summer) are extremely important to anticipate when to move livestock between pastures.

Throughout the winter (November to April), herders keep their livestock (specifically cows, goats, female yaks, and sheep) in the village, which is known as *koldo-karoo*. During this period people hand-feed livestock because there is no access to grazing lands due to deep snow in the upper Alai Valley. The period of hand feeding livestock depends on the period of snow cover. In other words, this period is determined by when snow accumulates, how long it remains, and how long it takes to melt. All of this is anticipated through local observations. The arrival of snowfall is typically expected between late September to early November; however, this timing has been changing. As snow accumulates, it prevents animals from grazing in the vicinity of the village. Therefore, the animals are sheltered and hand-fed in the barns until the snow melt in April.

As the snow disappears in spring (depending on snowmelt period), livestock are herded near the open grass fields both around the village and further away (depending on snow-free area). That short period of livestock herding (April to May) is called *kezuu*, which means to graze the livestock around a stationary camp. During this period, herders pay careful attention to temperature related cues like *guur-tyshty* (ice melt along the rivers), *ala-telek* (appearance of white and black snow patterns in the fields), and *sary-kar* (the arrival of the last yellow snow). White and black snow patterns (created by bare patches of ground being revealed by melting snow) determine the departure of winter, and arrival of spring. These cues inform when to initiate activities like moving livestock into the fields. This period of herding livestock around the village does not last long depending on when winter ends and when spring begins.

Depending on the snowmelt, herders then take their livestock to the *jailoo* summer pastures. According to the ecological calendar, summer begins when *kok chykyt* grass emerge. After which, *kok kubuu* livestock start grazing the newly emerged grass. Herders in Sary Mogul observe that livestock (cows, female yaks, goats, sheep) favor grazing upon fresh spring grasses as opposed to stored fodder. Herders then decide when to take their livestock to the summer pastures by observing snow melt in the pastures that are located at the southern Zaalai Range and the northern Alai Range (Figure 3.1). If herders remain in the village, managing livestock becomes impossible as new growth of barley will be in danger of being grazed by livestock. However, if it is too cold and snowy in the summer pasture valleys where they hope to graze livestock, then they must wait for the right time.

For herders, the summer is a time when more food is being produced. Throughout the warmest season (May to September), livestock produce dairy products. The period from April to October is known as *ak-chykyt* (milk products). From March to October, food produced by livestock, especially dairy products (*syt* - milk, *ayran* - yogurt, *kaimak* - cream, *kurut* cheese, *saamal*- horse milk, *kymyz*- fermented horse milk, *karyn mai* - butter, *sary mai* yak butter, and *syzmo*, processed yogurt), are eaten, processed, and stored in



Figure 3.3: Women from Sary Mogul Processing Dairy Products in the Pastures for Use in the Autumn, Winter and Spring. Photo credit: Karim-Aly Kassam 2016.

cold places. Dairy products are processed and stored in summer for consumption through to the following spring, especially in April and May. This period is known as the long yellow *uzun sary* (starvation period). Thus, from April to September, it is crucial to take advantage of the short growing season.

In early September when the *jailoo* summer pasture season ends, herders return to the village with their flocks to continue *kezuu* from late August to mid-September. The arrival of autumn is associated with the changing behaviors of livestock. In late August, livestock stop grazing in the higher pasture lands, and they descend to lower elevation fields due to decreasing temperatures. With the cold the livestock start to leave higher pastures even if grass is still available. This livestock behavior is called *otko-kachat*. An unexpected sudden frost during this time can threaten the herd.

Another vital decision for herders during the autumn is livestock breeding. As the winter approaches in October and November, the herders time domestic sheep breeding to plan for *baargi tol kiret* (spring lambing) in March and April. Currently, October seems to be the best time to breed sheep, because herders must be certain that lambing in spring takes place when temperatures are warmer. There is no fixed time for breeding, but people must consider the temperature changes in spring when breeding in the fall. The villagers allow for 5.5 to 6 months when breeding sheep. For example, if they breed in August, the livestock will lamb in March. When the herders return from summer pastures, and the temperatures are dropping (October or November) they begin breeding sheep and goats (known as *kochkor koshylat*). Five months after breeding, *baargi tol kiret* (spring lambing) takes place in March or April. Although some herders undertake *kyshky tol* (winter lambing), during January and February, this is not commonly practiced. Cold temperatures during the winter, the fear of exhausting fodder reserves, and the uncertainty

of spring arrival, are the primary concerns. For example, if the winter temperature is too cold, the young lambs might not survive during January.

Another essential event in the autumn is the mating and calving season of yaks (*Bos grunniens*). According to herders, yaks are very clever and climate-sensitive animals. Their mating and calving seasons are monitored to understand the seasonal shifts. Herders pay careful attention to yak mating periods, which vary from July to November; giving birth about nine months later (specifically 256-7 days after mating). Like sheep lambing season, yak calving takes place in spring when the temperature is warmer. If yaks mate early, then it is an indicator that the spring will come early, and the year would be *jenil* – meaning not difficult. *Topoz tol* yak calving period may occur from May to mid-July, during the favorable summer season. On the other hand, if the yaks delayed their mating in fall, this is an indication of the *oor* – difficult year. Pastoralists in Sary Mogul suggested that the average yak mating time should be in early October. The Yak mating season varies year-to-year, and the late mating of yaks is not desirable in the Alai Valley-signifying shifting of seasons.

Barley and Fodder Grass

The Alai Valley is known for its rich grasslands. Villagers grow barley and *Espartset* (*Onobrychis sativa*, known as common sainfoin) in addition to fodder grasses (*Leymus secalinus*, *Aceae spp.*, and *Atipa orientalis*). Barley, common sainfoin, and fodder grass are vital for several reasons. Collectively these plants are named *ot* – fodder grass. They ensure food security for livestock throughout the long winter and lambing season. Common sainfoin is a productive fodder grass that can provide 7-10 years of yield without re-planting. According to local people, barley is a top-quality fodder, followed by sainfoin, and other grasses harvested for livestock. Community members also rely on other fodder species such as *ak-bash godo* grass (*Stipa Orientalis*), *budai bashy* grass (*Poaceae spp.*), *kara-bash* grass (*Poaceae spp.*), and *kiyak* grass (*Leymus secalinus*). These are all widely grown in the Alai Valley.

Villagers follow sequences of planting and harvesting during the short growing season. As spring arrives, barley and common sainfoin are planted in late April. The right time to move livestock to summer pastures is a month after the barley was planted, when it develops *maiza* (spikelets) at the end of April to the end of May. *Maiza* or ripening time of barley is not the only cue used to determine the summer season. Barley and common sainfoin are planted in April, while potatoes are planted by mid-May. Planting cannot begin until the soil is thawed, as it is impossible to plant seeds into the frozen ground. Knowing when the ground will thaw in spring is vital for growing crops.

Throughout the summer, villagers depend on the climate for a good growing season (the taller the grass the better the yield). Depending on how much rain the area receives during the summer, barley will be irrigated 3-4 times during the growing season. The first irrigation occurs about 40 days after planting. Barley heads turning dark is a cue to irrigate. Rainy summers reduce the need for crop irrigation. However, too much rain also prevents successful crop growth. Ideally, there is a combination of enough sunlight and rain for a successful crop to grow.

As summer is coming to an end in early August, temperature related cues indicate the beginning of the harvesting season. When autumn arrives, days become colder, and a morning wind called *galdurgan shamal* occurs. People stated that this wind, in particular, indicates the beginning of autumn. The arrival of autumn is also informed by *ot-kaity* (color change in vegetation), particularly when the *ak-bash godo* (*Stipa orientalis*) and barley bends, stops growing, and changes color from green to yellow. Farmers also observe these changes in *ak-bash godo* grass (*Stipa orientalis*), *budai bashy* grass (*Poaceae spp.*) *kara-bash* grass (*Poaceae spp.*), *kiyak* grass (*Leymus secalinus*), and *at-kulak* common sorrel (*Rumex acetosa*). Quick changes of color in grasslands inform the seasonal transition from spring to autumn. Common sainfoin is harvested two times, in July and in September. Crops such as barley, common sainfoin, and natural hay

need to be collected during August to late September before livestock returns to the village. That is when grass dries, insects disappear, frosts begin, birds leave, and snow is expected. By the time snow arrives, it is crucial that people have stored fodder grass and are ready for the long winter.

Potatoes

Villagers have a small garden plot in front of their houses where they grow potatoes. Over the past two decades growing potatoes at elevations as high as 3000 meters has become possible. Although potatoes do not reach full size due to the short season, they are still cultivated, eaten, and stored for winter and spring. Some potatoes are sold in the market, and some are kept as seed for the next growing season.

The viability of growing potatoes locally, especially since 2000, is considered a positive change. However, many factors influence their successful yield. Local people have been experimenting with various potato varieties since 1990 and several local varieties exist: *Germansky*, *Picasso*, *Kardinal*, *Agava*, *Jele*, *Super Elita*, and *Chelpek*. Villagers have different perspectives on the successful adaption of these potato varieties. Villagers plant potatoes at different times in spring depending on their individual circumstances. In addition, some use fertilizers whereas others do not. The variability in growing seasons year-to-year also determines potato yields as factors such as the shifting times of spring snowmelt has created increasing uncertainty for the villagers. Further, potatoes are in the greatest danger during the harvest season, as an early frost in autumn may cause damage to the crop.

To address these challenges, we asked specific questions. How do you know when to harvest hay, barley, and potatoes? Focusing on the biophysical cues, villagers stated that they begin planting activities after the snow melts in spring, and then harvest crops before the arrival of snow in fall. However, snow melt and arrival depended on temperature changes, especially between April and May, and then August through October. For example, people start plowing and planting barley and common sainfoin when overall winter *tokson childe* ends, after snowmelt (*kar ketet*), when the earth becomes dark (*jerdin beti kararat*), and soil warms (*kerge tap kidi*) in April. Barley and common sainfoin are planted in late April, whereas potatoes are planted in early May. Changes in soil temperature varies slightly from year-to-year. The soil must become warm enough for potatoes to be planted, known as *jerge tap kirdi*. Generally, crops (barley, sainfoin, and potatoes) are planted in April through May, and are harvested in August through September.

Potatoes are also irrigated three to four times, the first occurring about 20-30 days after planting. Throughout the summer, villagers take turns irrigating plots. Each section of the village receives three-days of water flow, administrated by the village organization. Villagers also pay attention to the flowering time for different potato varieties compared to the previous year. Throughout the summer, they till the soil, creating extra space for crops to grow. They also remove extra grass that competes with the main crop.

Temperatures changing from warm to cold, play an essential role in harvesting crops, especially potatoes. Given the presence of multiple temperature indicators (e.g., insects, animals, and plants), observing co-occurring temperature-related events provides growers with valuable knowledge to make decisions. For example, potatoes are collected when frosts begin, their leaves start to drop and change color, pasturelands start to turn yellow, and when migratory birds begin to depart. Potatoes are important for the community because they provided food, income, and seed stock. Food sources such as processed or dried dairy products and especially potatoes, are stored in root cellars to be consumed during winter and spring. Most villagers harvest potatoes before the end of September. Other indicators, such as the departure of migratory birds or hibernation of marmots, may also be informative when deciding when to harvest potatoes.

Participants shared several ecological indicators, such as frost being related to the departure of migratory birds, or hibernation of marmots. The primary threat in autumn is *kyrgyek*, a sudden frost that could kill both young livestock as well as damage potatoes. The notion *kyrgyek* referred to sudden frost and the departure of the migratory birds in the Alai Valley. Early signs of frost are vital indicators for crop harvest. Participants reported a co-occurrence between bird migration and land-use activities, especially in the fall. People also stated that crops are planted only after the arrival of migratory birds, especially *torgoi* (skylarks) and another small green bird that we could not identify. The departure or return of migratory birds informs the community about temperature changes, in particular, the arrival of cold weather in the fall.

The community harvests crops relying on biophysical events in spring and autumn. Further, by observing ecological indicators of autumn, specifically observing early signs of frost (changes in the color of potato leaves and dropping of their leaves) when collecting potatoes. Villagers collect potatoes prior to arrival of cold, frozen ground, and arrival of snow, which is usually after the second week in September. Sudden temperature declines (frost and cold weather) prevent them from keeping potatoes in the soil until October. Hence, understanding ecological cues may further aid seasonal coping strategies. By observing ecological indicators that are triggered by temperature changes (e.g., cold days, frost, and drying plants), villagers may protect potatoes from sudden frosts in fall.

Working with the Ecological Calendar

The knowledge in the calendar was collected from villagers with diverse ecological professions. Therefore, it represents a variety of needs, priorities, and decisions that can be specific to individuals, but could also be common to many villagers. Some people raise horses and others are yak herders. Some people specialize in crops like barley and potatoes. Depending on the needs and priorities of decision-making in the cycle of the season, they could be looking at different cues for different purposes at different times. To demonstrate, let us situate ourselves in spring and autumn and take a few examples of how to use the knowledge in the ecological calendar.

Springs and summers are crucial seasons for livestock (sheep, horses, and yaks) breeding in the Alai Valley. For that to occur, herders consider temperature change driven cues in spring. The days must be warm enough when sheep lambing starts. Villagers also pay close attention when snow vanishes, and icicles melt. While yaks and horses mate with minimal human involvement, sheep breeding is very important for villagers in the autumn. As mentioned above, there are two practices of sheep breeding, winter, and spring. We have learned that villagers prefer to time sheep breeding for spring because they consider cues like warmer days, snow melt, and ice melt. In addition, they are concerned that sometimes fodder grass is not developed enough in the spring. Therefore, more fodder in fall might be useful to anticipate changes (shifting seasons) in spring (Figure 3.4).

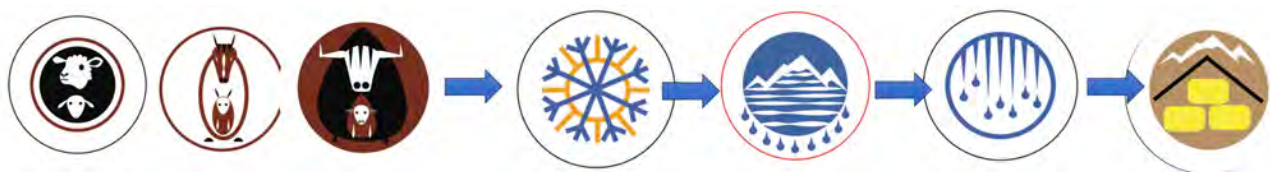


Figure 3.4: Sheep Lambing in Spring

As mentioned above and in the calendar, seasonal herding is vital to insure the wellbeing of livestock and community throughout the season. We have learned that herders pay attention to snow related changes as they move their livestock to different pastures. Snow melt in the spring informs herding livestock around the

village. As snow melts in the summer pastures, farmers take their livestock to the summer pasture during the snow free time. With temperature changes in fall and upon arrival of snow, farmers bring their livestock to the village. During the snow cover period, herders hand feed livestock in the village (Figure 3.5).



Figure 3.5: Seasonal Livestock Herding Cycle

During the short growing season, farmers do their best to grow barley, sainfoin and potatoes. Especially, potatoes are essential crops for the villagers. Farmers know the right time to plant crops by observing frosts. Then, farmers plant barley and sainfoin. With potatoes, farmers pay attention to the heat and steam coming out of soil. The soil must be right for potatoes to be planted (Figure 3.6).

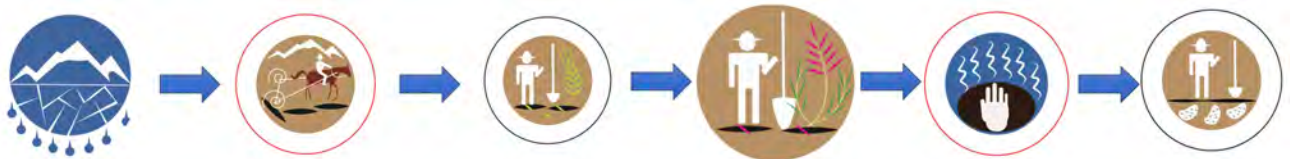


Figure 3.6: Harvesting Barley, Sainfoin and Potatoes in Spring

The use of ecological calendar in spring is not limited to one or two cues. When herders make decisions, they also consider other co-occurring biophysical events in spring. For example, warmer days (temperature change), ice-break-up in the river, emergence of flowers, waking of marmots from hibernation, surfacing of grass, appearance of insects, and arrival of migratory birds all inform of the onset of spring (Figure 3.7).



Figure 3.7: Co-Occurring Indicators in Spring

An important moment of decision making occurs with the arrival of autumn with temperature changes. People prepare to harvest hay, barley, sainfoin, and potatoes. An important indicator of autumn begins with temperature changes that drive many other changes and seasonally related human decisions. As for the fodder, villagers consider color changes in the north and south facing hills and mountain valleys. As the growing season ends, rich grass fields bend and dry. That is when farmers undertake harvesting fodder grass (Figure 3.8).

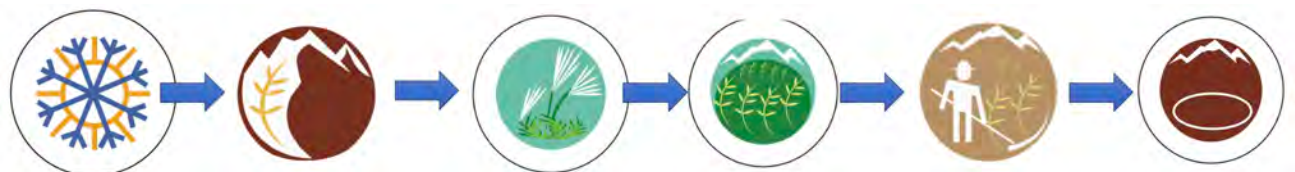


Figure 3.8: Fodder Harvest

During the harvesting season, herders do their best to store enough fodder as livestock return to the village. Farmers continue harvesting sainfoin, barley, and potatoes. One of the important weather events affecting the harvesting of potatoes is an unexpected frost. By observing early signs of frost on the grass and drying and dying potatoes leaves, farmers gather their crops. Early signs of temperature changes in the autumn are vital for a successful harvest. If not collected, frost might destroy the potatoes. By the time of ground freeze, farmers must collect potatoes and all crops (Figure 3.9).

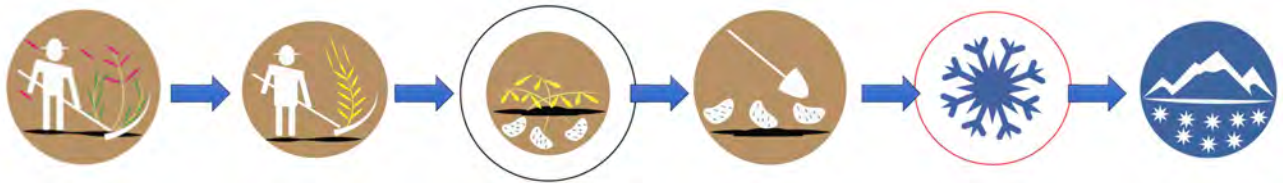


Figure 3.9: Sainfoin, Barley and Potatoes

Similarly, there are co-occurring events that are anticipated during the seasonal decision making, especially in the autumn. Villagers pay attention to the arrival of wind, departure of birds, disappearance of insects, hibernation of marmots, arrival of snow and freezing water in the rivers and streams (Figure 3.10).



Figure 3.9: Co-Occurring Indicators in the Autumn

As a result of five years of collaboration with the farmers and herders, we have documented and revitalized a rich local knowledge of the ecological calendar in response to specific community needs and climate change. Changes related to snow cover during winter, snowmelt in spring, snow free in summer, and snow accumulation in autumn are key for the seasonal rotation of livestock. Hence, an ecological calendar offers practical benefit for livestock related seasonal decisions. Such a calendar may help time sheep breeding to ensure that the lambs are born in warmer spring. However, lately herders are facing shortage of fodder because of shifting spring seasons. Herders could store more fodder to prepare for increasingly variable times of snowmelt in the spring. As for the cropping and agriculture, our research with the community revealed that potatoes were essential for the villagers' food system. Although yet to be validated by the community, this draft ecological calendar reveals essential knowledge about the timing of crops, growing season, and harvesting period. Despite the challenge of frost damaging potatoes, early indicators of autumn could help villagers to harvest potatoes on time. Furthermore, given the importance of herding and animal husbandry in Sary Mogul, better understanding of timing of seasons through the ecological calendar for fodder production is fundamentally linked to livestock management and survival.

The Seasonal Calendar of Life: Sary Mogul, Alai valley, Kyrgyzstan

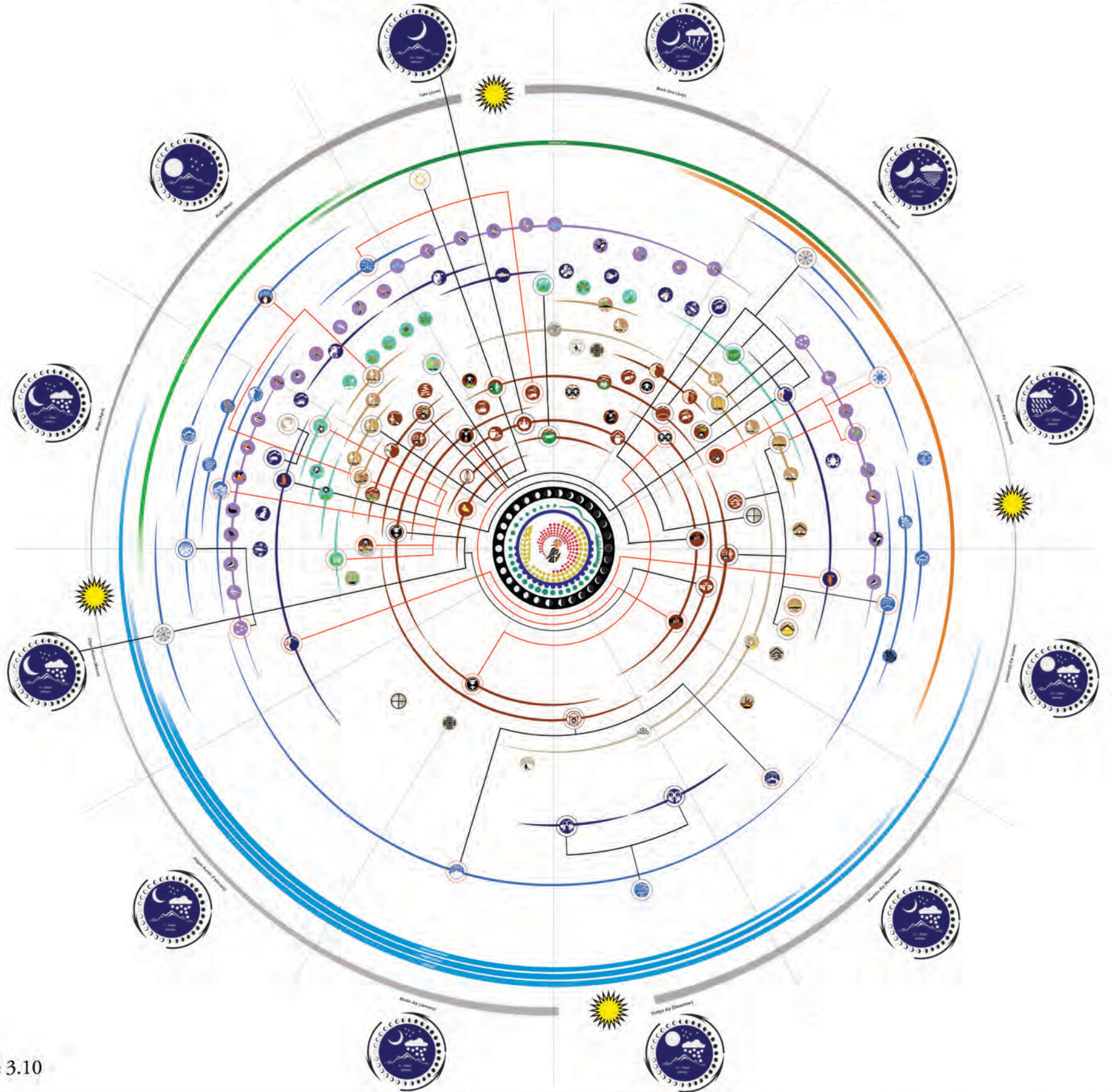


Figure 3.10

Upstate New York, USA

Oneida Lake Watershed

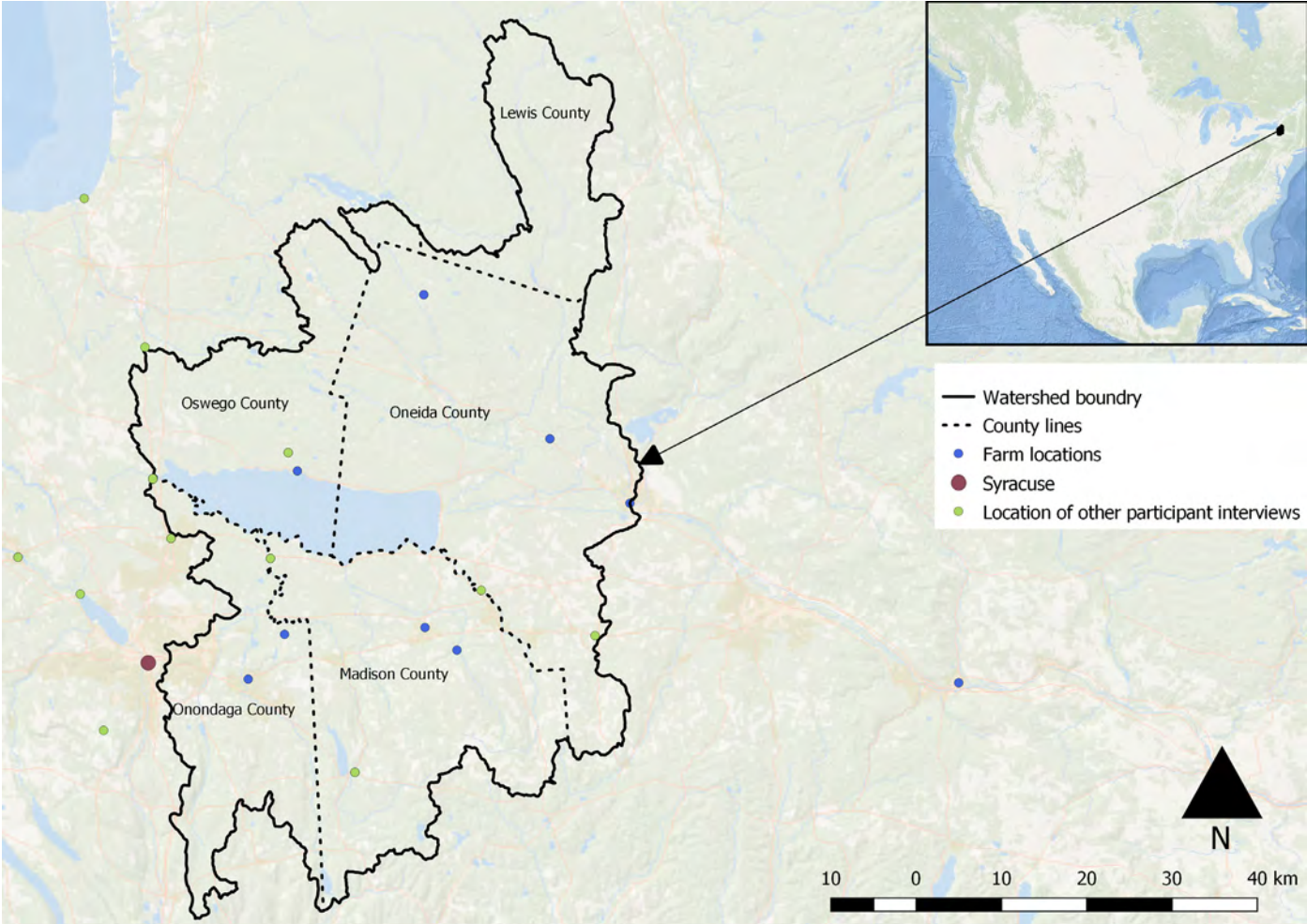


Figure 4.1: Map of the Oneida Lake Watershed

Oneida Lake Watershed

Upstate New York, United States of America

Context

Following a research methodology described in the Introduction, this project began in 2016 with a workshop held at the Cornell Biological Field Station at Shackleton Point on the south shore of Oneida Lake near Syracuse, New York, USA (Table 4.1). Anglers, hunters, farmers, orchardists, local business owners, state employees, and other community leaders and professionals were invited to participate. The goal of the workshop was to determine the priorities and concerns of the resident ith respect to climate change (Table 4.1). At the workshop, participants shared an abundance of knowledge relating to phenological events, seasonal practices, and environmental changes by generating seasonal rounds (Figure 4.2). The workshop was repeated on two consecutive days, with different people participating on each day. Twelve community members and several researchers from Cornell participated both days.

