The nutritious springtime candy of people and animals in British Columbia: Lodgepole pine cambium (*Pinus contorta* Douglas ex Louden var. *latifolia* Engelm. ex S. Watson)

by

Megan Dilbone
Bachelors of Science, Ohio Northern University, 2009

A Master's Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

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in the School of Environmental Studies

Supervisory Committee

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Abstract

This thesis examines the ethnobotany, physiology, anatomy, and nutritional value of edible lodgepole pine (*Pinus contorta* Douglas ex Louden var. *latifolia* Engelm. ex S. Watson) cambium. Many First Peoples of the Pacific Northwest historically used lodgepole pine cambium. It was so popular among interior First Peoples of British Columbia that it was considered a universal food. Even though harvesting and consumption of pine cambium is diminishing in popularity today, I was able to learn from some Tsilhqot'in First Peoples on Redstone Reserve who had prior experience with pine cambium. Nutritional analysis of lodgepole pine cambium revealed the tissues to be high in protein and sugar as well as a suite of micronutrients, which contribute to overall immunity and electrolyte balance. While lodgepole pine cambium is considered a sweet, seasonal treat by many First Peoples it is evident through my analysis that there are added nutritional benefits beyond the pleasure of consumption. This research illustrates an important case study of an endangered traditional food, which can be integrated into modern diets today. It also explores the integration of multiple disciplines of knowledge to inform this subject matter, providing multiple dimensions to understanding cambium production, timing of harvest, and benefit of consumption.

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Acknowledgments

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Chapter 1: An Introduction

June 12, 1876 from Euchiniko Lakes: "Some Indians camped near us now engaged in preparing the cambium layer of the scrub pine. (Stick a muck-a-muck or food) They scrape it off in long ribbons and put these in two layers, one across the other, spread the sheets so formed, which resemble mats, on poles to dry. The taste is quite sweet, but slightly resinous and not otherwise agreeable" (Geologist, George Dawson, in Cole and Lockner, 1989: 207).

Stick a muck-a-muck is a Chinook term roughly meaning, "that one can eat wood". This term was used by G.M. Dawson to describe his observations of people peeling pine tree cambium[1] for consumption in the Chilcotin region of interior British Columbia in the month of June. However, Dawson characterized this traditional food terribly wrong. Eating pine cambium in the spring is far from eating anything made of wood. In the spring, when the vascular tissues are prime for harvesting, tree cambium scrapes off the woody pith in long, white, translucent ribbons which are extremely sweet, tender, and palatable (Figure 1).

[1] The terms cambium and inner bark are often used synonymously. Physiologically speaking, the term cambium refers to the layer of actively dividing cells in woody stems called the vascular cambium. This meristematic region produces xylem and phloem and is ultimately responsible for wood production and radial growth. The term inner bark encompasses three tissue layers, secondary phloem, the vascular cambium, and young secondary xylem cells. The edible portion scrapped from the tree technically is best described anatomically by the term inner bark, as it does contain mostly secondary phloem, cambium, and perhaps a few young secondary xylem cells, but traditionally in texts and conversation it is referred to as cambium. In my paper I will use the term pine cambium to refer to the edible tissues scraped and eaten but please note anatomically speaking the vascular cambium is not the only cellular layer present.   Some First Nations refer to tree cambium as "sap".

Figure 1. Scraping a piece of lodgepole pine cambium from a tree in Kalmalka Seed Orchard (Vernon, BC) on May 20, 2010.

This thesis presents a study, in a series of six chapters, of one species with edible tree cambium, lodgepole pine (*chendee*[2]) (*Pinus contorta* Douglas ex Louden var. *latifolia* Engelm. ex S. Watson), (Figure 2) historically used by interior First Nations people in British Columbia and neighbouring states of the United States. This first chapter is an introduction, providing some background information on pine cambium as a traditional food and describing the geographical area of the study. Many of the topics identified in this chapter will be discussed further in the following chapters. Chapter 2 provides a literature review of the ethnobotany of edible tree cambium, focusing on that of lodgepole pine, followed by a literature review of the physiology and function of the vascular cambium in gymnosperms presented in Chapter 3. Chapter 4 reports

[2] *Chendee* is the Tsilhqot'in word for lodgepole pine. Tsilhqot'in people speak Tsilhqot'in or Chilcotin, an Athapaskan dialect (Turner, 1997). Most Tsilhqot'in elders still speak Chilcotin as their first language today. While English is spoken in all communities, most people I encountered had a basic understanding of their native language. However, no one I spoke to could tell me the Chilcotin word for pine cambium or tree cambium in general, nor have I come across this term in any literature sources. However, Poser (2008a; 2008b) offers the words for cambium (*`eldzo*), bark (*t`ooz*), and sap (*k`unih*) in Carrier (Dakelh). Carrier is also an Athapaskan dialect with often similar words and overlap of tradition to their neighbours to the south (the Tsilhqot'in).

information gathered from experiences working with Tsilhqot'in people on Redstone Reserve and gathering pine cambium from forests in the area. I present qualitative information from interviews with elder Josephine Gregg as well as from participant observation of other community members. I then discuss this information in relation to other secondary interview resources from literature sources. Chapter 5 presents the nutritional value and anatomy of pine cambium. I report nutritional results (fat, protein, sugar, mineral, and vitamins) based on raw samples from the Chilcotin region processed by Sillker Laboratories in Burnaby, BC. Also in Chapter 5 carbohydrate levels are reported, based on raw, dried, and cooked pine cambium samples processed for sucrose, glucose, and fructose, using enzymatic sugar assays. I completed this work in The Centre for Forest Biology at the University of Victoria with the assistance of Dr. Lynn Yip and Dr. Peter Constabel. These results are novel to the field as no one has reported full nutritional analysis of lodgepole pine cambium. The last chapter (Chapter 6) provides integration and summary of major findings as well as a discussion about future use and future research potential of pine cambium and other tree species used for their edible cambium.

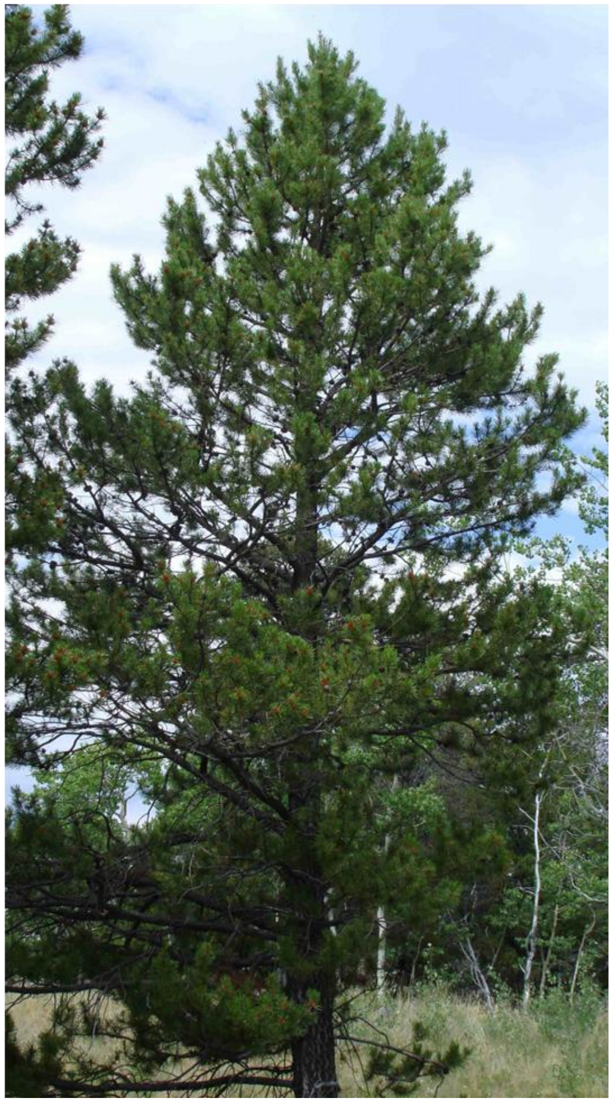


Figure 2. Lodgepole pine (*Pinus contorta* var. *latifolia*) in the Chilcotin area.

1.1 Background

Tree cambium is an oddity among traditional plant foods as it cannot be definitively classified as a fruit, vegetable, or grain. Indigenous peoples of the Pacific Northwest of North America have used at least 20 different tree species and many more species are used for their edible cambium throughout the world (Kuhnlein and Turner, 1991; Turner et al., 2009). Animals also consume edible tree cambium (Turner, 1997). The cambium of lodgepole pine is a food – sweet and nutritious. Its prime edible stage is in the spring at the beginning of the growing season. The advent of the thickening and ripening of the edible portion of the inner bark is greatly anticipated by those who enjoy the savoured food. It would have served as a break from the monotony of limited winter food options. Oftentimes people would strip and collect the pine cambium over just a few days. It could be eaten right away or dried for consumption later. All people – men, women, and children – were involved in the process of harvesting and enjoyed eating it. This same food which people consume as a candy-like treat is also a well respected traditional medicine for a wide range of ailments (Chapter 2 and Chapter 4). It's really a food of dreams, a vegetable that tastes like candy, and is widely accepted culturally as a healthy treat (Marshall, 2002; Deur, 2007; personal communication, 2010).

In British Columbia and bordering states to the south, starting in the late 1800s, bark stripping was heavily discouraged by forestry and governmental officials who feared economic loss and lasting damage to the forestry industry. By the early 1900's, tree cambium was no longer gathered regularly and in some cases not at all. Consequently, knowledge of this practice today is often limited and is entwined in distant memories that are not always easy to uncover. Words associated with edible pine cambium and its harvesting and preparation are limited. For example, none of the Tsilhqot'in people I spoke with could recall the Chilcotin word for edible pine cambium. To this day many people still associate fear and disdain with peeling pine trees and feel the need to conceal peeled trees or not practice peeling at all (Marshall, 2002; personal communication, 2010). Although, trees scarred from past harvesting activity provide strong historical evidence that tell a story of localized annual harvesting, this evidence is limited and does not replace information that may be lost through fading oral histories.

1.2 The Study Area

In 2010 I had the opportunity to visit the Tsilhqot'in community of Tsi Del Del and learned about the past use of this traditional food. I was able to spend time during summer 2010 harvesting lodgpole pine cambium on Tsilhqot'in traditional territory as well as talking to some people about this traditional food which they once annually harvested.

