GeoHealth

RESEARCH ARTICLE
10.1029/2022GH000612

Special Section:
Rhythms of the Earth: Ecological Calendars and Anticipating the Anthropogenic Climate Crisis

"When the Wild Roses Bloom": Indigenous Knowledge and Environmental Change in Northwestern North America

Nancy J. Turner[1] and **Andrea J. Reid**[2]

[1]School of Environmental Studies, University of Victoria, Victoria, BC, Canada, [2]Centre for Indigenous Fisheries, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada

Key Points:

- Indigenous Knowledge has guided Peoples of Northwestern North America in optimizing their seasonal activities in synchrony with biological species
- The breadth and variety of Indigenous Knowledge prepared people for interannual variation, and helped them face the impacts with resilience
- Currently, with biodiversity loss and climate change threatening protective systems, Indigenous Knowledge is as critically important as ever

Correspondence to:
N. J. Turner,
nturner@uvic.ca

Citation:
Turner, N. J., & Reid, A. J. (2022). "When the wild roses bloom": Indigenous Knowledge and environmental change in Northwestern North America. *GeoHealth*, *6*, e2022GH000612. https://doi.org/10.1029/2022GH000612

Received 15 MAR 2022
Accepted 31 OCT 2022

Author Contributions:
Conceptualization: Nancy J. Turner, Andrea J. Reid
Data curation: Nancy J. Turner
Formal analysis: Nancy J. Turner
Investigation: Nancy J. Turner
Methodology: Nancy J. Turner
Project Administration: Nancy J. Turner
Resources: Nancy J. Turner, Andrea J. Reid

Abstract Indigenous Peoples in Northwestern North America have always worked with predictable cycles of day and night, tides, moon phases, seasons, and species growth and reproduction, including such phenological indicators as the blooming of flowers and the songs of birds. Negotiating variability has been constant in people's lives. Long-term monitoring and detailed knowledge of other lifeforms and landscapes of people's home territories have assisted in responding and adapting to change. Aspects of cultural knowledge and practice that have helped Indigenous Peoples navigate nature's cycles at different scales of time and space include kin ties and social relationships, experiential learning, language, storytelling and timing of ceremonies such as "First Foods" celebrations. Working with ecological processes, Indigenous Peoples have been able to maintain optimal conditions for preferred species, reducing variability and uncertainty through taking care of productive habitats, leaving ecosystems intact, and allowing other species to change in their own cycles. Since the onset of colonization, however, Indigenous Peoples' lifeways have been changed drastically, culminating with the current impacts of global climate change and biodiversity loss. This paper, based on contributions of numerous Indigenous Knowledge holders from across Northwestern North America, outlines some of the key ways in which Indigenous Peoples have embraced predictability and change in their environments and lifeways, and addresses the particular threat of climate change: its recognition, ways of adapting to it, and, ultimately, how it might be reversed through developing more careful, respectful relationships with and responsibilities for the other-than-human world.

Plain Language Summary Indigenous Peoples of Northwestern North America have, for millennia, lived within seasonal cycles, using the life cycles of plants, birds, and other local species as indicators for harvesting. Their own calendars also mark the times of year when they can normally access and process the foods, materials, and medicines they rely upon and interact with. Indigenous Peoples have long held respectful, interdependent relationships with the plants and animals of their homelands, and have developed many different ways of tending and caring for these species, as well as creating adaptive practices, enabling them to respond to unanticipated shocks and events such as floods or unexpected loss of fish. The arrival of European colonizers caused many changes to Indigenous Peoples' lifeways, resulting in overall resource depletion and, most recently, drastic declines in biodiversity tied with global climate change, industrialization, and colonization. However, Indigenous Peoples' knowledge, practices, and strategies remain critically important, and are absolutely vital in identifying, alleviating, and reversing the impacts of these combined threats. Equally crucial are ethical ways of working together for the benefit of all.

1. Introduction

> "*Just when the wild roses bloom, in late May and June, that's the time they harvest the basket grass and the cedar roots*" (Peters, 1984; published previously in Turner, 1992a).

These words of Lil̓wat7ul (Lil'wat) basketmaker Elder Nellie Wallace Peters reflect just one focused example of an Indigenous Elder's place-based knowledge of natural cycles and connections to multiple species. Such knowledge is widespread among Indigenous Peoples worldwide, living in close relationship with the land and with other species, based on generations of observation, experimentation, kinship, and absolute reliance on such knowledge for survival and well-being as Peoples. The plural "Peoples" is an explicit recognition that many distinct Indigenous cultures comprise this term (Younging, 2018). Capitalization of Indigenous Peoples recognizes status as discrete, self-determining Nations. This knowledge is complex and nuanced, and, importantly, it is connected with knowledge and experience of environmental change—how to survive through unanticipated

Software: Nancy J. Turner
Validation: Nancy J. Turner, Andrea J. Reid
Visualization: Nancy J. Turner
Writing – original draft: Nancy J. Turner
Writing – review & editing: Nancy J. Turner, Andrea J. Reid

events and circumstances, and how to respond and adapt to such shifts (Steeves, 2021). While such knowledge may be key to coping with increasingly uncertain times in the face of global climate change, it is crucial to explicitly acknowledge that access to and application of such knowledge is by no means a given. These are knowledges and knowledge systems that are inseparable from the people who carry them and the lands from which they emanate, and so they cannot be taken out of context and utilized without appropriately engaging with the associated people and land in knowledge-gathering and decision-making processes.

Today, perhaps more than ever before in human history, life on Earth is threatened by destructive globalized industrial activities (IPCC, 2022). Actions are needed and policies developed and implemented to reverse the interlinked trends of climate change and biodiversity loss. Our intention in this paper is to highlight examples of deep environmental knowledge, practices and experiences of Indigenous environmental experts in one region of the world that, with appropriate permission and collaboration, can inform and inspire societal efforts to bring about an effective reversal of past and ongoing destruction (see Bennett et al., 2015).

In this paper, based on years of collaborative research with Indigenous partners, we bring together—*with consent*—knowledges and experiences shared by knowledge holders from diverse Indigenous Nations of Northwestern North America regarding ecological cycles and environmental change, emphasizing the critical importance and relevance of this knowledge in this era of climate change and biodiversity loss, both in terms of finding ways to survive change, and in slowing and reversing human impacts on the Earth's lands and waters. We (the authors) do not claim this knowledge as our own, or assume that by its inclusion in previously published works that is has entered the public domain or become *gnaritas nullius* (Latin for "no one's knowledge"; Younging, 2018); instead, we indicate knowledge provenance, naming and recognizing specific knowledge holders as the experts they are throughout this work, conveying only that which has been permitted for broader sharing.

Indigenous Peoples of Northwestern North America have, in some cases over at least the past 15,000 years, lived with and organized around generally predictable cycles within Indigenous homelands. At the same time, Indigenous Peoples have continuously adapted in various ways to unexpected change, building complex knowledge systems that have enabled mitigation of impacts and survival in diverse, biogeographically complex home places. Through observation and experimentation, technological development, intergenerational and cross-cultural knowledge sharing, trade and exchange of resources, seasonal movements and migration, Indigenous Peoples have not only survived, but have prospered, developing rich cultures and multigenerational relationships with lands and waters and the life within them.

At a time when Indigenous Peoples' influence over ecosystems remains contested by some (e.g., Oswald et al., 2020)—in strong alignment with the doctrines of terra nullius (Latin for "nobody's land" or "territory without a master") and discovery (Pope Nicholas V's papal bull *Dum Diversas*, 1452) and the concept of the "pristine" or "wilderness" free from human influence (Miller et al., 2010)—articles that draw together evidence of long-held, precise, and scientific knowledge held by Indigenous Peoples in relation to environmental care are sorely needed. In this paper, we collate evidence of natural cycles being embedded within Indigenous Peoples' lifeways, as reflected in language, stories, and in phenological indicators and other environmental knowledge shared by Indigenous Knowledge holders. At the same time, we emphasize how people have been prepared for, and usually able to respond to, unexpected events that have occurred at various scales, disrupting routines and posing threats to lives and livelihoods.

These practices have been tested in multiple ways over millennia, with arguably the greatest stressors and threats being those introduced by the arrival of European colonizers in recent centuries: industrialization, habitat destruction, species introductions, disease transmission, land theft, and coercive social policies (e.g., the Government of Canada's Residential School System and associated *Indian Act*, 1876; the United States Government's assimilation system and associated *Allotment Act*, 1887). These negatively affected, and continue to affect, Indigenous Peoples' lives, threatening health and well-being in multiple ways, which include disrupting previously predictable harvesting cycles as well as the associated transfer of knowledge from one generation to the next (the dual focuses of this article; Duff, 1997; Harris, 1997; Lutz, 2008; Ommer et al., 2007). Most recently, global climate change and accompanying biodiversity loss—two connected and largely unanticipated changes—have presented themselves as perhaps the most difficult, most persistent threats, not only for Indigenous Peoples of the region, but for all humanity and all other life on Earth. It is our contention that Indigenous Peoples' experiences and knowledges must be recognized as the evidence and expertise that they are if we are to change the course of these

planet-wide harms, and this must be achieved through means that embrace sincere collaboration and that respect multiple ways of knowing.

We emphasize that Indigenous Knowledge is intellectual property, belonging to the knowledge holders and their communities. In this work we have made every effort to reference, respectfully, the people and communities whose knowledge we have cited here. Guidance for ethical and moral practices regarding research and publication is provided through a number of publications, including: Kirkness and Barnhardt (1991); International Society of Ethnobiology Code of Ethics (2006); UN Declaration on the Rights of Indigenous Peoples—United Nations (2007), Wilson (2008), and Kovach (2009).

2. Methods

2.1. Research Area

Here, we focus on the knowledge and lifeways of Indigenous Peoples of Northwestern North America, a region extending from central Alaska and the Yukon River south to the Columbia River and east to the Rocky Mountains, with emphasis on the land now known as British Columbia (Figure 1). This region encompasses about 18 major vegetation zones and the homelands of approximately 50 different Indigenous language groups, some related to each other (e.g., Wakashan, Salishan, Ts'msyenic, and Athabaskan groups), and some (e.g., Haida and Ktunaxa) recognized as linguistic isolates (First Peoples' Cultural Council, 2018).

2.2. Research Origins and Positionality

The lead author (N. Turner) is an ethnobotanist of European heritage from French/German/Dutch/English ancestry who has dedicated her research career to building relationships with Indigenous communities in North America and carrying out community-based research in respectful and reciprocal ways. The information on cultural environmental knowledge presented here is based mainly on previously published ethnographic and ethnobotanical records for Indigenous language groups from throughout the study area, most drawn directly from ethnobotanical and ethnoecological research in collaboration with Indigenous Knowledge holders and communities over the past 50 years led by the lead author (see Turner, 2014). Most interviews and conversations foundational to this research were conducted in English, but with linguists and Indigenous language experts recording and verifying Indigenous terms, such as names of the plants. Standard methods in collaborative ethnobotanical documentation were used in these studies and are described in greater detail in the original reference publications cited.

Sessions out on the lands and territories of the Indigenous Knowledge holders, as well as in their communities and homes, allowed firsthand and participatory observation and learning. While methods diverged across differing contexts, all interviews required explicit permission from the knowledge holders for the information they shared, to be used for the purposes of preparing research articles, such as this one. These conversations were audio-recorded, transcribed, coded and thematized, with information being reviewed and confirmed by those who shared it, to be discussed in research reports and articles (many cited herein), also with careful checking back with the Indigenous experts providing their knowledge and insights and often coauthoring the publications (e.g., Luschiim & Turner, 2021; Turner & Clifton, 2006, 2009). Knowledge that was for community-use only, or that could only be shared under specific circumstances (e.g., time of year, during a specific ceremony), was not included in these research or reporting efforts to respect individual and/or community wishes as well as to uphold Indigenous data sovereignty more broadly (Kukutai & Taylor, 2016).