Additional semi-structured interviews were conducted with 52 participants between 2016 and 2017. A follow up workshop was held February 22-23, 2019 with 16 participants. Its goal was to share the information we distilled

Concerns and challenges
Poor fall bite for fish (warm lake temperatures).
Increasing volatility of weather in spring.
Drought-like condition followed by heavy rain and flooding in the summer
Lingering winter conditions (low temperature and heavy wind) in spring. However, not cold enough for lake to remain frozen.
Increasing number of nuisance animal calls in early spring.
Warmer falls negatively impacting deer rut.
Shorter ice fishing season.
Clay soils/mud.
Wet spring impacting ability to plant crops, Wet spring impacting animal health.
More severe storms.
Higher cost of new equipment.
Later spring frosts.
Hotter summers.
Warmer winters cause more insect problems.
Long winters lasting through March can result in deer mortality.
No snow on the ground in late fall, which negatively impacts deer hunting.
If the ground does not freeze, then the soil remains compact, as freezing water expands in the soil creating room for aeration.
Trees budding early.
More difficult to catch fish.
Loss of habitat for birds.
Hard to find places to access lake.
Warmer weather impacting dairy production.

Table 4.1: A list of concerns and challenges as reported by residents living in and around the Oneida Lake Watershed. The list includes information shared during the initial workshops in 2016, as well as from two additional workshops held in 2019 and 2021.

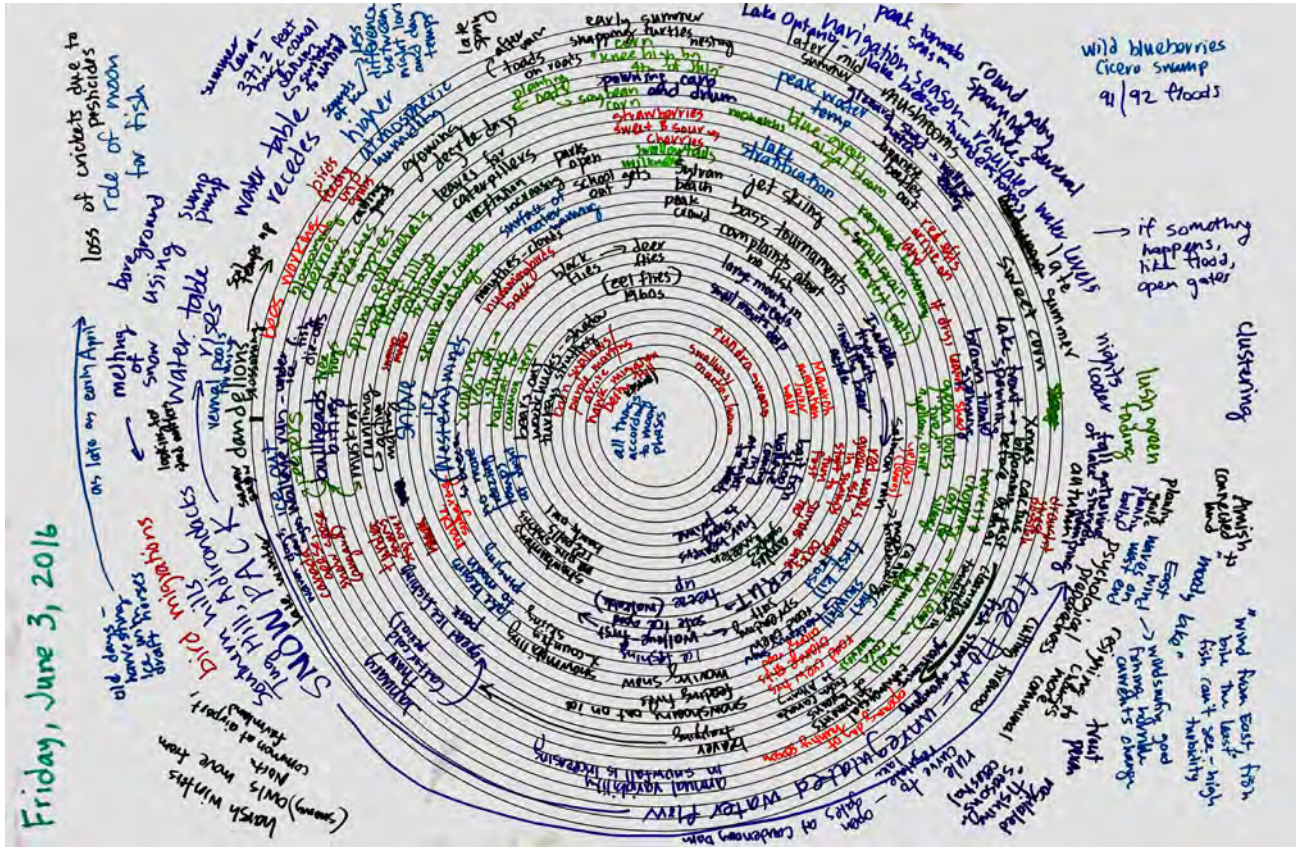


Figure 4.2: Seasonal Round Generated at the Friday June 3, 2016 Workshop

from the interviews and provide an opportunity for additional input on the project. We refer to this as a validation workshop, as it is an opportunity for the community to validate the researchers’ analyses, reducing the likelihood of misinterpretations, and providing an means to contribute clarifying information (Figure 1.2 in the Introduction). A second set of validation workshops was held July 23-24, 2021 with 15 community participants. A final version of the ecological calendar was presented at this workshop, and participants were given the opportunity to provide feedback, while also discussing possible future directions of the project.

In addition to concerns and challenges, the initial workshops in 2016 included a broader conversation

Desired outcomes
A network for gathering data.
An ecological calendar that: <ul style="list-style-type: none"> • Can be used from day-to-day for tracking the timing of migration and other phenological events. • Is interactive. • Informs about seasonal changes.
Information about trends and how they are affecting human activities.
Adaptive practices that take advantage of a changing climate.
Executive summary and report.
Scientific publications accessible to the public.
Inspire future generations to continue practices such as hunting and farming.
Help those involved to “think globally and act locally.”
Create “interest and love for the lake, within people.”

Table 4.2: A List of Desired Project Outcomes from Participants Living in and around the Oneida Lake Watershed. The list includes information shared during the initial workshops in 2016, as well as from two additional workshops held in 2019 and 2021.



Figure 4.3: Discussion During the Friday June 3, 2016 Workshop at the Cornell Biological Field Station at Shackelton Point.



Figure 4.4: Validation Workshop, February 23, 2019.

about desired outcomes for this research (Table 4.2). Many of the desired outcomes expressed in the initial workshops were echoed and added to in subsequent interviews and validation workshops. The [ecological calendar for Oneida Lake](#) is attached at the end of this chapter. Please read the subsequent sections along with the ecological calendar for Oneida Lake (Figure 4.8).

Phenological events

Here the term “related phenological events” is used to describe when an observed phenomenon (both biotic and abiotic) or set of phenomena occur at specific times relative to each other (Table 4.3).

- A sequence is when a set of phenomena are reported as occurring in a specific order (note that the time between the occurrence of each phenomenon in a sequence may vary); for example, the appearance of trillium, wild leeks, honeysuckle, and serviceberry (which themselves are considered a synchrony) inform the observer that frosts are coming to an end. This relationship is maintained because these plants require certain environmental conditions to grow, and thus time their emergence from dormancy with the period when the appropriate environmental conditions are most likely to occur.
- Synchrony is when a set of two or more phenomena are reported as occurring at relatively the same time—flies and bees coming out at the same time as hummingbirds showing up.
- A cue is when a phenomenon or set of phenomena prompt the beginning of an activity—Crocuses blooming act as a cue for good perch fishing.

Type	Timing	As seen in the calendar
Sequence	April/May	
Synchrony	April/May	
Cue	April	

Table 4.3: Examples of a Sequence, a Synchrony, and a Cue, as Depicted in the Ecological Calendar for the Oneida Lake Watershed.

Sequences

The calendar for the Oneida Lake Watershed contains 26 sequences (Table 4.4). Some crucial sequences to note are indicators signaling the ending of regular snowfall and frosts in the spring. For instance, the arrival of purple martin, followed by blue birds, then tree swallows, and finally, other swallows to the area, is an indicator that daily frosts will be coming to an end. Several sequences are associated with the ending of frosts, each providing different specificities in the information they convey, such as the migration of purple

martin, blue birds, tree swallows, and other swallows indicating the ending of daily frosts. Other sequences, for example, the appearance of trillium, wild leeks, honeysuckle, and serviceberry, indicate all frosts coming to an end. Even more specifically, the appearance of bedstraw indicates that 2-3 frosts likely remain.

The related phenological events discussed in Table 4.4 provide insight into how the ecological calendar can be employed. Events in the calendar are depicted as occurring within a window of time. For example, the events mentioned above occur between mid-April and late May, a critical period for decision making because farmers need to plant crops. However, planting crops too early puts them at

Sequence	Range of time
Mild winter → Turkeys begin to strut early.	February
Snowdrop budding and snow disappearing → Ice-out on Oneida Lake.	February – April
Bullheads spawn → Catfish spawn.	Mid-March – April
Snow beginning to disappear and Fiddle heads poking up through snow → Blue spruce tips ready to make tea → Horses shedding.	Mid-March – April
Ice-out → Cormorants return → Muskrats marking territory (distinct smell).	Mid-March – April
Northern pike spawn → Walleye spawn → Perch spawn.	Mid-March – Late May
Peepers start vocalizing and stone flies metamorphosize → Walleye spawn.	February – April
Redbud blossom → Dogwood blossom → Swamp and star magnolias blossom.	April
Plant oats and other small grains → Plant soybeans and corn → Plant haylage → Plant alfalfa → Plant other beans (Late frosts can be detrimental to these activities).	Mid-April – Early June
Maple in swamps turn red → Barn swallows and purple martins return.	Mid-April – Early May
Purple Martin arrive → Blue birds and tree swallows arrive → Other swallows arriving → Frosts no longer occur every day.	Mid-April – Mid-May
Appearance of trillium, wild leeks, honeysuckle, and serviceberry → Frosts coming to an end.	Mid-April – Mid-May
Appearance of bedstraw → Two to three frosts remain.	Mid-April – Mid-May
Serviceberry (also known as shad bush) flowers → Shad migrate and insects hatching.	May
Plant second round of fall crops (spinach, kale, beets, lettuce, broccoli) → Memorial Day Weekend → Last frost → Transplant warm weather plants (Tomatoes, peppers, eggplants, beans) → Plant winter squash and pumpkins.	Mid-May – Mid-June
Temperatures regularly reach -60°F → Woodchucks come out of holes.	June
Swallow tails arrive → Monarch butterflies arrive	Mid-June – Early July
(Mushrooms) Chicken of the woods → Edible russula → Edible amanita ready for harvesting.	Late June – Early September
Oneida Lake water temperatures rise → Walleye and other fish move to deeper water.	August
Blue winged teal and wood ducks migrate south → Wigeons migrate → Rest of dabbling ducks.	September
Songbirds migrate south → Native trout and salmon spawn.	Mid-September – October
Temperatures drop → Walleye follow bait fish closer to shore.	Mid-September – October
Several hard frosts occur → Vegetation dies back (Can be delayed by warmer than usual temperatures).	October
Cold October → Good coats on muskrats.	October
Rabbits out foraging and then hole up immediately prior to an incoming storm.	November
Inland swamps freeze → Mallards show up on lake → Lake freezes for duck hunters (ice around lake edges prevents boats from being launched).	December

Table 4.4: A Complete List of Sequences Found in the Ecological Calendar for the Oneida Lake Watershed. A dash indicates that there is a synchrony also involved in the related phenological events.

greater risk of crop damage by late frosts. On the other hand, planting crops too late will shorten the time for plants to mature and possibly reduce the yield at harvest. This trade-off between waiting until it is safe from frosts but planting early enough to take advantage of the entire growing season will come down to individual farmers and may be informed by the use of the ecological calendar. It is essential that individuals using the calendar also pay attention to other subtle shifts in the environment, such as temperature and precipitation. In doing so, users integrate their ability to sense the environment around them with the information being provided by the observable indicators.

Synchronies

Another type of related phenological event present within the ecological calendar is synchrony (Table 4.5). Again, synchrony describes when two or more phenomena consistently occur at the same time as each other. Like sequences, synchronies can be useful for orienting oneself within the ecological year.

Synchronies can also reveal shifting weather patterns. For example, participants associated the migration of mallards, black ducks, canvasbacks, and redhead ducks, blue winged teal, and wood ducks with frosts beginning in the fall. Notably, while sequences indicate the order in which events are observed, they do not convey the time between each event. As such, sequences may inform the user of incoming seasonal transitions, but not their specific timing. In contrast, synchronies inform us about events or indicators that occur at the same or overlapping periods of time. Furthermore, they may give contextual cues that one may be in a transitional phase between seasons.

Participants explicitly mentioned synchronies that were included in the calendar (Table 4.5). While it is possible to draw a vertical line through the calendar that would intersect several events occurring around the same time, these events may sometimes occur at different times of the year due to weather conditions or other factors. Therefore, unless the calendar indicates that a synchrony was explicitly identified by participants, such alignments should be considered as *potential* synchronies. With that said, these potential synchronies may be worth investigating to establish other instances of related phenological events that may further benefit the calendar user in situating their place within the ecological year. Below is a full list of synchronies included in the ecological calendar.

Synchronies	Range of time
Ground hardens – Snow becomes stable – Ice cap forms on lake (can be delayed or even obstructed entirely by a warm winter).	December – January
Snow beginning to disappear – Fiddle heads poking up through snow.	Mid-March – April
Start lettuce, broccoli, and cauliflower in greenhouse.	Mid-March
Flies and bees come out – Hummingbirds show up.	April – Early May
Crappie active – Crappie and bait fish appear near shores – Trout becomes more active – Lake temperatures warm to around -50oF.	April
Appearance of trillium, wild leeks, honeysuckle, and serviceberry.	Mid-April – Mid-May
Purple martin and barn swallows return.	Mid-April – Mid-May
Shad migrate – Insect eggs hatch.	May
Snapping turtles lay eggs – Carp spawn – Drum spawn.	Mid-May – Mid-June
Mallards - Canvas backs - Blue winged teal - Wood ducks - Redheads migrate – Frosts begin.	October – December
Mice hole up – Muskrat huts appear – First freeze.	October – Late November
Sweet tooth hedgehog - yellow foot chanterelles - bears tooth - lion's mane mushrooms are ready to gather.	Mid-September – Early November

Table 4.5: A Complete List of Synchronies Found in the Ecological Calendar for the Oneida Lake Watershed.

Cues

Participants also noted phenomena and other related phenological events that acted as specific cues to begin activities (Table 4.6). For example, a rapid drop in temperature, usually observed in October, is a cue for good walleye and perch fishing.

Cues	Range of time
Deep snow → Rabbit and grouse hunting.	January
January thaw → Good ice fishing (Warm winters may delay or prevent the lake from forming stable ice).	January
Freezing nighttime temperatures and warm daytime temperatures → Begin tapping maples.	January – March
Skunks and raccoon come out of dens – Freezing temperatures at night above freezing during the day – Let cows out to pasture.	March – April
Crocus bloom → Good bullhead fishing	March – April
Ground thaws → Transplant brassicas and plant oats.	March – April
Grass begins to grow, and ground hardens → Let cows out to pasture (Muddy ground due to wet spring or freezing and thawing events may impact timing).	March – April
Peepers start vocalizing and maple trees budding → Stop tapping maple trees.	March – April
Apples blossoming, and muskrats begin marking territory → Good bullhead fishing.	Mid-March – April
Ground temperature ~ 50° F → Begin planting corn.	May
Timothy (grass) and orchard grass seed heads appear → First cut of hay (can be delayed by heavy rain).	Mid-May – Mid-July
Frosts start → Cover plant beds with leaves and straw.	September – October
Top two thirds of garlic leaves turn yellow → Harvest garlic.	September – October
Corn dries → Begin shelling corn with a combine.	October – November
First killing frost → Good for harvesting apples, grapes and chokecherries.	October – November
Vegetation dies back → Put decoys out for duck hunting.	Mid-October – November

Table 4.6: A Complete List of Cues Found in the Ecological Calendar for the Oneida Lake Watershed.

Other Events

Several activities and other phenomena were not reported as part of a related phenological event (Table 4.7). These were included as reference points throughout the year. For example, ice on the Lake making moaning and pinging noises (January – February) was not explicitly linked to other events. However, it represents a time when the temperature is fluctuating; this may be useful for situating oneself within the ecological year.

Event	Range of time
Lake moans and makes pinging noises.	January – February
Chaga mushroom around.	Late January – Late February and Mid November – Early December
Start transplants indoors.	Late January – Mid-March
Pigs let out of barns.	April – Mid-May
Pheasant's back mushrooms appear.	Mid-April – Early May
Walleye fishing best in shallow water (2 feet deep).	Early May – Early June
Direct seed radishes.	Early May – Early June
Strawberry picking.	Early June – Late June
Blueberry picking.	July – Late August
Harvest salt potatoes.	Mid-July – Late July
Shaggy mane mushroom around.	Mid-August – Mid-October
Apple picking.	Late August – Mid-October
Bring dairy cows into barn.	Late September – Mid-October
Puffballs ready to harvest.	Late September – Mid-October
Yellow foot chanterelles around.	October – Mid-November
Ice begins to form on Oneida Lake (delayed or obstructed by a warm winter)	November – December
Regular snows can begin.	November

Table 4.7: Other Events Found in the Ecological Calendar for the Oneida Lake Watershed.

Working with the Ecological Calendar

Structure

The ecological calendar for the Oneida Lake Watershed Consists of four major sections. The bottom section includes the seasons (spring, summer, fall, and winter) as well as hunting, fishing, and trapping seasons. These seasons are linked to the calendar dates and are set by the state government, and thus, are not flexible.

Moving up, the second section above the seasons is bird abundance data, which is separated by county, based on data gathered from eBird¹ (a citizen science data platform). The graphs in the calendar indicate average abundance between January 1, 2014, and December 31, 2019. Some birds are observable all year but are more visible and active during specific periods of the year. For example, mallards migrate in early fall, which coincides with the first frosts. However, mallards are observable during other periods of the year, so their presence or absence alone does not provide enough information for decision making. Rather, their behavior (such as migration) along with other related phenology (for example, the migration of canvas backs, blue winged teal, wood ducks, and redheads migrate) should also be considered.

The third section from the bottom includes observations of several other groups of organisms. The data for these observations comes from the same period as the bird data (January 1, 2014, through December 31, 2019) and is primarily sourced from iNaturalist, herbarium specimens, and the U.S. National Phenological Network.² The bars in this section represent ranges of time wherein observations have been made. However, they do not provide insight into the abundance of those organisms at different times of year, but only the time periods when observation is possible. Like the bird abundance data, these observations can help to interpret the indicators above. These observations provide some insight into the degree to which organisms' activity and observability vary within the year and from year to year.

The top section consists of the indicators, sequences, synchronies, cues, activities, and weather events shared by community members who participated in the research project via workshops and interviews. The bars represent the timing of observations and activities. Importantly, as illustrated in the example above with mallards, these ranges may not represent the only times that a particular organism is observable. Instead, they may represent a time when observations of that organism may have special significance. Related phenological events are depicted with arrows. A solid arrow indicates a sequence, a dotted arrow indicates a cue, and a double-sided arrow indicates a synchrony. Hazards such as heavy rain are also included to indicate that the related phenological event may be impacted by such events (Figure 4.5).

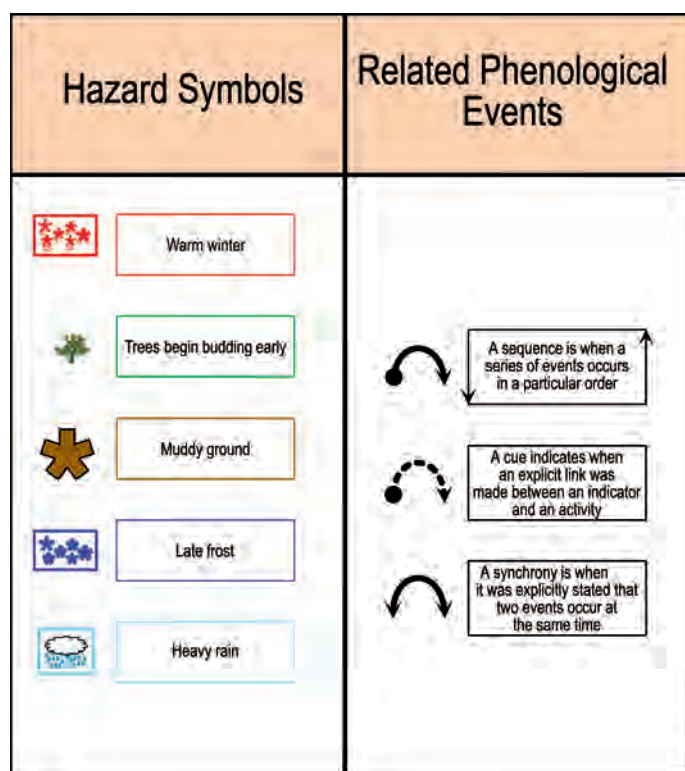


Figure 4.5: Legend for Ecological Calendar and Notation Used to Indicate Hazards and Related Phenological Events.

- 1 eBird. (2020). eBird: An online database of bird distribution and abundance [web application]. Cornell Lab of Ornithology. <http://www.ebird.org>
- 2 GBIF.org (2020), GBIF Home Page. Available from: <https://www.gbif.org> [13 January 2020]

Indicators and events are color-coded based on the type of organism (Figure 4.6).