The Tsilhqot'in traditional territory lies west of Williams Lake on the Chilcotin Plateau. The Chilcotin Plateau is a flat sloping area that runs from the Fraser River canyon west to the Coastal Mountain Range. The west Chilcotin is covered in lodgepole pine (*Pinus contorta* Douglas ex Louden var. *latifolia* Engelm. ex S. Watson), Engelmann spruce (*Picea engelmannii* Parry ex Engelm), ponderosa pine (*Pinus ponderosa* C. Lawson), and Douglas-fir (*Pseudotsuga menziesii*

(Mirb.) Franco), along with sparse meadows and many lakes. The eastern Chilcotin is relatively dry and dominated by meadows with broken areas of spruce, lodgepole pine, and poplar trees (Dinwoodie, 2002). There are six separate Tsilhqot'in communities which are accessible from Highway 20, one of the few paved roads in the area. Traveling from east to west the communities encountered are: "Toosey (Tl'esqoxt'in), Stone (Yunesit'in), Anaham (Tl'etinqox), Redstone (Tsi Del Del), and the mixed Tsilhqot'in-Carrier community of Ulkatcho at Anahim Lake." The sixth community, Xeni Gwet'in, is about an hour and half south of Hanceville on Highway 20 in Nemaiah Valley (Figure 2) (Lutz, 2008: 120).

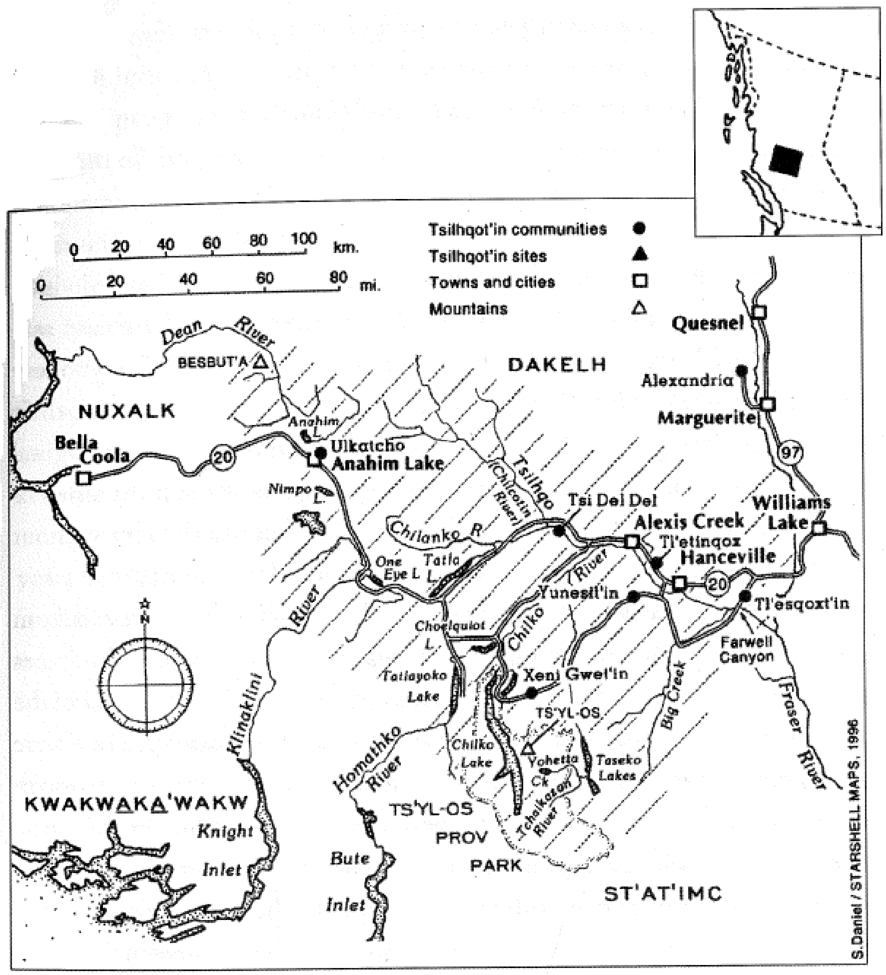


Figure 3. Map of Tsilhqot'in territory, highlighting the six different communities and neighbouring first nations (Lutz, 2008: 121).

In my field research I spent time predominately at Tsi Del Del but spoke with people from other areas of the territory or who presently live elsewhere. Each community is distinct, with its own governing body. Important hunting and gathering sites are shared, as well as many traditions and

ancestry between people in all six areas. Tsi Del Del is located 112 km west of Williams Lake, on the Chilanko River, 12 miles west of the junction with the Chilcotin River and four miles south of Puntzi Lake, along Bella Coola Highway (Hwy 20), (Government of Canada, 2003; British Columbia.com, 2010). The total registered population of Tsi Del Del is about 630 people including residents on and off the reserve (Indian and Northern Affairs, 2008).
The community has a school, medical clinic, elder's center, band office, service station and convenience store. It is home to Tsi Del Del Enterprises LTD, a forest products company (Alexis Creek First Nations, 2010).

1.3 Case Study Approach: Research Design and Ethics

Case studies of traditional foods can give detailed insight about the ethnobotany and nutritional value of wild foods and can also provide written documentation of often abandoned practices that are in danger of being lost over time as associated knowledge fades. While this thesis is specific to one traditional food, pine cambium, many of the same themes, methods, and conclusions are applicable to other traditional foods and medicines studied through community-based research.

I built this project from the need for further research on the ethnobotany and nutrition of edible tree cambium. Ultimately, I chose to focus on the edible cambium of lodgepole pine because many Interior First Nations in British Columbia preferred lodgepole pine cambium over cambium from other tree species (Kuhnlein and Turner, 1991) heavily utilized it. I was particularly interested in the nutritional attributes of pine cambium, a subject matter which had not been studied to date in any detail. I was able to both harvest pine cambium in Tsilhqot'in (Chilcotin) territory and to talk to some community members about this widely forgotten traditional food.

This project was structured to have distinct but complementary aspects of research based on edible lodgepole pine cambium in the Chilcotin region of British Columbia. Literature reviews conducted on the ethnobotany and physiology of edible lodgepole pine cambium informed my own harvesting techniques and interview questions. Knowledge shared by elders and other community members were conducted under an ethics agreement approved by the chief and council of Tsi Del Del and the University of Victoria (Human Research Ethics Board University of Victoria, May 18, 2010).

This ethics approval certificate required consent from chief and council to conduct research on their traditional territory and in the community of people living at Tsi Del Del. I gave all people who contributed to my research a written and verbal explanation of my intentions for the information gathered during their interview. They were given the opportunity to opt out of the study at anytime. I will inform people involved with the project and other community members of the results through a condensed version of this thesis as well as pamphlets, posters, and a possible public presentation based on the information presented in this thesis.

1.4 Conclusion –situated at the start

Although it is unpalatable, the outer bark of a pine tree can communicate many things about the internal and external health of the tree as well as the integral health of the entire pine stand. The outer bark of a tree can be unique as a human fingerprint. It can reveal past trauma, age, or pest infestation as well as communicate information about the potential quality and quantity of edible pine cambium concealed by the rough exterior (Chapter 4). This idea is expressed perfectly in the words of Schwankl (1956) in a book titled Bark:

> *The bark reveals the tree, and is the outward expression of its inner character. For example, pale, silver grey bark on beech encloses a sound tree. But should anything go amiss with the tree's life processes, then the bark will lose its fresh aspect and probably acquire some abnormal color. Should the bark break right away from the trunk, then the tree is at death's door, and the withered leaves and branches of its crown will confirm this. In this manner, any change in the natural condition of a tree may surely be recognized by the state of its bark (1956: 7).*

Such information reflected by the exterior may not be obvious at first, only subtle in nature, but is vital to understanding what is kept on the interior. With time and patience such subtle cues are noticed. In many ways this is how knowledge presented in this paper has evolved from the exterior of many situations –by sitting, looking, listening, and analyzing places, objects, and people which have an abundance of life lessons to share if one is patient to learn. This paper presents just a small portion of the potential knowledge to learn about edible tree cambium of a prime tree consumed by interior First Peoples in British Columbia.

2 Chapter 2: The ethnobotany of lodgepole pine cambium

2.1 Introduction

Ethnobotany is an encompassing discipline which can be defined as the study of "mutual relationships between plants and Indigenous peoples", essentially the documentation of how specific groups of people utilize and interact with plants (Cotton, 1996: 1). In this chapter I discuss the use of lodgepole pine (*Pinus contorta* Douglas ex Louden var. *latifolia* Engelm. ex S. Watson) cambium as a food and medicine by Indigenous Peoples of North West North America. Edible tree cambium has long been a food for people of the Northern Hemisphere (Turner et al., 2009), as well as being considered to have medicinal value. First Peoples use over 20 different species of trees in the Pacific Northwest in varying capacity for cambium harvesting (Table 1). Lodgepole pine is the most widely used edible cambium species of Interior Plateau and Subboreal First Nations, and people once considered it a universal food in the spring (Turner, 1997; Deur, 2007; Moerman, 1998). Use and knowledge of pine cambium as a food/medicine today is limited due to historical restrictions by colonizers on hunting and gathering, decreased intergenerational knowledge transfer, and limited harvesting potential due to landscape changes from mountain pine beetle infestation, logging, and shifted management techniques. Although it is little known today, some individuals still have memories of its use and a few still harvest it as a food.

This chapter presents a consolidated literature review of lodgepole pine cambium as a traditional food used by Interior people of Northwestern North America. There is mention of Coastal people of BC (Coast Salish) using lodgepole pine cambium (shorepine variety, *Pinus contorta* Douglas ex Louden var. *contorta*) but is unclear to what extent (Turner, 1995). Gottesfeld (1992) suggests that lodgepole cambium was little used on the coast because the coastal variety of lodgepole pine is slow growing, thus making it "unsuitable for cambium collection" (151). It seems western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) cambium was the preferred tree cambium of many coastal First Peoples, used to a similar extent to that of lodgepole pine cambium in the interior. Cambium of Sitka spruce (*Picea sitchensis* (Bong.) Carrière), amabilis fir (*Abies amabilis* (Douglas ex Louden) Douglas ex Forbes), red alder (*Alnus rubra* Bong.) and cottonwood (*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & A. Gray ex Hook.) Brayshaw) are other species used in particular regions (Turner, 1995).

This literature review is based on a compilation of both recent and historical resources, interviews (primary and secondary source data), and participant observation experience. After a brief background about the ecology of lodgepole pine and animal consumption of tree cambium, I discuss the history of use, harvesting methods, and preparation and consumption of pine cambium. I end with a brief discussion about the use of pine cambium today and the implications of environmental detriments and historical events which have affected the continuation of use and knowledge of pine cambium as an annually harvested traditional food.