Within the past couple of decades, many Indigenous Knowledge holders of western Canada (cf., Luschiim & Turner, 2021; Turner & Clifton, 2009; Thomas et al., 2016), as well as Indigenous experts from other regions (see Krupnik & Jolly, 2002; Salick and Ross, 2009) have noted explicitly how the health and productivity of their lands and waters have changed relatively rapidly. In short, elders and others have expressed concerns about environmental changes that they have witnessed over their own lifetimes (Reid et al., 2022). At the same time as they have described the ways in which they and their ancestors have been able to mark the changing seasons—for example, through naming of the different moons, or tracking the flowering of certain plants or the songs of certain birds—to help them determine the best times for undertaking particular activities, many have noted both the importance of these phenological markers and the effects of environmental change that have caused them to shift. Given the wide spectrum of experiences and observations reflected by local land experts from different regions, presenting

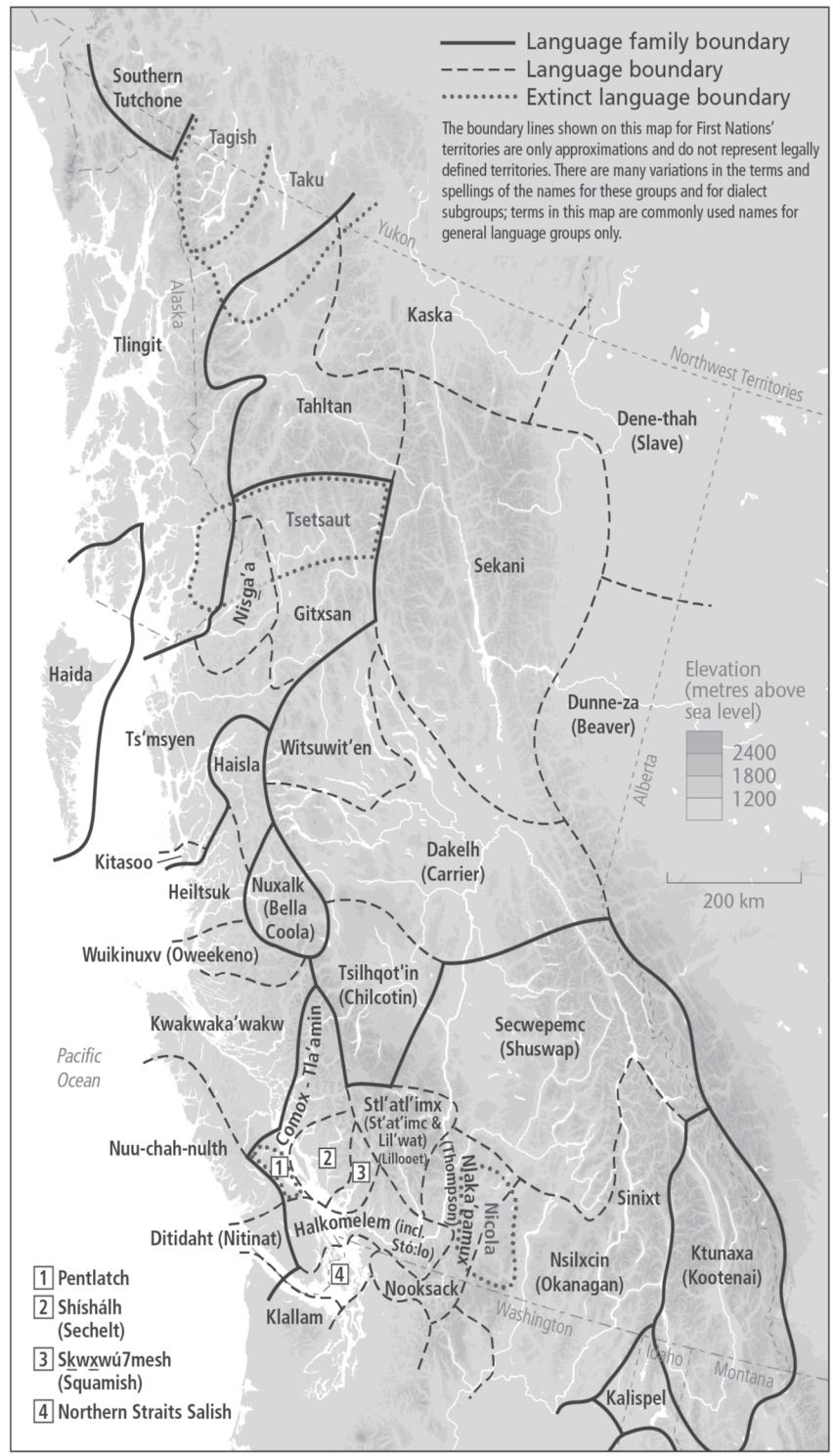

Figure 1. Indigenous language groups of the area known today as British Columbia and adjacent areas in Northwestern North America; boundaries are approximate and not intended to represent legal boundaries of any Indigenous Nation. Map created by Robert D. Turner.

a synthesis of their collective, firsthand knowledge about environmental change and its impacts is of critical importance (Reid et al., 2014). Taken together, compendia of detailed, place-based environmental knowledge about changing climate and changing biodiversity, at all its levels, are a key aspect of knowledge from which to

Figure 2. Nootka wild rose (*Rosa nutkana*); its coming into bloom is a key indicator of the time for Lil'wat basketmakers Nellie Peters and Margaret Lester to start harvesting the materials for their coiled cedarroot baskets: decorative grass stalks, bitter cherry bark, cedar roots and cedar splints. (Photo by N. Turner).

develop approaches and policies required to halt and reverse global environmental change.

The second author (A. Reid) became involved in this article through the peer-review process. As a reviewer of the original manuscript, she had offered considerable guidance for its improvement based on her expertise as an Indigenous scientist (A. Reid is a citizen and member of the Nisga'a Nation, leading the Center for Indigenous Fisheries at The University of British Columbia). N. Turner, recognizing the significance of her contributions, asked her if she would be willing to assume co-authorship and help guide the revisions required for the original manuscript to more fully and appropriately reflect the role of Indigenous Knowledge in this work. The editorial team concurred. What proceeded was a series of exchanges centered on Indigenous Knowledge Systems, scientific expertise, and data sovereignty that are, as a result of A. Reid's guidance and advice, more thoroughly acknowledged throughout this now co-authored article.

2.3. Research Partners

Since 1967, the lead author has been working with and learning from Indigenous botanical and environmental experts in British Columbia and beyond. Their knowledge and insights regarding plants, animals and the environment of their homelands have been profound, as have their kindness, interest, and generosity in sharing relevant information with others. They have, almost universally, expressed worries about the state of the lands and waters in their home territories and the associated loss of ancestral knowledge, due directly and indirectly to the impacts of colonization. The observations of many of these people are reflected in this paper; they are cited individually throughout, and also in the Acknowledgments.

2.4. Research Approach

This paper presents some overarching themes relating to environmental cycles and environmental change, and how these have been experienced, responded to, and mitigated by Indigenous Peoples in Northwestern North America over millennia. We focus on seasonal cycles and indicators of seasonal change and congruence in the life cycles of plants and animals, as reflected in Indigenous Peoples' knowledge systems and calendars. We then discuss how Indigenous Knowledge Systems, developed over countless generations, have allowed people to respond to unexpected events, outside of the anticipated cycles of environmental change. This includes approaches for maintaining and enhancing the productivity or well-being of key plant and animal species, and how these practices have been impeded and obstructed through diverse colonial impacts. In each of these areas, we present examples of relevant knowledge and insights of Indigenous experts. These are only some illustrations and do not, in any way, represent a complete compilation of what people know or have experienced. Most of the information we present here has been published elsewhere (e.g., Lantz & Turner, 2003; Turner, 2014), but not contextualized or brought together within this particular framework.

3. Results

3.1. The Ethnoecological Choreography: Predictable Cycles and Events

The knowledge systems of Indigenous Peoples in Northwestern North America are replete with information on natural cycles at different scales of time and space, as discussed above and evidenced below. Knowledge holders engaged across the works referenced herein identified their knowledge of natural cycles as emanating from past experience, close and long-term monitoring, and accumulated observations. This knowledge is reflected in people's day-to-day and month-to-month activities; the names and understood habits and life cycles of various species: plants, birds, mammals, fish, and other lifeforms; the stories and teachings passed on between generations; as well as the timing of important ceremonies.

Figure 3. Nellie Peters, Lil'wat Nation, drying bundles of basket grass, collected at the time of blooming of the Nootka rose. (Photo by N. Turner).

Kwakwaka'wakw knowledge holder *Kwaxsistalla Wathl'thla* Clan Chief Adam Dick, described how, during his boyhood, he and his family moved around their territory throughout the year, his grandfather referring to the stars (possibly planets) to know when to travel back to the Kingcome River to harvest the early runs of oulachen [*Thaleichthys pacificus*; also spelled oolichan, ooligan, hooligan]:

> *"The people are busy all through the year when a different season comes along. Herring time, cod time, clam time, all different. Keep you busy. How are you going to live through the winter? What you can eat? And what you're going to put away for winter. Has to be smoked heavy or sundried … If the fish don't come, the clam gardens are a backup. Clams, oulachens,* ***ts'ats'ayem****s [*eelgrass, *Zostera marina], back out [to the coast], up the river … up to the mountains … Two or three families on this island, three to four families on that island. Different spots. They keep looking at the stars,* ***Q*****ʷ*****am'a*** *and* ***Alujoy****, then they move up the inlet, to get the salmon and smoke them. Then, out to clams, then back up to oulachens. After that, they spread out closer to the seaweed picking, then they move to where there's lots of berries to make* ***t'əqaʔ*** *[*dried berry cakes*]. When I was growing up, there was no time. We go to bed when it gets dark … Get up in morning and do the same thing."* (pers. comm. to NT, 2005; Turner, 2014, p. 27)

Indigenous Peoples everywhere have experienced the seasons, being out on the lands and waters at specific times in order to harvest and care for the habitats and species on which they have relied for countless generations (Claxton & Elliott, 1993, 1994; Deur and Turner, 2005). Important species are widely recognized ceremonially at key times in their life cycles, for example, with First Salmon, First Roots, and First Berries ceremonies in different regions (Claxton & Elliott, 1994; Compton, 1993, p. 197; Turner et al., 1980, 1990).

Every individual/community engaged in the works drawn together below has developed place-based knowledge of life cycles of key species that inform times for harvest or various associated activities (often, these were/are brought together visually in the form of seasonal rounds). Species whose lifecycle events are used to determine those of other species—usually culturally important species—are referred to as "phenological indicators" (Lantz & Turner, 2003). Virtually all Indigenous languages incorporate terms for the different "moons" and seasons—oral calendars that reflect these indicators and describe or embody key activities at various times of the year (Kassam et al., 2011). For instance, the month of March is known as ***X̲saak*** in the Nisga'a language (literally, "to eat oolichans"), and is labeled as such in the Traditional Nisga'a Harvesting Seasonal round, as this is the time of year when ***saak*** (oolichans; *Thaleichthys pacificus*) return to fresh waters to spawn, marking the beginning of ***Hobiyee*** (Nisg̲a'a new year), the end of winter foods, and the start of feasting for the Nisg̲a'a as well as a multitude of animals who together descend on the river—***Lisims*** (e.g., gulls, eagles, and seals). As well as the seasons, knowledge of the tides in marine ecosystems, and of snowmelt patterns, especially in the mountains and northern regions, also influences people's activities and decisions around resources and travel. Weather patterns, including rainfall, snow, direction of prevailing winds, and summer heat, are also important aspects of peoples' knowledge and practices.

3.2. Phenological Indicators

Phenology—the study of periodic plant (including fungi and algae) and animal life cycle events and how these are influenced by seasonal and interannual variations in climate—was a theme common among conversations with knowledge holders. They were keenly aware of how observing the developmental stage of one species can help to predict lifecycle events in other species, either because they are directly connected, or because they are both influenced by similar external factors (e.g., seasonal temperature, day length, and available food). Table 1 provides a (non-exhaustive) list of phenological indicators shared by partnering knowledge holders. In all, examples in this table include 16 relating to the blooming of flowers, 6 to ripening berries, 12 to other plant life cycle states, 4 to birdsongs, and 5 to insect activities.