Using and maintaining the ecological calendar

Drawing a vertical line anywhere on the calendar will link together events that occur at similar times of year. When using the calendar (Figure 4.7), the reader may first want to identify the activity that they would like to engage in, and the necessary conditions for that activity. For example, farmers may want to begin planting oats in the spring, but to do so, they need to ensure that the risk of a hard frost has passed. Therefore, the reader will look above and below the activity or the conditions needed for related phenological events. In this case, the appearance of certain plants and migratory birds coincides with frosts coming to an end. Now you may consider when the indicator species signaling the desired conditions (for example, the appearance of trillium, wild leeks, honeysuckle and service berry indicating that frosts are coming to an end) were observed in the past. As mentioned above, looking at the timing of observations in years past can help interpret observations in the current year.

After a window of time is identified, one can begin making new observations of the relevant indicator species. These new observations can be added back into the calendar, thus updating it. Once the necessary conditions have been met, then you can begin the activity.

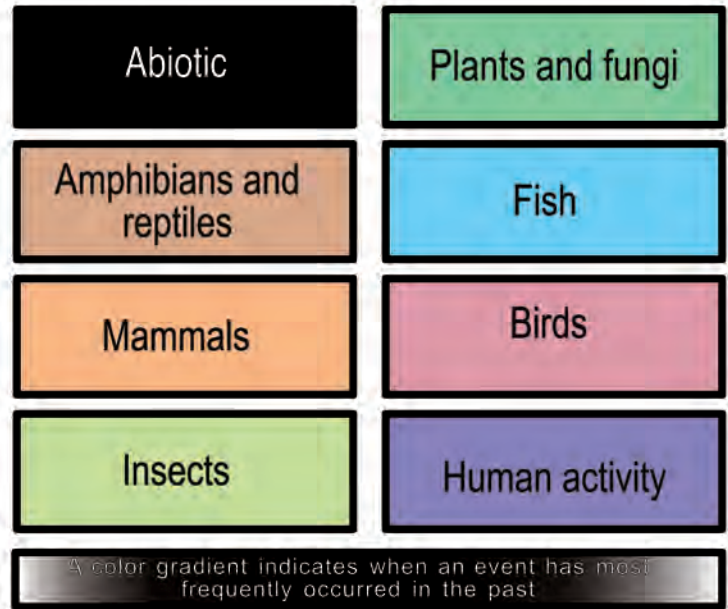


Figure 4.6: Color Codes for Different Organisms and Events in the Ecological Calendar.

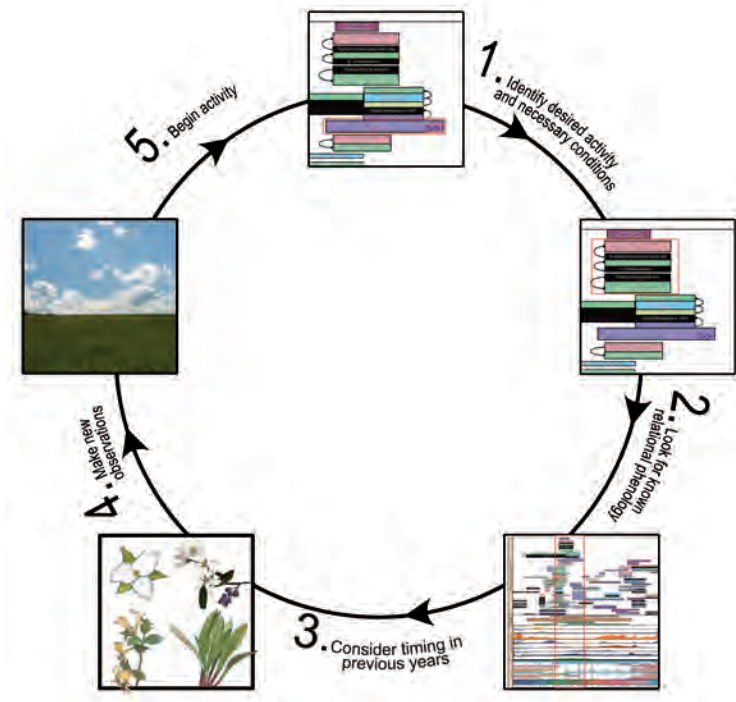


Figure 4.7: Diagram Depicting the Iterative Process of Using and Updating the Ecological Calendar.

Further Research

There is a need to further investigate the environmental challenges that individuals face and who specifically is most at risk under ongoing climate change. This ought to include those engaging in different ecological professions and other factors that influence people's risk, such as age, gender, and income. Importantly people often engage in a multitude of ecological professions. As such, their understanding often reflects a diversity of skills and ecological knowledge. Untangling the unique challenges and benefits associated with these groups may provide additional insight into how specific segments of the population will be impacted by changing environments.

As has been noted, the relative timing of phenological events may shift in the future. In some cases, the development or behavior of species may no longer occur in synchrony, and even the order of sequences may change. In such cases, there will be a need to identify new indicator species that are more reliable under future conditions. However, depending on the rate of change, this may not be practically possible if, for example, no reliable indicators can be identified. This is one of the major challenges for the application of ecological calendars as a tool for climate adaptation. The ecological calendar depends on being able to identify consistently reliable indicator species.

Phenology is heavily context dependent. Many organisms are responding to both biological and physical phenomenon. Among scientists, long-term phenological observations for any given species within a specific context are relatively rare. This report demonstrates the value of local knowledge held by people who engage in practices within their environment (for example, hunting, farming, and trapping) that require them to learn about the relationships between phenological events. In the context of anthropogenic climate change, this knowledge serves as a basis for future research, in that it can focus research on known phenology relevant to the people living in the area. Scientists can bring added value to the relationships observed by communities by engaging in more in-depth investigations of specific indicator species' response to local environmental change.

Another critical area of study would be examining the flowering or sprouting time among different species within a genus of interest, for example, *Amelanchier* (serviceberry) or *Lonicera* (honeysuckle). Many of the phenological indicators included in the calendar are only specific to the level of genus. Future work should ensure that indicators are identified at the level of species when possible. Lastly, different stages of development (phenophase) may provide different information to fine-tune the calendar. It is possible that documenting different life stages for the organisms used as indicators could provide additional detail to the calendar.

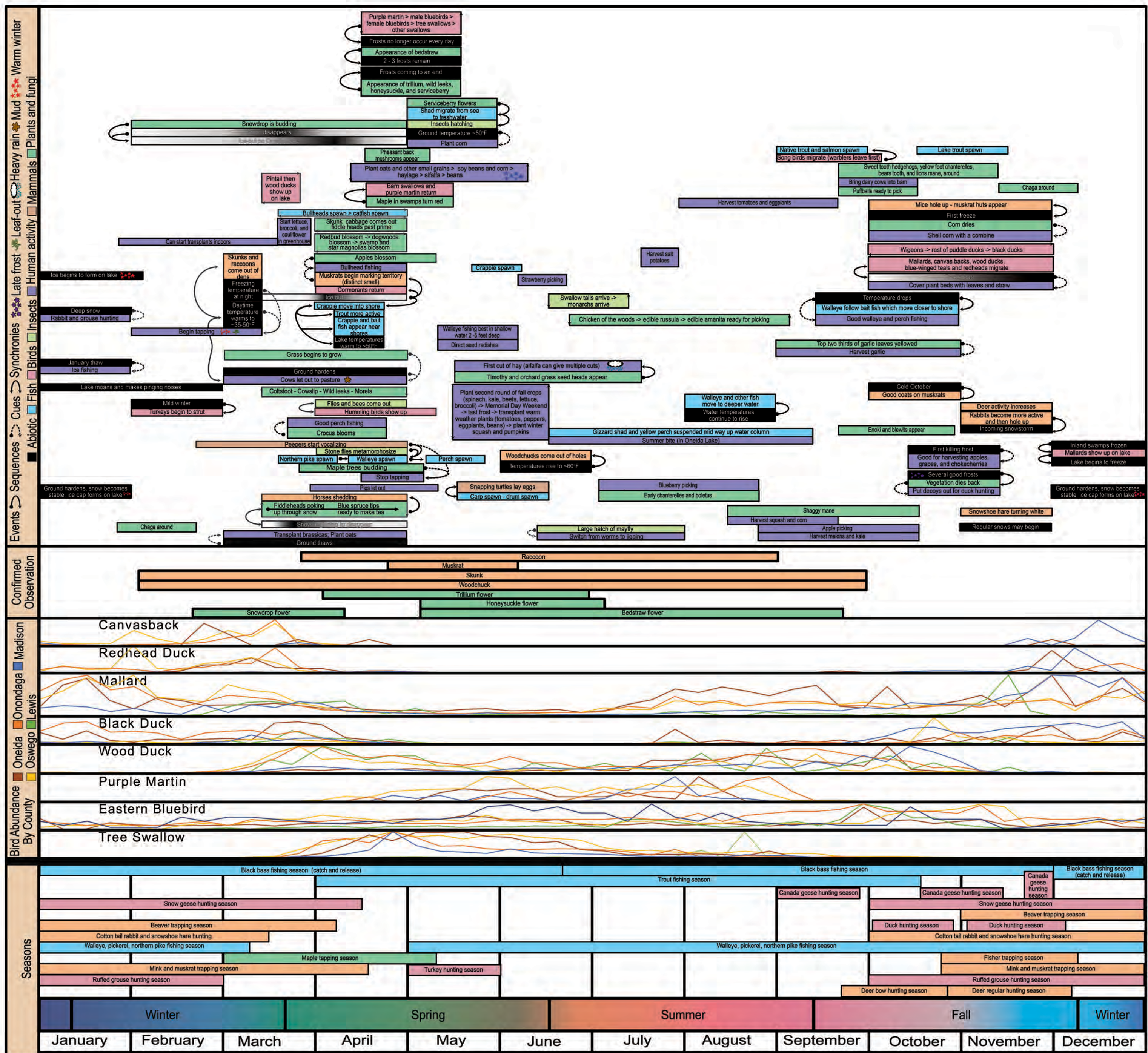


Figure 4.8

Ecological Calendar for Oneida Lake Watershed, 2021



North and South Dakota, USA

Standing Rock Sioux Nation

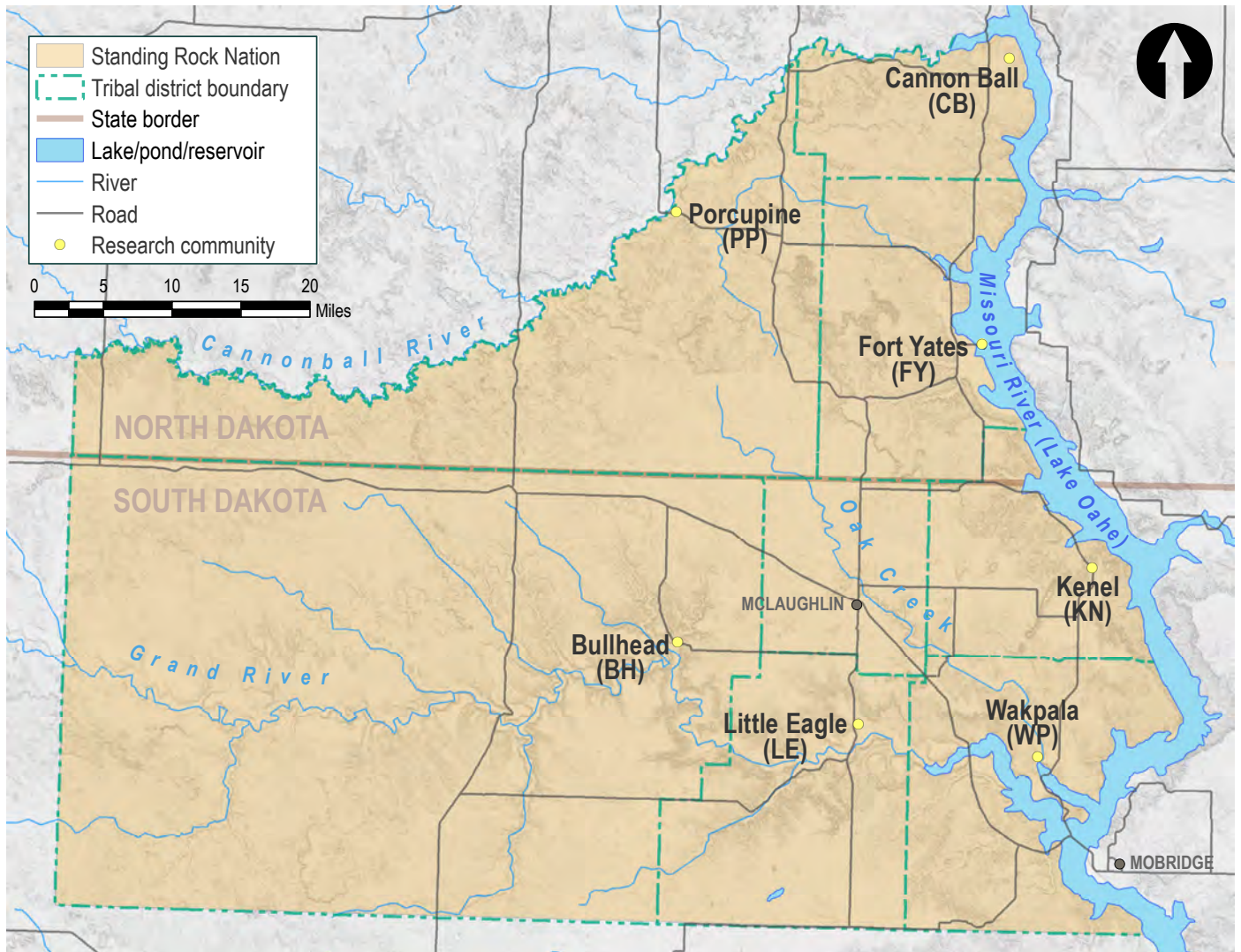


Figure 5.1: Map of the Seven Communities in the Standing Rock Nation where Participants Co-generated Ecological Calendars. Two-letter codes beneath each community name are used in the Community Knowledge Base.

Standing Rock Sioux Nation

North and South Dakota, United States of America

Context

In our workshops and interviews to develop and validate ecological calendars, participants pointed out that every community is unique based on its location, history, and traditions. We worked with seven communities (Figure 5.1) to develop their own ecological calendars that reflect and honor those differences. Before we present the seven ecological calendars from Standing Rock, we introduce the communities and highlight some of the unique qualities of their calendars.

Bullhead is in the southern part of Standing Rock, along Rock Creek where it joins the Grand River. Bullhead's calendar reflects a wide range of activities related to the local food system, including gathering plants, gardening, hunting, and livestock husbandry. As can be seen in many other calendars, the first and last frosts (in the fall and spring, respectively) serve as important cues for several of those activities. Powwows and memorial rides are included in this calendar, indicating their significance to the community.

Cannon Ball is in the far north of Standing Rock, just south of the Cannonball River where it joins the Missouri. Many residents of the community were forcibly relocated from their homes along the river following the completion of the Oahe Dam in 1959. Nevertheless, their ecological calendar includes many references to rivers and fishing. Other highlights include changes in the timing of hunting (from summer to fall) as a result of regulations, and attention to the qualities of clouds through the seasons.

Fort Yates is south of Cannon Ball in the northern part of the reservation on a hill overlooking the Missouri River, which has become an island because of the Oahe Dam. Fort Yates is the largest community in Standing Rock and the seat of government for the Standing Rock Sioux Tribe. Many residents grew up in other parts of Standing Rock and moved to Fort Yates to work for the tribal government. The ecological calendar, therefore, incorporates knowledge from multiple communities including details about gardening and raising animals.

Kenel is south of Fort Yates along Highway 1806. Most Elders in Kenel grew up in 'Old Kenel', which was permanently inundated by the Oahe Dam, and relocated to their current community on a hill overlooking the river. Much of the information in the ecological calendar is from the past, reflecting life before the dam. In those days, residents of Kenel could more easily cross the Missouri to the Euro-American settler community of Pollock, South Dakota, which is mentioned frequently in the knowledge base. Finally, Elders in Kenel assigned seasons to months differently than the other communities, with winter lasting five months, from November to March.

Little Eagle is in the southern part of Standing Rock along the banks of the Grand River. The river near Little Eagle is lined by riparian forests, which provide habitat for many of the plants and animals included in their ecological calendar. The Little Eagle calendar includes Lakota names for many plants because several fluent speakers participated in our workshops.

Porcupine is on the northeastern border of Standing Rock, on the south bank of the Cannonball River directly across from the Euro-American community of Shields, North Dakota. The forests along the river include many boxelder trees, which are mentioned in the calendar and knowledge base.

Wakpala is in the far southeastern corner of Standing Rock, in a low area where the Oak Creek joins the Missouri River. As in Cannon Ball and Kenel, many families in Wakpala were relocated from homes along the Missouri following the completion of the Oahe Dam. The calendar refers to popular activities within the community including raising and riding horses as well as fishing, and incorporates Lakota names for most of the months. However, the Elder who provided these names emphasized that families name months differently according to their knowledge and experience.

The [ecological calendars for Standing Rock Sioux Nation](#) are included at the end of this chapter. Please read the subsequent sections along with the ecological calendars for Standing Rock Sioux Nation (Figures 5.22 - 5.28).

Working with the Ecological Calendar

Season

A season is a period of time identified by criteria established within a community. For example, most participants identified the season winter (*waniyetu*) based on cold temperatures and snow. Participants also use specific dates and months to define seasons. For instance, winter is typically described as starting in December and ending in February. For the ecological calendars in this community report, seasons are indicated by colors around the outside of the calendar. English and/or Dakota or Lakota names are included, depending on the terms that were used by community members during workshops and interviews.

Seasonal event

An *event* is a phenomenon that occurs at a particular point in time. For example, hearing the sandhill cranes flying north, going to a basketball playoff game, or visiting the dentist are all events. *Seasonal events* are phenomena that take place within a particular period of time. The sandhill cranes fly north in the spring, and basketball playoffs are usually in the late winter or early spring, so these could be considered seasonal events. By contrast, a dentist appointment could be scheduled at any time, so we would not consider it to be a seasonal event. The ecological calendars in this report are comprised of seasonal events. Events that could occur at any time of year are not included in the calendars.

Seasonal indicator

A seasonal indicator is an event that signifies the beginning or end of a season. Individuals and communities may use several seasonal indicators to determine that one season has ended, and another has begun. For example, in Standing Rock there are numerous indicators of spring: the first thunder, the meadowlark singing, and the blossoming of pasque flowers (known to some as prairie crocuses). Seasons might begin and end earlier or later (in terms of months and days) depending on when these events are observed. For example, in 2016, many participants heard a meadowlark sing in early March, indicating that spring had come earlier than usual that year.

Seasonal indicators are marked on the ecological calendars with a hexagon that contains two colors representing the transition from one season to the next (Figure 5.2). Blue, green, yellow, and orange represent winter, spring, summer, and fall (autumn), respectively.

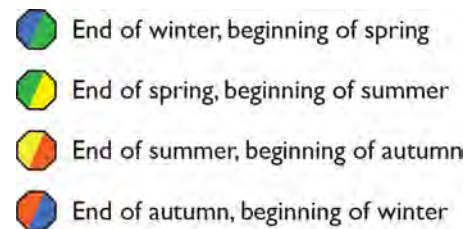


Figure 5.2: Legend for Seasonal Indicators in the Standing Rock Ecological

For example, the icon with blue on the left and green on the right represents a seasonal indicator for spring, signifying the end of winter and beginning of spring.

Synchrony

A synchrony occurs when two or more events occur at the same time. For instance, some community members always gather wild onions and prairie turnips (*thiŋpsinla*) together or observe that eagles and geese migrate north around the same time. In those cases, the two events are marked with two-directional green arrows pointing to both events on the ecological calendar (Figure 5.3).

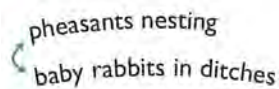


Figure 5.3: An Example of Synchrony from the Bullhead Ecological Calendar.

Sequence

A sequence is a series of seasonal events that occur in a particular order. For example, many participants said that Juneberries ripen before chokecherries, which ripen before wild plums. The timing of these events may change from year to year, but they consistently occur in the same order. In the ecological calendar, sequences are identified with an orange arrow beginning with a solid circle that points from one event to the next, indicating the first occurs before the second (Figure 5.4).



Figure 5.4: An Example of a Sequence in the Cannon Ball Ecological Calendar.

Cause-and-effect

Sometimes one event is directly responsible for another, either immediately or after a short period of time. For example, members of some communities say that the first thunder wakes up hibernating animals. In the ecological calendars, cause-and-effect relationships are indicated by a blue arrow beginning with a closed triangle that points from the cause to the effect (Figure 5.5).

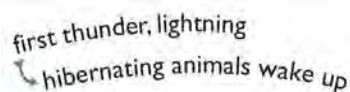


Figure 5.5: An Example of a Cause-and-effect Relationship in the Little Eagle Ecological Calendar.

Cues

A cue is a seasonal event that informs the timing of a human activity, usually based on direct observation. Cues are like cause-and-effect phenomena, but they rely on acting in response to the event. For instance, many participants harvest buffalo berries after the first frost, because the berries become sweeter and drop off the bush more easily. If the frost comes earlier than usual, gatherers need to be ready to gather the buffalo berries. The window of opportunity is limited because birds will start eating the berries as soon as they are sweet. Another example of a cue was passed down to an Elder from her grandfather, who explained it is time to plant a garden when the wild roses along the roadsides bloom, as this indicates the frost is out of the ground.

Cues are a particularly important part of ecological calendars because they allow communities to synchronize their livelihood activities with the seasonal events in their habitat, even if those events come earlier or later in the year. In the ecological calendars, cues are indicated by a purple arrow beginning with an open circle pointing from the seasonal event to the activity (Figure 5.6).

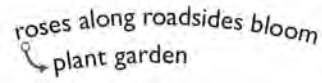


Figure 5.6: An Example of a Cue from the Little Eagle Ecological Calendar.

Block

A block is a seasonal event that indicates it is time to stop or finish an activity. In some ways, a block is the opposite of a cue. For example, members of several communities say they stop gathering red willow (*čhanšáša*) when thunder returns at the beginning of spring. In the ecological calendars, blocks are indicated by a red arrow beginning with an open square. The arrow points back from the seasonal event that serves as a block toward the activity that should be stopped whenever the block occurs (Figure 5.7).



Figure 5.7: An Example of a Block in the Wakpala Ecological Calendar.

Predictor

A predictor is a seasonal event that provides information about whether another seasonal event will occur, or if that season will have a specific character or quality. Predictors are a type of sequence, because one event provides information about a future event. Predictors differ from cause-and-effect phenomena because the first event is not responsible for the predicted event. For example, community members in Wakpala predict it will be a cold winter if they see crows fly south. In the ecological calendars, predictors are indicated by a blue arrow beginning with an open triangle. The arrow points from the predictor to the prediction (Figure 5.8).



Figure 5.8: An Example of a Predictor in the Wakpala Ecological Calendar.

Other features of the ecological calendars

Seasonal phenomena are said to occur in a season, perhaps in relation to other phenomena (in which case arrows describe those relations), and still others are associated with a period on the Gregorian calendar (for example, the months of July and August). Phenomena associated with a **specific period of time** are underlined, with two white arrows pointing inward to identify the beginning and end of that period. Phenomena that are associated with a season but not a specific period of time on the Gregorian calendar are not underlined. In the example from the Little Eagle ecological calendar, April showers are known to occur in the Gregorian month of April, whereas planning and fundraising for powwows could occur at any time in the spring (Figure 5.9).

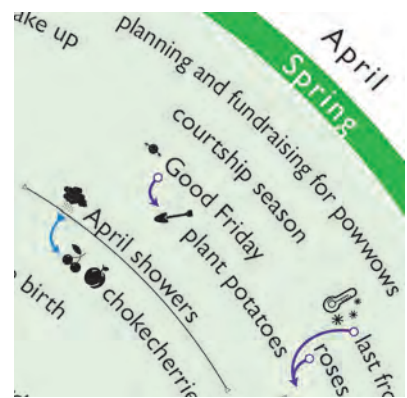


Figure 5.9: An Example from Little Eagle of a Seasonal Event Known to Occur at a Specific Time (April showers, underlined) as well as One Associated Within a Season (planning and fundraising for powwows, not underlined).

Icons are used to link knowledge related to the plant, animal, or activity in different parts of the calendar. For example, the Wakpala calendar refers to geese in the spring as well as the fall, so a special icon for geese is included. The same icons are included in the Community Knowledge Base to follow. However, no icon is included if a plant, animal, or activity appears in only one season. Subsequently, many of the entries in the Community Knowledge Base do not include an icon, because they are associated with only one season in the ecological calendars.

Past phenomena that no longer occur are written in brown type. For example, participants in Cannon Ball reported that in winters past, their grandparents would lay cedar boughs on the woodstove, which filled their houses with a pleasant smell. To our knowledge, this activity is no longer practiced, so it is written in brown on the calendar.

Community Knowledge Base

It is not possible to visualize all of the knowledge shared and documented during workshops and interviews. This Community Knowledge Base is intended to accompany the seven ecological calendars and provide additional nuance and insight. It is organized into five sections: seasons, weather, plants, animals, and human activities. It is meant to serve as a reference, meaning the reader is able to locate information pertaining to any item on the ecological calendars without reading from start to finish.

The Community Knowledge Base honors the diversity of knowledge among Standing Rock communities. Each of the seven communities contributed to the knowledge base. Information from different communities is compiled but not combined in order to showcase similarities and differences among communities. For example, the entry for Juneberries includes information about the best time to gather this species, which differs among communities. The reader can see the source of information based on two-letter codes – one for each community. For example, a sentence followed by ‘LE’ in parentheses indicates the knowledge came from the community of Little Eagle. In addition, the Community Knowledge Base includes additional information obtained from other sources, which are cited using footnotes.