2.2 Sources of information

In order to compile this literature review I consulted botanical, ethnographic, historical, and recent unpublished theses/reports. Some of the most notable ethnographical texts about pine cambium use are found in a group of memoirs based on the explorations of James Teit, published by the American Museum of History, as well as the journals of geologist, G.W. Dawson. Turner's series of handbooks and monographs, published by the British Columbia Provincial Museum, about food plants, medicines, and technology of Interior and Coastal First Peoples in Canada, as well as Kuhnlein and Turner's *Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use* are consistently referenced (Turner, 1995; Turner, 1997; Turner, 1998; Kuhnlein and Turner, 1991). The most notable academic papers used were a paper written by Amanda L. Marshall (2002) titled *Culturally Modified Trees of the Nechako Plateau: Cambium utilization amongst traditional Carrier (Dakhel) Peoples* and an unpublished report by Douglas Deur (2007) called *Culturally Modified Trees at Spring Creek*[3]*: An Ethnographic Overview*. These and other references consulted are cited in the text and listed at the end of this thesis.

[3] Spring Creek is an area of cultural significance to the Klamath Tribe in Oregon, and is a site with many culturally modified ponderosa pine (*Pinus ponderosa*) and lodgepole pine (*Pinus contorta* var. *latifolia*) utilized for edible cambium in the spring. Spring Creek is located along State Highway 97; adjacent to the Williamson River (Deur, 2007).

Table 1. Tree species commonly used for edible cambium by selected groups of people in Pacific Northwest North America.

Extent of Use	**Western Hemlock** *Tsuga heterophyla*	**Spruce** *Picea* sp.	**Lodgepole Pine** *Pinus contorta*	**Ponderosa Pine** *Pinus ponderosa*	**White Pine** *Pinus monticola*	**Whitebark pine** *Pinus albicaulus*	**Trembling Aspen** *Populus tremuloides*	**Black Cottonwood** *Populus trichocarpa*	**Red Alder** *Alnus rubra*	**Bigleaf Maple** *Acer macrophyllum*	**Western Larch** *Larix occidentalis*	**Balsam Fir** *Abies* sp.
Flathead			X	X	X	X	X	X			X	
Ktunaxa			X	X			X	X			X	
Blackfoot				X		X	X	X			X	
Nlaka'pmux (Thompson)		X	X	X			X	X	X		X	X
Okanagan			X	X			X					
Stl'atl'imx			X				X	X	X			
Secwepemc			X	X		X						
Tsilhqot'in		X	X									X
Tahltan			X									
Gitxsan	X		X									X
Dunne-Za			X									
Dakelh (Carrier)			X									
Haida		X										
Nuxalk (Bella Coola)	X	X					X	X				
Kwakwaka'wakw	X							X				
Tlingit	X	X										
Tsimishian	X	X	X									
Vancouver Island Coast Salish[4]	X		X				X	X	X	X		

[4] The Vancouver Island Coast Salish occupied the territory from Comox to Sooke on the southeast part of Vancouver Island. The term Vancouver Island Coast Salish encompasses 3 Salish language groups, the Comox Salish, the Halkomelem Salish (including subgroups: Nanaimo, Cowichan, Malahat, and Chemainus), and the Staits Salish in Saanich. A fourth Coast Salish group on the island, the Pentlatch Salish, is now extinct (Turner and Bell, 1971).

	Western Hemlock *Tsuga heterophyla*	**Spruce** *Picea sp.*	**Lodgepole pine** *Pinus contorta*	**Ponderosa Pine** *Pinus ponderosa*	**Western White Pine** *Pinus monticola*	**Whitebark pine** *Pinus albicaulus*	**Trembling Aspen** *Populus tremuloides*	**Black Cottonwood** *Populus trichocarpa*	**Red Alder** *Alnus rubra*	**Bigleaf Maple** *Acer macrophyllum*	**Western Larch** *Larix occidentalis*	**Balsam Fir** *Abies sp.*
Nutritional Analysis	17	None	4, 39	None	None	None	None	17	3	None	None	None
Reference (See below)	2, 7, 8, 11, 17, 21, 23, 34, 36, 37	7, 8, 11, 17, 21, 23, 30, 34, 36, 37	1, 5- 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29-35, 38, 39, 40	6, 7, 11, 15, 17, 20, 21, 23, 27, 28, 29, 30, 34, 35, 37, 40	17, 21, 23	17, 23, 24, 35, 37	7, 11, 17, 21, 23, 30, 33, 34, 37	7, 12, 15, 17,20, 21, 23, 30, 32, 34, 36, 37, 40	2, 17, 21, 30, 32, 34, 37	2, 17, 21, 11	8, 17, 21, 37	7, 9, 17, 21, 23, 30, 34, 37

1. Andersson, 2005
2. Barnett, 1955
3. Brown, 1954
4. Chapter 5
5. G.M. Dawson in Cole and Lockner, 1989
6. Deur, 2007
7. Eldridge, 1982
8. Emmons, 1991
9. Gaertner, 1970
10. Glynn-Ward, 1926
11. Gottesfeld, 1992
12. Hayden, 1992
13. Hellson and Gadd, 1974
14. Honigmann, 1954
15. Hunn et al., 1998
16. Keely, 1980
17. Kuhnlein and Turner, 1991
18. Mackenzie, 1801
19. Marshall, 2002
20. Peacock and Turner, 2000
21. Moerman, 1998
22. Morice, 1906
23. Ostlund et al., 2009
24. Prince, 2001
25. Sandgathe and Hayden, 2003
26. Smith-Birket, 1953
27. Swetnam, 1984
28. Teit and Boas, 1906
29. Teit and Boas, 1909
30. Teit and Boas, 1900
31. Thwaites, 1959
32. Turner and Bell, 1971
33. Turner et al., 1980
34. Turner et al., 2009
35. Turner, 1988
36. Turner, 1995
37. Turner, 1997
38. White, 1954
39. Yanovsky and Kingsbury, 1938
40. Hart, 1992

2.3 Lodgepole pine (*Pinus contorta* Douglas ex Louden) ecology

"Lodgepole pine is <u>Pinus</u> <u>contorta</u>, but the name is not a good description of the shape of the tree as a whole, except those growing within a short distance of the Pacific coast, which belong to a special, untypical group and are indeed contorted. Most lodgepole pines have tall, slender trunks as straight as ramrods" (Pielou, 1988: 26).

There are two varieties of lodgepole pine which grow in the Pacific Northwest - shore pine, (*Pinus contorta* var. *contorta*) and lodgepole pine (*contorta* var. *latifolia)* The Shore pine is confined to the Pacific coast region while the latter grows in the drier interior (western Canada, from BC to southwest Saskatchewan, north to southern Alaska, the Yukon, and Northwest territory, and south to Baja California, Colorado, Utah, and South Dakota) (Figure 4). The two varieties have similar needle structure and reproductive organs, including seed cones, thus they cannot be considered different species. They do, however, differ in some physical features. Shore pine is smaller and scrubby up to 4.5 meters tall and 0.5 meter diameter, with more branching along the entire trunk, while lodgepole pine has a large, straight trunk (15-30 meters tall, 0.6 meters diameter) with branches typically confined to the top third of the trunk (Figure 4) (Hosie, 1969; Fowells, 1965; Klinkenberg, 2009; Kuhnlein and Turner, 1991).

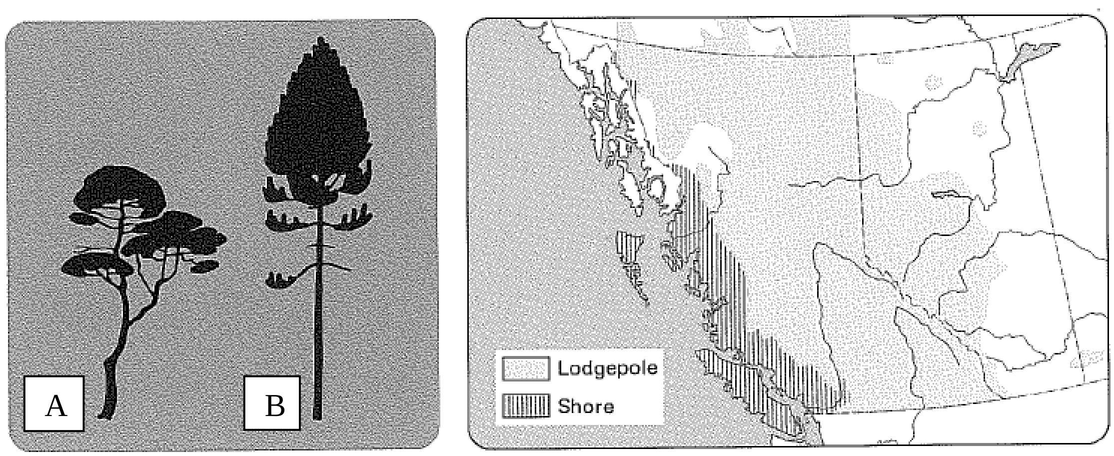


Figure 4. Structure and range of shore pine (A) (*Pinus contorta* var. *contorta*) and lodge pole pine (B) (*Pinus contorta* var. *latifolia*) (Hosie, 1969: 52).

Lodgepole pine needles grow with a spiral twist in groups of two (Figure 5). The needles range in color from dark green to yellowish-green, are 2-7 cm long, straight, stiff, and sharp. The bark of lodgepole pine is brown to greyish, thin, rough, and increasingly scaly with age and size. Lodgepole pine seed cones are thick, spiny and slightly tapering (Figure 5). The cones often remain unopened on the tree for many years and will only release seed after a fire (Hosie, 1969; Turner, 1997). The male pollen cones grow in clusters and are reddish-green (Figure 5) (Hosie, 1969; Fowells, 1965; Klinkenberg, 2009; Turner, 1997).