Table 1
Examples of Phenological Indicators From Indigenous Knowledge Holders

Indigenous nation(s) (sources)	Indicator	Process or phenomenon indicated
Type 1.1: Flowers blooming		
Nlaka'pamux (Bandringa, 1999)	Saskatoon (*Amelanchier alnifolia*), choke cherry (*Prunus virginiana*), and balsamroot (*Balsamorhiza sagittata*) blooming	Bitterroots (*Lewisia rediviva*) ready to dig
Syilx/Okanagan (Selina Timoyakin, 1975; cited in Turner et al., 1980)	Timber milkvetch (*Astragalus miser*) blooming	Edible cambium and inner bark of lodgepole pine (*Pinus contorta*) ready to harvest
Comox, Tla'amin (D. Kennedy and R. Bouchard, pers. comm. to NT; W̱SÁNEĆ (Elsie Claxton, cited in Turner & Hebda, 2012)	Oceanspray (*Holodiscus discolor*) blooming	Butter clams (*Saxidomus giganteus*) are ready to harvest; "time to go out there and get ready for the [sockeye] salmon run!" (*Oncorhynchus nerka*)
Nlaka'pamux (Bernadette Antoine, 1990; in Turner et al., 1990)	Fireweed (*Epilobium angustifolium*) in full bloom	Time to hunt mule deer (fawns have been born)
Haida (Florence Davidson, 1972; in Turner, 2021a)	Cow-parsnip (*Heracleum maximum*) blooming	Seagull (*Larus* spp.) eggs are no longer good to eat
Syilx/Okanagan (Selina Timoyakin, 1975; in Turner et al., 1980)	Blue lupine (*Lupinus sericeus*) blooming	Time to hunt marmots (*Marmota* spp.)
Nlaka'pamux (Annie York, pers. comm., in Turner et al., 1990)	Indian-pipe (*Monotropa uniflora*) blooming and plentiful	Edible mushrooms (*Tricholoma* spp.) will be abundant
Syilx/Okanagan (Selina Timoyakin, 1975; in Turner et al., 1980)	Pricklypear cactus (*Opuntia fragilis*) blooming	Saskatoon berries (*Amelanchier alnifolia*) are ripening
Syilx/Okanagan (Martin Louie, 1975; in Turner et al., 1980)	Mock-orange (*Philadelphus lewisii*) blooming	Marmots (*Marmota* spp.) are fat and ready to be hunted
Fraser River Stl'atl'imx (Sam Mitchell, 1984: pers. comm. to NT)	Wild rose (*Rosa acicularis*, and possibly also *R. nutkana*) blooming	Second run of spring salmon up Fraser River, named after rose; have a rose-pink line along their bodies; also, first sockeye coming upriver
Lil'wat/Stl'atl'imx (Nellie Peters, 1984: pers. comm. to NT)	Wild rose (*Rosa acicularis*, *R. nutkana*) come into bloom (Figures 2–4)	Basket materials—roots and splints of western redcedar (*Thuja plicata*), cherry bark (*Prunus emarginata*) and basket grass (*Phalaris arundinacea*) are ready to harvest
Fraser River Stl'atl'imx (Sam Mitchell, 1984; pers. comm. to NT)	Sagebrush buttercup (*Ranunculus glaberrimus*) blooming—snow still on ground; called "spring salmon eye"	First run of spring or Chinook salmon (*Oncorhynchus tshawytscha*) up the Fraser River above Lillooet; eyes same color as the buttercups
Nuu-chah-nulth/Ahousaht (George Louie, 1994, in: Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, 1995)	Red elderberry (*Sambucus racemosa*) blooming	Halibut prime for fishing; time to hunt gray whale (*Eschrichtius robustus*) and harbor seal (*Phoca vitulina*)
Type 1.2: Berries/fruits		
Syilx/Okanagan (Nettie Francis, 1979; in Turner et al., 1980)	Black hawthorn (*Crataegus douglasii*) berries ripening	Black mountain huckleberries (*Vaccinium membranaceum*) are ripening in the high country
Stl'atl'imx (Sam Mitchell, 1984; pers. comm. to NT)	Wild strawberries (*Fragaria vesca, F. virginiana*) begin to ripen	Second run of spring salmon (*Oncorhynchus tshawytscha*; 'rose-bud fish') migrate up the Fraser River
Nlaka'pamux (Annie York, 1975; in Turner et al., 1990)	Black currant (*Ribes hudsonianum*) presence around a lake	Indicates that there are fish in the lake
Ditidaht (Tl'iishal John Thomas, 1978; in Turner et al., 1983)	Salmonberries (*Rubus spectabilis*) ripening	Beginning of sockeye salmon (*Oncorhynchus nerka*) migration; time to fish for sockeye; blueberries (*Vaccinium ovalifolium*) ripening
Stl'atl'imx (Sam Mitchell, 1984; pers. comm. to NT)	Soapberries (*Shepherdia canadensis*) begin to ripen	Second run of spring salmon ("rose-bud fish")—see under *Rosa* spp.
Nuu-chah-nulth/Hesquiaht (Alice Paul and George Ignace, 1975; cited in Turner & Efrat, 1982)	Evergreen huckleberry (*Vaccinium ovatum*) ripening	Beginning of chum, or dog salmon (*Oncorhynchus keta*) run

Table 1
Continued

Indigenous nation(s) (sources)	Indicator	Process or phenomenon indicated
Type 1.3: Other plant growth		
Nlaka'pamux (Bandringa, 1999)	Choke cherry (*Prunus virginiana*) leafing out	Bitterroots (*Lewisia rediviva*) ready to dig
Syilx/Okanagan (Turner et al., 1980)	Western larch (*Larix occidentalis*) needles turning yellow in the fall	The time the black bears go into their winter dens
Nisg̲a'a (Deanna Nyce and Harry Nyce Sr., 2012; pers. comm. to NT)	Cottonwood (*Populus balsamifera*) seed fluff first starts to swirl around like snow	Sockeye salmon have arrived up the Nass River (early June)
Nlaka'pamux (James Teit, cited in Turner et al., 1990)	Choke cherry (*Prunus virginiana*) or possibly bitter cherry (*P. emarginata*), when filled with worms	Pacific salmon (*Oncorhynchus* spp.) are abundant
Syilx/Okanagan (Martin Louie, 1975; in Turner et al., 1980)	Douglas-fir (*Pseudotsuga menziesii*) pollen cones shedding pollen	Edible inner bark of ponderosa pine (*Pinus ponderosa*) ready to harvest
Nlaka'pamux (Louie Phillips, pers. comm. to D. Kennedy, cited in Turner et al., 1990)	Desert currant (*Ribes cereum*) leafing out in spring	Beginning of spawning migration for steelhead trout (*Oncorhychus mykiss*)
Ts'msyen, Gitga'at (Helen Clifton, 2002; pers. comm. to NT)	Thimbleberry (*Rubus parviflorus*) shoots ready to eat	Edible seaweed (*Pyropia abbottiae*) is ready to harvest
Nuu-chah-nulth/Hesquiaht (Alice Paul, George Ignace, 1975; cited in Turner & Efrat, 1982)	Green pond slime/algae (*Spirogyra* and other species) washed out to sea with first heavy rains	Beginning of coho salmon (*Oncorhynchus kisutch*) and dog salmon (*O. keta*)
Sḵwx̱wú7mesh (Louis Miranda, 1976; pers. comm. to R. Bouchard & NT)	Stinging nettle (*Urtica dioica*) shoots "a couple of inches" high	Time when baby harbor seals (*Phoca vitulina*) are born
Tla'amin (Sliammon) Coast Salish (R. Bouchard and D. Kennedy, pers. comm. to NT, 1983)	Stinging nettle (*Urtica dioica*) shoots about 15 cm high	Time to hunt harbor seals (*Phoca vitulina*)
Nuu-chah-nulth/Hesquiaht (Alice Paul, 1982; in Turner & Efrat, 1982)	Stinging nettle (*Urtica dioica*) shoots are elongating [called ***mu·mu·yink'was***]	Halibut (*Hippoglossus stenolepis*) are ready for fishing; beginning spawning migration
Ts'msyen/Gitga'at (Helen Clifton, 2002; pers. comm. to NT)	Stinging nettle (*Urtica dioica*) shoots are elongating	Growth rate parallels that of the edible red laver seaweed (*Pyropia abbottiae*)
Type 1.4: Bird songs		
Stl'atl'imx (Lantz & Turner, 2003)	Hermit thrush (*Catharus guttatus*) or veery (*C. guscescens*) is singing	Yellow avalanche lily (*Erythronium grandiflorum*) bulbs ready to harvest
Gitxsan (Lantz & Turner, 2003); Nisg̲a'a (Deanna Nyce and Harry Nyce Sr., 2013; pers. comm. to NT)	American robin (*Turdus migratorius*) sings, ***gii gyos milút! gii gyos milút!*** (Nisg̲a'a)	Beginning of spawning migration for steelhead (*Oncorhychus mykiss*); robin sings "The steelhead are here! The steelhead are here!"
W̱SÁNEĆ (Elsie Claxton and Violet Williams, 2012; in Turner & Hebda, 2012); Sḵwx̱wú7mesh (Louis Miranda and Andy Natrall 1976, in Bouchard & Turner, 1976; Kwakwaka'wakw (*Kwaxsistalla Wathl'thla* Adam Dick, 2006, pers. comm. to NT; Ditidaht (John Thomas, in Turner et al., 1983) (also Haida, Haisla, Oweekeno, Nuu-chah-nulth, Tlingit)	Swainson's thrush (*Hylocichla ustulata*) singing to the salmonberries	Salmonberries (*Rubus spectabilis*) are ripening
Secwépemc (Aimee August, Mary Thomas, in Ignace and Ignace, 2018; Lantz & Turner, 2003)	American robin (*Turdus migratorius*) and/or meadowlark (*Sturnella neglecta*)	Time to dig biscuitroot, ***qʷeqʷ'íle*** (*Lomatium macrocarpum*)
Type 1.5: Insect life cycles		
Ts'msyen (Helen Clifton, 2002; pers. comm. to NT)	Presence of horseflies (*Tabanus*spp.) and deerflies (*Chrysops*spp.)	Beginning of coho salmon run (*Oncorhynchus kisutch*)
Sḵwx̱wú7mesh (Louis Miranda, 1976; pers. comm. to R. Bouchard & Turner, 1976; Lantz & Turner, 2003)	"Salmonberry bug"—stink bug (*Elasmostetlus cruciatus*) presence	Salmonberry (*Rubus spectabilis*) shoots ready to harvest
Tahltan (Julia and Charley Callbreath, pers. comm. To NT, 1995)	Swallowtail butterflies (*Papilio rutulus*) accumulate in great numbers on muddy banks of Stikine River	indicate the start of the spring salmon (*Oncorhynchus tshawytscha*) runs; the butterflies are called "spring salmon butterfly"
Stl'atl'imx (Sam Mitchell, 1974; pers. comm. to Kennedy and Bouchard, 1986)	Clicking of the grasshoppers (possibly *Xanthippus corallipes*) and other species	mid-summer Sockeye salmon (*Oncorhynchus nerka*) run indicated

Note. For a more complete listing and original references, see Lantz and Turner (2003) and Turner (2014, vol. 2, p. 18–20); within indicator categories, species listed alphabetically by scientific name.

Most of the species discussed by knowledge holders are seasonal, going through various lifecycle stages according to regular cyclical patterns in the weather, animal reproduction and migration, and plant growth. Different species are available, or are at their prime for harvesting, at particular times of the year—times that often coincide with lifecycle events of other species. Traditionally, most Indigenous Peoples of the region have followed routine travel patterns, or seasonal rounds, in order to be ready for harvesting at particular locales, at particular times of the year. We place emphasis here on this being a historic state of affairs, given that colonial processes have actively disrupted these responsive practices through forced relocations and confinement to reserve land. Families or other social groupings such as clans might have had, and in some cases still have, their own recognized places for harvesting and processing food, material and medicine species, and the combined movements of different families/groups within a People can therefore be very complex, but are nevertheless fairly predictable, based on the general predictability of different species and their availability. In addition to this seasonal nature, knowledge holders have noted that there can be year-to-year differences, depending on weather, ocean currents, or other factors. These tend to affect all the species of a given region in similar ways, which is why phenological indicators can serve so well. Through synchronicity of life cycles, the state of one species, close at hand, can inform a harvester, hunter or fisher, about the likely readiness of another species, perhaps more distant and difficult to reach (e.g., underwater, down in a canyon, up on a mountain).

Often, phenological indicators are used to indicate the presence or availability or current state of an organism that is difficult to monitor because it is hidden, cryptic, or distantly located—as suggested by the overrepresentation of such species in the Process or Phenomenon column of Table 1. For example, traveling by water to a distant harvest site would not be undertaken lightly, without some assurance that the sought-after food could be obtained. As cited in Table 1, Gitga'at matriarch Helen Clifton, from Hartley Bay on the British Columbia North Coast, is an expert harvester of the nutritious edible seaweed, ***lhəʔask*** (*Pyropia abbottiae*) (Turner & Clifton, 2006; Turner & Thompson, 2006). Even starting at the spring harvest camp at Ky'el, on Princess Royal Island, traveling across the channel to the seaweed harvesting rocks on Campania Island is difficult, which is why using stinging nettle (*Urtica dioica*) as an indicator of the likely growth stage of the seaweed is so helpful:

> *"…I know that seaweeds grow at least six, seven inches a week, I know it's growing out there [*Campania Island*], it must be three feet long, at least…. I can look at the nettles out here [*at the seaweed camp*], and say, 'well the seaweed's just as long as those nettles!'…. They grow about the same time, they're about the same length, and we've got such long nettles around here. And I think of that seaweed that's growing out there …."* (Helen Clifton, pers. comm., May 2001, K'yel)

Similarly, for the Xaxl'ep community along the Fraser River Canyon north of Lillooet, descending the steep canyon down to the river is a long, arduous trip, not to be undertaken lightly. Therefore, using the blooming of plants growing nearby the village on the benchland above the river to indicate the likelihood of particular salmon runs is very convenient, greatly increasing the chances of a successful fishing attempt down at the river. As explained by Stl'atl'imx fishing and plant expert Sam Mitchell (pers. comm., 1984), when the bright flowers of the sagebrush buttercup (*Ranunculus glaberrimus*) appear at the winter's end, often amongst the last vestiges of melting snow, the people are confident that the first run of spring, or Chinook salmon (*Oncorhynchus tshawytscha*) will be running up the Fraser River far below. As an added reminder, these salmon are said to have eyes the same color as the yellow buttercups, which are named ***s-kʷəx̲m-álus*** ("eye of the first spring salmon, ***skʷáx̲əm***"). Then, later, around the beginning to middle of June, when the wild roses (*Rosa acicularis*) start to bloom, a second run of spring salmon, fast swimmers and weighing 15–20 pounds (7–9 kg), are ascending the river. Called ***kel'kásulh*** ("rose-bud fish"), these have a distinctive rose-pink line on their sides. Soon, the first run of sockeye salmon (*Oncorhynchus nerka*) appears down in the river, indicated by the ripening of wild strawberries (*Fragaria virginiana*) and soapberries (*Shepherdia canadensis*), among the first fruits of the season. Around mid-summer, another run of sockeye salmon is associated with the clicking sound of the grasshoppers around the village (Sam Mitchell, pers. comm., 1984). It is no coincidence that, as shown in Table 1, the use of many phenological indicators revolves around fisheries, since the presence of fish, being hidden underwater and often in locales requiring travel, can be especially difficult to predict.

