RHYTHMS *of the* LAND

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

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

Logo Credit: Natani Notah, Karim-Aly Kassam, Anna Ullmann

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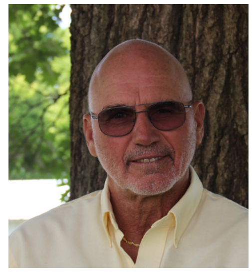

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Introduction

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

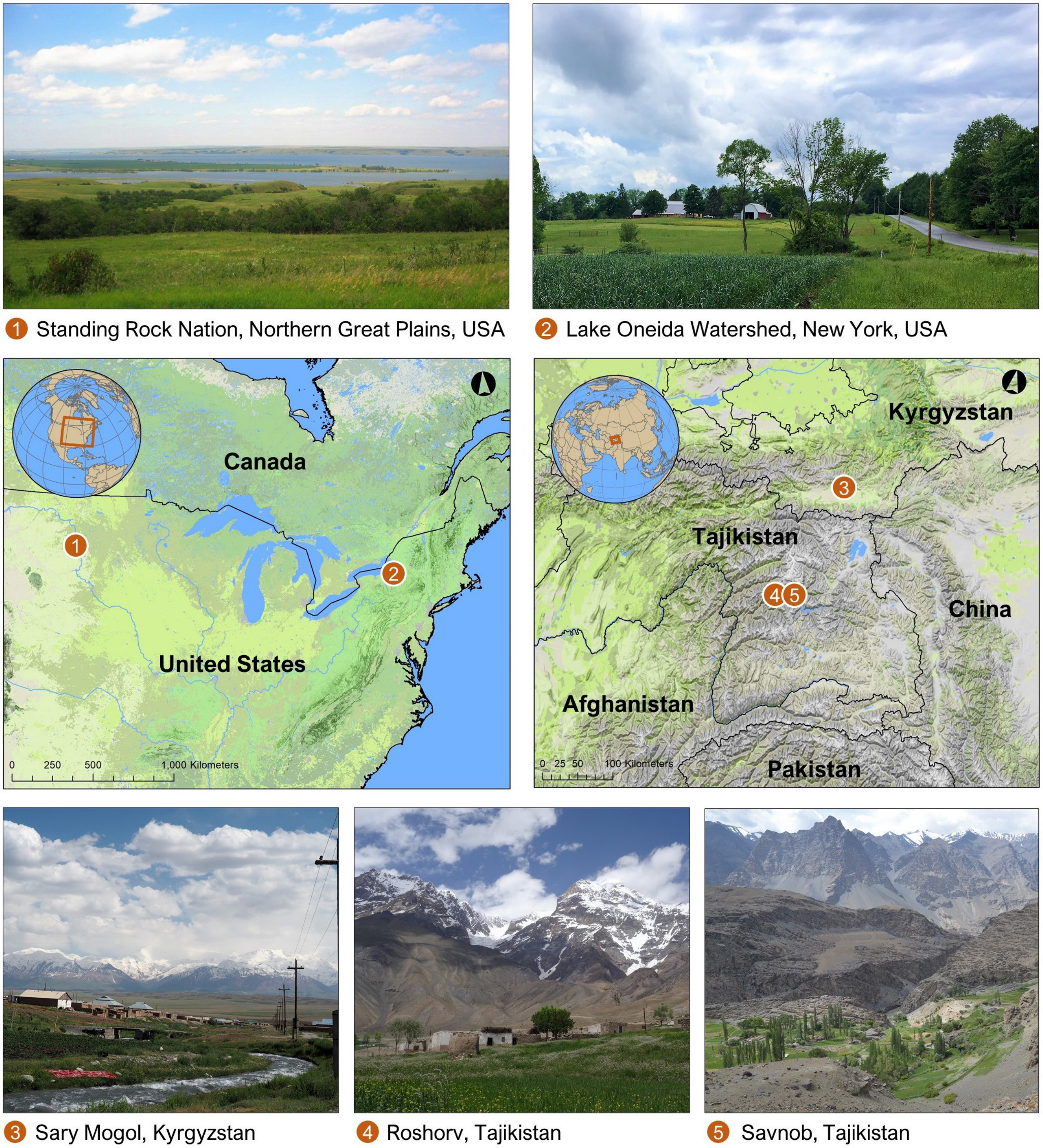


Figure 1.1: Research Context in Central Asia and North America

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 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.