There are many reasons why knowledge differs among communities in Standing Rock. First, geographic location (for example, latitude, elevation, proximity to the Missouri River) affects the timing of seasonal events in each community. Second, differences reflect the cultural diversity within Standing Rock, which is home to the Ihaŋkthunwaŋna, Huŋkpatina, Huŋkpapha and Sihasapa of the Western Dakota and Lakota, other Indigenous nations, Euro-American settlers, and other cultural groups. Many Standing Rock residents belong to multiple cultural communities; that complexity is reflected in the ecological calendars and accompanying knowledge base.

Third, Indigenous ecological knowledge has been negatively impacted by colonialist policies of the U.S. government. Beginning in the 1880s, government agents and church officials began a long-lasting campaign to assimilate Standing Rock children into ‘mainstream’ society by taking them away to boarding schools. They were not able to speak their language or spend time on the land with their families. In 1959, the U.S. federal government completed the Oahe Dam on the Missouri River, one of many dams that permanently inundated and destroyed riparian forests on tribal lands. Hundreds of families that lived along the river and relied on the forests were forcibly removed to new communities on the prairie, where they were required to adapt to an unfamiliar and more challenging way of life. The ecological calendars of those communities reflect the deep impacts of that traumatic displacement on their knowledge systems, as well as their resistance and determination to retain their social systems and cultural values.

Finally, the impacts of anthropogenic climate change vary among Standing Rock communities, resulting in different experiences and knowledge. One purpose of this community report is to exchange knowledge

about climate change among Standing Rock communities, as well as with the other communities in this book. Building on one another's knowledge will expand our options to anticipate and respond to the most complex and pressing challenges of our time.

Seasons

Most communities explained spring begins in March and continues through April and May. One word for spring is *wóžu*, a word that refers to planting (LE). In the past, spring lasted from March to May; now, March is too cold to plant, and spring starts in April or May (KN).

Most communities said summer occurs in June, July and August. One name for summer is *wétu* (LE), which is also used for spring.¹ Another name for summer is *blokétu*, which refers to heat (FY). Summer lasts from June until August (KN).

Most communities said fall (autumn) includes September, October, and November. Fall is *ptanyétu* (LE) and *ptanyétu wi* refers to the sun turning into a cold region (FY). Fall is in September and October; November is already winter; fall is short, and winter is long (KN).

As for winter, most communities said it is in December, January, and February. Winter is *waniyetu* (LE). In one community, participants describe winter to last from October to March; it is therefore the longest season (KN).

Weather

Blizzards

Blizzards come in winter (BH), and the end of blizzards is an indicator of spring (FY). The last blizzard of the year can come as late as May (CB). A blizzard can last for several days (KN), two or three days (BH), or three to five days (CB), with heavy snow and wind (BH). Community members cannot do anything but stay inside (BH). During a blizzard there is wind as well as snow so you cannot see (KN). A snowstorm includes blowing snow, but a blizzard is different because there is a total white-out (CB). During a blizzard it is difficult to go anywhere (KN). Even a community member with a lot of money and a truck will have difficulty traveling, because only horses are useful in a blizzard (KN). Blizzards cause a lot of problems (CB). In the past, if a family ran out of water during a blizzard, they would melt snow to drink (KN). There were more blizzards in the past (PP). There was a very bad blizzard in 1966 and another in 1990 (KN). Cannon Ball was relocated following the construction of the Oahe Dam in 1959, away from the shelter of the river valley to the top of a hill. As a result, the community is more vulnerable to wind and blizzards (CB).

Weather data from 1996 to 2020 indicate blizzards occur between October and April, with the highest prevalence recorded in December, January, and March. Figure 5.10 illustrates the number of recorded blizzards in northern and southern Standing Rock (Sioux County, North Dakota and Corson County, South Dakota, respectively).

Clouds ☁

The clouds in spring are white and fluffy, whereas in mid-summer, there are 'wind clouds', a wall of dark clouds with tall formations on top (CB). 'Fall clouds' are grey and cold (CB).

¹ *New Lakota Dictionary: Lakǰótiyapi-English, English-Lakǰótiyapi & Incorporating the Dakota Dialects of Yankton-Yanktonai & Santee-Sisseton*, ed. by J. Ullrich (Bloomington, IN: Lakota Language Consortium, 2008).

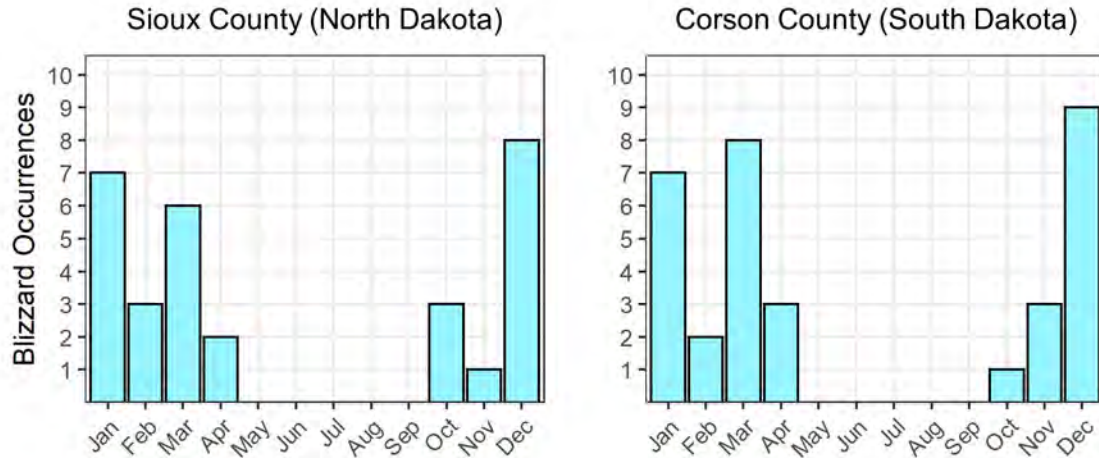


Figure 5.10: Occurrence of Blizzards in Standing Rock (1996-2020).²

Fire

Wildfires can occur in spring, summer, or fall, whenever there is a drought (BH).

Flooding

In the spring, melting snow causes rivers and creeks to rise, which results in flooding (KN, WP). It is important to be prepared for floods (KN). In Porcupine, the river can reach the baseball field and cover the road (PP). However, if there is not much snow, there is not much of a spring flood (WP). Later, in June, there is a phenomenon known as June rise when water from the mountains fills all the streams (FY).

In Porcupine, there were bad floods in either 2012 or 2013 that destroyed the bridge above the town (PP). Porcupine was also flooded out in 1966 (PP). In Wakpala, the most recent flood came soon after the construction of the Oahe Dam in 1959. The floodwaters were unable to subside because the dam held the water within the community (WP). In Bullhead, there has not been a flood for some time (BH). When it floods, some families park on top of hills, while young people tend to go to the casino (BH). In the past, families used to stay at the bingo hall in McLaughlin during floods (BH).

Weather data from 1996 to 2020 indicate that floods occur between February and October, with the highest numbers of flooding events recorded in March, April, June, and July. Figure 5.11 shows the number of flooding events recorded in northern and southern Standing Rock (Sioux County, North Dakota and Corson County, South Dakota, respectively). Many more flooding events were recorded in the southern part of Standing Rock, particularly in the spring during March and April as well as in June.

Frost

The last frost generally occurs in May (BH, CB). One participant said “you just know” when it is the last frost of the spring (LE). Most gardeners wait to plant until the risk of frost has passed (LE). One Elder recounted her grandfather explaining when the roses along the road bloom, it means “the frost is out of the ground” and it is safe to plant a garden (LE). Spiders appear outside when the risk of frost has passed (WP).

² National Centers for Environmental Information, ‘Climate Data Online’, *National Oceanic and Atmosphere Association* <<https://www.ncdc.noaa.gov/cdo-web/>> [accessed 25 August 2021].

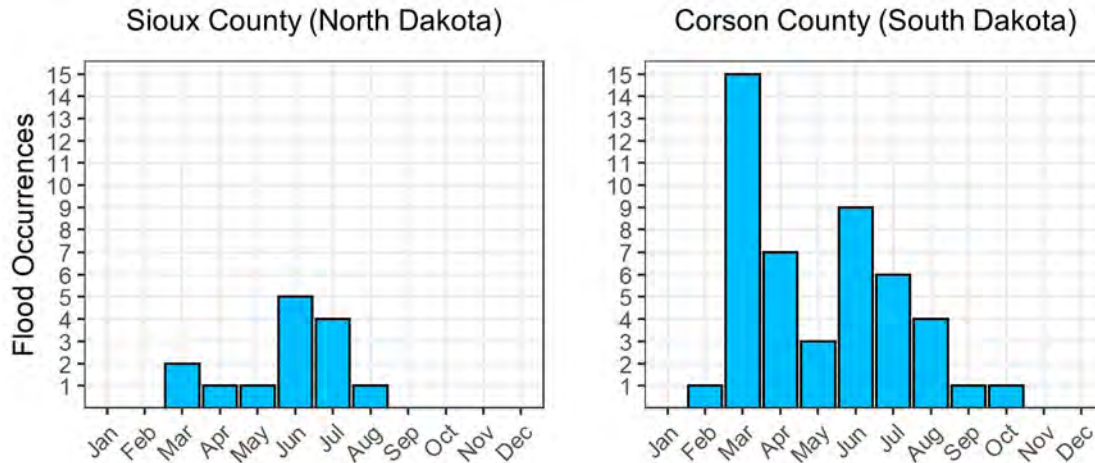


Figure 5.11: Occurrence of Floods in Standing Rock (1996-2020).³

A late frost can occur after the chokecherries and wild plums blossom, which prevents them from producing fruit (LE). If gardeners anticipate a late frost, they cover their plants with milk jugs (LE).

The timing of the first frost varies from year to year (FY). The first frost can arrive in mid-September (CB), late September (BH, CB, FY, LE), or early October (CB, LE).

Historical data collected at weather stations in Mandan, North Dakota (1914-2020) and Mobridge, South Dakota (1911-2020) indicate that the first frost occurs in September or early October. In Mandan, we did not observe a significant change in the date of the first frost ($p = 0.099$). However, in Mobridge, the first frost has been arriving significantly later ($p=0.001$), on average one day later every seven years. The graphs below (Figure 5.12) show the long-term trend illustrated by a dashed red line, with confidence interval shaded. They also reveal the 10-year moving average, depicted by a solid blue line.

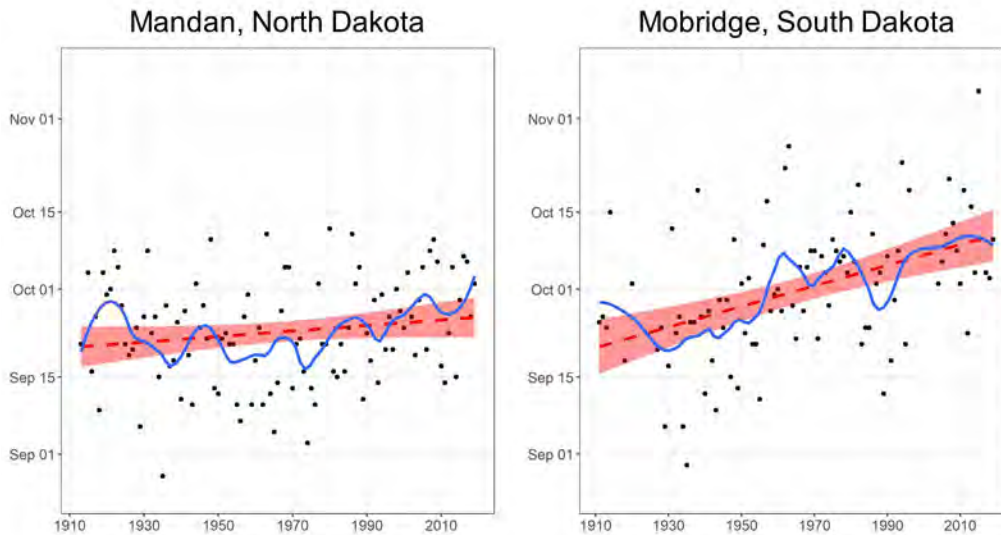


Figure 5.12: Change in Date of First Frost in Autumn, as Recorded at Local Weather Stations (1911-2020).⁴

3 National Centers for Environmental Information.

4 National Centers for Environmental Information.

These historical data also indicated the last frost to occur between mid-April and early June. The date of the last frost is more variable than that of the first frost. In Mandan there is no significant trend ($p = 0.184$) in the date of the last frost. However, in Mobridge, the last frost has been coming significantly earlier ($p=0.005$). On average, it arrives one day earlier every ten years. Figure 5.13 shows the long-term trend in a dashed red line, with confidence interval shaded, as well as the 10-year moving average in a solid blue line.

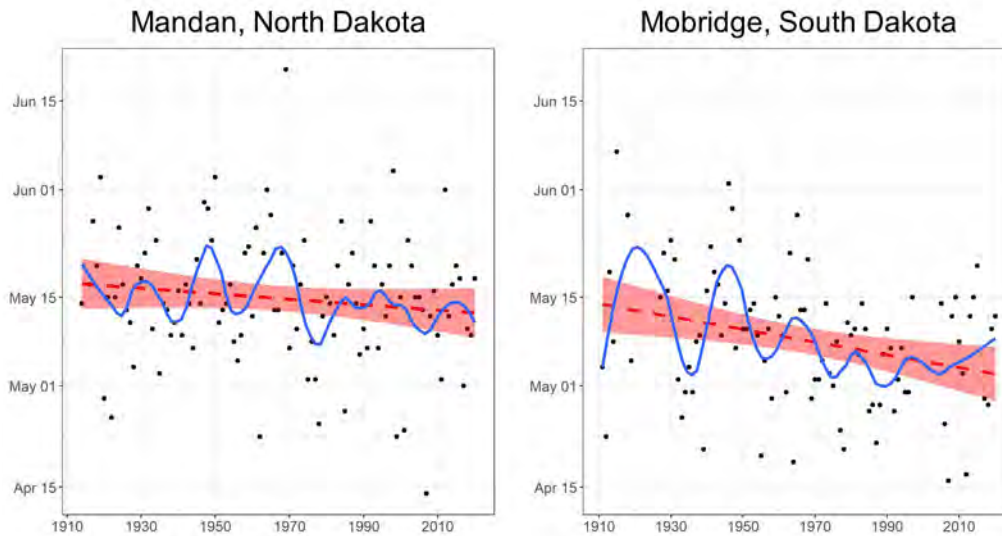


Figure 5.13: Change in Date of Last Frost in Spring, as Recorded at Local Weather Stations (1911-2020).⁵

Ice

The Missouri River freezes before Christmas and thaws at the beginning of spring in March (KN). In the past, residents of Pollock (a town across the Missouri River from Kenel) would cross the river to buy goods from the Kenel store and attend dances (KN). Residents of Little Eagle used to harvest ice from rivers and store it in a big wooden barrel for drinking (LE).

The breakup of ice in rivers, which often results in flooding, is an indicator of spring (BH, CB, KN, WP). For some Elders, it is the sound of ice breaking, which can sound like a rifle shot, that serves as an indicator (CB). One Elder remembered hearing the ice break and realizing her family needed to move their horses back to the right side of the river to prevent them from becoming stranded (WP). Usually, ice breakup occurs before the birds return, but the timing depends on how much snow has fallen during the winter (CB). One name for the moon in February is *Chága nážžu wí*, meaning 'ice breaking to pieces moon' (WP). At the end of April and beginning of May, the river pushes ice up onto its banks (CB). In 2016, when thousands had gathered to protest the construction of the Dakota Access Pipeline, residents of Cannon Ball warned that the rising ice threatened the safety of those camped along the river (CB).

Rain 🌧️

The first rain, specifically the sound of the first rain, is an indicator of spring (PP). Rain at the beginning of spring makes the grass turn green (BH). April (BH, WP) and May (WP) are the rainiest

⁵ National Centers for Environmental Information.

times of year, referred to as April showers (LE) or spring rains (WP). These cause the chokecherries and wild plums to blossom (LE) as well as the cacti, bluebells, and crocuses to flower (WP). In 2016, there was less rain (BH, LE), so the chokecherries blossomed later than usual (they had not blossomed by the time of our workshop on April 7) (LE). Rain also occurs throughout the summer (BH). October is another rainy time of year (FY, WP).

Historical data collected at weather stations in Mandan, North Dakota (1914-2020) and Mobridge, South Dakota (1911-2020) indicate the highest precipitation is observed in June. Figure 5.14 shows the average amount of rainfall per month, comparing the period before 1970 with the period from 1970 to 2020. Although statistical analyses have not revealed significant changes, June appears to have less rainfall, while the later summer and early autumn (July through October) exhibited increased levels of precipitation.

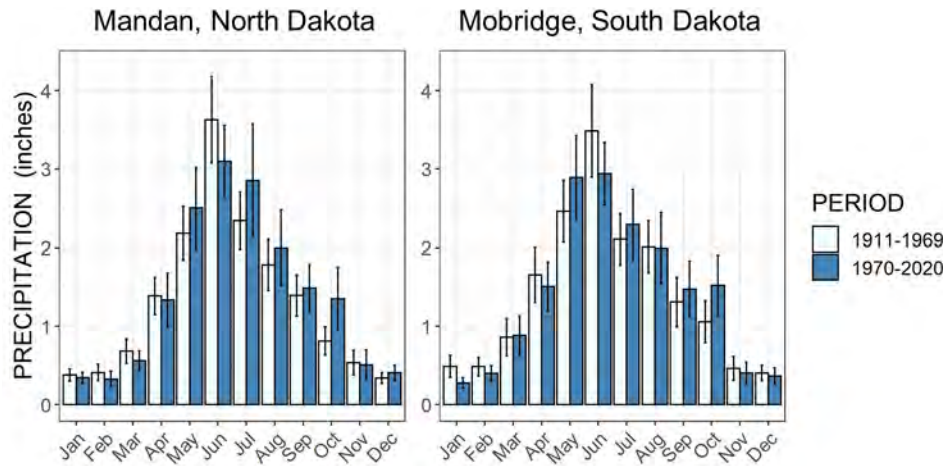


Figure 5.14: Change in Monthly Rainfall Recorded at Local Weather Stations.⁶ Error bars represent one standard error around the mean.

Snow ❄️

It can snow in any month with an R, from September through April, and sometimes even May (LE) and June (WP). One Elder said when she sweeps the snow from her porch, she notices it has become more powdery or cotton-like than in the past (LE).

The first snowfall is an indicator of winter (FY). Previously, snow arrived around the time of Halloween, when families from Wakpala went to Mobridge to trick-or-treat, but now there is rarely snow by Christmas (WP). In the winter, the height of a spider web on plants indicates how much snow will fall (WP). In the past, some residents lived in canvas military tents; in the fall and winter they would ‘bank’ or pile dirt or snow on the sides to make them warmer (LE).

In the spring, snow generally does not fall after the first thunder (LE). The last snow sticks to the outside walls or windows (LE). The snow melting is an indicator of spring (KN, FY). When it melts, water comes down from the hills and leads to flooding (PP). When the snow blows over the crocuses (PP) and when the grass comes out of the snow (KN) are both additional indicators of spring.

Weather data from 1996 to 2020 suggest heavy snows occur between October and May. Figure 5.15 shows the number of heavy snow events recorded in northern and southern Standing Rock (Sioux County, North Dakota and Corson County, South Dakota, respectively). The number of heavy snow events varies between the north and south; in the north, there were more heavy snows in December, whereas in the south, there were very few heavy snows in December and January.

⁶ National Centers for Environmental Information.

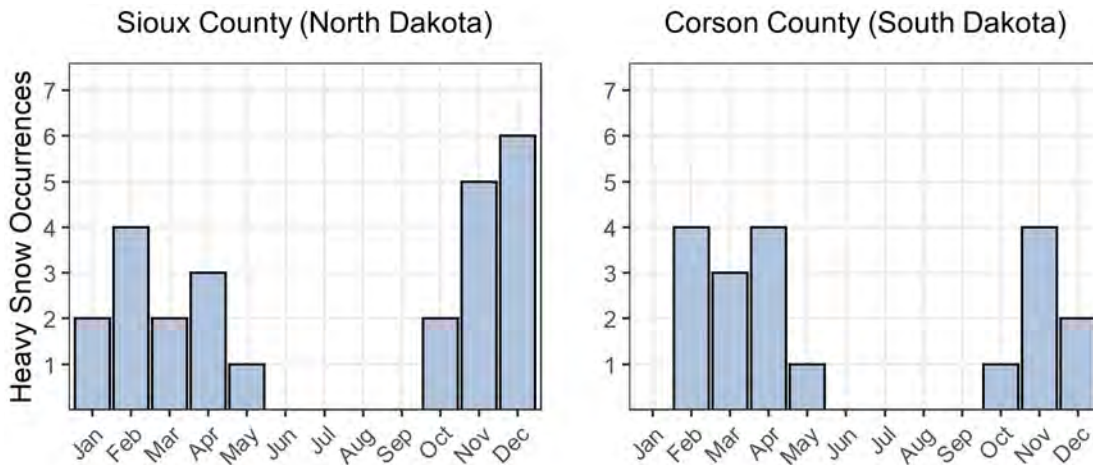


Figure 5.15: Occurrence of Heavy Snow Events in Standing Rock (1996-2020).⁷

Historical weather data for Bismarck, North Dakota indicate that the total annual snowfall has increased from 1886 to 2020. Although there is high variability in the amount of snow falling each year, regression analysis indicates this trend is statistically significant ($p < 0.001$). The total amount of snow observed in Bismarck has increased by one inch every seven years. Historical data for Mobridge, South Dakota is available for a shorter period (1938 to 2019), and no significant trend is observed ($p = 0.304$). Figure 5.16 shows the long-term trend illustrated by a dashed red line, with confidence interval shaded. It also reveals the 10-year moving average, depicted by a solid blue line.

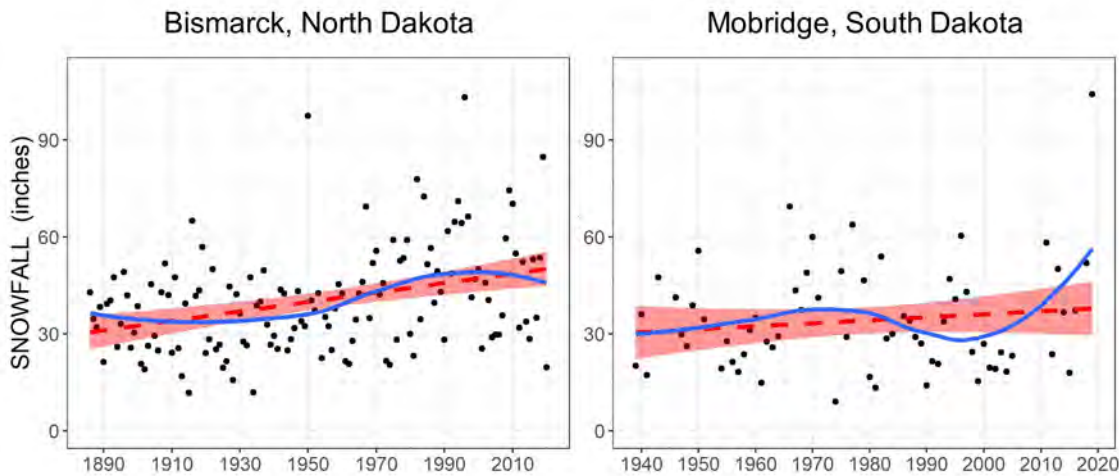


Figure 5.16: Change in Snowfall Recorded at Weather Stations in Bismarck (1886-2020) and Mobridge (1938-2019).⁸

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BH = Bullhead, CB = Cannon Ball, FY = Fort Yates, KN = Kenel, LE = Little Eagle, PP = Porcupine, WP = Wakpala

Storms (general)

Horses, cattle, birds, and other animals can feel a storm coming. Horses will run around acting crazy; cattle will bunch up and go to low-lying places (for example at the bottom of a valley) (KN). If there is going to be a storm, ducks stay low, but if it is going to be clear, ducks fly high (WP).

Weather data from 1996 to 2020 indicate that winter storms occur between October and May. Figure 5.17 shows the number of winter storm events recorded in northern and southern Standing Rock (Sioux County, North Dakota and Corson County, South Dakota, respectively).

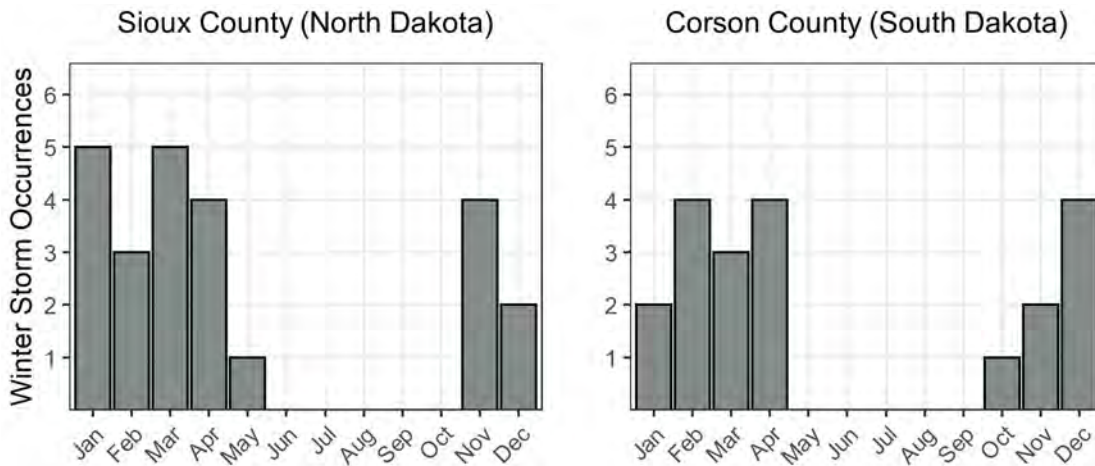


Figure 5.17: Occurrence of Winter Storms in Standing Rock (1996-2020).⁹

Sun ☀

When you see a ring or halo around the sun (referred to by participants as a sundog), it is going to be a cold day (BH, WP). The days get longer and there is more sunshine in the spring (CB).