The introductory quotation reflects the timely blooming of the wild rose (*Rosa nutkana*), this time on the west side of the Coast Mountains. Wild rose bushes are often common and easily visible around villages like Mount Currie, where expert basketweavers Nellie Peters (Figures 3 and 4) and Margaret Lester lived (both pers. comm., June 1984). N Turner had the privilege of going out with them to gather the materials they used in their basketry, and

Figure 4. Nellie Peters with her cedarroot basketry, decorated with grass stems and bitter cherry bark. (Photo by N. Turner).

learning from them how important it was for each material to be harvested at the right growth stage, at the right time—a time coinciding with the blooming of the wild rose. The harvest included: western redcedar (*Thuja plicata*) sapwood splints and roots; bitter cherry (*Prunus emarginata*) outer bark, carefully peeled off living trees, without cutting into the inner bark layers; and culms of pre-flowering reed canary grass (*Phalaris arundinacea*), apparently an introduced species but nonetheless important for basketry. These materials are all processed and then dried for basketry work later in the year. Nellie and Margaret went to particular locales in the Pemberton Valley and along the Birkenhead River to collect their basket materials, and so, having the wild rose blossoms as an indicator ultimately resulted in the exquisite harvesting and storage baskets, and other woven items, for which the Lil'wat and related Peoples are famous (Turner, 1992a, 1992b, 1996, Figure 4).

Bird songs are especially reliable types of phenological indicators, discussed frequently by partnering knowledge holders (see Table 1—Type 1.4), usually aligning with migratory patterns of particular songbirds. The most common association along the Northwest Coast is the flutey song of the "salmonberry bird" (Swainson's thrush, *Hylocichla ustulata*), so closely associated with the ripening of salmonberries (*Rubus spectabilis*) that it is said the song itself makes the berries ripen. In the language of the W̱SÁNEĆ people, the song of this thrush, called ***weweles'***, translates into words directed at the different color forms of the salmonberries, entreating them to ripen: "***xwexwelexwelexwelexwesh!*** ('ripen, ripen, ripen, ripen!')" (Elsie Claxton and Violet Williams, cited in Turner & Hebda, 2012). Ornithologists recognize that this thrush returns to its breeding range at salmonberry flowering time, just when fruits begin to ripen (Campbell et al., 1997). Belief that this bird's singing is responsible for salmonberries ripening is widespread (for Tlingit, Haida, Haisla, Oweekeno, Kwakwaka'wakw, Nuu-Chah-Nulth, Ditidaht, Sḵwx̱wú7mesh, Straits Salish), and the thrush is named after salmonberry in at least four languages (Turner & Bhattacharyya, 2016). Secwépemc Elder Aimee August said that meadowlark's song, ***tucictsemc ten qweq̓wíle!***, which signals the time to dig the roots of ***qweq̓wíle*** (desert parsley, *Lomatium macrocarpum*) in the spring, translates as "You waste my ***qweq̓wile!***" (Ignace and Ignace, 2018, p. 181).

3.3. Temporally Predictable Events

Along with the phenological indicators reflected in coinciding biological life cycles, Indigenous Peoples of the region have also relied on their knowledge of tidal cycles, including extremes in low and high tides according to the relative position of the sun and the moon, shifting views of stars and constellations at different times of the year (due to the relative position of the Earth orbiting around the sun), and shifting temperatures and levels of precipitation and sunshine over the course of the year. Predictable shapes and patterns emerging from snowbanks as they melt, predictable levels of lakes, rivers and creeks, and particular patterns of snowfall and snowdrift are all recognized and applied in planning, decision-making, seasonal movements and seasonal harvesting, based on past experience and accumulated knowledge.

Edible tree cambium and inner bark tissues are just one traditional food that must be harvested within a narrow window of environmental conditions. Secwépemc Elder Aimee August (pers. comm. 1991) explained, describing the inner bark of ***stiʔqʷ'əl'q***, lodgepole pine (*Pinus contorta*), that one had to collect it at just the right time, because if collected too early it would taste pitchy, and if collected too late it is "*too hard to eat.*" Sometimes people would test a tree before harvesting this food in quantity (Dilbone et al., 2013). Similarly, in harvesting cedar bark (*Thuja plicata*) or birch bark (*Betula papyrifera*) for basketry, it is important to find the exact window of time when the bark is easily peeled off, and this was often determined by a small test harvest. Secwépemc Elder and birchbark basketmaker Mary Thomas (1994, pers. comm. to NT; Turner, 2014, vol. 2, p. 11) explained, for birch bark: "*You have to know how to collect that bark, when to get it. You can only gather the birch bark, say, late May, June, and then it starts to stick back. Once it sticks, you can't get it. So, you have to get your supply when it's ready.*"

Table 2
Examples of Seasonal Calendar Terms for W̱SÁNEĆ (Saanich Straits Salish), Haida and Secwépemc (Shuswap) Indigenous Peoples (See Claxton & Elliott, 1993; Turner and Hebda, 2012; Ignace and Ignace, 2018; Turner, 2014, Vol. 2: Table 8.3; Turner, 2021a)

Approximate months	W̱SÁNEĆ (Saanich) moons	Haida	Secwépemc moons
January/February	***N̓IN̓ENE*** **(*ngingənə*)** ("moon of the child"); some warmth in the air and a few sunny days; assembling reefnets; some halibut, spring salmon, seals; fawns are born; ceremonial dances and story-telling	***hlgidguun*** **(*łgidguun*)** ***kongaas*** ("Canada goose moon"); Canada geese come down to the coast	**pelltsípwenten** **(*pełtsipwenten*)**: ("cache pit month"); people live on stored provisions ice fishing; fishing for steelhead with torch lights; trapping
February/March	***WEXES*** **(*wəxəs*)** ("moon of the frog"); tree frogs chorusing (Figure 5); Earth warms; canoes back in water; fishing continues; herring roe harvest; ducks caught in nets; time of the baby moon	***taan kongaas*** ("black bear moon"); bears come out of hibernation	***pellsqépts pesqépts*** ("Chinook wind month"); snow melts in valleys; fishing steelhead in river and at Loon Lake for cutthroat trout; spring hunting for male deer; first plants come out
March/April	***PEXSISEN̓*** **(*pəxsisəng*)**—("moon of opening hands; blossoming out"); plants leaf out and blossoms open; frogs start to sing; shellfish harvesting; hunting brant geese and other birds; cedar bark harvesting	***xiid gyaas*** ("laughing [white-fronted] goose moon"); laughing geese fly north	
April	***SX̱ÁNEŁ*** **(*sxwenəł*)** ("bullhead moon"); swallows arrive; weather usually good, but sometimes thunder and lightning storms; seaweed harvesting; grouse hunting; fresh shoots (horsetail, cow-parsnip, salmonberry) ready	***wiid gyaas*** ('salmonberry bird moon"); song of the salmonberry bird (Swainson's thrush) announces that winter is over	***pesll7éwten*** ("melting month"); or ***pellscwícwem*** ("month when yellow avalanche lilies grow"—Chase area); fishing at Tunkwa Lake; hunting in mountains; gathering fresh shoots from sprouting plants; begin digging roots (yellowbells, nodding onions, biscuit root, balsamroot)
April/May	***PENÁW̱EN̓*** **(*pənexwəng*)** ("moon of the camas harvest"); digging camas and other root vegetables; harvesting fresh seagull eggs, sea urchins, halibut, cod, spring salmon; visits to neighboring communities	***gansgee 'laa kongaas*** ("halibut moon"); also known as the month when berries are forming	
May/early June	***ĆENŦEK̓I*** **(*chənthəqi*)** ("sockeye moon"); sockeye fishing with reefnets; salmonberries, strawberries and other berries starting to ripen; First Salmon ceremony		***pell7é7llqten***, ***pell7ell7é7llqten*** ("root-digging month") (May); digging of balsamroot, Indian potatoes, and other roots; spring (Chinook) salmon run fishing at Hihium Lake and Tunkwa Lake; lodgepole pine cambium ready
Late May to early July		***wa.aay gwaalgee*** ('weather is still somewhat cold') (Note: this is the Haida New Year)	***pelltspéntsk*** ("mid-summer month"); or **pelltqítqe'*7ten*** ("strawberry month"—Chase area); picking strawberries and soapberries, harpooning spring (Chinook) salmon in the river, and trapping them in weirs in the creek; continue digging roots
June/July	***ĆENHENEN*** **(*chənhənən*)** ("humpback salmon return"); hot, dry time; fire danger; camping and fishing for humpback salmon; elk and deer hunting; prime berry-picking time; travel to neighboring territories; feasting and trading	***kong koaans*** ("great moon"); the weather becomes warm and food becomes plentiful; edible inner bark harvested from hemlocks and spruce	***pelltqwelqwĕltemx*** ("getting ripe month"); picking many species of berries ripe (e.g., saskatoon berries, strawberries, and huckleberries; root and medicinal plant gathering; salmon (Chinook) fishing in Thompson River
July/August	***ĆENŦÁWEN*** **(*chənthewən*)** ("coho salmon return to the Earth"); first fall rains swell the creeks; coho return to spawning streams; people fish for tommy cod and ling cod; many berries at their prime—eaten fresh and dried; canoe repairs	***sgaana gyaas*** ("killer whale moon"); when cedar bark is stripped from the trees, it sounds like blowing killer whales	***pesqelqlélten*** ("many salmon month"); sockeye salmon fishing in Thompson River; berry harvesting at higher elevations; chocolate lily and medicinal plant harvesting; hunting season starts

Table 2
Continued

Approximate months	W̱SÁNEĆ (Saanich) moons	Haida	Secwépemc moons
August/September	***ĆENQOLEW̱ (chənkw'alɔx)*** ("dog salmon return to Earth"); rainy, windy fall weather sets in; dog salmon return to spawn—honored with First Salmon ceremony; cod fishing; hunting deer, grouse, seals, sea lions; estuarine root vegetables dug; crabapples (Figure 6), cranberries, hazelnuts, and late blueberries harvested; clam digging, weaving blankets, mats; harvesting winter fuel	***k'iijaas*** ("belly moon"); animals begin to grow fat and their bellies get big	***pelltemllíkt*** ("spawned-out month"); hunting season and drying of meat (deer and moose) for winter; black tree lichen harvested; salmon fishing continues
September/October	***PEKELÁNEW̱ (pəkəlenexw)*** ("moon that turns the leaves white"); leaves fall off the tree; First frosts; end of harvest season; logs harvested for canoes, firewood; picking late berries/fruits; hunting elk, deer, seals, sea lions	***k'eed adii*** ("in-between month"); the month between summer and winter	**pesllwélsten** ("abandoning month") (~October); peak hunting season and drying of meat for winter; tanning hides; coho salmon run
October/November	***W̱ESELÁNEW̱ (xwəsəlenəxw)*** ("moon of the shaker leaves"); beginning of wintery weather; everything is put away; people stay close to shore and to winter villages; some elk hunting and fishing; winter gatherings begin	***k'algyaa kongaas*** ("ice moon"); first ice appears on rainwater in the canoes	***Pellc7ellcw7úllcwten*** ("entering month"); people enter into their winter homes; animals enter their dens; hunting continues; coho salmon run
November/December	***SJELĆÁSEṈ (sch'əlkwesən)*** ("moon of putting your paddle away in the bush"); the ground is shining, or glistening, from frost or ice; winter month; winter night low tides good for clam digging; basket weaving; repairing equipment; Winter ceremonials began; story telling; eating stored food and feasting	***jid kongaas*** ("digging month"); bears dig roots to prepare for hibernation	***pelteteq'em*** ("cross-over month") (~December); winter solstice month, when the days start getting longer; people celebrate and decorate their winter homes
December	***SIS,ET (sisət)*** ("Elder moon"); winter moon, with short days and stormy, rainy weather; some hunting, fishing, clam harvest, repairing nets; winter ceremonials; and story-telling	***kong gyaangaas*** ("cold moon"; lit. 'standing up [to defecate] month'); because the ground is snowy and cold	***pell7emtmín̓/pellkw̓ell7emtmín̓*** ("stay at home month," "stay underneath month"); people live on stored provisions; ice fishing; trapping; land frozen during this time; people stayed in their winter homes; much work done (making baskets, sewing clothing, and making implements for the harvest season)

According to partnering knowledge holders, most of their Indigenous languages incorporate their own calendars, with names for the moons or months of the year, almost invariably based on the resources available or the predominant activities that take place at that time (see Table 2 for examples). Often, these exceed the 12 moons/months of the Gregorian calendar (e.g., 13 moons in the traditional Nisga'a and W̱SÁNEĆ calendars), and so cannot be wholly compared 1:1, as shown in Table 2. Notably, harvest times, even for the same species, vary over geographic space. Many culturally important species are widely distributed, extending in range from lower elevations to higher altitudes, where their growth may be delayed by a month or more in comparison to lower altitudes (Turner et al., 2011). A vertical change of between 500 and 2,000 m may be the equivalent of a very wide latitudinal change, when it comes to blooming times for flowers or ripening of fruits. Seasoned berry pickers would be familiar with the conditions of particular locations within their seasonal rounds, taking these into account when planning harvest schedules and incorporating this knowledge into their virtual calendars.