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.

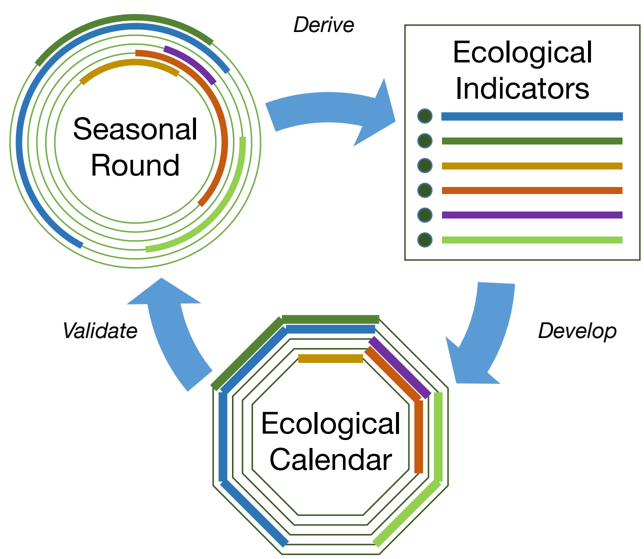


Figure 1.3: Collaborative Process of Developing Indicators for Ecological Calendars

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.

Upstate New York, USA
Oneida Lake Watershed

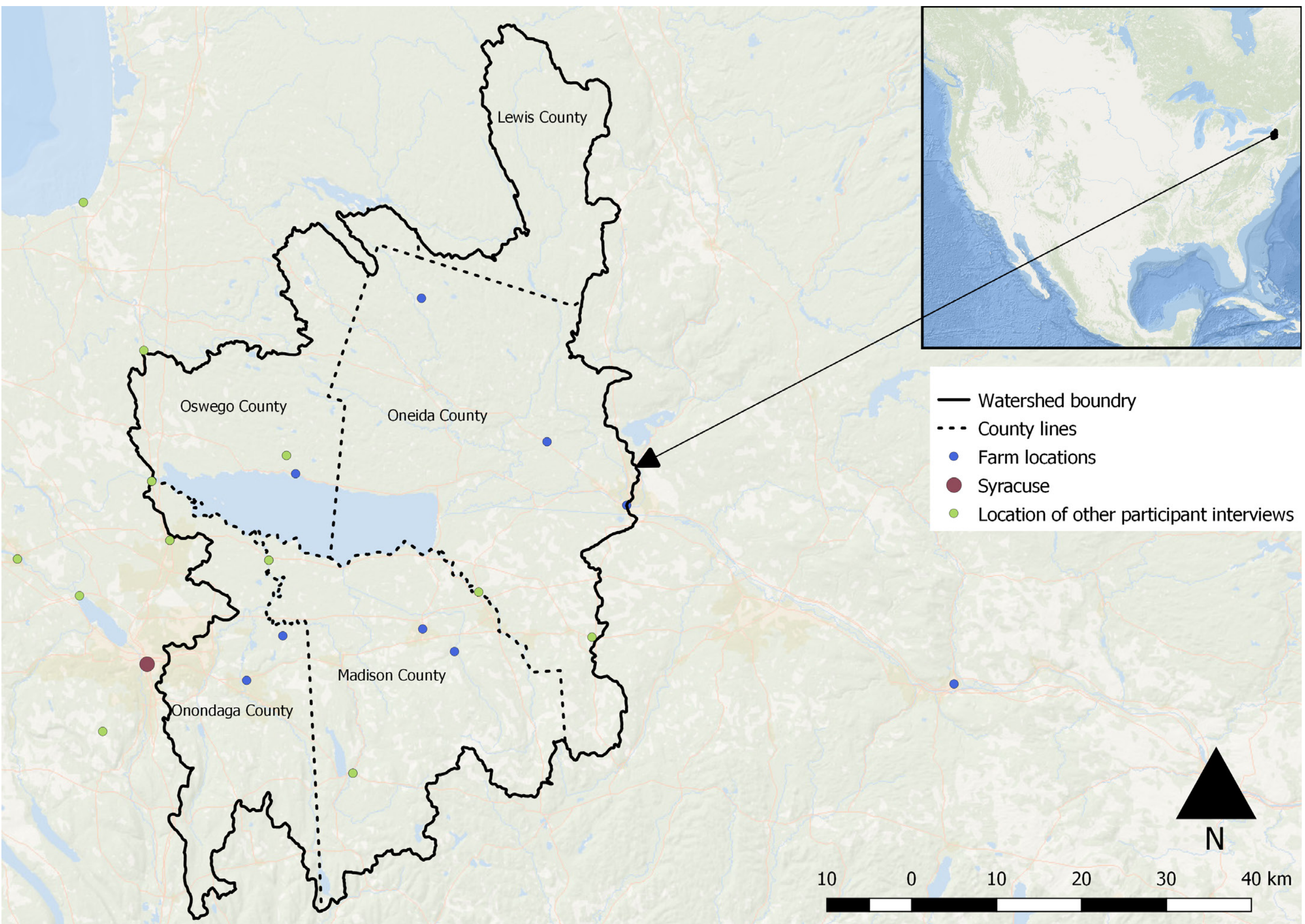


Figure 4.1: Map of the Oneida Lake Watershed

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.