Temperature

Warmer temperatures are an indicator of spring (FY, KN). In the spring it is nice out during the day but cold at night (PP). Some participants said it is always cold in spring; it gets warmer by June (PP). There are higher temperatures in summer (FY). In August it is hot during the day and cold at night (PP). In the fall it becomes cold and windy (PP). Winter is characterized by cold temperatures (PP); February is the coldest time of year (WP).

Thunder and lightning

The year begins with the first thunder in early spring (LE). Thunder returning is one indicator of spring (WP). Thunder wakes up all the hibernating animals, which serves as another indicator of spring (LE). The thunder also wakes up the snakes (BH, LE). There is usually no snow after the first thunder (LE). However, in 2016 when we were conducting the research, there was snow after the first thunder, which was considered unusual (LE). Some participants said that cottonwood trees attract lightning, and that lightning strikes spiders in the trees (BH). Other participants explained that thunder is associated with spiders (WP).

⁹ National Centers for Environmental Information.

Tornadoes

Tornadoes occur in the summer (BH). They are black and look like smoke, or white and look like a rope (BH). They are capable of tearing off roofs and breaking trees (BH). They tend to appear at the same time as rainstorms and thunderstorms (BH). Some participants said that they seem to be coming closer to their communities than they did in past. However, others said they are very rare, last seen in their communities in the 1980s, when there was hail followed by a tornado (BH). Others report seeing funnel clouds that had not become tornadoes (BH).

Wind

Wind in March is referred to as the March winds (CB) and is an indicator of spring (BH). One Elder recalled her grandmother explaining a hot summer day followed by a cool wind indicates it is snowing in the mountains (WP). In the fall it becomes cold and windy (PP). Cannon Ball is vulnerable to wind because the community was relocated following the construction of the Oahe Dam in 1959, away from the shelter of the river valley to the top of a hill (CB). Residents of Cannon Ball reported that the winds now last all year long (CB).

Plants

Alfalfa (*Medicago sativa*)

There are two crops of alfalfa each year; farmers harvest the first crop of alfalfa around June 1, although if the field is irrigated it may be ready to harvest sooner (KN).

Apple (*Malus* sp.) 🍏

Apple trees bud in April (CB, WP) and May (WP), after wild plums (WP). In 2016, apples were budding on April 4 (CB). In general, budding happened one month earlier than usual that year (WP). If there is a spring storm or late frost after apples have blossomed, they will not produce fruit (WP). Some apples, such as Granny Smith varieties, are ready to pick in July and August (CB). However, most apples are ready to harvest in late September (FY). Some apple varieties are sweeter after the first frost (CB).

Asparagus (*Asparagus officinalis*)

Asparagus grows on its own along fence lines (WP). Some years it is ready to harvest in late April, but usually between Mother's Day and Father's Day, when it is moist and cool outside (WP). One participant said he harvests asparagus while he is hunting (WP).

Beaver grass (possibly *Carex stricta*)

Beaver grass is gathered in June, July, and August; it needs to be gathered before it dries (CB). It is used as a switch during *inipi* (sweat lodge ceremony); chokecherry branches can be used in its place (CB).

In other parts of the country, beaver grass is a common name for *Carex stricta*, also known as upright sedge,¹⁰ but needs to be confirmed.

10 USDA-NRCS, 'PLANTS Profiles', *USDA Natural Resources Conservation Service | Plants Database*, 2020 <<http://plants.usda.gov>> [accessed 15 September 2020].

Bergamot (*waštémna* or *waǰpé waštémna*, *Monarda* sp.)

Waštémna has purple flowers; it is gathered in August (CB).

Bluebells

Bluebells are one of the first wildflowers to blossom, along with crocuses and cacti, usually in April; the blossoms are short-lived (WP).

Boxelder (*čhaŋšúška*, *Acer negundo*)

In February, the snow melts around trees and makes their sap run (PP). In the past, community members tapped boxelder trees for sap, which they boiled down into syrup (PP). Buds appear on boxelder trees in April to June (PP). Mushrooms grow on boxelder trees (BH, PP). Some participants said they grow out of the holes made for sap (PP). You can gather the mushrooms one year after tapping the boxelder tree (PP).

Boxelder sap contains between $\frac{1}{4}$ and $\frac{1}{2}$ of the sugar found in the sap of sugar maple (*Acer saccharum*) trees and has been used as a sweetener by Native American communities since at least the 1800s, most likely much earlier.^{11 12}

Buffalo berries (*maštínčaphuté*, *Shepherdia* sp.)

Buffalo berries are gathered after the first frost (BH, CB, FY, KN, LE, PP, WP) and before the first hard freeze (FY), in August (PP), September (CB, FY, LE, WP), or the first part of October (CB, LE). The timing of the first frost varies from year-to-year (FY). Some choose to gather buffalo berries at the same time as chokecherries, in July or August (PP). Buffalo berries are hard to find (WP). They are difficult to pick because their branches are covered with thorns (WP, PP). Gatherers place a blanket, canvas, or tarp under the bush and hit it gently with a stick (LE, WP), axe (CB), or shake the whole bush (LE); this way, gatherers avoid the thorns (CB). After the first frost, the berries are easier to gather (FY), drop more easily (LE), are sweeter (BH, CB, FY, KN, LE), and less sour (PP) or bitter (WP). Buffalo berries get worms after the first frost, so one needs to pick them right away (FY). Some years there are a lot of buffalo berries and other years very few (BH). Some participants said they are ripening one month later than in the past (CB). They can be used to make good wine (WP).

Beets (*pǰaŋǰí šašá*, *Beta vulgaris*)

Beets are ready to harvest in late August or early September, but they are longer and bigger by September (FY). Once they are harvested, community members often can the beets (FY).

Cactus (*uŋkčéla*, *Opuntia* sp.)

Cacti are one of the first plants to blossom in the spring, along with crocuses and bluebells (WP). They usually blossom in April, and serve as an indicator of spring, even if there is still some snow on the ground (WP).

In general, most *Opuntia* species blossom in May through July.¹³

11 Robert R. Maeglin and Lewis F. Ohmann, 'Boxelder (*Acer Negundo*): A Review and Commentary', *Bulletin of the Torrey Botanical Club*, 100.6 (1973), 357 <<https://doi.org/10.2307/2484104>>.

12 John Kort and Patricia Michiels, 'Maple Syrup from Manitoba Maple (*Acer Negundo* L.) on the Canadian Prairies', *The Forestry Chronicle*, 73.3 (1997), 327–30 <<https://doi.org/10.5558/tfc73327-3>>.

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Cedar (*ħanté, Juniperus sp.*)

In the past, community members laid cedar boughs on the stove during the winter, which gave off a nice smell (CB).

Chokecherry (*čhaŋphá, Prunus virginiana*) 🍒

Chokecherries are called *čhaŋphá* (FY). Their blossoms are similar to grape blossoms, in that they are arranged in a cone and droop in long bunches (CB). They blossom in April (LE, WP) during the ‘April showers’ (LE) or May (WP), either at the same time (LE) or after wild plums (WP). In 2016, when there was less rain, the chokecherries were expected to blossom later than usual (they had not blossomed by April 7) (LE). If there is a late frost (CB, LE, WP) or a spring storm (WP) after chokecherries have blossomed, they will not produce fruit.

Chokecherries leaf out in April (CB). Depending on the rain, chokecherries turn red in mid-July (WP). They turn black when they are ripe, although they may look black when seen from a distance; when you get closer you see they are red (WP). July is *Čhaŋphásápa wí*, meaning ‘black chokecherry moon’ (WP). Participants said they gather chokecherries at different times: throughout July (LE, PP), at the end of July (FY, WP), beginning of August (FY, WP), mid-August (CB, WP), throughout August (KN, LE), or in the fall (BH). Chokecherries are gathered after Juneberries (WP). One participant gathers chokecherries around the time of the Little Eagle Powwow, which occurs during the last weekend in July (FY). One participant joked that she knows the chokecherries are ready when gatherers come around with 5-gallon buckets (BH). Chokecherries are ripening one month later than in the past (CB). There are fewer chokecherries than in the past (PP). The number of chokecherries varies from year to year (WP).

Participants remembered their parents and grandparents making chokecherry patties to use for *wóžapi* in winter (FY). If you break open the seeds, the toxins are released so they are safe to eat (FY). Grinding the chokecherries with a stone covered with hide removes the pits better than a metal grinder and is easier to use (WP). The chokecherry patties need to be dried when it is warm, in August (FY, WP) and September (FY), at the same time as corn (FY), squash (FY), and meat or *pápa* (FY, WP). To make *wóžapi* the chokecherry patties are boiled and strained with a cheesecloth (FY). Eating too many chokecherries can cause constipation (WP).

Chokecherry tips, the ends of the branches, are used to hold open meat as it is dried (LE). Their branches can be used in place of beaver grass as a switch during *inípi* (sweat lodge ceremony) (CB). For this purpose, the branches should be gathered in June through August (CB). The inner bark of chokecherry stems is prepared as a tea to treat diarrhea; the stems can be gathered at any time of year (WP).

There are toxins in chokecherries, concentrated in the pit, wilted leaves, and new growth, as well as any parts affected by frost. Toxicity is highest in the spring and summer, and lessens when the fruit is ripe, in August and September.¹⁴

Corn (*wagmíza, Zea mays*) 🌽

Participants said they prepare to plant corn in the beginning of spring (FY). Corn is harvested in August (FY, LE) or September (LE). If it is going to be dried, corn should be picked when it is slightly ‘milky’ (not fully mature and dry) (PP). Drying corn is part of preparing for winter (PP). Dried corn is called *waštúnkala* (FY, LE). Corn needs to be dried when it is warm, at the same time as chokecherries, squash, and meat (FY). Corn is dried outside in July (CB), August (CB, FY, LE), September (CB, FY, LE, WP), and in the fall (CB, PP). It can be dried inside later in the year (LE). Corn and squash are dried on strings;

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both crops are dried at the same time as meat (LE). Some participants remove the kernels from the cob and spread them out to dry; other dry them on the cob (PP). In the past, drying corn and meat was a task performed by women (CB). Participants said that when they have finished drying corn, they are grateful because they have so much food; and others come and ask if they have any for sale (LE).

Cottonwood (*wáǵačhaŋ*, *Populus* sp.)

Cottonwood budding is an indicator of spring (CB). Some participants said that cottonwoods attract lightning, and the lightning strikes spiders in the trees (BH). In the spring, bald eagles, and golden eagles rest in cottonwood branches as they migrate north (CB). Throughout the summer, cottonwoods make a hissing sound, described as singing (BH). They drop their seeds in the summer (CB). Wild mushrooms grow on cottonwood trees (CB). February is *Čhaŋnáphopa wí*, meaning ‘moon when trees crack from the cold’; this is the coldest time of year, and cottonwoods pop loudly because they have soft wood (WP).

Cottonwoods bloom as early as mid-March,¹⁵ disperse their seeds in April through June, peaking in May.¹⁶ They are the dominant species in riparian woodlands, which provide habitat for many other species. As cottonwoods rely on seasonal flooding, their populations along the Missouri River and its tributaries have declined as floods are prevented by dams.¹⁷

Crocus, pasque flower (*hokšičheka*, *Anemone patens*)

Prairie crocuses emerge from the snow in March (BH), serving as an indicator of spring (BH, CB, KN, PP, WP). One participant in Porcupine specified that the snow blowing over the crocuses is an indicator of spring (PP). Crocuses are one of the first wildflowers to blossom (KN, WP), along with cacti and bluebells, usually in April. The name of the month for April refers to how crocus flowers resemble a baby’s navel (WP). They blossom all over the hillsides, like “a big blue rug of flowers”, according to one participant in Cannon Ball (CB). However, the blossoms are short-lived (WP). Residents of some communities know how to sew a prairie crocus quilt that tells a story (BH).

Pasque flowers, which are known as crocuses in Standing Rock but are quite different from the crocuses found in other parts of the United States, are found throughout the Midwest and Canada.¹⁸ In general, they emerge in March through May and bloom in April through August.¹⁹

Cucumber (*kuŋkúŋ*, *Cucumis sativus*)

Gardeners in Standing Rock harvest and pickle cucumbers in late June and early July (FY).

Elms (*Ulmus* sp.)

Elm trees bud in April and leaf out by May (WP). In 2016, the Chinese elms were budding in April (BH).

Data collected by citizen scientists indicates elm leaves emerge in April through June, primarily in May.²⁰

15 USA National Phenology Network, ‘Observational Data’ <<https://www.usanpn.org/data/observational>> [accessed 9 June 2021].

16 Jennifer L. Taylor, ‘Species: *Populus Deltoides*’, *USDA Fire Effects Information System*, 2001 <<https://www.fs.fed.us/database/feis/plants/tree/popdel/all.html>> [accessed 26 January 2021].

17 Mark A. Rumble and John E. Gobeille, ‘Avian Use of Successional Cottonwood (*Populus Deltoides*) Woodlands Along the Middle Missouri River’, *The American Midland Naturalist*, 152.1 (2004), 165–77 <[https://doi.org/10.1674/0003-0031\(2004\)152\[0165:AUOSCP\]2.0.CO;2](https://doi.org/10.1674/0003-0031(2004)152[0165:AUOSCP]2.0.CO;2)>.

18 USDA-NRCS.

19 USA National Phenology Network.

20 USA National Phenology Network.

Flowers (general)

In general, flowers blossoming is an indicator of spring (KN, PP). Some participants said they put out flowers in May (KN).

Gooseberries (*wičhagnaška*, *Ribes* sp.)

Gooseberries are called *wičhagnaška* in Dakota; they are also called currants in English (PP). In the past, participants gathered gooseberries in early June (PP) or after Juneberries (BH). The gooseberries were different colors but all tasted sour (BH). They do not all ripen at the same time, so some will be yellow while others are black (PP). They grow fast, are sweet, and make good *wóžapi* (BH). They are also used to make a pie (PP). Participants in some communities said they are rarely seen anymore (BH).

Grasses (general)

Grass coming out of the snow is an indicator of spring (KN). Rain at the beginning of spring turns the grass green, the first indicator of spring (BH). The grass turning green in is an indicator of summer (PP). This is important because the Fort Laramie Treaty of 1868 promised the U.S. government would honor boundaries of the newly established Great Sioux Reservation ‘as long as the grass is green’ (PP).

Buffalo grasses are warm season grasses that come out in mid-June and July, whereas cool season grasses come out earlier and hot season grasses later (PP).²¹

Hay needles

One participant said that when the ‘hay needles’ start falling, the prairie turnips are ready to harvest (CB).

The name ‘hay needles’ may refer to ‘needle and thread’ (*Hesperostipa comata*), but there are many other species that are referred to as ‘needlegrass’. In the Great Plains, the seeds of *H. comata* fall in July.²²

Iris

Iris come up in April, around the time of Easter (BH).

Juneberries (*wípazukħa*, *Amelanchier* sp.)

Juneberries blossom in May, around the time of the last frost (CB). Their blossoms are brighter white than other trees (CB). In recent years, a late frost comes after the Juneberries have blossomed, preventing them from bearing fruit (CB). Depending on the community, Juneberries are ripe and ready to be picked in June (BH, FY, WP), mid-June (CB), the middle and end of June (PP) or the first two weeks in July (FY). Juneberries are gathered before chokech–erries (WP). If there is more rain, they are ready earlier, sometimes in May (WP). To gather Juneberries, the weather needs to be dry, without too much wind, but lots of sun; this usually happens during the second week of June (LE). The size of the berries depends on the moisture (CB). *Wípazukħa wašté wí* is June, meaning ‘good Juneberries moon’; everyone shares this name (WP). Some participants say that Juneberries are ripening one month later than in the past (CB).

Juneberries are sweet and good to eat (FY). Participants said they are one of their favorite berries (PP). If you wait too long to harvest, the birds will eat them all up (FY). Participants recalled their parents

21 Most of the territory designated as the Great Sioux Reservation has been illegally taken from the Lakota and Western Dakota, included the Black Hills, Pahá Sápa.

22 ‘Species: Hesperostipa Comata’ <<https://www.fs.fed.us/database/feis/plants/graminoid/hescom/all.html>> [accessed 10 June 2021].

warning them to eat Juneberries slowly or they will cause diarrhea (WP). Juneberries are ‘delicious but rare’; one participant said that they are no longer found in their district (PP).

Juneberries are known to be resistant to frost. In New York, their fruits ripen in mid-June to July.²³ There have been efforts to reestablish Juneberries on the Fort Berthold Reservation in North Dakota.²⁴

Melons (cantaloupe, muskmelon, watermelon)

Cantaloupe is harvested in late September (FY). Muskmelon and watermelon are harvested during the summer (FY).

Nannyberry (*mná*, *Viburnum lentago*) 🍷

Nannyberries are called *mná*, which refers to their smell (CB). Nannyberries blossom late, after chokecherries (CB). They have white flowers (CB). As with other berries, if there is a late frost after they blossom, they will not produce fruit (CB). Nannyberries are gathered in July and August (CB). They grow close to the ground (CB).

In general, nannyberries bloom in May and June and bear fruit in July through September. Their leaves turn red in the autumn. When cut, the plant will sprout from its roots. Old branches will sometimes bend toward the ground and take root. Nannyberry can be propagated from cuttings.²⁵

Potato (*bló*, *Solanum tuberosum*) 🥔

Many participants said they plant potatoes on Good Friday (BH, FY, LE, WP); it is best time to plant even if the ground is still frozen (LE). One participant remembered their grandfather planting potatoes on Good Friday because he believed it had positive connotations (WP). Others plant potatoes one week before Memorial Day (CB) or in June (FY). Potatoes can stay in the ground even if it frosts (CB). They are ready to harvest in September or October; one Elder remembered traveling to work harvesting potatoes at that time of year (FY). In the past, potatoes were a major crop because they were the main food during the winter (FY).

Prairie cone flower (*Echinacea angustifolia*) 🌸

Some participants said that they eat echinacea flowers in the spring and roots in the fall (CB).

Prairie turnip (*thínpsila* or *thípsiyña*, *Psoralea esculenta*) 🥕

Prairie turnips bloom with purple flowers at the end of May (BH, FY), although in 2016, they were observed in mid-April because it had not been very cold (BH). Prairie turnips can be harvested in the last part of May (FY, LE), June (BH, CB, FY, LE, PP, WP) and July (FY, LE, WP). The availability of turnips depends on moisture; if it is dry, they are available one week earlier (WP). In 2016, one participant said their son harvested turnips in May (KN). One participant explained when ‘hay needles’ start falling, the prairie turnips are ready to harvest (CB).

The best time to harvest turnips depends on the rain (WP). If there is no rain, the turnips won’t grow (LE). However, too much rain before digging turnips will cause them to be soft (cottony or spongy) (LE).

23 Jim Ochterski, ‘Juneberries – They Go Where Blueberries Can’t’, *Cornell Small Farms*, 2011 <<https://smallfarms.cornell.edu/2011/10/juneberries-they-go-where-blueberries-cant/>> [accessed 25 September 2020].

24 Kerry E Hartman, ‘Reestablishing the Juneberry on the Fort Berthold Indian Reservation: Cultural, Horticultural, and Educational Connections’ (unpublished Electronic Theses and Dissertations, South Dakota State University, 2008).

25 ‘*Viburnum Lentago* (Nannyberry) | Native Plants of North America’ <https://www.wildflower.org/plants/result.php?id_plant=vile> [accessed 25 September 2020].

The turnips will be pulpy if there is a lot of rain but not enough sun; you need both rain and sun (KN). Prairie turnips are woody if they are harvested late (FY, PP), for example in July (PP). If it is hot, the turnip flowers fall off or blow away and it is difficult to find them, which usually happens by the end of July (LE, PP). Wild onions are available at the same time as prairie turnips (PP).

Turnips should be picked after they seed so that they can reseed themselves (CB). When digging turnips, the plant needs to be put back in place so it can regenerate (CB). Some choose to break off the tops and put them back in the hole, upside-down, so that can regrow (BH). However, gatherers refill the turnip holes so cattle do not break their hooves (BH, LE). Turnips can be braided and hung up to dry right after they are harvested (LE). They can also be sliced and placed in plastic bags in the freezer; this is easier because they are difficult to cut after they are dried (LE).

Prairie turnip seeds mature in July and August; at that time, the seed heads will break off and the seeds will spread. These plants are sensitive to root disturbance, which makes it difficult to transplant or divide them. Nevertheless, they grow rapidly from seed. Prairie turnips are nutritious, containing more protein than most tubers. However, they also contain furanocoumarins, a category of chemicals also found in grapefruit that can have deleterious effects when taken at the same time as certain medications. Cattle grazing may impact prairie turnip populations.²⁶

Puffball (*hokšičheka*, *fungi*)

Puffballs form after crocuses bloom in the beginning of spring; they are used by midwives to treat newborn babies' navels (PP).

Pumpkin (*wagmúzi*, *Cucurbita* sp.)

Pumpkins are harvested in October (LE).

Red willow (*čhaŋšáša*, *Cornus sericea*)

Čhaŋšáša is used in the *čhaŋnúŋpa* (pipe) during ceremonies (CB). When gathering *čhaŋšáša*, you leave tobacco and offer prayers (CB). One can gather red willow after December 21 until the first thunder, or February 21, whichever comes first (CB). It cannot be taken for ceremonies after there has been thunder, which comes in the early part of spring, because it has turned green (LE). It needs to be harvested before the first thunder or lightning, but these days some gatherers are harvesting it at any time (WP).

Red willow is also known as American dogwood or red osier dogwood (both common names for the same species). Previous research measured seasonal changes in the content of its stems; starches accumulate in the spring and summer, peaking in October, and then dropping in the winter. By contrast, sugar content is highest in the winter.²⁷

Rosehips (*uŋžínžintka*, *Rosa* sp.)

Rosehips are *uŋžínžintka* (BH). They look like small tomatoes (BH). Rosehips are gathered in the summer (WP) and fall, when the temperatures drop, and children begin getting stomach flu (BH). Rosehips are both food and medicine (WP) for the stomach (BH). In the past, community members harvested rosehips

26 April Stahnke and others, 'Prairie Turnip *Pedimelum Esculentum* (Pursh) Rydb.: Historical and Modern Use, Propagation, and Management of a New Crop', *Native Plants Journal*, 9.1 (2008), 46–58 <<https://doi.org/10.2979/NPJ.2008.9.1.46>>.

27 E. N. Ashworth, V. E. Stirm, and J. J. Volenec, 'Seasonal Variations in Soluble Sugars and Starch within Woody Stems of *Cornus Sericea* L.', *Tree Physiology*, 13.4 (1993), 379–88 <<https://doi.org/10.1093/treephys/13.4.379>>.

at the same time as chokecherries and plums (PP). The fruits can be stored through the winter (WP) and are boiled like tea (BH).

Rosehips are known to be a good source of antioxidants and other nutrients.²⁸

Sage (*Artemisia* sp.)

Man's sage is gathered from May to August, before it seeds (CB). You need to dream before you gather it, and the spirits will tell you how to use it, as is true for all medicinal plants (CB). Plants like sage are cut rather than pulled up by the roots (CB).

Sandcherries (*Prunus besseyi*)

Sandcherries are also called snakeberries (BH). Participants said that sandcherries are gathered in the summer during the powwow season (CB), in the middle or end of June (PP), the middle of August (WP), around the same time as Juneberries (BH) or the same time as chokecherries (WP). Sandcherries are gathered from the ground (BH), along the road (PP), on the north side of hills (CB), or in ravines (WP). In sheltered locations, such as in ravines, they last longer, up until late September or early October (WP). However, one participant explained they were afraid to pick them in ravines because of snakes (PP). When gathering sandcherries, you need to approach them from downwind (meaning the wind is blowing toward you) or they will be bitter (WP). Some community members have not seen them for a long time (PP).

Squash (*wagmú*, *Cucurbita* sp.)

Wagmú usually refers to Hubbard squash (LE), but it can refer to other varieties. Hubbard squash is harvested and dried in August (LE) and September (LE), specifically late September (FY) once the stem is dry (LE). Buttercup squash is also harvested in August and September (LE). Squash and corn are dried on strings, at the same time as drying meat (FY, LE) and chokecherry patties (FY). Squash can be dried inside later in the year (LE). Buttercup squash is usually eaten fresh or cooked for a short time (blanched) and then frozen (LE).

Strawberries (*wažúšteča* or *waziškeča*, *Fragaria* sp.)