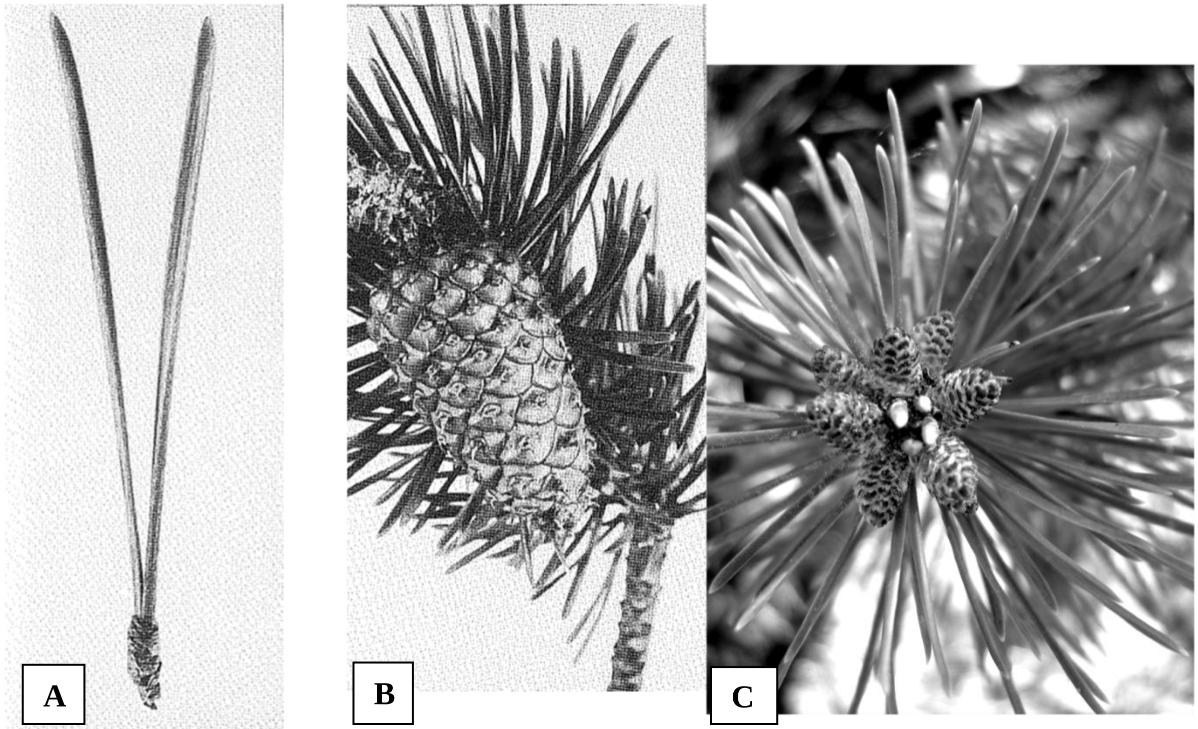


Figure 5. Photos of lodgepole pine needle arrangement and male and female cones. Lodgepole needles are arranged in groups of 2 with spiral formation (A). Female cones remain closed (B) and often only open and release seed after a fire. Male pollen (C). (Hosie, 1969: 53; personal photo, June 17, 2010).

2.3.1 Pine cambium as food for animals

Humans are not the only mammals which consume the inner bark of pine and other trees during the spring season. Gray squirrels, porcupine, mountain beaver and particularly black bears in the American Northwest all consume inner bark of multiple tree species in the spring (Scheffer, 1952). Both black and grizzly bears exhibit similar behaviours and dietary patterns as human and thus can be used as indicators for certain harvesting and nutritional patterns. Numerous stories are present about bears digging for root vegetables and eating berries in similar manners as humans (Turner, 1997). Black bears are the primary cause of tree debarking in northwestern North America, leaving evidence of claw marks, tooth marks, and tufts of fur on the exposed wood. Bears literally scrape the “cambium” with their incisors, moving their head up and down against the trunk (Scheffer, 1952; Ziegltrum, 2004). When black bears emerge after winter sleep from their dens, around mid-March in western Washington, food stores are limited; salmon and berries are not yet available and the new growth of vegetation is just beginning to emerge. The cambium of Douglas-fir, western hemlock, pines, and some spruces provide these animals with an energy source available in early spring (in Washington, bears target western hemlock about two weeks after Douglas-fir). In Western Washington black bears are able to access edible cambium starting as early as mid-April in the lower elevations and continuing into late June. At the beginning of July the bear's consumption of cambium slows down as berries ripen. While this seems early for human consumption, and ultimately for the "fattest" inner bark, the bears seem not to care about the thickness of the tissues, only the presence of some substance containing sugar and ultimately energy (Ziegltrum, 2004; Radwan, 1969).

This behaviour is detrimental to the forestry industry, since a single black bear can girdle 60-70 trees in a day, killing an entire stand with "high growth potential" within 5-6 years. Even partially girdled trees suffer from a weakened state, making them more susceptible to insects and disease. This has been such a problem that alternative food programs have been developed. Feeding stations, containing carbohydrate pellets with about 8 times the sugar concentration than the actual inner bark, are set up in forests. These are reported to be successful for accommodating emerging black bears in the spring but do not alter the feeding habits of bears after other food supplies are available (Ziegltrum, 2004; Nolte et al., 2002).

2.4 Other uses of Lodgepole Pine products

Good for anything that pine –Elder from Fort St. James, November 27, 1999 (Elder from Fort St. James in Marshall, 2002: 195)

Lodgepole pine has other purposes besides its edible cambium; its pitch, needles, and wood are all important culturally. Pine pitch is a medicinal product which many native and non-native people collect and utilize today (Deur 2007; Marshall, 2002). Pitch is a natural defence mechanism against pests and microbes which has antiseptic and antioxidant properties. A study done by Ritch-Krc et al. (1996) found that lodgepole pine pitch completely stopped the growth of *E. coli* and *Staphlococcus aureus* and retarded the growth of *Pseudomonas aeruginosa*. More work must be done to isolate the specific anti-microbial compounds as they are largely unknown.

Pine pitch is often is often combined with grease to make a healing salve for sores, cuts, and burns, acne, boils, eczema, and chapped lips. Pitch salve can also be rubbed on the neck for sore throats, and on sore joints and muscles, as well as being used in steam or hot water baths (Deur, 2007; Marshall, 2002, personal communication, 2010). Some people suck on harder chunks of pitch for throat ailments or chewed like gum for pleasure and medicine. At other times people combine hard pitch with cambium for chewing. Some believe pitch gum promotes dental health. Pine pitch is also used in veterinary medicine, particularly with horses and as water proofing or adhesive for canoes, baskets, spears, or fishing line and hooks (Deur, 2007; Marshall, 2002; Turner, 1998).

Carrier (Dakelh) collected young limbs of lodgepole pine trees and boiled them with honey (introduced); this is good for treating asthma and colds. They also saved the juice that comes off with cambium scraping and used the juice as a sweetener, a sweet drink, or a lotion for the skin to prevent sores, particularly for babies (Marshall, 2002). Lodgepole pine wood from the trunk was often preferred for construction due to its rigidity and straightness. However, pine wood is soft and often weak in quality (Turner, 1998). Despite this, lodgepole pine was and is used in building houses and boats. The Okanagan, Nlaka'pamux, Flathead (Montana), and the Blackfoot (Alberta) used lodgepole pine lumber in construction, specifically for tipi building and more recently log cabins. Pine wood also makes good fuel for fires because it is very pitchy. Today many people shavings from particularly pitchy regions for fire starters (Marshall, 2002; Turner, 1998).

There are few accounts of spiritual or ceremonial significance of lodgepole cambium, pitch, or other products. Deur (2007) mentions a ceremonial area near the Klamath territory that has a series of stacked and arranged rocks surrounded by peeled lodgepole pine trees. He has found evidence of concentrations of peeled trees around various ceremonial sites but it is unknown whether the bark was used as medicine or offerings during ceremony or if it was simply eaten while people were staying at a particular site during a ceremonial time (Deur, 2007).

2.5 History of Use

Cambium stripping for food and medicine occurred annually until the early 1900's (White, 1954). In many areas this practice then abruptly stopped for two main reasons: 1) discouragement by colonial commercial loggers and forestry officials; and 2) the introduction of processed sugar and molasses (White, 1954). Commercial loggers were worried that cambium stripping would seriously damage the trees that now had economic value. Although there is no formal documentation of laws that prohibited cambium harvesting, many feared punishment by jailing or fines[5] (Marshall, 2002). Today there remains a stigma by many First Peoples around harvesting tree cambium. Harvesters still worry about being reprimanded or fined by forestry or government officials for the harvesting activity (Hunn et al., 1998; Turner et al., 1990).

One Carrier (Dakelh) man, when asked about peeling lodgepole pines, admitted he was fearful of going to jail for stripping the trees. He said that people did not understand that they were not seriously damaging the trees: "We are not cutting all around, we just cut a little strip from each tree, we cut a little strip that's all" (Russell, A. in Marshall, 2002: 198). Even though authorities warned him he continued harvesting the inner bark, adding a bit of trickery to the process. When he finished stripping the inner bark he would rub sap on the stripped region and the slab of outer bark removed. This created an adhesive to stick the outer bark back on to the tree, making it look like the tree had never been peeled. One of the elders participating in Marshall's interviews did not want to reveal their name out of fear that he/she still held even today about the authorities finding out that he/she had peeled lodgepole pine trees back in the old days (Marshall, 2002). Historical accounts of Indigenous people peeling and eating tree cambium, particularly that of lodgepole pine, are prevalent in ethnographies, oral histories, and creation stories. Part of a Blackfeet Nation creation story says, " Old Man [the sun] showed them the roots and the berries,

[5] From 1865 to 1907 rights to harvest timber were granted through leases and licenses to private stake holders with no formal government control. This led to a mad rush of harvesting by individuals looking to make money off areas of prime lumber. After concerns of overexploitation arose, the first Forest Act along with the B.C. Forest Branch was created on February 27, 1912. The Forest Act set guidelines allowances for timber harvesting and funnelled all the buying and selling of forested Crown Land through the B.C. government branch of forestry (Parminter, 2000). While there is no evidence that a law directly inhibited First Peoples from harvesting timber related products; the massive rush of people seeking profit from lumber along with loose government regulation probably created situations of coercion and resource greed in territories of First Peoples. An early form of the Forest Act published in Anderson (1925) reports that Part II of the act deals with "the prevention of trespassing on Crown timber lands and provides penalties for unauthorized cutting" (162). Violation of this act is punishable by a fine or jail time. Since settlers did not recognize traditional lands of First Peoples conflicting interests arose dealing with resource use such as the harvesting of pine cambium.

and showed how to gather these, and certain times of the year they should peel the bark of some trees and eat it" (Ostlund et al., 2009: 95).

Alexander Mackenzie who described the practice of inner bark peeling by unidentified "interior Indians", apparently first documented the collection of inner bark from pine trees in the Americas, in 1793. Mackenzie wrote on July 13:

> As they were used to sustain themselves in their journeys on herbs and the inner tegument of the bark of trees, for the stripping of which we had a thin piece of bone, then hanging by his side. The latter is of the glutinous quality, of a clammy, sweet taste, and is generally considered by the more interior Indians as a delicacy, rather than an article of common food (Alexander Mackenzie in Lamb, 1970: 352-353).

In June of 1898, Hamlin Garland (1899), wrote of tasting pine cambium while traveling through Carrier (Dakelh) territory:

> Like the Jicarilla Apaches, these people have discovered the virtues of the inner bark of the black pine. All along the trail were trees from which wayfarers had lunched leaving a great strip of the white inner wood exposed.
> 'Man heap dry – this muck-a-muck heap good,' said they young fellow, as he handed me a long strip to taste. It was cool and sweet to the tongue, and on a hot day would undoubtedly quench thirst. The boy took it from the tree by means of a chisel-shaped iron after the heavy outer bark has been hewed away by the axe (82).