3.4. Responding to Unexpected Events

As noted in the previous section, the phenological indicators and the seasonal calendars embedded in each language and culture indicate a knowledge of the cycles of harvesting and associated lifeways, as well as more subtle variations in timing of events like berry ripening or particular salmon runs from 1 year to the next. Notably, there is also oral evidence shared by Indigenous Knowledge holders of drastic and unexpected events and stresses,

Figure 5. Pacific tree frog (*Pseudacris regilla*); its spring chorus inspired the W̱SÁNEĆ name of the early spring moon: ***WEXES*** (***wəxəs***) ("moon of the frog"). (Photo by N. Turner).

some occurring in ancient times, some more recent, that had to be overcome in one way or another. For example, the Nisga'a experienced a horrific volcanic eruption over 250 years ago (Williams-Jones et al., 2020), in which a huge area of the Nass River Valley was filled with lava, covering entire villages, causing major loss of life (>2,000 Nisga'a lives), and changing the course of the river, as well as covering vegetation and impacting fish and wildlife. Even in areas not covered by lava, the destruction of berries and other food plants would have been immense (see Hunn & Norton, 1984, for a description of the impact on berries of the Mount St. Helen's eruption in May 1980). This event was translated into a lesson, still taught today, about how salmon had been disrespected and harmed by some young boys by putting burning sticks into the backs of salmon and watching them swim up the river in the dark with their backs glowing. To this day, the occurrence of the volcano is associated with this abusive act, and the story teaches young people to always treat the animals (and all life) respectfully. Similar lessons teaching respect for the environment are embodied in many other narratives (e.g., Johnson, 2010; Johnson & Hunn, 2010).

Severe winters, volcanic eruptions, earthquakes, tsunamis, floods, and fires have all been experienced, sometimes with deadly results, requiring people to move away from places, at least temporarily (Hutchinson & McMillan, 1997). In these cases, kinship ties have been critically important, with reciprocity between in-laws and relatives from other locations serving to support those facing such disruption (Suttles, 1987). Preparedness, for example, caching food for emergency use, and leadership, with effective planning and decision-making, have been key elements for people's survival in times of unexpected trauma. For example, as described by *Mayanilth* Daisy Sewid-Smith of the Kwakwa̱ka'wakw Nation, on one occasion in the late 1700s when the salmon run failed on the Nimpkish River on northeastern Vancouver Island, the Chiefs of the villages along the river decided to move all the people down to the mouth of the river, where they had houses built for them, and where they could live on clams in the interval when the salmon were scarce. In fact, archeological evidence shows that there have been many fluctuations in peoples' use of different foods over time, presumably to accommodate times of shortage of one species or another (Ames & Maschner, 1999). Using alternative foods was, and remains, one strategy for coping with unexpected change (Turner & Davis, 1993). In fact, there were and are a number of diverse environmental care practices that help people to maintain and promote culturally-significant species, as described in the following section.

Figure 6. Pacific crabapple (*Malus fusca*), a late summer/fall ripening fruit, ready to harvest in the W̱SÁNEĆ moon ***ĆENQOLEW̱*** (***chənkw'ələx***) ("dog salmon return to Earth"). (Photo by N. Turner).

3.5. Traditional Management Practices for Resource Production and Enhancement

The knowledge of cyclical events and seasonal or phenological indicators described in the previous sections is inextricably tied to the diverse ways in which Indigenous Peoples of the region have cared for, managed and enhanced key species and habitats within their homelands. As evidenced through conversations with partnering knowledge holders, as well as through botanical, zoological and archeological research, we know that people throughout N.W. North America developed and applied, over many millennia, a wide range of practices that have helped ensure the productivity, quality, and sustainability of the species on which they have relied, and have therefore supported their resilience (Anderson, 2005; Thornton, 1999; Turner et al., 2013).

These practices range from transplanting plants, and sometimes animals, to the use of controlled fire, rotationally, at different sites across the landscape, a practice which had the effect of diversifying the foods, materials, and medicines available by creating multiple successional stages, each with its own predictable species combinations with enhanced availability and productivity

(Boyd, 2021). Other time-honored management techniques include: planting or scattering seeds, fruits, or other propagules; transplanting plants from one locale to another, sometimes across considerable distances (Turner et al., 2021), pruning, coppicing or burning individual berry bushes or trees, like willows, used in technology, to stimulate new growth; clearing away rocks and weeding over areas to create more habitat for desired species; creating additional habitat for roots, berries and other species through structural development such as berms, terraces, and even shell middens; tilling and aerating soils and substrate; fertilizing and mulching berry patches and other key resource areas; and selective, partial or rotational harvesting of resources, whether they be bird eggs, clams, fish, or root vegetables like camas bulbs.

These practices are described in detail elsewhere in the literature (Boyd, 2021; Deur and Turner, 2005; Turner, 2014; Turner, Deur et al., 2013) and are actively practiced by Indigenous Peoples today. They go hand-in-hand with 'customary tenure systems,' or rights to harvesting areas by individuals, families, or clans, which allow intergenerational monitoring and conservation. Teamwork, division of labor, ceremonial protection of particular places, species, and populations, distributed harvesting, as in Peoples' "seasonal rounds," trading and distributing surplus resources, through feasting and Potlatching, are all aspects of caretaking, conservation, and enhancement. Estuarine root gardens, tended eelgrass beds, cedar groves, berry "gardens" and forest "gardens" are all results of generations of combined work in sustaining resources (Armstrong et al., 2021; Deur and Turner, 2005; Ignace and Ignace, 2018), many recognized today as "cultural keystone places" (Cuerrier et al., 2015; Lepofsky et al., 2017). Thus, Indigenous Peoples are not only active participants in seasonal cycles, but their practices help to stabilize these cycles and increase their predictability, as well as lessening the impact of unexpected events and stressors, through providing reserves of key species that can be used locally or traded as required.

3.6. Colonial Times

As noted in the Introduction, since the arrival of Europeans into the region, starting in the late 1700s, there have been many changes and disruptions to Indigenous Peoples' lifeways, including schedules of harvesting and seasonal movements. Many knowledge keepers engaged in the works included here recognized the toll that numerous factors have taken on Indigenous Peoples' ability to harvest and use traditional plants and animals. These include: compulsory attendance for children at residential schools, language suppression, loss of Indigenous foods and traditional harvesting locales, removal of people from their traditional territories and taking over of lands and resource harvesting areas, banning the use of fire, harvesting of tree bark and other traditional practices, depletion of herring, salmon, and old-growth trees, banning of the Potlatch, introduction of invasive plants, participation of Indigenous Peoples in the wage economy, urbanization, industrialization, and accompanying pollution of traditional harvesting lands and waters. All have resulted, individually and cumulatively, in loss of associated knowledge and practices, as well as of vocabulary and stories relating to this knowledge (Duff, 1997; Harris, 1997; Lutz, 2008; Ommer et al., 2007; Reid et al., 2022; Turner & Turner, 2008; Turner et al., 2008).

Despite the availability and adoption of new foods like potatoes, carrots, and turnips, and orchard fruits (apples, pears, plums, cherries), and new technologies, which have been readily adopted by Indigenous Peoples (Lutz, 2008; Nabhan, 2006), these have not compensated for the losses of Indigenous foods from grazing by cattle, sheep and pigs, deforestation, use of herbicides and pesticides, and overfishing and pollution that have decimated fish stocks (Harris, 2001). W̱SÁNEĆ Elder Chief Sammy Sam (1999; pers. comm. to NT and B. Beckwith) vividly described the changes he had witnessed in wildlife of Saanich Inlet of southern Vancouver Island: He said there used to be thousands of murres [diving seabirds] in the inlet: *"Now you don't see one."* There were also *"lots of salmon, lots of cod and other groundfish like flounder. Now there's nothing; it's so polluted. There used to be lots of "black ducks" too [*scoters*], but now none.… The herring were so thick. In the old days, at herring spawning time [*spring*] Uncle used to walk through the village shouting 'Herring!' [*in Saanich language*], and then there was a flurry of activity. People used to put branches into the water, and they'd soon be covered with really thick layers of herring eggs [*4–6 inches/10–15 cm thick*]. Now there are no herring spawning in Saanich Inlet. There were also lots of orcas [*killer whales*]; you could hear them at night, slapping on the water. Now you don't see any, because there is no food there anymore."* Chief Sam's words point to the cumulative impacts of these losses; entire food chains are affected when one or two species are destroyed.

> Kwakwa̱ka̱'wakw Clan Chief *Kwaxsistalla Wathl'thla* Adam Dick sadly recounted, *"We were a very wealthy people before the Europeans came. We had lots of berries! I'm not talking about money-wise. I'm*

> *talking about food-wise – whale, clams… and there's nothing any more. There's nothing left."* (Clan Chief Adam Dick, pers. comm. to NT, 1997). W̱SÁNEĆ plant expert Elsie Claxton echoed his words, about her territory on southern Vancouver Island: *"No money long ago, but it's nice: lots of food, lots of clams, lots of wild berries all over… even they are gone…. We lost everything. Nothin' [left]!*" (pers. comm. to NT, 1998).

Experiences of depletion of culturally important species are widespread throughout the region, reiterated over and over again. Dakelh (Carrier) Elder Mary John, recalled similarly, *"When I was a small girl, the land, the rivers and creeks and lakes, were full of life – birds and animals of all kinds were as much a part of the landscape as trees and clouds and sun. Now I can travel five hundred miles in any direction from our village and not see so much as a field mouse. I think with sadness of those trips to the hunting grounds when I was a child and I remember our land as it used to be"* (Moran, 1988, p. 30).

Few of the newcomers recognized the sophistication with which the First Peoples managed their environments and resources, or even the importance of their traditional foods and lifeways to their very health and well-being. Few could have understood the richness and complexity of Indigenous Knowledge Systems, or the subtleties of their resource stewardship. The degradation of resources has gone hand in hand with alienation of people from their territories and government prohibitions against their approaches to 'environmental management'—including the use of controlled burns, the partial harvesting of tree bark, use of fish traps and fish weirs—as being "unsustainable" (Turner, 2021b; Turner & Berkes, 2006).

The colonizers had their own agendas—clearing land for farming, cutting timber for commercial markets, mining, commercial fishing, and building cities, roads, railroads, and power lines. The attitude is reflected in the words of the National Commission of Conservation from 1918:

> *"All the efforts of the Dominion must be devoted to production and economy. The vast resources of Canada, to which the term 'illimitable' has been so frequently applied, because of lack of knowledge, must be turned to some useful purpose. Untilled fields, buried minerals or standing forests are of no value except for the wealth which, through industry, can be produced therefrom."* (Whitford & Craig, 1918, p. 1).

Right around the time this was written, at the end of World War I, Sumas Lake, one of the prime resource harvesting areas of the Fraser Valley, was drained and dyked to provide land for farming. It was a shallow lake, within Stó:lō Nation territory, known widely for its sockeye salmon spawning and sturgeon habitat, as a locale for hunting geese and ducks, and as a source of wapato tubers, cranberries and other types of berries, crabapples, and western redcedar, cattails, and tule for mats and basketry. Indigenous Peoples traveled from Vancouver Island and other regions, hosted by the Stó:lō, to harvest the resources around the lake. But, according to oral accounts from some knowledge holders who were children at the time, when they left to attend Residential School, the lake was there, and when they returned at the end of the year, it was gone (Carlson, 2001). This is just one example of countless instances of how the colonizers destroyed the lands and lifeways of Indigenous Peoples. Ironically, in the "atmospheric river" rainstorms of 2021, the former lakebed flooded, causing millions of dollars of damage, killing immense numbers of livestock (Hopes, 2021).