Strawberries are gathered in the summer (CB), specifically in June (WP). One participant remembered their mother and sister looking for strawberries during haying time, in July and August (FY). Strawberries are generally found in wet places (FY), along cutbanks and cliffs (WP). The fruits can grow as large as a cherry or as small as the end of a pen (WP).

Sunchoke (*pħaŋǵí*, *Helianthus tuberosus*)

Sunchokes, also known as 'Lakota potatoes' are harvested in the fall (WP). They can be made into a flour that doesn't contain starch, so they are good for diabetics (WP).

Tomatoes (*Solanum lycopersicum*)

Tomatoes are ripe and ready to harvest in August (FY).

28 Huri Ilyasoğlu, 'Characterization of Rosehip (*Rosa Canina* L.) Seed and Seed Oil', *International Journal of Food Properties*, 17.7 (2014), 1591–98 <<https://doi.org/10.1080/10942912.2013.777075>>.

Trees (general) 

Trees budding is an indicator of spring (KN, PP) and generally occurs in April (BH). The month when leaves turn green is called *Čhaŋwápe wí*, meaning ‘leaf moon’ (PP).

Leaves turn (change color) in the fall (FY). Leaves falling from the trees is an indicator of fall (CB). The moon in late August or September is *Čhaŋwápe ģí wí*, meaning ‘brown leaf moon’, and the next moon (in late September or October) is *Čhaŋwápe kasná wí*, meaning ‘leaves fall moon’ (WP).

In general, there are fewer trees than in the past (PP).

Tulips (*Tulipa* sp.)

Tulips come up in April, around the time of Easter (BH).

Wild grapes (*čhuŋwíyapehe*, *Vitis* sp.)

Depending on the community, wild grapes are gathered in August (FY, WP), September (BH, CB, FY, LE), the first part of October (CB, LE), early fall (WP), after gathering chokecherries (FY), at the same time as wild plums (FY), and at the same time as mushrooms (BH). Wild grapes should be gathered after the first frost (BH, CB, LE, PP) because they taste sweeter (LE). Birds eat wild grapes, so one must get to them quickly (CB). Some question whether it is necessary to wait for the frost (FY, PP), because they will dry up or be eaten by the birds (FY). Wild grapes grow along rivers and creeks, but they can be challenging to find (PP). Some participants said they do not see as many of them as in the past (PP). One Elder remembered standing on the back of her horse to gather grapes (WP). Before the Oahe Dam, there used to be grapes by the river in Kenel (KN). Wild grapes and wild mushrooms are usually for sale at the same time (BH). In 2018, visitors from outside Standing Rock came to buy grapes before they were ripe (WP). Wild grape flowers are used to treat sunburn (PP).

Wild mint (*čheyáka*, *Mentha* sp.) 

There are many kinds of wild mint (LE). Both peppermint and spearmint are called *čheyáka* (CB). *Čheyáka* is gathered in June (WP), August (CB, KN, LE), September (WP) and October, although some say it dries out by October (WP). It is gathered at the same time as chokecherries (KN). One can smell *čheyáka* from far away (WP). It goes to seed fast, so it needs to be gathered quickly (LE). It can be dried and stored from year to year (WP). *Čheyáka* means ‘let us clean out our kidneys’ (CB).

The most common species of wild grape in the Northern Great Plains is *Vitis riparia*, or riverbank grape. In general, this species flowers in May through July, and its fruits ripen in August and September.²⁹

Wild mushrooms 

Please note many kinds of mushrooms are toxic, and their consumption can lead to serious illness or death. Toxic mushrooms may closely resemble those that are edible, so it is important to learn how to gather mushrooms from someone who is familiar with the mushrooms of the area, as they differ from place to place.

Participants distinguished three kinds of edible wild mushrooms. The first kind grow on trees and are called *čhájŋnákpa*; *čhájŋ* means ‘tree’ or ‘wood’ and *nákpa* means ‘ears’ (LE). *Čhájŋnákpa* grow on boxelders (BH, WP), cottonwoods (CB), and elms (FY). If it rains a lot in August and September, the *čhájŋnákpa* on elms become very large (FY). If there are several periods of rain, there may be several crops of *čhájŋnákpa*

29 ‘Vitis Riparia’, Plants for a Future <<https://pfaf.org/user/Plant.aspx?LatinName=Vitis+riparia>> [accessed 9 June 2021].

(WP). *Čhájǵnákpá* are gathered at the end of August and beginning of September; if it rains and then gets hot, they will get wormy (LE). Others gather *čhájǵnákpá* when it starts getting colder, in September, October, or November (FY). Some say *čhájǵnákpá* should be gathered after the rain but before the first frost; in 2018, the season for gathering *čhájǵnákpá* ended on October 11, presumably due to the frost (WP). Community members gather and sell *čhájǵnákpá* at the same time as wild grapes (BH). Gatherers pick *čhájǵnákpá* along the Grand River and bring them to Cannon Ball (CB). Wild mushrooms can be eaten fresh, but some choose to dry them (LE), or wash and freeze them (FY) for storage. Participants prepare *čhájǵnákpá* by frying them with butter (FY).

The second type of mushroom is harvested from alfalfa fields and cattle pastures in May (WP). According to one participant, if you lift the head and it comes off, it's poisonous, whereas if the head stays with body, it is safe to eat (WP). (Note that more knowledge is necessary to determine if a mushroom is poisonous or edible.)

The third type of mushroom is available in the fall, after the leaves fall and there is a rain (WP). Three or four days later, the leaves rise (the mushrooms push the leaves off the ground as they grow); one must get them quickly before they are full of worms (WP).

Wild onion (*pšijs'ámna*, *Allium* sp.)

Wild onions are available in May and June (PP, WP), at the same time as prairie turnips (PP). As they have a strong flavor, they can be used sparingly (WP). There are not as many wild onions now as there were in the past (PP).

Wild plums (*kǵáŋta*, *Prunus americana*) 🍒

In April, the wild plum bushes start to turn grey, indicating they are about to blossom (CB). They blossom in April (LE, WP) during the April showers (LE), or May (CB, WP), either at the same time as chokecherries (LE) or before chokecherries blossom (WP); the timing depends on the temperature (CB). According to one participant, their blossoms are arranged “any which way” and emit a pleasant smell (CB). If there is a late frost (CB, LE, WP) or a spring storm (WP) after wild plums have blossomed, they will not produce fruit.

Depending on the community, wild plums are gathered throughout July (PP), at the end of July (FY), beginning of August (FY), throughout August (KN, LE, WP), the beginning of September (LE), or throughout September (BH, WP). They are gathered either at the same time as chokecherries (PP) or after chokecherries (BH, CB, FY, WP). In some communities, wild plums and wild grapes are available at the same time (BH). As it gets cooler, wild plums get sweeter (FY). Participants remove the seeds and dry them, but do not make patties as they do with chokecherries (WP). Wild plums are also used to make jelly (FY).

In general, wild plum buds appear in mid-April through late May. Their fruits appear in the beginning of June and ripen in mid-August through September, as indicated by a bright red color.³⁰

Willow (*Salix* sp.)

Willow is gathered in the summer; it is used as aspirin (as a painkiller) and to treat diarrhea (WP).

Zucchini (*wagmútho*, *Cucurbita pepo*)

Zucchini is harvested in August and September (LE). Zucchini is usually eaten fresh or cooked for a short time (blanched) and then frozen (LE).

30 'Prunus Americana (American Plum) | Native Plants of North America' <https://www.wildflower.org/plants/result.php?id_plant=pram> [accessed 9 June 2021].

Animals

Animals (general)

Animals shedding their fur is an indicator of spring (FY).

Antelopes (*Antilocapra americana*)

Although community members hunt antelope, at a certain time of the year the meat tastes *sewimna*, meaning it smells like fish and is slimy (FY). Antelope are abundant west of Wakpala (WP).

Research conducted in California in the 1940s found the quality of antelope meat changes through the seasons.³¹ The meat was judged to be most tender and desirable in September while the toughness increased in October after the rut. Antelope meat was found to have higher levels of the thiamine (vitamin B1) and riboflavin (vitamin B2) than deer, beef, veal, and lamb.

Birds (general) ~ ~

Birds returning is an indicator of spring (FY, LE, PP). Crows, meadowlarks, and cranes fly north in the spring (WP).

In the fall, when it starts to get cold and a steam rises from the water, the birds flock up and prepare to migrate (WP). Birds start ‘bunching up’ to fly south in late September and October; by November, they are all gone (LE). If crows fly south, it is going to be a cold winter (WP).

‘Snowbirds’ (Elders described them as ‘little baby sparrows’) arrive in the fall and spend the winter (CB, LE). The arrival of chickadees and snow buntings are indicators for winter; when chickadees arrive, you know it is going to be cold soon (CB).

Birds are not confused by weather; they know what they are doing (LE). Birds can feel a thunderstorm or another storm coming (KN).

According to ornithologists, chickadees do not migrate; they move in flocks, but remain in the same home range throughout the year. Snow buntings migrate to the Arctic in summer and return to the Standing Rock in late October or November.³²

Boxelder bugs (*čhaŋšúška wablúška, Boisea trivittata*)

Boxelder bugs come out in late summer and stay through the winter (PP). They seem to be emerging earlier; in 2016 they were observed in March (PP).

According to researchers at Pennsylvania State University,³³ boxelder bugs emerge from hibernation when the buds on boxelder trees (*Acer negundo*) begin to open. Boxelder bugs tend to congregate in large numbers in the fall, and this is when they may enter buildings in search of a place to spend the winter.

31 Bessie B. Cook and others, ‘The Influence of Seasonal and Other Factors on the Acceptability and Food Value of the Meat of Two Subspecies of California Deer and of Antelope’, *Hilgardia*, 19.8, 265–84.

32 Cornell Laboratory of Ornithology, ‘All About Birds’, *All About Birds*, 2021 <<https://www.allaboutbirds.org>> [accessed 8 June 2021].

33 ‘Boxelder Bug’, *Penn State Extension* <<https://extension.psu.edu/boxelder-bug>> [accessed 25 January 2021].

Buffalo, bison (*ptéřčaka*, *Bison bison*)

Buffalo shed their fur in June when it gets warmer (PP). Although they can calve any time of year, they do not calve every year, either because their previous calves are not yet strong enough or the grass is not plentiful (PP).

Coots (*čbaŋtípaŋ*, *Fulica americana*) 

In the past, community members would hunt coots as they migrated north in the spring or south in the fall (CB). Coots were prepared by packing them in clay and baking them until the clay broke open; the coots tasted good (CB)!

The breeding range for coots extends from south of the Dakotas into Canada; they migrate through the Dakotas in large flocks.³⁴

Cows, cattle 

Depending on the community, calves are born in late March (FY), April (BH, FY, PP, WP), May (BH), or after all the storms have passed (BH). Some participants said that calves are born at the time the prairie chickens dance (FY). Others said that cows give birth during a late snow, which can serve as an indicator of spring (LE).

In the past, calves were born much earlier, in February (FY). Now, some ranchers who want bigger calves might have them as early as February (BH), but this requires certain facilities (PP).

Calves are branded and vaccinated in April and May (WP). Cows' hair starts getting thick in late September (BH). Cattle can feel a thunderstorm or another storm coming; they will bunch up and go to low places (KN).

Crickets 

Crickets are seen and heard in the end of spring and early summer as well as at the end of the summer (PP). There are fewer crickets than in the past (PP).

Deer (*tháhča*, *Odocoileus* sp.) 

Fawns are born in June (BH). They are born with spots (BH). Deer turn rust-colored in the summer and grey in the fall and winter (LE). Some participants feed deer through the winter (CB).

Dogs (*šúŋka*, *Canis familiaris*)

Dogs shed their fur in June when it gets warmer (PP). Dogs' fur starts getting thick in late September (BH).

Ducks (*mağáksiča*)

Ducks returning to Standing Rock is an indicator of spring (LE). In 2016, the ducks came back earlier than usual, and then a storm in March caused some of them to return south (LE). In the past, community members hunted ducks in the spring; now ducks are hunted any time before they migrate south (FY). If there is going to be a storm, ducks stay low, but if it is going to be clear, ducks fly high (WP).

Eagles (*waŋblí*, golden eagle, *Aquila chrysaetos*; *anúŋkħasaŋ*, bald eagle, *Haliaeetus leucocephalus*)

Both bald eagles and golden eagles migrate through in the spring (CB). For some, eagles migrating is an indicator of spring (WP). They migrate with geese and feed on the weak ones (WP). They can be seen

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resting in the cottonwood trees and hunting prairie dogs (CB). Eagles are observed throughout the year (PP). In the past, eagles nested where the Sacred Stone Camp was located, on the Cannonball River; now they are more common in Porcupine, where you can see two or three bald eagles each day (PP). Bald eagles are more common than golden eagles, although both can be observed (PP). There are also spotted eagles (which may be juvenile bald or golden eagles) (CB).

Juveniles of both golden and bald eagles can have spots or patches of brown or white.³⁵

Flies

Flies in the windows are an indicator for summer (BH). They often lay their eggs in meat, so participants wait to dry their meat in August and September, when there are usually fewer flies (LE).

Frogs and toads

Frogs and toads appear after the first rains in the beginning of spring, in puddles along the roads (PP). In the past some participants caught frogs from the river and used them as bait for fishing (PP).

Geese (*maǵá*, multiple species)

Geese migrate north in the spring (CB), which can serve as an indicator of spring (BH, PP) or that summer is coming (WP). Participants begin seeing geese even before they see meadowlarks (WP). Some say the snow geese are the first to come back in the spring (PP), others say the Canada geese fly north before the snow geese (WP). Eagles travel with geese and feed on the weak ones (WP). The migrations in 2016 were unusual because the geese went north, then turned around and went south, then back north again (CB).

The geese go south in the fall at the time of the first snow (LE). They are good indicators of weather and the best sign of fall. The elders say when the geese fly south in the fall, they knock down the snow. The word for knocking down the snow is *wakabhapi* (*wa* is 'snow', *kabhapi* is 'knocking down') (LE). The snow geese are the first to go south, at the end of fall and beginning of winter, and therefore serve as a good indicator of winter (PP). Canada geese are not a good indicator because they stay as long as there is open water (PP). Community members hunt geese during their migrations, and there is no limit on the number of geese that they are allowed to take (WP).

The four most frequently observed species of geese in Standing Rock include: Canada geese (*Branta canadensis*), white-fronted geese (*Anser albifrons*), snow geese (*Chen caerulescens*), and Ross's geese (*Chen rossii*). Only Canada geese nest in Standing Rock; the others pass through during migration. Due to their color, snow geese and Ross's geese are often called 'light geese'. Snow geese have two plumage morphs, one white and one gray or blue, which is sometimes referred to as a 'blue goose'. Standing Rock Sioux Tribe Game & Fish sets hunting seasons for geese on tribal land. The season for Canada geese runs between September and December with a daily limit of 24 geese.³⁶ Hunting season for light geese runs from February through May with a daily limit of 20 geese.³⁷ The states of North and South Dakota set hunting

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36 'Standing Rock Sioux Tribe Game and Fish - Early Fall Canadian Geese' <<http://gameandfish.standingrock.org/dates-and-fees/early-fall-canadian-geese/>> [accessed 29 January 2021].

37 'Standing Rock Sioux Tribe Game and Fish - Light Geese' <<http://gameandfish.standingrock.org/dates-and-fees/light-geese/>> [accessed 29 January 2021].

seasons for geese on non-tribal land. Hunting seasons run from September through December or January, with daily limits range from 3 to unlimited, depending on the species and precise location.³⁸

Grouse (*čháŋšiyó* and *wóš'iyyeyela*, multiple species) 🦉

Grouse are hunted in the fall, as the season is regulated (CB). Grouse go under the snow in the winter (CB). Adding salt pork to grouse makes it taste good (LE).

Hawks (*čhetáŋ*, multiple species)

Hawks are seen throughout the year and are considered beautiful (PP).

Red-tailed hawks are one of the most frequently observed birds in Standing Rock. Figure 5.18, based on citizen science data collected in Standing Rock,³⁹ shows that hawks can be observed most months, although more frequently between March and October, with the highest number of observations in June.

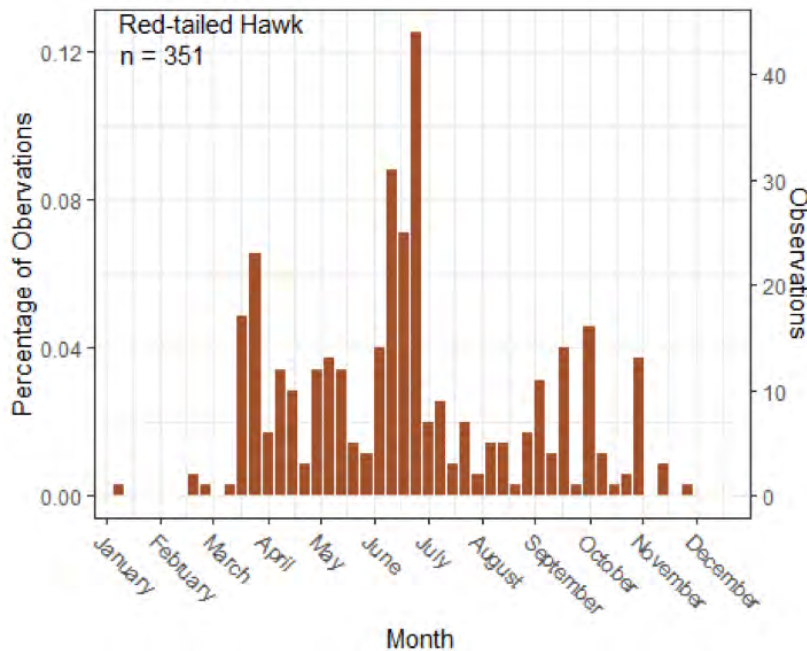


Figure 5.18: Observations of Red-tailed Hawks in Standing Rock.

Horses (*šúŋkawakháŋ*, *Equus ferus caballus*) 🐎

Horses do not shed until it gets warm, which usually happens before June (PP). They begin to grow their winter coat around the time of the first frost, usually in late September (BH). Horses can feel a storm coming; they will “run around acting crazy”, according to some participants (KN). Horses are bred in May and take 11 months and 10 days to gestate (WP). If breeding is controlled, foals are born around April 1, otherwise foaling can occur any time between April and October (WP).

38 ‘Goose’ <<http://gfp.sd.gov/goose/>> [accessed 25 January 2021]; ‘Canada Goose Hunting | North Dakota Game and Fish’ <<https://gf.nd.gov/hunting/canada-geese>> [accessed 25 January 2021].

39 Cornell Laboratory of Ornithology, ‘Download Data’, *EBird*, 2021 <<https://ebird.org/data/download>> [accessed 9 June 2021].

Meadowlark (*t̥hašiyagmuŋka*, *Sturnella neglecta*) 🐦

Meadowlarks are the first birds to return to Standing Rock in spring (LE, PP). Seeing a meadowlark is an indicator of spring for some communities (KN). However, in most it is the meadowlarks’ singing that indicates the end of winter and beginning of spring (BH, CB, LE, KN, PP, WP), usually in March or April (WP). When we met with them in 2016, participants reported having heard a meadowlark in early March (PP, WP, LE), which some considered one month earlier than usual (WP). One Elder who had already seen a meadowlark told us she had spoken to it in Lakota, saying ‘You’re back!’ (LE). When someone hears a meadowlark singing, they tell others in their community (BH).

Meadowlarks go south in the fall (LE). When the meadowlarks flock up, they are “making plans” to migrate, according to some participants (WP).

Meadowlarks are one of the most frequently observed birds in Standing Rock. Figure 5.19, based on citizen science data collected in Standing Rock,⁴⁰ shows meadowlarks are observed between March and early October, with the highest number of observations in June. Male meadowlarks fly up and vocalize (sing) to claim territory during their breeding season.⁴¹

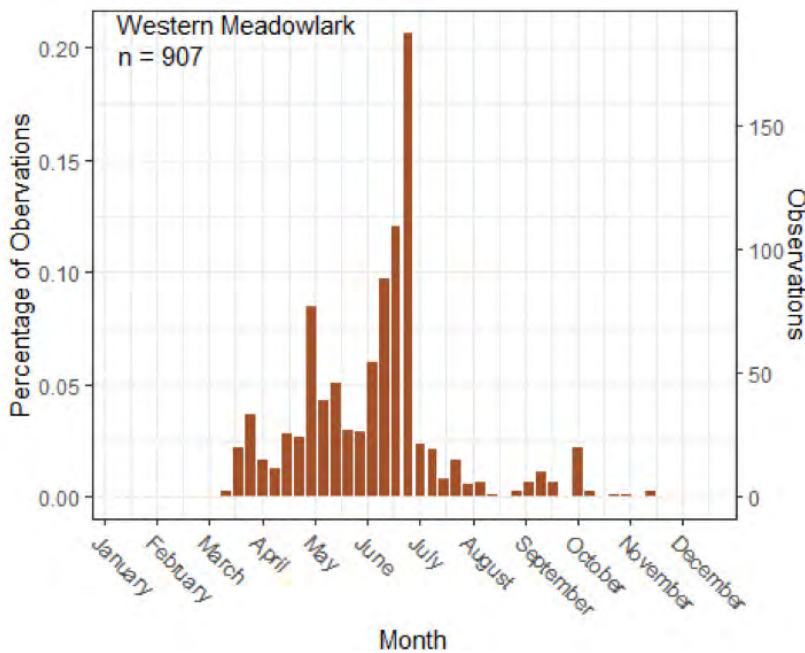


Figure 5.19: Observations of Meadowlarks in Standing Rock.

Nighthawks (*piško*, *Chordeiles minor*) 🦉

Nighthawks are the last birds to come back in the spring and the first to leave and migrate south (usually in August) (PP).

Nighthawks migrate a long distance every year,⁴² most likely effecting their arrival and departure dates in Standing Rock.

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Owls (*hiyháy*)

Owls are seen throughout the year, but less often than in the past; they seem to be disappearing (PP). Some participants say that hearing an owl means there is going to be a death in your family (PP). Owls perch on telephone poles (PP). Some participants do not like owls (PP).

Owls found in Standing Rock are experiencing population declines due to loss of habitat, including burrowing owls and short-eared owls.⁴³

Pheasants (*šiyóša*, *Phasianus colchicus*)

Pheasants mate in April, which means the roosters compete for hens at that time (CB). The pheasants will nest in roadside ditches in the spring at the same time that baby rabbits are born (BH). Participants pointed out that in the past, when they cut the grass in the roadside ditches, the pheasants were still nesting, but more recently baby pheasants are already running around, suggesting they have hatched one month earlier than before (BH). Pheasants live in thickets in the winter (CB). Some participants feed pheasants through the winter (CB). Adding salt pork to pheasant makes it taste good (LE).

In Minnesota, about 25% of pheasants nest along roadsides. Pheasants nest for about six weeks and learn to fly about 7-12 days after they hatch. Mowing grass along roadsides during the nesting or brood-rearing periods results in the death of many pheasant hens and chicks. Mowing after August 1 is recommended to enhance pheasant survival.⁴⁴

Ring-necked pheasants are one of the most frequently observed birds in Standing Rock. Figure 5.20, based on citizen science data collected in Standing Rock,⁴⁵ shows that pheasants are observed throughout the year, although more frequently between April and July, with the highest number of observations in June.

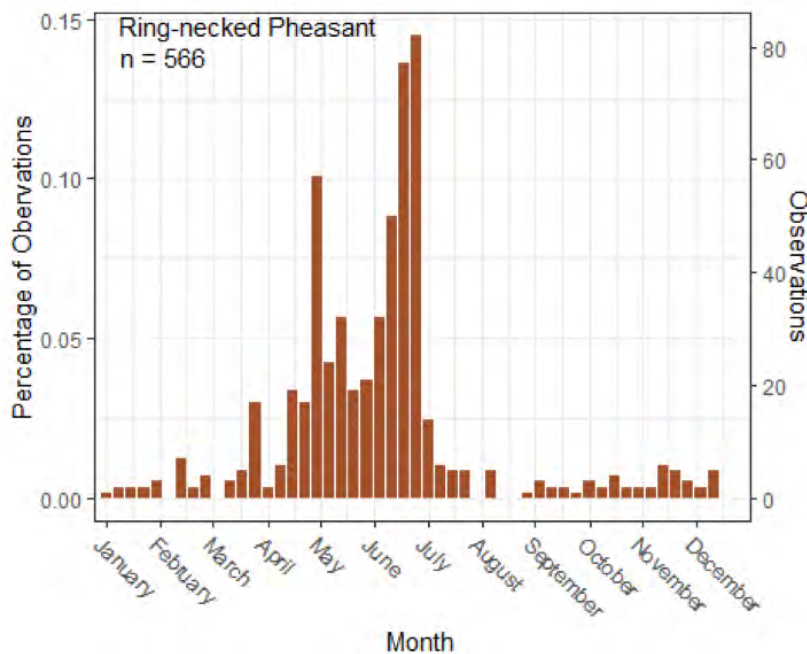


Figure 5.20: Observations of Pheasants in Standing Rock.

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44 'Roadsides: Ecological Traps or Opportunities to Provide Habitat?', Pheasants Forever <<https://pheasantsforever.org/BlogLanding/Blogs/Field-Notes/Roadsides-Ecological-Traps-or-Opportunities-to-Pro.aspx>> [accessed 25 January 2021].