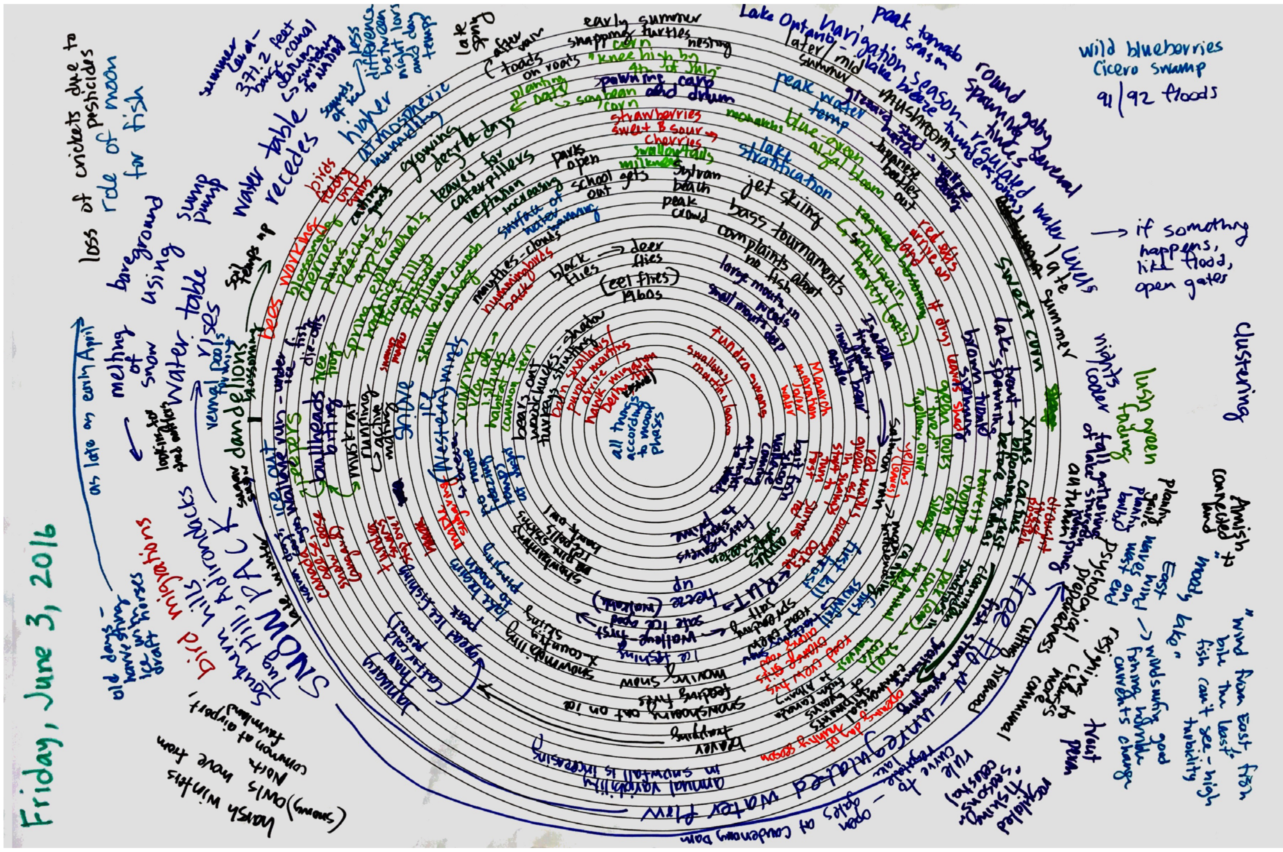


Figure 4.2: Seasonal Round Generated at the Friday June 3, 2016 Workshop

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: • 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).

Type	Timing	As seen in the calendar
Sequence	April/May	Frosts coming to an end; Appearance of trillium, wild leeks, honeysuckle, and serviceberry
Synchrony	April/May	Flies and bees come out; Hummingbirds show up
Cue	April	Good perch fishing; Crocus blooms

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