In the early 1900's, Glynn-Ward in the *Glamour of British Columbia* (1926) wrote of bark-stripped trees while in an unspecified area of the Chilcotin:

> Almost the only form of vegetable that custom allows them is a jelly-like substance found just under the bark of the young jack-pine in early summer when the sap is flowing strong. Then you may see among the young growth side (so as not to hurt their growth) of a bit of bark three or four inches wide and perhaps half a yard long, from beneath which the (natives) have collected this jelly and stored it in barrels (138-139).

Another account is given Lewis and Clarke while traveling the Lolo trail in Montana they observed stripped trees: "…on this side of the road and particularly on this Creek the Indians have peeled a number of pine for the under bark which they eat at certain seasons of the year, I am told in the prong they make use of this bark…" **(**Thwaites, 1959: 63**).**
These are only a few of numerous examples of accounts of cambium harvesting from the literature.

2.6 Harvesting lodgepole pine cambium

2.6.1 Preference of tree characters and location

Harvesters of tree cambium develop a very specific set of characters for prime harvesting of lodgepole pine cambium in order to select the best trees for cambium harvesting (Chapter 4). Processing, storage (or not) and consumption are different for each tree species as well as across cultural groups and environments. It is clear that people carefully selected trees and not every tree was good for peeling. Through observation and experience of harvesting each year, certain environments and tree characters are preferred over others. Within the favoured sites, trees were tested and identified based on exterior bark quality, size, health, and taste and maturity of edible tissues (Cunningham, 2001; Marshall, 2002).

Some sources mention that trees growing in moist, well drained, microenvironments were preferred. Turner notes that, “Certain trees, notably those of the montane region in damper sites, yielded more cambium than others” (Turner, 1997: 53). Archaeologically culturally modified trees are often found on south facing slopes near riverbanks, where families would set up camp (Eldridge, 1982). Some people thought such trees had longer peeling seasons and were accessible to women who must stay close to camp (Eldridge, 1982). Ostlund et al. (2009) suggest that culturally modified trees in North America were commonly peeled on the north side (Ostlund et al., 2009). This pattern they maintain does not reflect any religious connotation but reflected, according to Ostlund, a way to gauge thickness of the entire tree: if the shaded side was ready for peeling, then harvesters assumed the rest of the tree was also ready for peeling. Also, the north side tends to have fewer branches to obstruct the peeling of bark (Ostlund et al., 2009). Other studies and conversations have contradicted this suggestion. Some Carrier elders interviewed by Marshall, expressed no preference for side, whereas others were adamant that the “sunny side” (ie. the south side) produced the thickest and best tasting inner bark (Marshall, 2002). Doug Deur also reported preference for harvesting on the south side from his conversations with some Klamath people. Deur did not find any explanation for this belief and mentioned that, in recent years, the preferred side of harvest may well be the one that is least inconspicuous to the eyes of passersby (Deur, 2007). While people’s opinions vary about the preference for particular harvesting aspects, there may be some physiological explanation for the phenomenon (See Chapter 3).

Age and size of the tree is a major factor for people selecting a tree for bark stripping, and may play a more important role in selection than the location of the tree. As lodgepole pine trees age and grow, the girth of the tree expands along with the thickness of the outer bark. Oftentimes, as trees age and expand radially the bark becomes too thick to peel and the inner bark too woody to harvest for edible cambium. Turner et al. (1990) says a tree about 30 cm around was ideal for harvested edible cambium. Young trees with fewer branches were preferred near camps, along trails, or water ways (Ostlund et al., 2009). Middle-aged trees are the best for harvesting edible tree cambium. Carrier elder Sebastion Anatole said,

> *The tree shouldn't be too old or too young. Somewhere between thirty or forty, forty or fifty years old trees. That's when you get the best. They don't know something about the bark, that's why they cut it. If the bark looks kind of thick then they don't bother those trees. The smaller are smooth and easy to roll down… if it rips off to about three or four feet without a darn fuss of breaking up, then they use that* (Anatole in Marshall, 2002: 204).

2.6.2 Timing of harvest

Lodgepole pine cambium, along with most edible and medicinal tree cambiums, is only available during a short window of time in the late spring and early summer months. The exact timing of harvest varies with climate, elevation, and the fluctuation of local environmental variables such as temperature and rainfall (Turner, 1997; Turner et al., 1990; Kuhnlein and Turner, 1991; Turner, 1997). Late May and the first few weeks in June is said to be the optimal time. Some say the whole month of June is the best, others only say it is available from one to three weeks (Marshall, 2002; Eldridge, 1982; Turner, 1997; Kuhnlein and Turner, 1991). At the ideal time, cambium cells are thin with expansion from flows of water and fresh sap and the outer bark is easily removed in large continuous chunks. After this short window of availability the tissues dry up and become lignified and woody, and the outer bark is not as easily removable. The cambium is no longer palatable.

When conditions are "normal" and the tree physiology is as usual, the harvest time for lodgepole pine cambium is quite predictable. A cold spring can delay ripening, and thus harvesting, by up to a few weeks, whereas a warm spring can speed up the growth process (Eldridge, 1982). As noted in Chapter 1, journal entries by George Dawson in early to mid June 1875, report lodgepole pine cambium prime for harvesting near Tatlayoko Lake (Cole and Lockner, 1989). Carrier elders reported similar timing, mentioning the month of June as the time they remember stripping trees for cambium as children. According to Josephine Austin people harvested the cambium over a span of only one week in June when she was a child. After that, she said, the bark "tightens up" (Austin in Marshall, 2002). [She was likely referring to the onset of new wood production and lignifications of the xylem tissues as well as the dwindling of sap flows in the phloem.] Other people talk about the tissues "gluing back together", making the cambium unpalatable and unfit for harvest during the fall and winter (Deur, 2007).

Some environmental indicators of prime cambium harvesting time include: running sap, pollen release by pollen cones, and the production of the new flush of needles (Kuhnlein and Turner, 1991; Turner, 1997; Deur, 2007). A cool, cloudy day, when the sap is running, is preferred by some over a hot sunny day for harvest. The whitish fleshy cambium is said to be best when it is watery instead of sticky (White, 1954). Some Carrier elders reported that the inner bark is best harvested at daybreak, before the sun has had a chance to warm the milky sap and stop it from running; others did not believe that the time of day affected the quality of the inner bark harvested (Marshall, 2002).

Depending on location, the timing of harvest of lodgepole pine cambium may be associated with the harvest of other plant foods. In Thain White's paper, "Scarred Trees in Western Montana" (1954), William Gingros discussed harvesting the edible cambium of pine (possibly ponderosa pine) in Montana when bitterroots (*Lewisia rediviva* Pursh.) were ready for digging (before flowering) in the spring. People were not allowed to peel the bark before the women harvested the first bitterroot. If this protocol was not followed, the people believed it would bring bad luck and the offender would be punished by the spirits (White, 1954). Ponderosa pine inner bark is generally ready for harvest two weeks prior to lodgepole pine inner bark, at least in the Okanagan area (Kuhnlein and Turner, 1991).

2.6.3 Harvesting cycles for lodgepole pine cambium

It appears that lodgepole cambium, berries, and greens were gathered mainly by women and children, but men also participated. A missionary in Northern British Columbia, Father A.G. Morice noted, "Though it is incumbent on the women to gather it for the household, no hunter will deem it below his dignity to have an occasional thrust at a pine with his knife or scraper when he travels through the woods" (1906: 201). Peeling sites could be associated with sites of other activities such as fishing, hunting, pitch collecting, or gathering of other plant products. The sites where culturally modified trees are found today are often near water sources, such as rivers or streams, which most likely were areas of spring and summer camping villages (Prince, 2001).

A few Carrier interviewees from Marshall's research discussed the idea of peeling the cambium of lodgepole pine as part of an entire cyclical use of the tree. Carrier elders reported peeling some trees not only for the production of prime cambium, but also to promote the production of other materials the pine offers. If the harvester killed the tree by peeling all the way around the stem, he/she took great care to use all parts of the tree for different purposes. Another elder, said that the exposed wood from the peeling scar made for perfect "chopping and kindling" and also could be used as a smooth area of wood for carving messages (Marshall, 2002). This practice of carving messages and pictures in exposed wood of tree trunks is documented often by explorers traveling through Lillooet, Shuswap, and Chilcotin territories (Tiet and Boas, 1909; Blackstock, 2001). This appears to be a common method of communication, marking trails, sacred sites, and passing on messages. Another Carrier elder Annie, said one of the most important aspects of harvesting the cambium of lodgepole pine was allowing people to congregate and socialize in the bush; during this time elders taught young people the value of medicines and food from the forest (Mattas in Marshall, 2002).

In some cases, the harvesting of products from lodgepole pine trees reflected an extended cycle that often took years to complete. Russell (1999) reported that the cycle started in the springtime with the harvesting of the inner bark. If people needed lumber from a lodgepole pine tree, they girdled the tree. The tree would react to the peeling by producing sap around the injury site and in the subsequent months the sap would be absorbed into the wood. At this time people would shave wood chips from the sap soaked wood. These shavings were used as fire starters. Over time the sap droplets on the surface of the wood would harden and turn into pitch. About a year after the peeling, pitch clumps were ready for harvesting for use as adhesive, for chewing and medicine. After about ten years after the bark stripping, the tree would die and people then used the dead tree for firewood and building materials (Russell in Marshall, 2002: 199). Turner et al. (2009) also mentions this same process in regards to Gitskan harvesting cycles of pine cambium and pine pitch.

2.6.4 Harvesting Methods

Harvesters peeled small test strips (20 cm in length) as samples from a prospective tree before peeling it further. The strips of cambium were tested for consistency and thickness, and for the right taste which was sweet but not too sour (from tannins and resins) (White 1954; Kuhnlein and Turner, 1991). If a tree was deemed suitable for harvest, then a larger strip of outer bark was removed. A flap of outer bark was created by cutting an arch or "V" at chest or eye level (Deur, 2007; Eldridge 1982; Turner 1997). Historically, an antler or chiselled piece of wood was often used to pry open the outer bark. The flap was then pulled downward. If the tree is at the right stage for harvesting, the outer bark peels off easily in long strips and tapers to an end at the bottom. Lodgepole pine cambium generally adheres to the trunk of the tree (unless it is later in the season), whereas in other trees, such as ponderosa pine, the cambium tends to come off with the outer bark (Eldridge, 1982). Okanagan people reportedly harvested lodgepole pine cambium later in the season and thus had to scrape the cambial tissue off the inside of the outer bark instead of the wood trunk (Turner 1997). Klamath elders say that pine bark gets thinner as you move up towards the crown up the tree, so they would not harvest much above the tops of their heads. They also said the older trees may be better to peel higher up but the younger trees produced sufficient bark only up to chest and eye level (Deur, 2007).