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Porcupine (*p̄hahíŋ*, *Erethizon dorsatum*) 

Porcupine hair is used to make head roaches (*waph̄éša*) (LE) and other traditional items. Porcupine quills are soft in spring and summer and harden in the fall and winter; porcupine hair can be seen standing straight up at that time (LE). Because they need to be hard to use them, porcupine are hunted or the quills are collected in fall and winter (LE). The quills are soaked and flattened with fingernails or teeth before they are used (LE). One Elder shared that whenever a porcupine is killed on the road, her daughter uses a hard sponge to pick out the quills (LE). In the past, porcupine were hunted or trapped for food; they were prepared by boiling until the grease was removed (CB).

Prairie chickens (*šiyóka*, *Tympanuchus cupido*) 

Depending on the community, participants reported that prairie chickens gather to dance (as part of their courtship) in late March (FY, WP), April (CB, FY, WP), late May (LE), June (LE), and September (FY). Prairie chickens dancing is an indicator of spring (WP). Some observe prairie chickens dancing at the same time as calving (FY). In the past, prairie chickens danced from spring until the fall, every morning (WP). They gather on top of a hill, usually out in the prairie away from people, sometimes for two days (CB). One participant identified a buffalo pasture where the ground was covered in feathers, suggesting it was a place where prairie chickens dance (FY). During their dance, the males show off by raising their chests (CB). The prairie chickens' dances were the inspiration for the chicken dance at powwows (CB). Prairie chickens are hunted in the fall as the season is regulated (CB). Participants in Wakpala reported that very few prairie chickens are observed near their community; they have been replaced by pheasants, the state bird of South Dakota (WP).

Male prairie chickens tend to return to the same mating area, known as a lek, which they establish and defend from spring through autumn. Prairie chickens mate from late February through April. A hen may visit multiple leks to locate a mate.⁴⁶ Females nest from April through June; they may return to the lek and re-nest if the first attempt fails.⁴⁷ The geographical area where prairie chickens are found is much smaller than it was in the past.⁴⁸

Prairie dogs (*pispíza* or *piŋspíŋza*, *Cynomys* sp.)

Prairie dogs are active throughout the year (LE). In the spring, bald and golden eagles hunt prairie dogs as they migrate north (CB). In the past, prairie dogs were hunted and trapped throughout the year for food (CB).

Rabbits, including cottontails (*maštíŋčala*, *Sylvilagus* sp.) and jackrabbits (*maštíŋska*, *Lepus* sp.) 

Baby rabbits are born in roadside ditches in the spring at the same time that pheasants are nesting and are often killed when the grass in the ditches is cut (BH). Jackrabbits are grey or brown in the summer and turn white in the winter (LE). They go out in the hills and flats in the winter (LE). Cottontails retain a grey coat and live in the forest during the winter (LE).

Rabbits are hunted and snared during the winter (FY, LE). It is possible to grab rabbits from their logs by their fur; rabbit fur is used to make gloves and moccasins (LE). Cottontails (FY, LE) and jackrabbits

46 SD-GFP, *Prairie Grouse Management Plan for South Dakota* (Pierre, SD: South Dakota Department of Game, Fish and Parks, July 2017) <<https://gfp.sd.gov/UserDocs/nav/PrairieGrouseManagementPlan.pdf>> [accessed 23 October 2020]; SD-GFP.

47 NRCS, *Greater Prairie-Chicken (*Tympanuchus Cupido*)* (Natural Resources Conservation Service, 2005), p. 12 <https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_010041.pdf> [accessed 23 October 2020].

48 SD-GFP.

(LE) taste better in winter. Whereas it is best to boil jackrabbits, it is better to roast cottontails (LE). Elders recommend mixing salt pork with your jackrabbit soup to make it taste good (LE).

Studies of commercial rabbit meat production show that many factors influence the quality of rabbit meat, including diet, processing, storage, as well as adrenaline at time of slaughter.⁴⁹

Robins (*šišóka*, *Turdus migratorius*)

Robins returning is an indicator of spring (CB, KN).

Robins are one of the most frequently observed birds in Standing Rock. Figure 5.21, based on citizen science data collected in Standing Rock,⁵⁰ shows robins can be observed in most months, although more frequently between March and November, with the highest number of observations in June. Robins remain in their breeding ranges through winter, but spend most of their time roosting in trees where they are unlikely to be observed.⁵¹

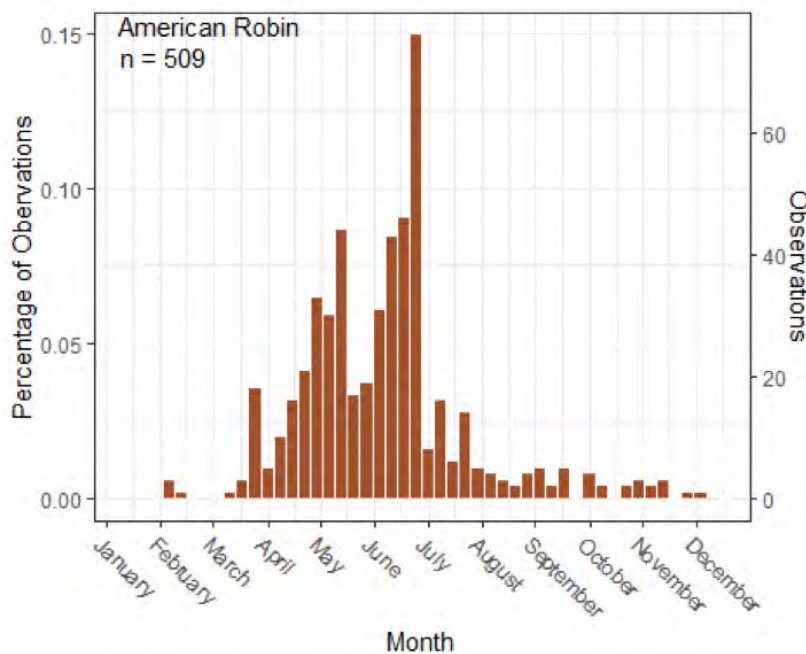


Figure 5.21: Observations of Robins in Standing Rock.

Skunk (*maká*, *Mephitis mephitis*)

In the past, skunks were trapped and hunted; some participants' mothers and grandmothers knew how to remove the skunks' scent glands and use the oil as a cold remedy by rubbing it on their chest (CB).

Smelt (*Osmeridae*)

Thousands of smelt, a type of small fish, come up the Missouri River in June or July (CB). During the smelt run it is possible to catch them using a 5-gallon bucket (CB). Walleye and northern pike feed on smelt (CB).

49 A Dalle Zotte, 'Perception of Rabbit Meat Quality and Major Factors Influencing the Rabbit Carcass and Meat Quality', *Livestock Production Science*, 75.1 (2002), 11–32 <[https://doi.org/10.1016/S0301-6226\(01\)00308-6](https://doi.org/10.1016/S0301-6226(01)00308-6)>.

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Snakes (*zuzéča*) 

The first thunder in early spring wakes up snakes (BH, LE). They generally come out in May or June. It is important to watch out for rattlesnakes in August, when they are out at night (BH), as well as when gathering berries (PP). In the fall, when it starts to get cool, snakes warm themselves on pavement (PP). During the validation workshops in 2018, participants reported there were not as many snakes as usual (PP).

Spiders (*iktómi*)

Spiders are seen in houses in fall and winter and appear outside in spring when the risk of frost has passed (WP). There are black and brown types of spiders, including species that bite such as the brown recluse, which is best to avoid (PP). Some participants said spiders are associated with thunder (WP), and others said lightning strikes spiders in cottonwood trees (BH).

Turkeys (*waglékšun* or *zizíča*, *Meleagris gallopavo*) 

Turkeys are seen throughout the year; one participant used to see them around Becker Day School (PP). Turkeys call loudly during their mating season in the spring (WP). In March, hunters get ready for the spring turkey hunting season by sighting their guns and tuning their four-wheelers (WP). Turkeys go off by themselves in the fall (BH). The fall turkey hunting season coincides with other birds flocking and preparing to migrate south (WP). Some participants feed turkeys in the winter (CB).

Wood ticks (*třaskákpa*, *Dermacentor variabilis*)

Wood ticks usually emerge in April; however, participants in the workshops in 2016 reported they had come out by March 15 (WP). It is common to find wood ticks on your pets (WP).

Woodpeckers (*čhankátotola*)

Woodpeckers are an indicator of spring (KN).

Some woodpeckers migrate south during the winter, while some are full-time residents of the Dakotas.⁵² Citizen science data from northern South Dakota and southern North Dakota⁵³ shows red-bellied woodpeckers (*Melanerpes carolinus*), pileated woodpeckers (*Dryocopus pileatus*), downy woodpeckers (*Dryobates pubescens*), and hairy woodpeckers (*Dryobates villosus*) remain throughout the year. In contrast, yellow-bellied sapsuckers (*Sphyrapicus varius*) and red-headed woodpeckers (*Melanerpes erythrocephalus*) are observed from May through October, indicating these species migrate.

Activities**Allergies**

Some participants get allergies at the beginning of spring, which serves as a seasonal indicator (BH).

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Blue clay

Some participants gather blue clay or mud in the summer (CB). Blue clay is used to treat a variety of ailments by ingesting it or by using it as an eye pack (CB).

Butchering and drying meat

Participants said they butcher twice each year, once in summer (June) when it's warm enough to dry the meat and once in the fall (October or November) when it is cold enough to freeze the meat (FY). Some said they avoid butchering animals right after they have consumed wild onions or green grasses because this may cause the meat to taste bad (PP).

Drying meat is part of preparing for winter; one can dry meat at any time, whenever you kill the animal (PP). Whenever one obtains meat, it is best to dry it right away (KN). In the past, residents of Kenel would trade with the people in Powell, located directly across the Missouri River, and if they received meat and it was hot outside, they would dry the meat before returning home (KN). It is possible to dry meat starting in July through the fall (CB).

Pápa is dried meat, traditionally prepared from deer or bison (PP). Previously, drying meat and corn were tasks performed by women (CB). It is necessary to cut the meat into thin slices to prepare for drying. Some women have learned to cut it so thin that you can see the knife blade through the slice (FY). Longer pieces are better for drying, but it is challenging not to slip and cut the piece too short (FY). The sliced meat is hung on poles and covered with netting (FY). Chokecherry tips (the ends of the chokecherry branches) are used to hold the meat open as it dries (LE). After one side is dried, it is turned around to dry the other side (LE).

Community members start making *pápa* in August and September when there are no more flies (LE, PP, WP); otherwise, flies will lay eggs in the meat (LE). Some participants prefer to make *pápa* when it is still hot (in August), while others do it in the fall inside with fans (WP). According to some, *pápa* tastes better when it is dried in the sun (PP). Nonetheless, various technologies are used for drying meat, including dehydrators, ovens, and air-drying, which make it possible to dry meat throughout the year (CB, WP). Even in the past, woodstoves were used to dry meat; one Elder remembered her grandparents drying *pápa* throughout the year on the woodstove (WP).

Canning

Canning is part of preparing for winter, but the timing depends on what food is being canned (PP). Participants said they can food right after it is harvested, usually in the summer (LE) and fall (BH, KN, LE). For example, cucumbers are harvested and pickled in late June and early July (FY). Beets are canned soon after harvest, in late August or early September (FY). However, many community members now freeze food (such as berries) for storage (BH).

Church activities

After school gets out, there are spiritual and Bible camps (LE). The Virginia Baptists come to Porcupine for one week at the end July to prepare meals, lead activities, and provide medical supplies; everyone looks forward to their arrival (PP).

Crafts

Beading, quilting, and quilling is possible throughout the year (LE), but winter is the time when many participants devote time to beading and sewing to prepare for powwows (BH, CB). Winter is a time to

sit and work together (CB) and for adults to teach children craft skills (LE). One participant talked about how it is important for aunties teach younger girls how to sew (CB).

In the past, before the Oahe Dam, there was a ferry that could carry a wagon and team across the river from Kenel to Pollock to trade beadwork, quilts, and crafts for sugar, flour, coffee, and sometimes meat (KN). Villagers from Kenel would camp near the trading store for up to a week (KN).

Feelings

Participants said that they associate spring with ‘a good feeling’ because they can finally go outside after spending much of the winter inside (PP). They are usually excited to ‘get going’ in the spring (KN). By contrast, participants have negative feelings about the fall because of the challenges they associate with winter, such as cars not starting and the difficulty of finding a ride (PP). Winter is *šiča* and *osní* (‘bad’ and ‘cold’) (PP). On the other hand, community members are generally kind and helpful during winter (PP). The winter of 2015/2016 was relatively mild, with ‘spring weather’ (warmer than usual conditions) (PP).

Firewood

Firewood is collected and chopped throughout the year (LE, CB), whenever it is needed (KN). Some wait to gather firewood in the fall after the rattlesnakes are gone to avoid encountering them (FY). Previously, firewood was gathered for the winter in the summer (CB) and fall (BH, CB), specifically in August (FY). Families had to cut enough firewood to last through the winter (KN). They would pile the wood in the summer so it had time to dry (CB). Families would visit with each other when they were cutting wood in the forests along the Missouri River (KN). Some non-Native residents of McLaughlin or Pollock would need more wood for the winter, so they would trade or buy firewood from Kenel (KN). Similar to hunting, access to firewood is now regulated, and those without access cannot gather wood at all (BH) or they must cut it late, in September (FY).

Firewood can be used for cooking throughout the year (FY). Green wood burns slower than dry wood (CB). Oak and ash generated the most heat, whereas cottonwood burns like paper (quickly, and giving off little heat) (CB). In the past, everyone burned wood, but now most families use propane (KN). Filling up your propane tank is important because it is hard to get deliveries in the winter (KN).

Fishing

Participants in most communities said they fish in the summer (CB, FY, KN, LE), while those from Wakpala specified April through November (WP). The fish mentioned include bluegills (*Lepomis macrochirus*, WP), bullheads (*Ameiurus* sp., FY, WP), catfish (Siluriformes, CB, FY, KN, WP), crappie (*Pomoxis* sp., WP), northern pike (*Esox lucius*, CB, WP), perch (*Perca* sp., WP), smelt (Osmeridae, CB), sturgeon (*Scaphirhynchus* sp., CB), and walleye (*Sander vitreus*, CB, WP). Participants in Cannon Ball said they fish for walleye, northern pike and smelt in June and July. Walleye and northern pike feed on smelt, so after the smelt come up the river, walleye and northern pike are harder to catch (CB). There are three kinds of catfish: blue catfish, channel catfish, and mud catfish (WP). Catfish are good to eat, including the eyeballs (CB). There are blue catfish around Little Eagle (WP). Channel catfish are the best for eating (WP). It is not safe to eat catfish from Bullhead because of the uranium mines (WP). Sturgeon is also good to eat, including the snouts (CB).

Participants from Wakpala said they go ice fishing from November through April (WP).

Gardening

Some participants said their communities learned to garden from the Mandan and Hidatsa (CB). Fields are prepared for planting by tilling the soil in the spring when the ground thaws (KN, WP), usually in May (WP). In Wakpala, because the soil has a high clay content, some gardeners enrich the soil with horse manure and river water. They mix in the manure before they plant, whereas the river water is applied as plants grow. Horse manure needs to age before it is applied to the garden, so they let it over winter and apply it in the spring or fall (WP). Some also use ‘no till’ agricultural practices to build up the soil (WP). It is important to let the land sit for a couple of weeks after tilling or plowing before planting (WP).

The name of the moon associated with the end of April or May, *Wóžupi wi*, refers to planting (PP, WP). While the names of other moons may differ, everyone shares the same name for this moon (WP). However, gardeners watch the weather to decide when to plant (WP). Some plant gardens in May (BH, CB, WP) or June (CB, WP). Others make decide when to plant based on the temperature (BH) or the timing of the last frost (BH, LE, WP). Potatoes and some flowers can be planted before the last frost (BH, CB). In general, seeds will survive a frost if they are below ground, but not if they have emerged above ground (WP). Gardeners cover the plants in their gardens with milk jugs if they think there is going to be a late frost (LE).

Some gardeners say the weather is changing, becoming ‘weird’, and they do not know when to plant because the timing of the last frost is highly variable (CB). Some say they now wait until the end of May, often Memorial Day, or early June to plant their gardens (CB). One Elder explained that it is always safe to plant a garden by the beginning of June, whether planting seeds or transplanting seedlings from indoors (LE).

One Elder related how her grandfather waited for the wild roses along the roadside to bloom, which indicated ‘the frost is out of the ground’ and it was safe to plant a garden (LE). Participants from other communities agreed roses bloom around the time of the last frost, so this could be used as a cue (CB). Spiders appear outside when the risk of frost has passed (WP), which might be used as another cue.

The soil needs to be moist to plant a garden (CB). When the first plants appear, usually in May, gardeners start weeding and watering (CB). However, some crops need watering before they appear (CB). If growing plants under hoop houses, they need to be watered continuously throughout the growing season (CB). Otherwise, the need to water depends on the rain (CB).

In the past, everyone had a garden and a section of a root cellar they could access with their own key (KN). An Elder recalled her grandparents storing potatoes, onions, carrots, and squash in their root cellar, which they relied on in the winter (KN). Nowadays, most community members use freezers rather than root cellars (KN).

Gathering plants (general)

In late July and August, those who gather berries start getting out their baskets (LE). In general, August is considered the time for gathering plants; the August moon is *Wasúthun wi*, which means ‘ripening moon’ (WP). When the Big Dipper dips, it is time to collect berries (FY). The community members who gather the most berries are young men in their 40s and early 50s who are looking to sell them to others in their community (PP). Gatherers must look out for poison ivy, poison oak, and snakes (PP).

Haying, cutting grass

The grass in roadside ditches is cut in spring, at the time when pheasants are nesting and baby rabbits are born (BH). However, participants have noticed that the time for cutting the grass no longer corresponds with pheasants nesting; recently the baby pheasants are already running around (BH).

'Haying time' is in July and August (FY). Community members used to put up hay in June or July, but now it is primarily done in July through September (KN). If there is enough rain, it is possible to harvest two cuttings; otherwise, there is only one (KN). One participant remembered their mother and sister looking for strawberries while the hay was cut (FY). Hay can be purchased throughout the year (LE).

Holidays

Valentines' Day used to be a time to honor couples that have been together for a long time (CB). On Traditional Memorial Day (May 30), families bring food, such as oranges, to veterans' graves (BH). The Battle of Little Bighorn is commemorated on June 25 (FY). Halloween is celebrated on October 31 (PP). Thanksgiving is celebrated at the end of November (PP). Christmas, celebrated on December 25, is a time to be together with family (PP).

Horsemanship

Community members ride and race their horses in the summer (KN, LE, WP). There are horse races at the Left Hand's ranch south of Kenel (KN, WP) and another associated with the Little Eagle Powwow (WP). Horse racing is no longer as common around Wakpala as it was in the past (WP).

Memorial rides, also called spirit rides, are organized every year. In May there is a memorial ride called 'Honoring the Chiefs', when riders visit the burial sites of Standing Rock's leaders (BH, WP). In June there is a ride to Montana to commemorate the Battle of Little Bighorn (WP). In December, the Dakota 38 Ride honors the lives lost at Mankota, Minnesota (WP). The Big Foot Ride begins on December 15, the day Sitting Bull was murdered, and follows chief Big Foot's path to Wounded Knee as a tribute to those massacred by U.S. soldiers on December 29, 1890 (BH, WP).

Hunting

In the past, community members were able to hunt throughout the year (FY, PP), most frequently in the in the summer (BH) and fall (CB), which is a good time to dry meat (BH, CB). Furthermore, summer hides (from animals killed in the summer) are lighter and easier to tan (CB). It is still possible for residents to hunt anytime on their own land, although they should avoid killing pregnant animals in the summer (BH). However, today hunting is regulated (CB). For example, mule deer and white-tailed deer have the same hunting season, but different tags are needed (WP). Some participants said official hunting seasons have 'displaced' the timing of hunting (BH).

The official hunting seasons are in the fall (LE). On the reservation, hunting begins one month earlier and ends one month later than those set by the states of North and South Dakota (PP). Nonetheless, most community members hunt in the fall (LE), specifically October and November (PP). Deer are hunted in fall to avoid killing a pregnant doe (WP). By November, the deer already have their young (FY). One participant said her family hunts before Thanksgiving in November (FY). Hunters avoid making the animal run to avoid increasing adrenaline in the meat (PP). After a successful hunt, the tradition is to eat the liver right away, and to dip it in the gall (FY).

Ducks and geese are hunted in the fall, whereas turkeys and pheasants are hunted throughout the year (WP).

Participants in Cannon Ball remembered how they used to hunt deer and rabbits (cottontails and jackrabbits) in the winter (CB). There were hunting contests in December, January, and February. After the contests, the women would sit and pull hides from the rabbits in large washtubs (CB).

A table with hunting seasons for mammals and birds is included as Appendix A.

Memorial feeds 🍴

Memorial feeds are meals held for the community to honor someone who has passed away, usually during the summer after the person's passing (LE). Memorial feeds are associated with giveaways which can include shawls, blankets, pots, pans, and potholders (LE). Preparations for a memorial feed often begin in winter, including saving up to buy more expensive items like Pendleton blankets (LE).

Planting trees

Trees can be planted in early spring when the ground has thawed but it is still cold (BH). However, trees are most commonly planted in fall (BH). Trees need to be planted in the same orientation in which they grew, so it is important to mark them before they are moved from the nursery (BH).

Powwows

Summer is a time of social gatherings and celebrations, including powwows (CB, KN). Powwows are held throughout the reservation, as well as in Rapid City and other cities in the region (WP). They are organized from May until September (LE). In the past, Standing Rock's first powwow took place in Kenel in May, but one year it was delayed due to several deaths in the community, and ever since it has been held in June; now the first powwow is in Cannon Ball (LE). The second powwow is in Porcupine, during the second or third weekend in June (PP). The Doughboy Powwow (in honor of veterans of World War I) is held on June 28 (BH). The Little Eagle Powwow takes place during the last weekend in July (LE). The Little Eagle Powwow includes the Monument Celebration, in which veterans' parade from the powwow grounds around the monument in Little Eagle. Previously, it was held on July 27, but now it is on the last weekend in July (LE). The Wakpala Powwow occurs on the third weekend in August (WP). The Bullhead Powwow is the second-to-last powwow in Standing Rock (BH). The last powwows (of the summer) are at United Tribes Technical College (LE, PP) and Cheyenne River in September (LE). The Veterans Powwow is held on November 11 (WP). During the winter there is a mid-winter Powwow at Prairie Knights Casino and Resort (WP). Schools hold their own powwows in April and May (WP). Community members start planning and fundraising for powwows in the fall (PP) and spring (LE). There used to be a tradition called *tiopi nazhi* where singers would come to a house to honor a family member, and then the family would donate blankets or food for the powwow (LE).

School 📖

In the fall, students are back to school and concentrating on their grades and sports (PP). They start getting ready for school in August (LE), and school starts in August or September (BH). Those who attend boarding schools depart in August (FY) or September (KN) and return in May (FY, KN). In Standing Rock, the school year ends in May (BH, PP) or June (LE). Graduation is usually in May (BH, PP, WP). Students take time off from school in the summer (CB).

Seasonal dishes

Some traditional foods are prepared at certain times of the year. Participants in Porcupine talked about eating *thaniŋa* (tripe) in spring and fall. Farmers give out tripe in the spring, and cattle are often butchered in the fall, hence *thaniŋa* is available (PP). In the winter, participants in Cannon Ball said they prepare a soup with prairie turnips, dried corn, and dried meat, including dried intestine (*thasŋupa*) and dried kidney fat (CB). Participants in Fort Yates described a similar winter soup made with prairie turnips, dried corn, meat, and squash (FY). Another popular winter dish is *wožapi*, a fruit pudding prepared from berries gathered and dried in the summer (WP) or chokecherries that have been dried as patties (FY).

Sledding

Some community members enjoy sledding in the winter (BH, KN, PP). Children used to ice-skate and go sledding with toboggans, but using a toboggan is difficult now because there are more fences (BH). One Elder remembered that her father used to make sleds (KN). Others remembered using the hood of an old car as a sled, which went surprisingly fast (FY). These days kids are happier to be inside during the winter (PP).

Social events

In the winter there is more time for social events, including sharing food and eating together (LE). Parties at schools include bingo tournaments and Valentine's days celebrations (LE). In recent years there was an event called 'Greet the Spring', which was held in the Black Hills at the beginning of spring. The Porcupine Residents Organization raised funds for community members to attend (PP). Elders remember that farther back, dances were organized throughout the year with musicians who played piano, drums, guitar, and fiddle (KN).

Sports

Community members participate in a variety of sports throughout the year. In the spring, students compete in track and field, as well as baseball, which is organized at United Tribes Technical College (PP). Road runs, including sobriety runs, are held in the summer (LE). Most of these races are five or ten kilometers long, and some of them are associated with powwows (LE). Memorial walks are also organized in the summer (LE). Some participants enjoy biking in the summer (LE). In the past, summer was the time to play hand games (also known as moccasin games), which were organized by a men's society (CB).

In the fall, young people play football and run cross-country (PP). Basketball (LE, PP) and volleyball (LE) are played in the winter. Basketball season starts in December (WP). Some diehards play basketball all year (PP).

The Lakota Nation Invitational is an event in Rapid City that lasts three or four days, including a Lakota language bowl, wrestling, archery, traditional handgames and basketball; all schools from the Sioux Nation gather for this event (LE).