- 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.

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 ~ 50º 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 eBird[1] (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).

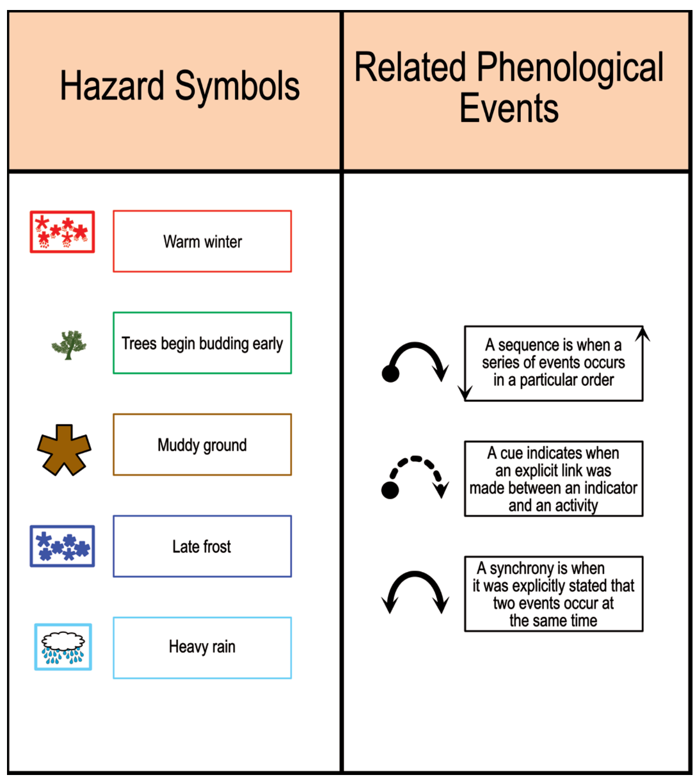


Figure 4.5: Legend for Ecological Calendar and Notation Used to Indicate Hazards and Related Phenological Events.

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).

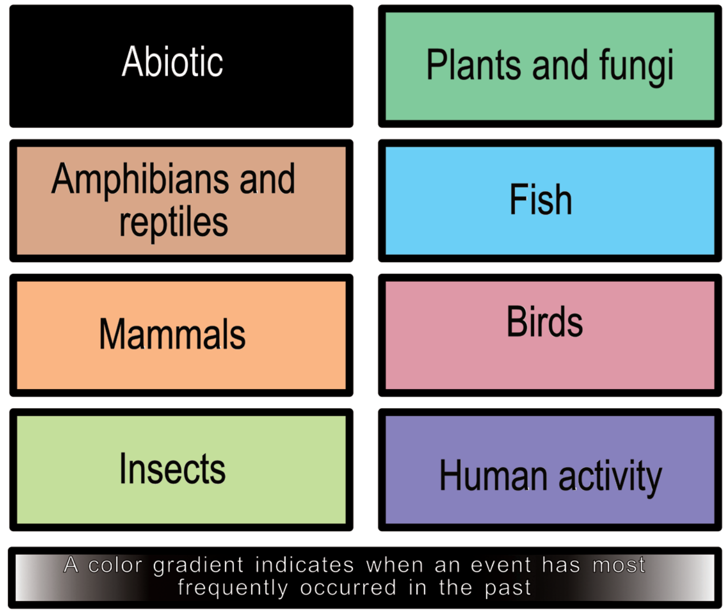


Figure 4.6: Color Codes for Different Organisms and Events in the Ecological Calendar.