The whitish tissues, or "bark noodles," are peeled off in strips about 3 cm wide and 60 cm long (1 inch wide and 23 inches long) using a sharp knife or traditional scraper (Kuhnlein and Turner,1991; Turner, 1997). When collecting some people placed a basket at the foot of the tree to catch the strips of cambium as they fell off the tree (Kuhnlein and Turner, 1991). Stl'atl'imx elder Edith O'Donaghey described memories of harvesting lodgepole pine cambium: "That's the kind my dad used to [get]. In the springtime he'd take the peeling [bark] off and he'd scrape the white part off and… bring it home in buckets…. It comes off in white strips…. The white stuff around the wood" (Turner et al., 2009: 240-241).

People would rarely peel around the entire circumference of the tree, unless their intention was to fall the whole tree. Trees have proven to survive injury caused by outer bark peeling and cutting of vascular tissues quite readily. Trees, which were scraped three-quarters around, were reported not only to survive but to "look as vigorous as the unpeeled trees" (Marshall, 2002).

2.6.5 Harvesting Tools

> *June 5, 1876 entry while on Euchiniko River: "The little boy furnished with a curious implement for procuring the cambium layer of P. Contorta for food. A sharpened stick with wedge like end, tied at the upper end to a piece of bone with chisel shaped outer end, something like a shoe-horn. With the first a longitudinal incision made, and the bark peeled off. The sweet pulp then scraped off the wood and eaten by the second. The whole carried through the belt also furnished with horn spoons of bone manufacture, and this shape [sketch in diary]"* (G.M. Dawson 1876, in Cole and Lockner, 1989: 204).

A long wooden stick-like tool, similar to that of an axe handle, was often used to pry off the outer bark of trees whose edible cambium was sought. The tool could also be made from antler or other material. The wooden tool was about 1-1.5 meters long with a chiselled end, narrowed to a rounded point. This was used to cut into, get under and lift up the outer bark (White, 1954; Teit and Boas, 1900). Traditionally, a scraper made of caribou antler, deer ulna or rib, or shoulder blade of deer or bear was used to remove the inner bark. The natural concave shape of the end of the scapula worked to conform to the natural curvature of a tree trunk (Kuhnlein and Turner, 1991; Teit and Boas, 1909 ; Turner, 1997).

Several records of the structure and material of cambium scraping tools are found in ethnographies (Figure 6). Scrapers made of bone or antler were sometimes decorated with etchings and designs, as the ones recorded by Teit during two weeks spent traveling through the Chilcotin (exact locations unspecified). He reported that pine cambium was "much relished". (Figure 6 B) (Teit and Boas, 1909: 781). Teit (1909) also provides another account of tools used for cambium by the neighbouring Secwepemc (Shuswap). He noted,

> People peeled the outer bark off with bark peelers made of antler. A few were made of wood and horn. People generally made sap-scrapers from caribou-antler or of the shoulder-blade of the black bear. A few were made of other bones, notably the ulna of the deer. They were similar in form to those used by the Thompson (Nlaka'pmx) Indians, Cree, Chilcotin, and Carrier. Many were double ended (Figure 6 D) (Teit and Boas, 1909: 515-516).

Over time the preferred cambium scraping tool changed to a sharp knife or a piece of metal cut from a tin can (Kuhnlein and Turner, 1991; White, 1954). While in Thompson territory Teit recorded: "To separate the bark from the tree, a short piece of horn or wood was used, and the cambium was scraped off with an implement of bone or horn sharpened to an edge. Such implements were similar in shape and size to those now used by the Athapascan tribes of the northern interior. At the present day knives are used for scraping" (Figure 6 A) (Teit and Boas, 1900: 233). The piece of tin was flattened a bit but still maintained the curvature of the can, with the thickened rim the end for grasping. People sharpened the tin tool on one end in order to easily penetrate the bark tissues to easily shave off the cambium (White, 1954; Marshall, 2002; Turner, 1997; Kuhnlein and Turner, 1991).

2.7 Processing and consumption of lodgepole pine cambium

Lodgepole inner bark tissues were often eaten fresh, shortly after harvest (Kuhnlein and Turner, 1991). Inner bark does not keep well and after a day would become "sour" in open air. Swetnam reports people rolling ponderosa pine bark into balls or tying the strips into knots, followed by wrapping the knots in leaves to prevent them from drying out so quickly (Swetnam, 1984). White (1954) reports freshly harvested ponderosa pine bark strips placed into baskets or bags with fresh leaves or grass to keep in the juices while traveling back to camp. Several Carrier elders remembered as children peeling lodgepole bark and rolling the strips up; this kept them fresh for the day or turned them into something comparable to a fruit-roll-up that could be snacked on at a later time (Marshall, 2002).

Some groups (Secwepemc (Shuswap), Nlaka'pamx (Thompson), Wet'suwet'en) sometimes dried lodgepole inner bark for later consumption (Moerman, 1998; Kuhnlein and Turner, 1991;

Turner 1997). Carrier people dried it on drying racks, sometimes made of willow, similar to those used for drying salmon. George Dawson said the cambium strips were laid out on wooden racks in crisscross format, creating a woven mat of bark strips. Strips of inner bark were left to dry in the sun for one to three days or were dried over a fire (Cole and Lockner, 1989: 207). Father A.G. Morice offers another account of this: "after undergoing the usual drying process, the substance will retain for quite a while much of its original spicy taste; but most of the supply procured by the women is often eaten on the spot, or immediately after their return from the forest (Morice, 1906: 200-201). Pine cambium was also often dried in the sun, after a few hours the cambium completely dried out, especially in arid environments such as the interior of British Columbia.

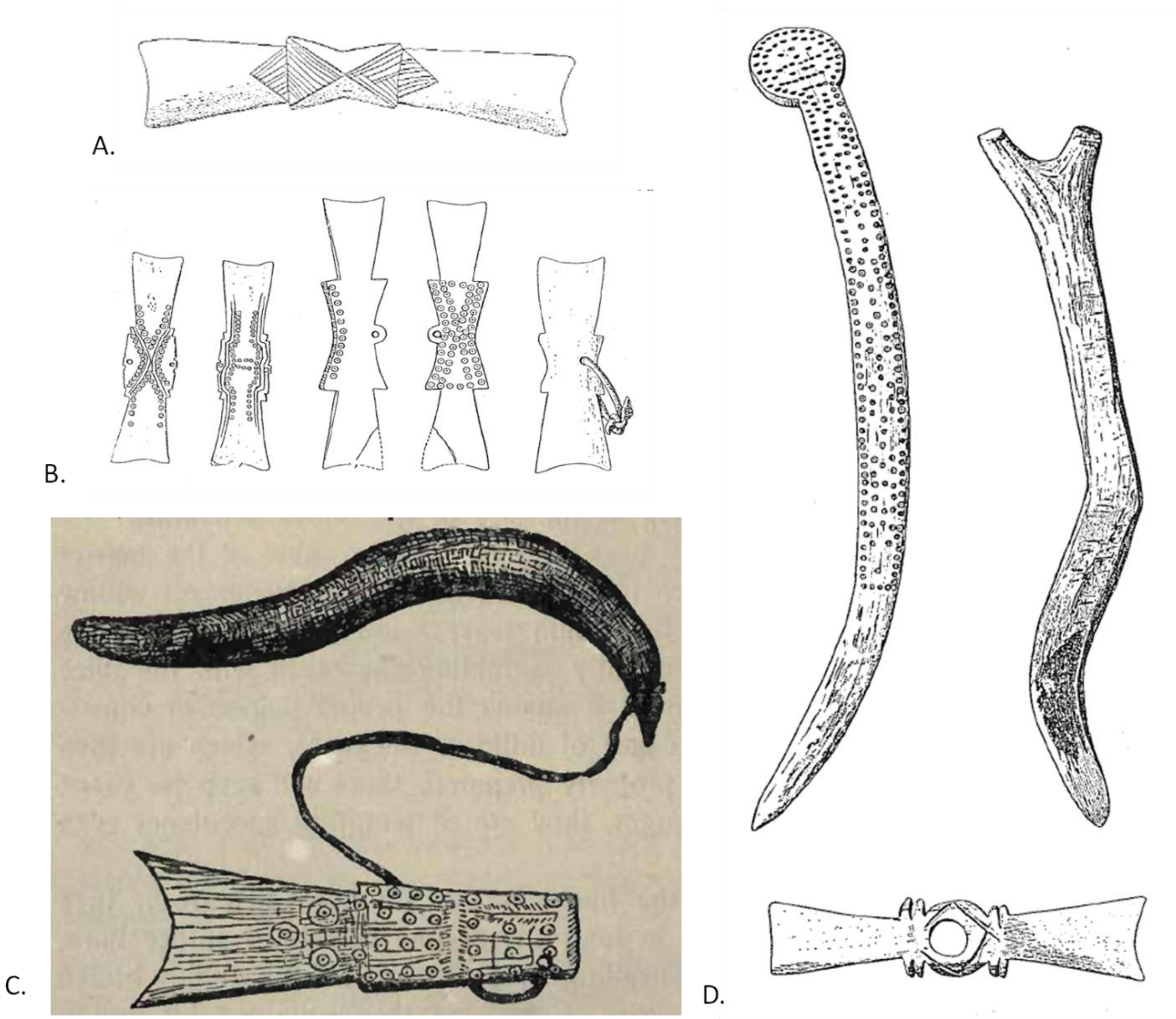


Figure 6. A series of drawings of cambium scraping tools recorded in several ethnographies. **A**: A sap scraper similar to the ones used by the Thompson recorded by Teit. Drawing is half the actual size (Teit and Boas, 1900: 233). **B**: Traditional tools used for scraping tree cambium. The top photo is a drawing by Teit during a two week expedition in the Chilcotin for the Jesup North Pacific Expedition in 1900 (Teit and Boas, 1909: 780). **C**: This sketch is from the journals of Father A.G. Morice based on work with the Carrier (Dahkel). No scale is offered for this drawing (Morice, 1906: 200). **D**: Shuswap bark peelers and cambium scrappers recorded by Teit. The lengths starting at the top left peeler are 49 cm, 44 cm, and 21 cm (Teit and Boas, 1909: 515-516).

Cooking or pit cooking[6], specifically of lodgepole pine does not seem to be a common practice, as it was for other barks, most notably Scots pine and hemlock (Ostlund et al., 2009; Nuxalk

[6] Pit-cooking, is essentially a slow steaming process, preserves much of the nutritional value of the food and in some cases make the food more palatable by leaching out some of the tannins, resins, and other potential toxins. Pit-cooking can also render complex carbohydrates into more easily digested forms, allowing their energy to be utilized, by breaking large polymers down into smaller compounds (Eldridge, 1982).