Even earlier, the rich estuarine root gardens and crabapple stands of the Kingcome River were destroyed and the local Tsawataineuk Kwakwa̱ka'wakw excluded from their traditional ***tekilakw*** root gardens when settlers moved in and took over these rich lands after the first surveys (Turner & Turner, 2008). Similar displacement and environmental destruction occurred in the Fraser River estuary, continuing to this day, as industrial development, urbanization and associated pollution and extirpation of native species leaves only a few remnants of a once thriving, carefully tended landscape in the homeland of the Musqueam and other Salishan Peoples.

Almost everywhere, waters—lakes, rivers, estuaries, marshes, bogs, and coastal lagoons—all so important for Indigenous Peoples as cultural centers—are particularly vulnerable to impacts of development, and the lasting effects of industrial activities such as logging are widely felt (Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, 1995). Secwépemc Elder Mary Thomas described and identified the environmental loss and degradation of wetlands in her territory around Salmon Arm and Enderby on numerous occasions (Thomas et al., 2016); Elders and knowledge holders throughout the area have concurred.

Along with the inexorable changes of the contemporary mainstream industrial society, there have been abrupt shocks that have been particularly challenging to Indigenous Peoples trying to maintain and honor their ancestral

ways and teachings. Long-term environmental damage has been a common occurrence: for example, nearly 11 million US gallons of crude oil spilled in Prince William Sound, Alaska, when oil supertanker *Exxon Valdes* struck a reef in 1989 (Gill, 2022). Then in 2006 the BC Ferry *Queen of the North* sank off the northern tip of Gil Island in Gitga'at territory, leaving oil and contaminants in prime marine harvesting grounds (Fraser, 2013). Another example, from 2016, is the sinking of the US tugboat *Nathan E. Stewart*, in Gale Pass, an important Haíłzaqv (Heiltsuk) food harvesting, village, and cultural site, spilling 110,000 L of diesel fuel and other contaminants, making this prime fishing and clam harvesting area, again, unusable (Chief Marilyn Slett, 2022).

Coupled with restrictions to food harvesting locales and other impacts of colonialism, Indigenous peoples' food sovereignty rights have been severely impacted. Most of Indigenous Peoples' food today, like that of the rest of society, is purchased from stores, and much of it is processed in various ways (Kuhnlein et al., 2009, 2013), with significantly fewer wild-harvested greens and root vegetables being used. Some of these changes are from personal preference, but many are because of the externally imposed constraints. This loss and depletion of traditional food has been a source of pain and sadness for the Elders and more traditional community members throughout the region and, indeed, for Indigenous Peoples worldwide (Turner & Turner, 2008; Turner, Berkes et al., 2013). Indeed, the forces of colonialism and capitalism, coupled with climate change and biodiversity loss have been responsible for major disruptions for the lifeways of Indigenous Peoples in numerous ways.

4. Discussion: Environmental Change, Restoration, and Renewal

Two major obstacles to the continuation and renewal of cultural connections to the lands and waters—global climate change and erosion of biodiversity, both directly resulting from human activity—are interconnected worldwide environmental challenges. In the study region there are many examples of their impacts.

Gitga'at Elder Helen Clifton pointed out, as just one example, that in the past, the month of called ***ha'li' làx là'àsk*** (May: "the month for gathering seaweed"), was invariably warm and sunny at the time of the lowest early morning tides, making it relatively easy for people to harvest their nutritious edible seaweed (*Pyropia abbottiae*) starting at daybreak in mid-May, bringing it back to the spring harvest camp at K'yel, and spreading it out in square frames or in squares on the rocky bluffs near the camp to dry over the afternoon. They turned the squares over in mid-afternoon, and brought them in, fully dried, around sundown. In the last couple of decades, however, the month of May has often been rainy, and people cannot safely pick their seaweed or sun-dry it as formerly. Later in the summer, previously, they could count on another stretch of warm, dry weather to dry their fish. Helen recounted, *"Back in the days when there was an Indian summer, they could dry the fish easily. Nowadays the fish get rancid and moldy, or full of bugs because there is so much rain; it's so different today"* (Turner & Clifton, 2009). Helen also noted (May 2001), the appearance of a *"strange bird"* in the village of Hartley Bay which no one had ever seen before: a yellow-headed blackbird. They called this bird, *Naxnox*, meaning "supernatural power" in Sm'algyax, as a portent of major change.

Many other Elders have noted such changes. Many berries have not been as productive as in the past. Wild strawberries (*Fragaria* spp.), for example, are not as prevalent as they used to be. *"A long time ago they used to go out on the hills and pick [*wild strawberries*], but we don't see them now"* (Bill Edwards, Stla'tl'imx, pers. comm. to NT, 1984). Helen Clifton has attributed the observed lower productivity of berries like huckleberries and blueberries to a lack of pollinating bees and other insects at a time when the berry blossoms are ripe (Turner & Clifton, 2006). Others suggest the government prohibitions against burning are responsible. In his story, "Burning Mountainsides for Better Crops," Lil'wat Elder Baptiste Ritchie summed up this situation:

> *"Where we used to pick berries, oh, they were really plentiful! Right here where our house is situated now [*in Mount Currie*], that is where we used to come to pick berries, like gooseberries [**sxniz'** - Ribes divaricatum]. Now there are no gooseberries near us. Now the other berries are the same. They have all disappeared. We named other grounds of ours around here; called them 'The Picking Places' because that is where we went to pick berries. Now you will not find one single berry there"* (quoted in Turner, 2021b, p. 190).

Drastic declines in seafood populations—oulachen, herring, and Pacific salmon—have also been widely experienced (Harris, 2001; Marushka et al., 2019; Moody, 2008; Reid et al., 2019; Thornton et al., 2015), at least in part due to climate change, as well as other confounding factors such as commercial overharvesting, unin-

tended by-catch, and farming Atlantic Salmon resulting in sea lice infestations (Krkošek et al., 2007; Marushka et al., 2019).

The constraints against traditional caretaking practices have exacerbated the impacts of climate change and biodiversity loss. Traditional tending and caretaking practices have helped to provide stability and predictability in resource use. Today, with the banning of cultural burning, the draining and filling of wetlands that were formerly used and maintained, the cutting of culturally valued old-growth trees, the pollution of beaches and the prevalence of invasive species, maintaining traditional knowledge and practices is obviously severely constrained. The impacts of wildfire, floods, contamination of clam beds, the spread of introduced tree diseases such as white pine blister rust (*Cronartium ribicola*) killing off the western white pines (Luschiim & Turner, 2021), are undeniable. Invasion of vast tracts of lands and waters with non-native species, such as broom (*Cytisus scoparius*), knapweed (*Centaurea* spp.), and grasses like orchard grass (*Dactylis glomerata*) and couchgrass (*Agropyron repens*), many intentionally introduced, is also impactful on Indigenous Peoples' land use and associated knowledge.

Despite these real concerns and impacts to the rhythms of the Earth and to Indigenous Peoples' lifeways, there is hope in the resilience of nature and the commitment of associated Peoples. Perhaps remarkably, even in the face of all the changes to Indigenous Peoples' lifeways, their knowledge, practices, languages and relationships with their lands still exist—this is Indigenous resistance. Indigenous foodways, environmental knowledge, and many land-based activities, stories, practices and ceremonies relating to caretaking of lands and waters have persisted. This is largely thanks to the perseverance, experiences and teachings of Indigenous Knowledge holders in many communities. These knowledge keepers and cultural teachers can be referred to as "cultural refugia," culturally speaking in parallel with environmental refugia—areas of land or water that, for various reasons, have remained after major disturbances such as glaciers, fire, or floods, and have allowed the repopulation of the disturbed landscape or seascape following the disruption. Indigenous Knowledge holders like *Kwaxsistalla Wathl'thla* Adam Dick, Helen Clifton, Dr. Mary Thomas, Nellie Peters and many others have not only gained experience and learned their languages from their own Elders, but they have retained this knowledge and passed it on to younger generations.

Thus, guided by these Elders, leaders and tradition carriers, families still travel to many culturally important locales and harvest sites, such as K'yel, the Gitga'at spring harvest camp, albeit using speedboats or other powered vessels instead of canoes. Like all peoples, their rights to determine their own futures, to change their practices, and to adopt new foods, technologies and lifeways are paramount. As well, food sovereignty is an essential element of Indigenous Peoples' rights, which is why environmental health is of overriding importance. Indigenous Peoples still care for their lands as their ancestors have done (Kuhnlein et al., 2009, 2013; Thompson et al., 2019, 2020); they still harvest oulachens, herring eggs, and salmon, although these species are not as plentiful as previously (Turner, Berkes et al., 2013). They still pick wild berries in season in locales where their ancestors frequented, although now they might preserve their berries in the freezer, or make them into jam rather than spreading them out to dry in cakes. And, in the age of Truth and Reconciliation (2015) and the United Nations Declaration on the Rights of Indigenous Peoples (United Nations, 2007), the knowledge and land rights of Indigenous Peoples—and their rights to be consulted in land use decisions—are being more widely acknowledged, both in the legal arena and more widely within mainstream society (Asch et al., 2018; Curran & Napoleon, 2020; Eckert et al., 2018; Menzies & Butler, 2007; Parks Canada, 2022; Turner, 2020; Uprety et al., 2012). Along with land-based knowledge, ongoing language revitalization is closely connected (Maffi & Woodley, 2012; Thompson, 2012) and parallels ecocultural restoration initiatives (Senos et al., 2006), and children and youth are being taught and experiencing cultural practices, from canoe journeys, to seaweed harvesting, to pit-cooking (Beckwith et al., 2017).

Cultural keystone places with long histories of Indigenous occupancy and caretaking are being recognized, honored, and taken into consideration in legal disputes (Armstrong et al., 2021; Ignace & Ignace, 2020; Lyons et al., 2018). Indigenous chefs and authors are producing cookbooks featuring traditional foods (e.g., Watts & Watts, 2007), and the nutritional and cultural values of these foods are being widely promoted (Kuhnlein et al., 2009, 2013). And, Indigenous scholars like *Umeek* Richard Atleo (2011) have led an entire generation of Indigenous researchers who are undertaking their own research, with associated teachings, publications and presentations, about the close, inextricable connections between cultural knowledge, language and environments. There is much reason for optimism, as well as for action.

5. Conclusions

All of Earth's lifeforms are guided by cycles: day and night, tides and currents, seasons, eating and rest, life and death—all in endless rotation. We humans have responded to these cycles since the beginning of time, and through various means we have found ways to work with them. Sometimes, though, we have found ourselves needing to respond to disruptions in anticipated cycles, and our capacity to respond and adapt to the unexpected can determine our survival over generations. We have also been disruptors of Earth's cycles, through careless practices such as overharvesting, and inattention to the needs of our other-than-human relations.

Indigenous Peoples of Northwestern North America are experts at balancing the expected with the unexpected in their lifeways. Working in subtle ways with the processes and cycles of nature, such as nutrient recycling, weather patterns, meristematic regeneration of plants, interspecies connections and ecological succession—observed and learned over countless generations in particular places—they have embraced this knowledge and land-based wisdom into their ways of being, languages, stories, teachings, and ceremonies. This includes recognizing and preparing for unexpected events and occurrences, as well as ongoing care and stewardship of plants, animals, and habitats. In themselves, these practices actually help mitigate and reduce the effects of unexpected events. For example, the routine burning over of small areas of land to enhance the growth of berries, root vegetables, and other culturally important species—a widespread practice by Indigenous Peoples—reduces the fuel load in these places and lessens the chance of catastrophic wildfires, such as those witnessed in British Columbia and elsewhere in recent years.

This paper has provided examples of ways in which Indigenous Peoples have used phenological indicators to assess year-to-year variations in the life cycles of fish, birds, berry plants and other resource species. It has also shown how language embodies Peoples' seasonal changes through the naming of the different months or "moon cycles" over the course of the year, as well as tending and stewardship practices that mediate the productivity of resource species and habitats. Lifeways of Indigenous Peoples have changed considerably since the coming of Europeans into the region, but despite the immense changes, individual knowledge holders have carried the traditional environmental knowledge, practices and beliefs forward right up to the present time in many cases. Today, this knowledge is more important than ever as humans everywhere struggle with the impacts of climate change and all that it brings.

Worldwide, Indigenous Peoples are stewards of the majority of Earth's biodiversity. Detailed environmental knowledge at local and regional scales, such as that presented here, is increasingly recognized as important in developing effective and equitable scientific and governance approaches to addressing the intertwined impacts of climate change and biodiversity loss (Truth & Reconciliation Commission of Canada, 2015; United Nations, 1992, 2007). By directly linking cultural knowledge, practice, and values with ecological science, stronger approaches to alleviating and reversing such major environmental impacts can be developed (Armitage et al., 2007; Berkes, 2018, 2021; Kimmerer, 2013; Levin and Poe, 2017; Uprety et al., 2012). These approaches must be taken in true collaboration with Indigenous Peoples, recognizing their ownership of their knowledge and their capacity for leadership, following the highest standards of ethics, accountability, and recognition.