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.

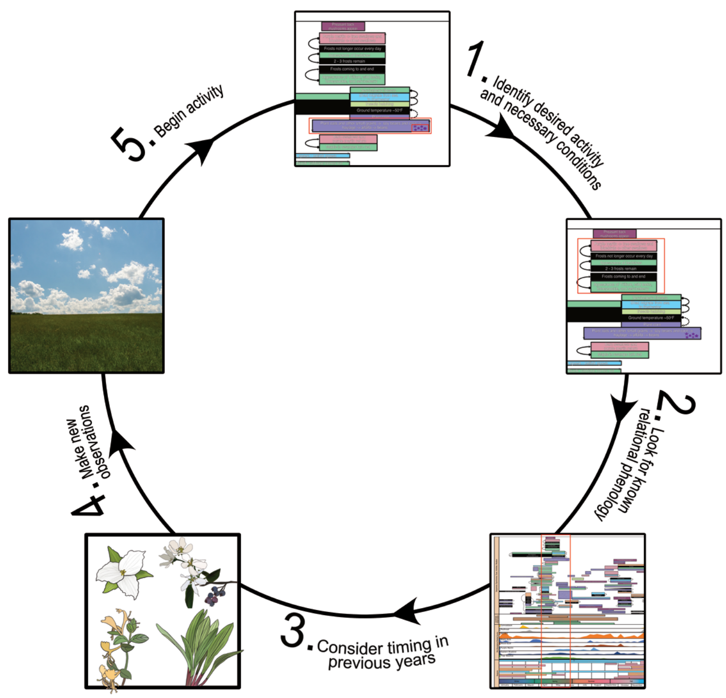


Figure 4.7: Diagram Depicting the Iterative Process of Using and Updating the Ecological Calendar.

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 adaption. 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.