Food and Nutrition Program Staff, 1984). This may be due to the coarser/thicker nature compared to lodgepole pine. Lodgepole pine is already palatable raw and contains little fibre when harvested correctly at the right time of year. Western hemlock (*Tsuga heterophylla*) cambium, particularly, was often pitcooked and dried into cakes or dried on racks for overwintering (Eldridge, 1982; Gottesfeld, 1992; Emmons, 1991; Turner 1995). Dried bark cakes were then soaked in water to rehydrate the tissue before consumption (Kuhnlein and Turner, 1991). June 3, 1793, Captain Vancouver observed northern Kwakwaka'wakw people preparing a paste from the inner bark of a pine tree and making it into a food that was meant to substitute for bread. The bark bread was prepared by washing it in sea water, next beating with a rock, and then rolling into balls. Based on the actions of the Kwakwaka'wakw, Vancouver judged that this was a food they really liked. Below is a similar account of mashing, drying, and then pit cooking of lodgepole pine (the shore variety) by unspecified people in Alaska:

> The Indians cut the trees down and strip out the inner bark. This is broken into pieces by the patient squaws who mash it in water into pulp which they mold into large cakes. Then a hole is dug in the ground and lined with stones, and a fired kindled. When the stones are hot, the embers are removed, and the cakes packed in with leaves of the Western Skunk Cabbage between. A damp moss is built on top, and the baking takes an hour or more. Then the cakes are laid on slat frames and smoked for a week in a closed tent. Now they are ready to be put away for future use or to carry in canoes or on ponies to distant places. This hard bread is prepared for use by breaking it in pieces and boiling them until soft. The pieces are skimmed out and laid on the snow to cool. "Ulikou" fat is used on this strange Alaskan bread as we use butter (Medsger 1939, 93-94)[7].

A similar practice by the Sami made bread from Scots pine cambium ground into flour. Preserved loaves made of Scots pine cambium have been found by archaeologists in excavated graves (Hansson, 2002). Today, people most commonly consume cambium fresh. Some experimentation with other methods of preservation such as freezing and canning is worth trying.

2.7.1 Taste and consistency

Lodgepole pine cambium, with a slightly acidy sweet taste, is said to be more "pleasant" tasting than that of other pine species (Ostlund et al., 2009). It is sweet and juicy when consumed fresh although it sometimes has a tendency to be resinous-tasting (Kuhnlein and Turner, 1991). It

[7] This reference to "pine" cambium may be actually be referring to hemlock cambium. Explorer journals often reported many plant items as "pine" that were not pine. In this context it may just be a general label for useful tree so I do not believe this processing technique is actually used with pine cambium.

appears cambium was eaten out of pleasure; people really enjoyed consuming it. When eaten in bowls with sugar, people said it tasted like honey (Turner et al., 1990). Depending on the tree, the taste can range from slightly distasteful to quite distasteful. Taste is influenced by the concentration of tannins and resins present and also by sucrose production of each individual tree. Sugar can vary in concentrations from 22 to 43% among individual trees (Swetnam, 1984). Cambium harvested later in the season is said to be progressively more distasteful and full of tannins than cambium harvested in late spring or early summer (Kuhnlein and Turner, 1991; Marshall, 2002).

The consistency was described by Glynn-Ward as a jelly-like substance (Marshall, 2002). Others describe it as milky in consistency, watery or sticky. Camille Joseph said, "It's soft and powdery (when it's dry), you know…Sometimes he says you might dip it in grease…It's been so long, I forgot the taste of it" (Joseph, C and Joseph, W. in Marshall, 2002: 216).

2.8 Concluding Discussion

An educated assumption can be made that tree cambium has many healthful and healing properties based on thousands of years of knowledge and harvesting by Indigenous peoples. A host of possible vitamins and antioxidants in pine cambium were thought to ward off sicknesses such as the common cold, consumption and tuberculosis (Gitksan, Kutenai, Blackfoot), scurvy, respiratory illness, and stomach illness (Moerman, 1998). The Gitksan ate the inner bark of pine as a blood purifier and cathartic. A decoction of cambium was also taken by the Gitksan for a purgative, diuretic and as gonorrhoea treatment. The Okanagan-Colville ate inner bark to treat stomach troubles and ulcers (Moerman, 1998; Turner et al., 1980). The Tlingit pounded dried hemlock cambium into a powder and applied it combined with oil as a poultice (Emmons, 1991). These are just a few examples of specific medicinal uses of pine cambium. I provide further about this in Chapter 5. Based on literature sources; tree cambium consumption most likely supports immune system health, contains significant micronutrients, and contributes to overall health.

Unfortunately environmental factors, such as the mountain pine beetle, intergenerational knowledge gaps, and history negatively impacts the future use of pine cambium as a traditional food and medicine. As discussed earlier in the historical use section, the advent of large scale forestry and other resource extraction for profit claimed colonial control of resources which First Peoples had been using for thousands of years. Bans and permits were placed on gathering, hunting, and landscape management practices, which were once done freely by First Peoples (Turner and Turner, 2007; Turner and Turner, 2008). Consequently, First Peoples seldom harvest and use pine cambium and most edible tree cambiums. The people who remember harvesting this food are quite elderly or have learned about the knowledge from their parents.

In the article *Traditional food systems, erosion and renewal in Northwestern North America*, Turner and Turner (2007), cite ten influences as major factors which have caused a decline of traditional food systems and their specific components – "loss of territory for accessing traditional food; loss of traditional management practices; introduction of new foods; land degradation and transformation; barriers to intergeneration knowledge transfer; colonial policies privileging agriculture; regulations against indigenous cultural practices; and globalization and domination of mainstream food systems" (Turner and Turner, 2007: 1). These influences and changes which affect each indigenous community are complex and hard to characterize in general terms, however the broad context reveals that peoples' diets today are generally lower in micronutrients and higher in saturated fats and processed sugars, and therefore not as healthy (Turner and Turner, 2007).

This chapter consolidated key literature sources about lodgepole pine cambium as a traditional food. I presented information about the history of use of pine cambium, methods of harvest, tree selection processing, and consumption, and characterized pine cambium as an endangered food. Both social and environmental issues are factors that must be considered when thinking about the potential of reintroduction of tree cambium into annual cycles of traditional harvesting.

3 Chapter 3: Physiology and function of the vascular cambium region in pine and other gymnosperms, in relation to its value as a food

3.1 Introduction

This chapter provides a literature review and discussion about tree physiology particularly the physiology of vascular tissue production and sugar transport which affect the seasonality, composition and taste of edible pine cambium[8]. In order to understand the traditional knowledge and techniques of using cambium as a food it is first necessary to know how the tree produces the edible tissues. Information about stem structure, the ascent of sap and minerals, translocation of carbohydrates and cambial growth are all pertinent to understanding the timing and nutritional composition of edible pine cambium. I begin with background information concerning the anatomy of gymnosperm tree trunks, bark, and the functions of the vascular cambium, phloem, and xylem. Next I discuss the annual cycle of the vascular cambium and secondary growth production, including the effects of hormonal controls and environmental controls of the vascular cambium. Lastly, I present data on carbohydrate metabolism in trees, leading into a discussion about how this information can be integrated into understanding pine cambium as traditional food. These physiological processes are highly sensitive to changes in the environment and affect both health of organisms and ecosystem. They are complex and often do not fit in a neat box; simplifying them can run the risk of presenting only a two-sided picture when there are many gray areas in between. So while I present topics under neat headings, these processes are inextricably linked and influence each other in various ways.

3.2 Woody stem and bark anatomy of gymnosperms

Tree trunks are composed of woody elements, designed to provide structural support and vascular conducting tissues to allow transport of nutrients and water (Figure 7) (Kramer and Kozlowski, 1979). The formation of wood involves cellular division of the vascular cambium

[8] All of the studies referenced in this section took place in the northern hemisphere where fluctuations in seasonal patterns are pronounced. According to Pallardy (2008), “Most information on cambial growth characteristics has been obtained from studies of temperate zone trees. Secondary growth of such species is considered to be ‘normal’” (64). Cambium growth patterns reported in studies cited in this section can be applied to lodgepole pine trees growing in the Chilcotin region in British Columbia as well as other gymnosperms growing in temperate zones.

towards the inside of the tree, resulting in xylem cell expansion followed by secondary wall formation. This process is regulated and influenced by a combination of intrinsic factors (genes and hormones) as well as external conditions (temperature, photoperiod, pests, precipitation, etc.) (Deslauriers et al., 2008). Wood of gymnosperms (softwoods), as well as of hardwood trees, consists of both heartwood and sapwood. The heartwood is located in the center of the trunk, surrounded by a ring of younger sapwood. The sapwood is composed of young xylem and living parenchyma cells (about 10% of the cells in the sapwood are living) (Kramer and Kozlowski, 1979). Sapwood cells primarily conduct water and serve as support and storage tissues (Saranpaa and Holl, 1989). The heartwood cells are all dead, are darker in color than sapwood, and are not involved in any growth or physiological processes. The primary function of heartwood is structural support for the living trunk and crown. Dead cells in the heartwood are full of oils, gums, resins, and tannin extractives, which often make up to 30% of total weight of the wood (Kramer and Kozlowski, 1979). Also, heartwood of some trees species contains terpenoids, tropolenes, flavonoids, and stilbenes, all compounds, which deter fungus and thus protect the tree against rotting (Kramer and Kozlowski, 1979; Butterfield and Meylan, 1980).

"Bark is structurally more complex than wood" (Pallardy, 2008: 27). In mature trees, the bark includes all layers on the outside of the trunk from the vascular cambium to the outer bark. The bark is usually sectioned into two regions, the inner and outer bark. The outer bark is composed of cork cells (phellum), cork cambium, and phelloderm. It is sometimes called true bark and serves as an exterior protective layer as well as a source of some annual thickening via the cork cambium (Schwankl and Edlin, 1956; Kramer and Kozlowski, 1979). The inner bark includes secondary phloem, a meristematic region called the vascular cambium, and some young xylem cells. (Schwankl and Edlin, 1956; Kramer and Kozlowski, 1979).