Ultimately, then, the most significant, effective, and imperative route to restoring biodiversity and adapting to, alleviating, and reversing global climate change is for society at large to pay attention to the ways of knowing, practices, perspectives, values, and rights of those Peoples with the closest and deepest ties to specific places. With respectful, ethical collaboration, bringing together Indigenous ecological knowledge, scientific knowledge, and the relationships we have with other life, we humans can re-learn our place in local and global ecosystems. Within such partnerships, we can come to recognize the value of the other species that share this precious planet with us and learn how to live fulfilling lives without causing so much damage to ourselves and to the Earth.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

Data were not used nor created in this article.

Acknowledgments
Our sincere appreciation goes to all the Indigenous Elders and teachers for sharing their rich knowledge about plants and environments, especially those cited and named here, including all those mentioned in Table 1 as sources of specific phenological information. We would especially like to acknowledge the following people, who we have cited or included quotes from: Elsie Claxton, Dr. Earl Claxton Jr., Dr. John Elliott, Dr. Sammy Sam and Violet Williams (W̱SÁNEĆ); Dr. *Luschiim* Arvid Charlie (Quw'utsun); *Kwaxsistalla Wathl'thla* Clan Chief Adam Dick and Dr. *Mayanilth* Daisy Sewid-Smith (Kwakwaka'wakw); Helen Clifton (Gitga'at); Florence Davidson (Massett, Haida); Dr. *Umeek* Richard Atleo (Nuu-chah-nulth); Bill Edwards, Margaret Lester, Nellie Wallace Peters, Baptiste Ritchie (Lil'wat, St'at'imc); Sam Mitchell (Fraser River St'at'imc); Annie York (Nlaka'pamux); Dr. Aimee August, and Dr. Mary Thomas (Secwépemc); and Mary John (Dakelh). Thanks, too, to Dr. Karim-Aly S. Kassam and editorial team for their ongoing advice, to the reviewers of our manuscript and to our research collaborators, whose work is cited. Thanks to Robert D. Turner, for drawing the map in Figure 1. Our research over the years has been supported by the Social Sciences and Humanities Research Council of Canada, the Killam Foundation, The Pierre Elliott Trudeau Foundation and the Tula Foundation and Hakai Institute. Funding to support open access publication of this work was provided by the Rita Allen Foundation under agreement NS-2111-02233.

References

Ames, K. M., & Maschner, H. D. G. (1999). *Peoples of the Northwest Coast: Their archaeology and prehistory*. Thames & Hudson.
Anderson, M. K. (2005). *Tending the wild: Native American knowledge and management of California's natural resources*. University of California Press.
Armitage, D., Berkes, F., & Doubleday, N. (Eds.). (2007). *Adaptive co-management: Collaboration, learning, and multi-level governance*. UBC Press.
Armstrong, C., Miller, J., McAlvay, A. C., Ritchie, P. M., & Lepofsky, D. (2021). Historical Indigenous land-use explains plant functional trait diversity. *Ecology and Society*, *26*(2), 6. https://doi.org/10.5751/ES-12322-260206
Asch, M., Borrows, J., & Tully, J. (Eds.). (2018). *Resurgence and reconciliation: Indigenous-Settler relations and Earth teachings*. UT Press.
Atleo, E. R. (2011). *Principles of Tsawalk: An Indigenous approach to global crisis*. UBC Press.
Bandringa, R. W. (1999). *The ethnobotany and descriptive ecology of bitterroot, Lewisia rediviva* Pursh (Portulaceae) in the lower Thompson River Valley, British Columbia. MSc thesis. UBC.
Beckwith, B. R., Turner, N. J., & Halber Suarez, T. (2017). "You have to *do* it": Creating agency for environmental sustainability through experiential education. In H. Kopnina & E. Shoreman-Ouimet (Eds.), *Routledge handbook of environmental anthropology* (pp. 412–427). Routledge.
Bennett, N. J., Blythe, J., Tyler, S., & Ban, N. C. (2015). Communities and change in the anthropocene: Understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. *Regional Environmental Change*, *16*(4), 907–926. https://doi.org/10.1007/s10113-015-0839-5
Berkes, F. (2018). *Sacred ecology* (4th ed.). Routledge.
Berkes, F. (2021). *Advanced introduction to community-based conservation*. Edward Elgar.
Bouchard, R., & Turner, N. J. (1976). Ethnobotany of the Squamish Indian people of British Columbia. B.C. Indian Language Project, Victoria, B.C. Report to the Squamish Indian Band.
Boyd, R. T. (Ed.) (2021). *Indians, fire and the land in the Pacific Northwest* (2nd ed.). OSU Press.
Campbell, W., Dawe, N. K., McTaggart-Cowan, I., Cooper, J. M., Kaiser, G. W., McNall, M. C. E., & Smith, J. E. J. (1997). *Birds of British Columbia, Volume 3. Passerines—flycatchers through vireos*. UBC Press.
Carlson, K. T. (Ed.) (2001). *A Stó:lō—coast Salish historical atlas*. Stó:lō heritage Trust, Douglas & McIntyre.
Claxton, E., & Elliott, J. (1993). *The Saanich year*. Saanich Indian School Board.
Claxton, E., & Elliott, J. (1994). *Reef net technology of the Saltwater People*. Saanich Indian School Board.
Compton, B. D. (1993). *Upper North Wakashan and Southern Tsimshian ethnobotany: The knowledge and usage of plants and fungi among the Oweekeno, Hanaksiala (Kitlope and Kemano), Haisla (Kitamaat) and Kitasoo peoples of the central and north coast of British Columbia. Ph.D. Dissertation*. UBC.
Cuerrier, A., Turner, N. J., Gomes, T. C., Garibaldi, A., & Downing, A. (2015). Cultural keystone places: Conservation and restoration in cultural landscapes. *Journal of Ethnobiology*, *35*(3), 427–448. https://doi.org/10.2993/0278-0771-35.3.427
Curran, D., & Napoleon, V. (2020). Ethnoecology and Indigenous legal traditions in environmental governance. In N. J. Turner (Ed.), *Plants, people and places* (pp. 269–281). MQU Press.
Deur, D., & Turner, N. J. (Eds.) (2005). *"Keeping it living": Traditions of plant use and cultivation on the Northwest Coast of North America*. UW Press, UBC Press.
Dilbone, M., Turner, N. J., & von Aderkas, P. (2013). The nutrition of lodgepole pine cambium (*Pinus contorta* var. *latifolia*): A springtime candy of people and animals in British Columbia. *Ecology of Food and Nutrition*, *52*(2), 130–147.
Duff, W. (1997). *The Indian history of British Columbia: The impact of the White Man (Original Publication 1965)*. Royal BC Museum.
Eckert, L. E., Ban, N. C., Tallio, S. C., & Turner, N. J. (2018). Linking marine conservation and Indigenous cultural revitalization: First Nations free themselves from externally imposed social-ecological traps. *Ecology and Society*, *23*(4), 23. https://doi.org/10.5751/ES-10417-230423
First Peoples' Cultural Council. (2018). Language diversity in B.C. first peoples' cultural council fact sheet series. Fact Sheet 1. March 2018. Retrieved from https://fpcc.ca/wp-content/uploads/2020/08/Fact_Sheet_1_Language_Diversity.pdf
Fraser, K. (2013). The night the *Queen of the North* sank: Jury to decide fate of officer in charge. The Province May 7, 2013. Retrieved from https://theprovince.com/news/b.c./queen-of-the-north-sinking-what-happened-that-night
Gill, K. E. (2022). Exxon Valdez oil spill effects still linger. WiredPen. 24 March, 2022. Retrieved from https://wiredpen.com/2022/03/24/exxon-valdez-oil-spill-effects-still-linger/
Harris, D. C. (2001). *Fish, law, and colonialism: The Legal capture of salmon in British Columbia*. UT Press.
Harris, R. C. (1997). *The Resettlement of British Columbia: Essays on colonialism and geographical change*. UBC Press.
Hopes, V. (2021). Much of Sumas Prairie in Abbotsford still submerged in floodwaters (video). Retrieved from https://www.abbynews.com/news/video-much-of-sumas-prairie-in-abbotsford-still-submerged-in-floodwaters/
Hunn, E. S., & Norton, H. H. (1984). Impact of Mt. St. Helens ashfall on fruit yield of Mountain Huckleberry, *Vaccinium membranaceum*, important native American food. *Economic Botany*, *38*(1), 121–127. https://doi.org/10.1007/bf02904423
Hutchinson, I., & McMillan, A. D. (1997). Archaeological evidence for village abandonment associated with late Holocene earthquakes at the northern Cascadia subduction zone. *Quaternary Research*, *48*(1), 79–87. https://doi.org/10.1006/qres.1997.1890
Ignace, M., & Ignace, C. R. E. (Eds.). (2018). *Secwépemc People, land, and laws/Yerí7 re Stsq̓ey̓s-kucw*. MQU Press.
Ignace, M., & Ignace, C. R. E. (2020). A place called Pípsell: An Indigenous cultural keystone place, mining, and Secwépemc law. In N. J. Turner (Ed.), *Plants, people, and places* (pp. 131–150). MQU Press.
International Society of Ethnobiology. (2006). International society of Ethnobiology Code of Ethics (with 2008 additions). Retrieved from http://ethnobiology.net/code-of-ethics/
IPCC (Intergovernmental Panel on Climate Change). (2002). Climate change 2022: Impacts, adaptation and vulnerability. Working Group II Report. Retrieved from https://www.ipcc.ch/report/ar6/wg2/
Johnson, L. M. (2010). *Trail of story, traveller's path: Reflections on ethnoecology and landscape*. Athabasca U Press.
Johnson, L. M., & Hunn, E. S. (2010). Landscape ethnoecology: Reflections. In: *Landscape ethnoecology: Concepts of biotic and physical space*, In L. M. Johnson & E. S. Hunn (Eds.) (pp. 279–297). Berghahn Books.
Kassam, K.-A., Bulbulshoev, U., & Ruelle, M. (2011). Ecology of time: Calendar of the human body in the Pamir Mountains. *Journal of Persianate Studies*, *4*(2), 146–170. https://doi.org/10.1163/187471611x600369
Kimmerer, R. W. (2013). *Braiding sweetgrass. Indigenous wisdom, scientific knowledge, and the teachings of plants*. Milkweed Editions.
Kirkness, V., & Barnhardt, R. (1991). First Nations and higher Education: The four R's: Respect, relevance, reciprocity, responsibility. *Journal of American Indian Education*, *30*(3), 1–15.
Kovach, M. (2009). *Indigenous methodologies: Characteristics, conversations, and contexts*. University of Toronto Press.

Krkošek, M., Ford, J. S., Morton, A., Lele, S., Myers, R. A., & Lewis, M. A. (2007). Declining wild salmon populations in relation to parasites from farm salmon. *Science*, *318*(5857), 1772–1775. https://doi.org/10.1126/science.1148744

Krupnik, I., & Jolly, D. (2002). The Earth is faster now: Indigenous observations of Arctic environmental change. Arctic Research Consortium US, & Washington, D.C., Smithsonian Institution.

Kuhnlein, H. V., Erasmus, B., & Spigelski, D. (Eds.). (2009). Indigenous Peoples' food systems: The many dimensions of culture, diversity, and environment for nutrition and health. CINE, McGill U; UN FAO,

Kuhnlein, H. V., Erasmus, B., Spigelski, & Burlingame, D. B. (Eds.). (2013). *Indigenous Peoples' food systems for health: Interventions for health promotion and policy*. CINE, McGill U; UN FAO

Kukutai, T., & Taylor, J. (2016). *Indigenous data sovereignty: Toward an agenda*. ANU Press.

Lantz, T., & Turner, N. J. (2003). Traditional phenological knowledge of Aboriginal Peoples in British Columbia. *Journal of Ethnobiology*, *23*(2), 263–286.

Lepofsky, D., Armstrong, C. G., Greening, S., Jackley, J., Carpenter, J., Guernsey, B., et al. (2017). Historical Ecology of cultural keystone places of the Northwest Coast. *American Anthropology*, *119*(3), 448–463. https://doi.org/10.1111/aman.12893

Levin, P. S., & Poe, M. R. (Eds.). (2017)., *Conservation for the Anthropocene Ocean. Interdisciplinary science in support of nature and people*. Academic Press.

Luschiim, A. C., & Turner, N. J. (2021). *Luschiim's plants: A Hul'q'umi'num' (Cowichan) ethnobotany*. Harbour.

Lutz, J. S. (2008). *Makuk: A new history of Aboriginal-white relations*. UBC Press.

Lyons, N., Hoffmann, T., Miller, D., Huddlestan, S., Leon, R., & Squires, K. (2018). Katzie & the Wapato: An archaeological love story. *Journal of World Archaeological Congress*, *14*(1), 7–29. https://doi.org/10.1007/s11759-018-9333-2

Maffi, L., & Woodley, E. (2012). *Biocultural diversity conservation: A global sourcebook*. Routledge.