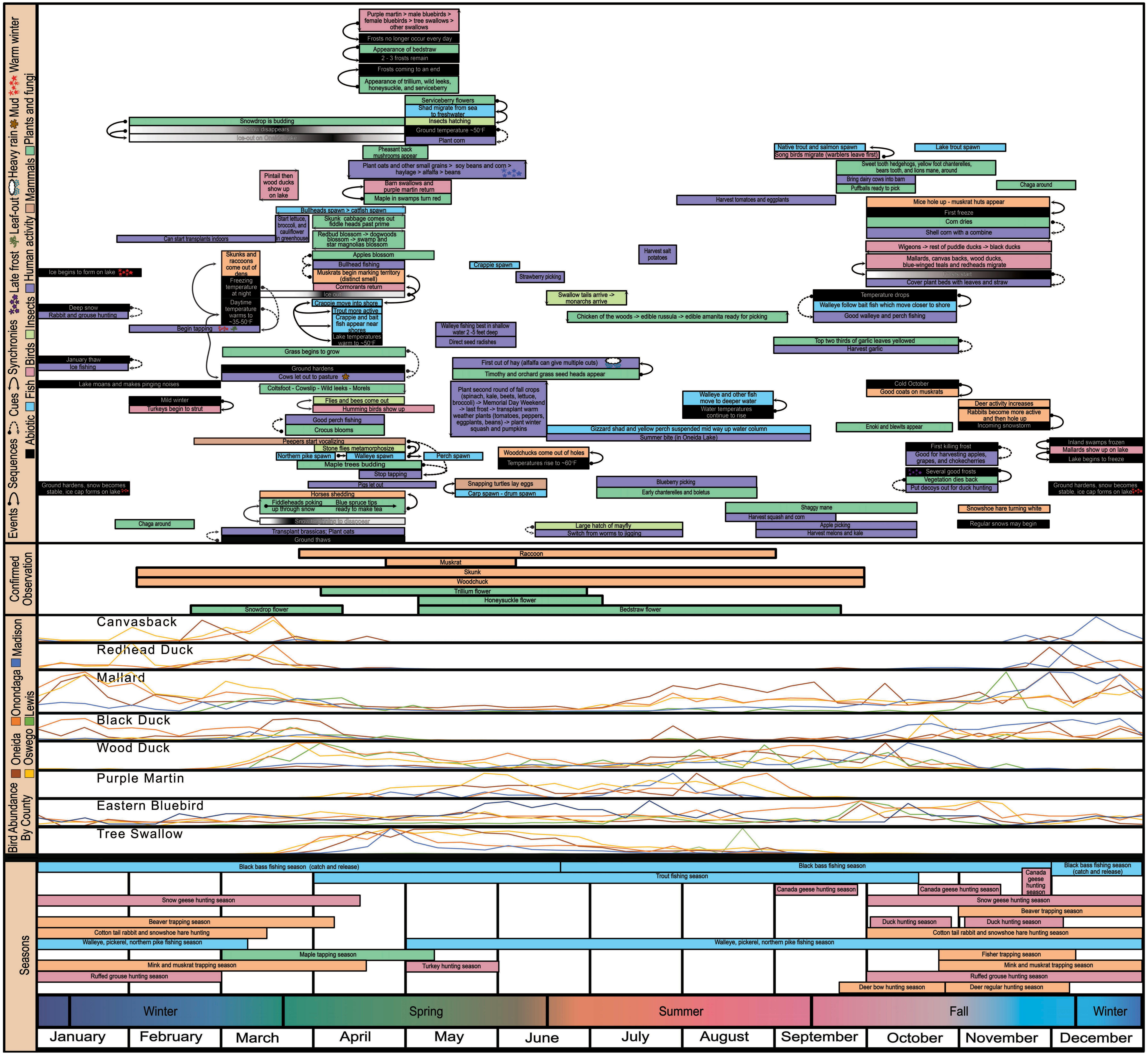


Figure 4.8

Ecological Calendar for Oneida Lake Watershed, 2021

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.

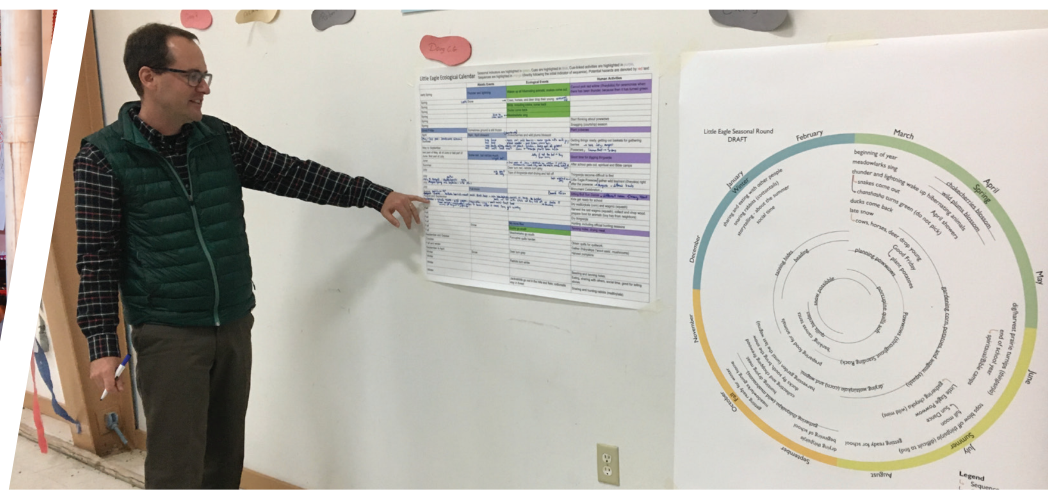
First, the ecological calendars for the communities in the Pamir Mountains and the Standing Rock Sioux Nation need to be validated. Given this publication and the intent of having it available electronically on the web, means the validation can be achieved more easily. In addition, new insights and ecological 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.


Little Eagle Seasonal Round
DRAFT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