Storytelling

Winter is a good time for telling stories (LE). Some parents read their children *Iktomi* stories that teach them how to overcome challenges in life (BH). They also tell scary stories featuring characters known as Grey Shawl and Tall Man (BH). However, some participants say that their storytelling traditions cannot continue because children speak English rather than Lakota (BH).

Sun Dance

Sun Dances are held on the full moons in June, July, and August (CB). Some participants say that when the "bear comes out of the cave" (referring to the stars), it is Sun Dance season (CB). The Strong Heart (*Čhaŋtét'inza*) Sun Dance is held on the first full moon in July (LE). The full moon was early in 2015 (on July 2) but later in 2016 (on July 19). Elders say the *Čhaŋtét'inza* Sun Dance lasts for five days (LE). However, participants prepare all year round, doing Sun Dance ceremonies every full moon (CB). If the full moon is not on the weekend, making it difficult to attend, they hold the ceremony three or four days before or after the full moon so that it falls on the weekend (CB).

Swimming

Community members swim in the summer (LE), specifically in July and August (KN). In the past, it was possible to swim in June, but now swimming starts in July because it is colder (KN). Community members from Bullhead usually swim in stock ponds or at the dam north of town (BH). It used to be safe to swim everywhere, but now there is more pollution from uranium mines near Grand River, and young people get sores or sick when they swim (BH). Cows also pollute the water (BH).

Conclusion

The ecological calendars and accompanying Community Knowledge Base bear witness to the rich ecological knowledge held within Standing Rock communities, particularly Indigenous knowledge of the timing of seasonal events related to their food and health sovereignty. The calendars and knowledge base also reveal losses of knowledge, especially in those communities that were forcibly relocated from their land following the construction of the Oahe Dam. One of the aims of this report is to facilitate knowledge exchange between communities to revitalize ecological calendars and anticipatory capacity for climate change. Ultimately, the diversity of Indigenous knowledge within and among communities will enable them to adapt to unprecedented conditions in accordance with their cultural values.

Appendix A

Hunting Seasons for Mammals and Birds in Standing Rock, as well as the States of North and South Dakota.

	Animal	Standing Rock Nation⁵⁴	North Dakota⁵⁵	South Dakota⁵⁶
Mammals	bighorn sheep	-	early November to late December ⁵⁷	early September to late December ⁵⁸
	bison (buffalo)	-	-	late October to mid-January ⁵⁹
	bobcat	mid-December to mid-February	early November to mid-March	late December to mid-February
	cottontail (eastern and desert)	year round	year round	early September to late February
	deer	late August to late December	late August to early January	early September to early January
	elk	-	early September to early January	early September to late October
	jackrabbit (white- and black-tailed)	year round	year round	early September to late February
	mountain lion	year round	late August to late March	year round
	prairie dog (black-tailed)	year round	year round	year round
	pronghorn (antelope)	early August to mid-October	late August to late October	late August to late October
Birds	Canada goose	mid-September to late December	mid-August or late September to early January	early September to mid-February
	ducks (multiple species)	late September to early December	mid-September to early January	mid-September to mid-January
	gray partridge	late August to late January	mid-September to early January	mid-September to early January
	greater prairie chicken	-	-	mid-September to early January
	grouse (sharp-tailed & ruffed grouse)	late August to late January	mid-September to early January	mid-September to early January
	light geese (lesser & greater snow goose, Ross's goose)	mid-February to mid-May	late September to early January; late February to mid-March	late September to early January
	mourning dove	early September to early November	early September to late November	early September to early November
	ring-necked pheasant	mid-October to early December	mid-October to early January	mid-September to late January
turkey	late March to mid-May; early September to late January	mid-October to early January and mid-April to mid-March	early November to late January and mid-April to late May	

Notes: This table is not intended to inform hunters of the specific dates for hunting seasons, which change from year to year. Rather it gives a sense of the times of year for hunting under current regulations. Please refer to more up-to-date information available from tribal and state agencies (see links in footnotes). ‘Early’ refers to the 1st through 9th day of the month, ‘mid’ to the 10th through 19th day of the month, and ‘late’ to the 20th day through the end of the month. Time periods indicated here combine all types of hunting (e.g., bow, rifle, musket) and all areas within the tribal or state jurisdiction.

54 Standing Rock Sioux Tribe Department of Game and Fish (<http://gameandfish.standingrock.org/>)

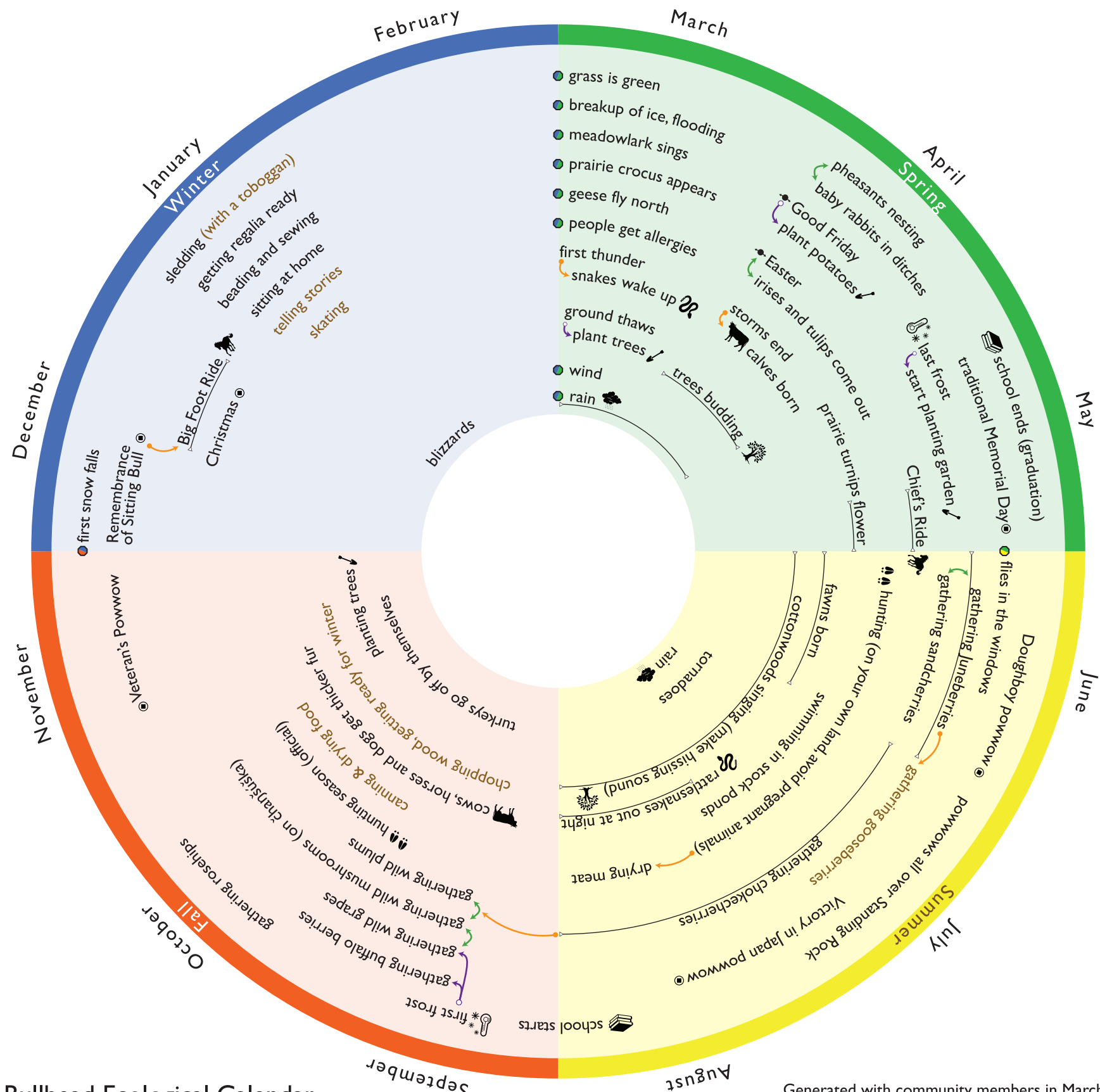
55 North Dakota Department of Game and Fish (<https://gf.nd.gov/hunting>)

56 South Dakota Game, Fish and Parks (<https://gfp.sd.gov/events/keydates/>)

57 Limited to areas around the Little Missouri National Grasslands in western North Dakota.

58 Limited to the Black Hills.

59 Limited to Custer State Park in the Black Hills.

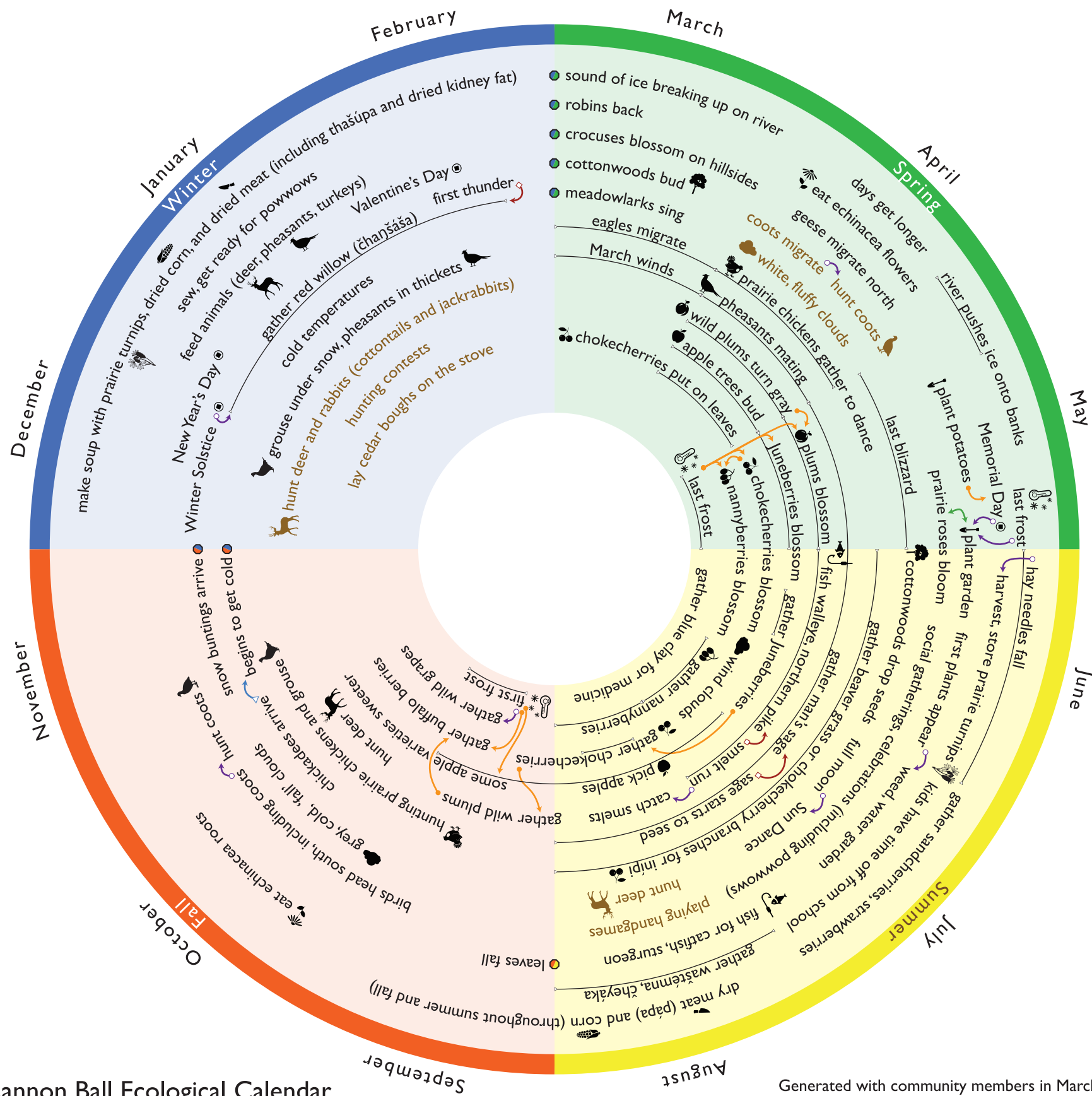


Bullhead Ecological Calendar
Standing Rock Nation

Generated with community members in March 2016
Validated with community members in October 2018
Most recent revision: July 2020

LEGEND	
●	Fixed Gregorian calendar date
●	Changing Gregorian calendar date
●	Seasonal indicator (ending/beginning season)
↔	Synchrony (occurring at the same time)
→	Sequence (occurring one after the other)
→	Cause-and-effect
→	Cue (prompts a seasonal activity)
→	Block (impedes another phenomena)
→	Predictor (foretells a future event)
<u>abc</u>	Likely range of time (underlined)
abc	Past event or activity (brown text)

Figure 5.22

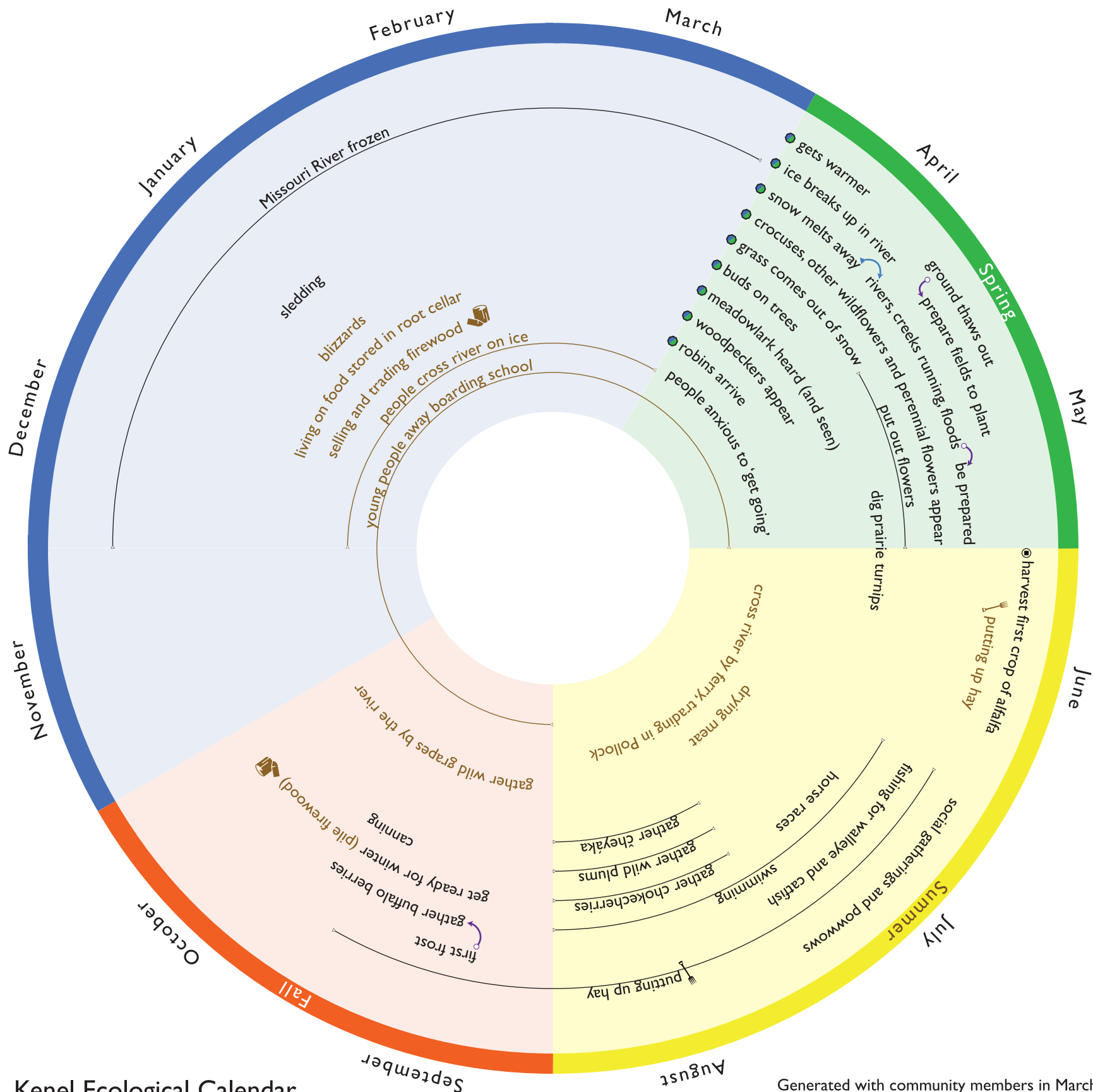


Cannon Ball Ecological Calendar
Standing Rock Nation

Generated with community members in March 2016
Validated with community members in October 2018
Most recent revision: July 2021

LEGEND	
☉	Fixed Gregorian calendar date
●	Changing Gregorian calendar date
●	Seasonal indicator (ending/beginning season)
↔	Synchrony (occurring at the same time)
→	Sequence (occurring one after the other)
→	Cause-and-effect
→	Cue (prompts a seasonal activity)
⊥	Block (impedes another phenomena)
→	Predictor (foretells a future event)
<u>abc</u>	Likely range of time (underlined)
abc	Past event or activity (brown text)

Figure 5.23



Kenel Ecological Calendar
Standing Rock Nation

Generated with community members in March 2016
Validated with community members in October 2018
Most recent revision: August 2020

LEGEND

- ⊙ Fixed Gregorian calendar date
- Changing Gregorian calendar date
- Seasonal indicator (ending/beginning season)
- ↔ Synchrony (occurring at the same time)
- Sequence (occurring one after the other)
- Cause-and-effect
- Cue (prompts a seasonal activity)
- ⊘ Block (impedes another phenomena)
- Predictor (foretells a future event)
- abc Likely range of time (underlined)
- abc Past event or activity (brown text)

Figure 5.25

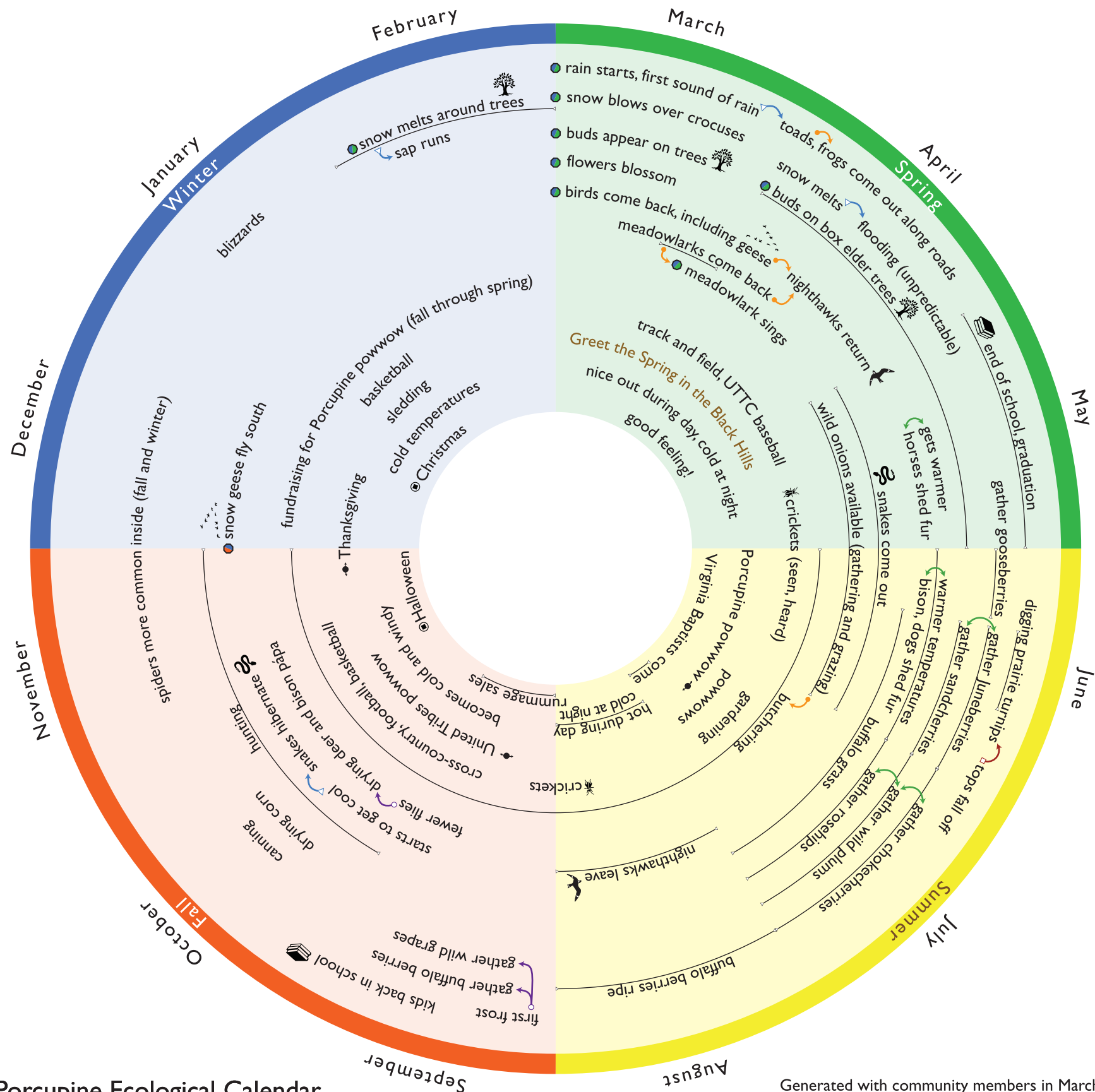


Figure 5.27

Generated with community members in March 2016
Validated with community members in October 2018
Most recent revision: July 2021

Future Directions

As we have demonstrated, the potential to develop ecological calendars exists across differing ecological and cultural contexts. The diversity of breadth and depth in these community reports is not a point of departure, but a moment of learning. The idea of ecological calendars is simultaneously universal and particular. Because of the connectivity that Indigenous and rural people have to their homeland, ecological calendars are inherently particular as they reflect the specific knowledge of a particular habitat. That connectivity also makes it universal because communities in different places and in other moments of time can develop such calendars precisely because of their linkage to their habitat. This is what gives the ecological calendar its anticipatory and adaptive potential. Where local knowledge has been diminished by a history of colonialism and injustice as well as the continuing global trend of unchecked industrialization, there is potential of rebuilding and revitalizing it through collaborative research.

It is our hope that through this report, other communities are inspired to develop their own ecological calendars. There is a demonstration effect resulting from this project, namely that other Indigenous and non-Indigenous communities may also have or are now considering developing their own ecological calendars. At a dismal moment in human history, where industrial civilization irrespective of its ideological roots in capitalism, communism, or socialism has undermined the linkage individuals and societies have with their habitat, the collaborative act of developing such calendars is empowering on several fronts. First, it creates a heightened awareness of one's own habitat whether it is urban or rural or some space in between. This heightened sense, brings forth an understanding of relationships inherent in that ecological space. Therefore, both the individual and community become conscious of the *rhythms* of their lands and cognizant of the consequences of their actions. Second, this exercise of awareness and understanding is the first step to co-creating an ecological calendar that suits a particular community and their cultural and ecological context. Third, with such an outlook, human-induced climate change ceases to be simply an overwhelming global phenomenon, it becomes particular because understanding these changes, anticipating their impacts, and developing adaptive capacity can be empowering when arising from uniquely place-based knowledge. Yet a response to climate change demands global commitment and action. That commitment cannot take place in a vacuum, it must be grounded in the knowledge and reality that is locally informed.

The process that we have described in these reports has been iterative and organic. It is an engagement that co-created insights through deliberative discussions even while a global pandemic ravaged the planet and, in some instances, armed conflicts destroyed the lives of people where we work. The very fact of the commitment of these diverse communities and our research team speaks to the necessity of this work and its capacity to build a meticulous methodology of hope. Therefore, several more tasks remain.

First, the ecological calendars for the communities in the Pamir Mountains and the Standing Rock Sioux Nation need to be validated. Given this publication and the intent of having it available electronically

on the web, means the validation can be achieved more easily. In addition, new insights and ecological relationships can easily be added.

Second an international conference that brings together scientific, local community, civil society, and governmental institutions will help strategies for future action, research, and policy formulation. Such a conference entitled *Rhythms of the Land: Indigenous Knowledge, Science, and Thriving Together in a Changing Climate* has been organized for October 2021 at Cornell University.

Third, an effort must be made that the Indigenous and local knowledge that is contained in ecological calendars is not only communicated but is also revised and revitalized by future generations in their respective communities. This is most easily achieved through environmental education and curriculum development not only in the social sciences and humanities but concomitantly in the biophysical sciences. Climate change knows no disciplinary, geopolitical, or cultural boundaries. Similarly, the response to understanding and adapting to its impacts must reflect that consciousness.

Fourth, policy in terms of hunting, fishing, farming, herding, or broadly land stewardship must reflect the insights that communities and researchers are collaboratively reporting through their ecological awareness and insights. This will have direct impact on regulations for hunting and fishing seasons. In addition, land use plans, policies, and practices will need to be examined in the context of the changing climate and in light of specific insights arising from these localized ecological calendars.

Finally, when communities described their ecological relationships, their knowledge, although fractured by the impact of industrialization and a colonial legacy, was intimate. Descriptions of their habitats did not separate their presence on the land from other living beings. They were cognizant that they are *living through* the environment not *from* it. There was no separation between mind and body because both exist because of and within an ecological space. This perspective should give us hope and inspire us to explore it in our own lives.