Marushka, L., Kenny, T.-A., Batal, M., Cheung, W. W. L., Fediuk, K., Golden, C. D., et al. (2019). Potential impacts of climate-related decline of seafood harvest on nutritional status of coastal First Nations in British Columbia, Canada. *PLoS One*, *14*(2), e0211473. https://doi.org/10.1371/journal.pone.0211473

Menzies, C. R., & Butler, C. F. (2007). Returning to selective fishing through Indigenous fisheries knowledge: The example of K'moda, Gitxaala territory. *American Indian Quarterly*, *31*(3), 441–464. https://doi.org/10.1353/aiq.2007.0035

Miller, R. J., Ruru, J., Behrendt, L., & Lindberg, T. (2010). *Discovering indigenous lands: The doctrine of discovery in the English colonies*. Oxford University Press.

Moody, M. F. (2008). *Eulachon past and present. Ph.D. Dissertation*. UBC.

Moran, B. (1988). *Stoney creek Woman, Sai'k'iz Ts'eke: The story of mary John*. Tillicum Library.

Nabhan, G. P. (2006). *Renewing salmon Nation's food traditions*. OSU Press.

Ommer, R. E., & CUS Research Team. (2007). *Coasts under stress: Restructuring and social-ecological health*. MQU Press.

Oswald, W. W., Foster, D. R., Shuman, B. N., Chilton, E. S., Doucette, D. L., & Duranleau, D. L. (2020). Conservation implications of limited Native American impacts in pre-contact New England. *Nature Sustainability*, *3*(3), 241–246. https://doi.org/10.1038/s41893-019-0466-0

Parks Canada. (2022). *Gwaii Haanas National Park reserve, National marine conservation area reserve, and Haida Heritage site*. Parks Canada. Retrieved from http://www.pc.gc.ca/eng/pn-np/bc/gwaiihaanas/plan/plan1.aspx

Reid, A. J., Carlson, A. K., Creed, I. F., Eliason, E. J., Gell, P. A., Johnson, P. T. J., et al. (2019). Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biological Reviews*, *94*(3), 849–873. https://doi.org/10.1111/brv.12480

Reid, A. J., Young, N., Hinch, S. G., & Cooke, S. J. (2022). Learning from Indigenous Knowledge holders on the state and future of wild Pacific salmon. *FACETS*, *7*(1), 718–740. https://doi.org/10.1139/facets-2021-0089

Reid, M. G., Hamilton, C., Reid, S. K., Trousdale, W., Hill, C., Turner, M., et al. (2014). Indigenous climate change adaptation planning using a values-focused approach: A case study with the Gitga'at Nation. *Journal of Ethnobiology*, *34*(3), 401–424. https://doi.org/10.2993/0278-0771-34.3.401

Salick, J., & Ross, N. (Eds.) (2009). Indigenous peoples and climate change. *Special issue, Global Environmental Change, 19*.

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. (1995). *First Nations' perspectives on forest practices in Clayoquot sound. Report 3*. Cortex Consulting & Government of BC.

Senos, R., Lake, F., Turner, N. J., & Martinez, D. (2006). Traditional ecological knowledge and restoration practice in the Pacific Northwest. In D. Apostol & M. Sinclair (Eds.), *Restoring the Pacific Northwest: The Art and science of ecological restoration in Cascadia* (pp. 393–426). Island Press.

Slett, C. M. (2022). Elected Chief, Heiltsuk Tribal Council. Youtube video presentation. Retrieved from http://www.heiltsuknation.ca/the-nathan-e-stewart-oil-spill/

Steeves, P. (2021). *The indigenous Paleolithic of the western Hemisphere*. University of Nebraska Press.

Suttles, W. P. (1987). Affinal ties, subsistence, and social classes among the Coast Salish. In W. P. Suttles (Ed.), *Coast salish essays* (pp. 15–25). Talonbooks, U Washington Press.

Thomas, M., Turner, N. J., & Garibaldi, A. (2016). "Everything is deteriorating": Environmental and cultural loss in Secwépemc territory. In M. Ignace, N. Turner, & S. Peacock (Eds.), *Secwépemc people and plants: Research papers in Shuswap ethnobotany. Contributions in Ethnobiology* (pp. 365–401). Society of Ethnobiology & Kamloops, BC: Shuswap Nation Tribal Council.

Thompson, J. C. (2012). *'Hede Kehe' Hotzi' Kahidi* —'our ancestors are in us': Strengthening our voices through language revitalization from a Tahltan worldview. Ph.D. Dissertation. University of Victoria.

Thompson, K.-L., Hill, C., Ojeda, J., Ban, N. C., & Picard, C. R. (2020). Indigenous food harvesting as social–ecological monitoring: A case study with the Gitga'at first nation. *People and Nature*, *2*(4), 1085–1099. https://doi.org/10.1002/pan3.10135

Thompson, K.-L., Reece, N., Robinson, N., Fisher, H.-J., Ban, N. C., & Picard, C. R. (2019). "We monitor by living here": Community-driven actualization of a social-ecological monitoring program based in the knowledge of Indigenous harvesters. *FACETS*, *4*(1), 293–314. https://doi.org/10.1139/facets-2019-0006

Thornton, T., Deur, D., & Kitka, H. (2015). Cultivation of salmon and other marine resources on the Northwest Coast of North America. *Human Ecology*, *43*(2), 189–199. https://doi.org/10.1007/s10745-015-9747-z

Thornton, T. F. (1999). Tleikw aaní, the 'Berried' landscape: The structure of Tlingit edible fruit resources at Glacier Bay, Alaska. *Journal of Ethnobiology*, *19*(1), 27–48.

Truth & Reconciliation Commission of Canada. (2015). Honouring the Truth, Reconciling for the future: Summary of the final report of TRCC. Retrieved from http://publications.gc.ca/site/eng/9.800288/publication.html

Turner, N. J. (1992a). 'Just when the wild roses bloom': The legacy of a Lillooet basket weaver. *TEK TALK: Newsletter of Traditional Ecological Knowledge (UNESCO, World Congress for Education and Communication on Env. & Development)* (Vol. *1*, pp. 2–5).

Turner, N. J. (1992b). Plant resources of the Stl'atl'imx (Fraser River Lillooet) people: A window into the past. In B. Hayden (Ed.), *A complex culture of the British Columbia plateau: Traditional Stl'atl'imx resource use* (pp. 405–469). UBC Press.
Turner, N. J. (1996). "Dans une Hotte". L'importance de la vannerie das l'économie des peuples chasseurs-pêcheurs-cueilleurs du Nord-Ouest de l'Amérique du Nord. *Anthropologie et Sociétiés*, *20*(3), 55–84. https://doi.org/10.7202/015434ar
Turner, N. J. (2014). *Ancient pathways, ancestral knowledge: Ethnobotany and ecological wisdom of indigenous peoples of Northwestern North America* (p. 2). MQU Press.
Turner, N. J. (Ed.). (2020). *Plants, people, and places: The Roles of ethnobotany and ethnoecology in Indigenous Peoples' land rights in Canada and beyond*. MQU Press.
Turner, N. J. (2021a). *Plants of Haida Gwaii. Xaadaa Gwaay guud gina k'aws (Skidegate), Xaadaa Gwaayee guu giin k'aws (Massett)* (3rd ed.). Harbour.
Turner, N. J. (2021b). "Time to burn": Traditional use of fire to enhance resource production by Aboriginal Peoples in British Columbia. In R. T. Boyd (Ed.), *Indians, fire, and the land in the pacific Northwest* (pp. 185–218). OSU Press.
Turner, N. J., Armstrong, C. G., & Lepofsky, D. (2021). Adopting a root. Documenting ecological and cultural signatures of plant translocations in Northwestern North America. *American Anthropologist*, *124*(4), 1–19. https://doi.org/10.1111/aman.13658
Turner, N. J., & Berkes, F. (2006). Coming to understanding: Developing conservation through incremental learning. In F. Berkes & N. J. Turner (Eds.), *Developing resource management and conservation, Special issue, Human Ecology* (Vol. *34*, pp. 495–513).
Turner, N. J., Berkes, F., Stephenson, J., & Dick, J. (2013). Blundering intruders: Multi-scale impacts on Indigenous food systems. *Human Ecology*, *41*(4), 563–574. https://doi.org/10.1007/s10745-013-9591-y
Turner, N. J., & Bhattacharyya, J. (2016). Salmonberry bird and Goose Woman: Birds, plants and people in Indigenous peoples' lifeways in Northwestern North America. *Journal of Ethnobiology*, *36*(4), 717–745. https://doi.org/10.2993/0278-0771-36.4.717
Turner, N. J., Bouchard, R., & Kennedy, D. I. D. (1980). *Ethnobotany of the Okanagan-Colville Indians of British Columbia and Washington*. BC Provincial Museum.
Turner, N. J., & Clifton, H. (2006). "The Forest and the seaweed": Gitga'at seaweed, traditional ecological knowledge and community survival. In C. Menzies (Ed.), *Traditional ecological knowledge and natural resource management* (pp. 65–86). U Nebraska.
Turner, N. J., & Clifton, H. (2009). "It's so different today." Climate change and Indigenous lifeways in British Columbia, Canada. Indigenous Peoples and Climate Change. In J. Salick & N. Ross (Eds.), *Global environmental change* (Vol. *19*, pp. 180–190).
Turner, N. J., & Davis, A. (1993). When everything was scarce": The role of plants as famine foods in Northwestern North America. *Journal of Ethnobiology*, *13*(2), 1–28.
Turner, N. J., Deur, D., & Lepofsky, D. (2013). Plant management systems of British Columbia's first peoples. In N. J. Turner & D. Lepofsky (Eds.), *Ethnobotany in British Columbia: Plants and people in a changing world, Special issue, BC Studies* (Vol. *179*, pp. 107–133).
Turner, N. J., Deur, D., & Mellott, C. (2011). "Up on the mountain": Ethnobotanical importance of Montane ecosystems in Pacific Coastal North America. *Journal of Ethnobiology*, *31*(1), 4–43. https://doi.org/10.2993/0278-0771-31.1.4
Turner, N. J., & Efrat, B. S. (1982). *Ethnobotany of the Hesquiat Indians of Vancouver island*. BC Provincial Museum.
Turner, N. J., Gregory, R., Brooks, C., Failing, L., & Satterfield, T. (2008). From invisibility to iransparency: Identifying the implications (of invisible losses to First Nations communities). *Ecology and Society*, *13*(2), 7. https://doi.org/10.5751/es-02405-130207
Turner, N. J., & Hebda, R. (2012). *Saanich ethnobotany: Culturally important Plants of the WSÁNEC' people*. Royal BC Museum.
Turner, N. J., Plotkin, M., & Kuhnlein, H. V. (2013). Global environmental challenges to the integrity of Indigenous Peoples' food systems. CINE, McGill U; UN FAO. In H. V. Kuhnlein, B. Erasmus, D. Spigelski, & B. Burlingame (Eds.), *Indigenous peoples' food systems & well-being: Interventions & policies for healthy communities* (pp. 23–38).
Turner, N. J., Thomas, J., Carlson, B. F., & Ogilvie, R. T. (1983). *Ethnobotany of the Nitinaht Indians of Vancouver island*. BC Provincial Museum.
Turner, N. J., & Thompson, J. C. (Eds.). (2006). *Nwana'a lax Yuup. Plants of the Gitga'at people*. Gitga'at Nation, & Coasts Under Stress, Cortex Consulting,
Turner, N. J., Thompson, L. C., Thompson, M. T., & York, A. Z. (1990). *Thompson ethnobotany: Knowledge and usage of plants by the Thompson Indians of British Columbia*. Royal BC Museum.
Turner, N. J., & Turner, K. L. (2008). "Where our women used to get the food": Cumulative effects and loss of ethnobotanical knowledge and practice. *Botany*, *86*(1), 103–115. https://doi.org/10.1139/b07-020
United Nations. (1992). *The Convention on biological diversity*. Secretariat of CBD. Retrieved from https://www.cbd.int/
United Nations. (2007). *United Nations Declaration on the Rights of indigenous peoples [UNDRIP]. Resolution 61/295*. United Nations General Assembly.
Uprety, Y., Asselin, H., Bergeron, Y., Doyon, F., & Boucher, J.-F. (2012). Contribution of traditional knowledge to ecological restoration: Practices and applications. *Écoscience*, *19*(3), 225–237. https://doi.org/10.2980/19-3-3530
Watts, A., & Watts, D. (2007). *Where people feast: An Indigenous People's cookbook*. Arsenal Pulp.
Whitford, H. N., & Craig, R. D. (1918). *Forests of British Columbia*. Commission of Conservation.
Williams-Jones, G., Barendregt, R. W., Russell, J. K., Le Moigne, Y., Enkin, R. J., & Gallo, R. (2020). The age of the Tseax volcanic eruption, British Columbia, Canada. *Canadian Journal of Earth Sciences*, *57*(10), 1238–1253. https://doi.org/10.1139/cjes-2019-0240
Wilson, S. (2008). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.
Younging, G. (2018). *Elements of indigenous Style: A guide for writing by and about indigenous peoples*. Brush Education.