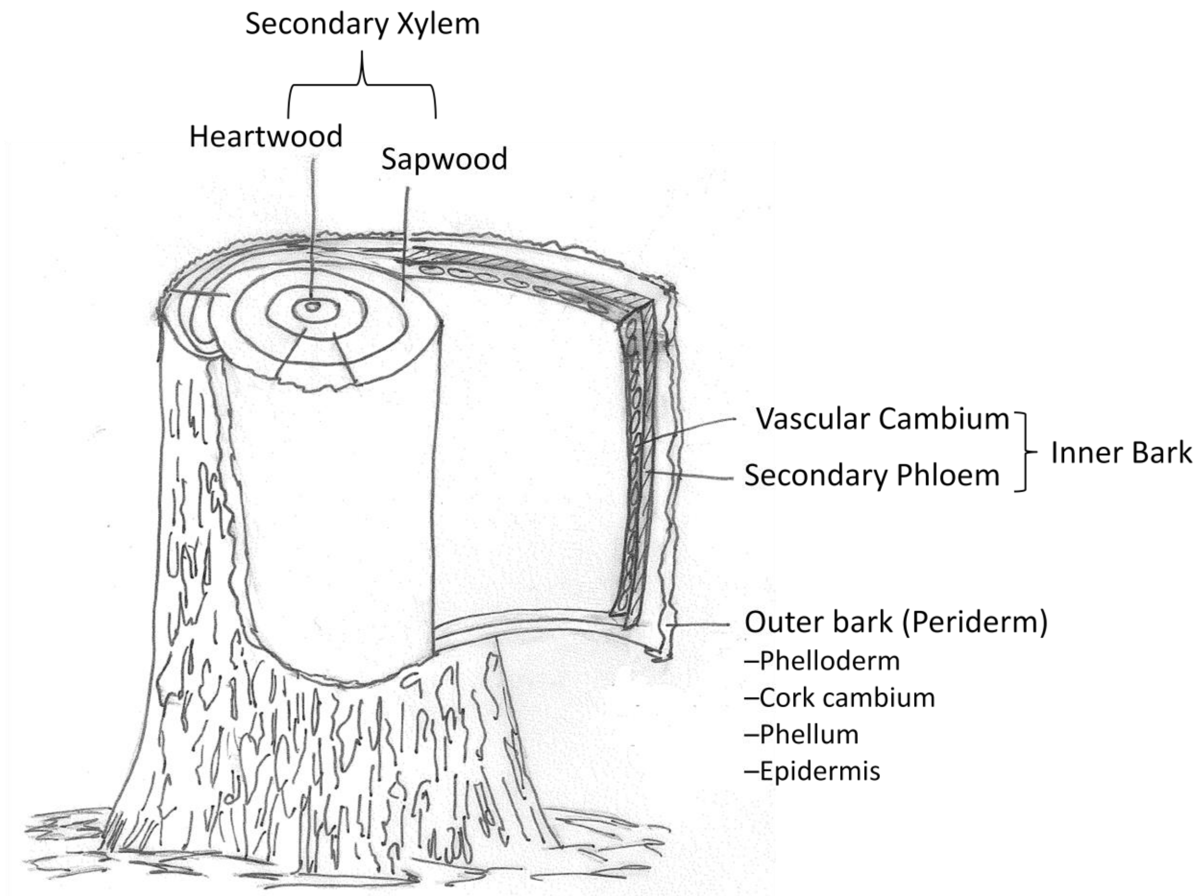


Figure 7. Diagram showing the different layers of vascular tissues including the outer and inner bark sections.

3.2.1 Secondary Xylem

Secondary xylem is the tissue which is responsible for annual woody girth expansion in trees. Each spring a new layer of xylem cells is produced via the vascular cambium; these cells mature, develop lignified secondary walls, and turn into wood. About 90% of the wood/secondary xylem in gymnosperms is composed of long, vertically stacked tracheid cells (Kramer and Kozlowski, 1979). Gymnosperm tracheids are arranged in fairly uniform horizontal rows and have characteristic thick walls of four to six sides with pits clustered towards the end. These cells are long and tapering in form, often about 100 times longer than they are wide (Kramer and Kozlowski, 1979). The secondary xylem of conifers is simple in structure. It is composed solely of tracheids and parenchyma cells, with no vessels (Schweingruber et al., 2006; Kramer and Kozlowski, 1979; Butterfield and Meylan, 1980). The primary responsibility of secondary xylem is transport of water and other nutrients from roots to leaves.

3.2.2 Secondary phloem

Secondary phloem is the vascular tissue responsible for long distance transport of sugars and other nutrients required for plant and cell growth. Like xylem, gymnosperm phloem is structurally relatively simple. It is composed of three types of cells: sieve tube elements paired with albuminous cells, parenchyma cells, and fibres. Sieve tube cells are aligned vertically and function to transport sugars from source to sink[9]. Parenchyma cells and fibres fill in spaces between the sieve tubes and are used to maintain structure. They often function as storage cells for tannins, resins and crystals (Pallardy, 2008). Parenchyma cells produced early in the season contain lower tannin concentrations than those produced later in the season (Pallardy, 2008). Thus edible cambium produced in spring and early summer is much preferred by people for taste and pleasure when parenchyma cells are filled with smaller amounts of distasteful tannins.

Translocation or long distance sugar transport via sieve tubes is a perplexing process which has yet to be fully explained, particularly in gymnosperms (Liesche et al, 2011). There are well established mechanisms to explain short distance transport (diffusion and osmosis) but few can explain the movement of material from the leaves to roots of a mature tree, a far greater distance. For most tree species phloem transport happens at speeds of 50-100 cm/h, a speed which cannot be accomplished by either diffusion or osmosis (Dickison, 2000; Cronshaw, 1981**).**

The sieve tubes themselves are about 20 µm in diameter and capable of transporting sugars over a distance of 100 m (Wardlaw, 1974). While the mechanism of sap transport is not conclusively known, research has established two hypothetical methods of sap transport: 1) sugars are transported by metabolic force without water; the source and sink control the pathway but do not actually control the movement itself (protoplasmic streaming, electroosmosis, transcellular strands and cytoplasmic pumping); 2) sugar is transported without the need of metabolic energy but with the presence of water, just purely controlled by the input of the source and the sink (mass flow/pressure flow) (Liesche et al., 2011).

[9] Sink is a term used for any part of the tree which requires fuel in the form of sugar to grow and expand in the spring. Different parts of the tree can be labelled as strong or weak sinks depending on their level of sugar demand. The area from which the sugar is produced via photosynthesis is called the source. Sugar travels from source to sink areas.

3.2.3 The Vascular Cambium

The vascular cambium is the lateral meristem responsible for the production of phloem and xylem and ultimately the annual growth of the trunk, branches, and roots (Butterfield and Meylan, 1980). Vascular cambium divisions in the spring produce juicy, edible secondary phloem tissues each spring. Understanding the physiological function and timing of increased cambial activity in the spring/summer followed by the onset of dormancy and decrease of thickening during the fall and winter months adds further understanding about the annual harvesting of edible tree cambium. It is also apparent that hormones are involved in this timing process as well as a suite of other factors (genetic controls, environmental influences, age and health of the tree, and many others).

Early studies claimed the vascular cambium to be a liquid substance, with suggestions that the layer "poured into the free space between the wood and the bark or bast" (Bannan, 1995: 117) but as methods and technology evolved, the vascular cambium was revealed to be a layer or multiple layers of actively dividing cells responsible for the production of vascular tissues and wood (Chaffey, 1999). Murmanus (1970) described the vascular divisions: "Cambium is interesting as a tissue in which differentiating and senescing cells coexist with cells that retain the ability to grow and react to growth substances and physical agents… the two daughter cells produced are of unequal potency; one, the initial cell, remains physiologically young and keeps its totipotency, whereas the other, the xylem or phloem mother cell, undergoes senescence" (137). The vascular cambium is composed of long fusiform cells and shorter cells called ray initials. The fusiform initials divide in the cambium each producing two cells. One of these cells is the xylem/phloem mother cell, which divides to produce secondary phloem and xylem. The other cell is an initial, remaining in the vascular cambium, it divides into more mother cells and more initials (Pallardy, 2008). Eventually the mother cells themselves mature into a vascular cell and are replaced by newly created mother cells. These divisions both increase the width of the vascular cambium region itself during the height of activity and also, as noted, lead to the production of vascular tissues (xylem to the outside, phloem to the inside) for water and food transport, and the eventual annular secondary thickening (Chaffey, 1999) (Figure 8).

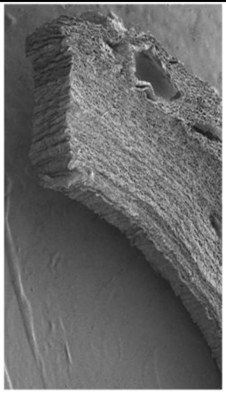
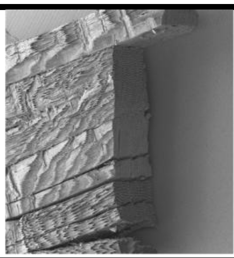
<table>
<tr><td rowspan="6"></td><td rowspan="6">Portion of that is edible</td><td colspan="3">Mature Phloem</td></tr>
<tr><td rowspan="3">DIFFERENTIATING PHLOEM</td><td colspan="2">Maturing Phloem</td></tr>
<tr><td colspan="2">Radially Enlarging Phloem</td></tr>
<tr><td>Phloem mother cells (dividing)</td><td rowspan="3">CAMBIAL ZONE</td></tr>
<tr><td>CAMBIUM</td><td>Cambial initials (dividing)</td></tr>
<tr><td rowspan="3">DIFFERENTIATING XYLEM</td><td>Xylem mother cells (dividing)</td></tr>
<tr><td rowspan="3"></td><td rowspan="3">Portion of vascular tissues which are fibrous and woody</td><td colspan="2">Radially enlarging xylem</td></tr>
<tr><td colspan="2">Maturing xylem</td></tr>
<tr><td colspan="3">Mature xylem</td></tr>
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Figure 8. Evolution of vascular tissue production via the vascular cambium showing the edible and non-edible tissues produced via this lateral meristem.

The cambial initial cells are difficult to distinguish from the phloem and xylem mother cells and early undifferentiated vascular tissues. Thus the entire area of undifferentiated, dividing cells is referred to as the cambial zone. The cambial zone in dormant trees can vary from one to ten cells in thickness (Kramer and Kozlowski, 1979). In growing trees the cambial zone is much thicker but thickness varies from tree to tree. In slow-growing trees it can be as thin as six to eight cells in width, but in faster growing trees at the height of activity the cambium zone can reach 12 to 40 cells in width (Kramer and Kozlowski, 1979). The cambial zone reaches its greatest width typically during the first half of June, with the highest activity lasting for about one month. This varies by species, elevation, and climate (Kramer and Kozlowski, 1979; Murmanis, 1971; Alfieri and Evert, 1968; Rensing, 1922; Creber and Chaloner, 1984).

3.3 Annual cycle of the cambium/secondary growth

The vascular cambium grows in a cyclical pattern governed by seasonal changes in temperate and other environmental parameters (Figure 9). In the spring, the vascular cambium activates as temperatures increase followed by rapid cell divisions and production of phloem and xylem in May and June and continuing over the summer (Smith and Hinckley, 1995). As temperatures cool in the fall, the vascular cambium slows to a halt in temperate environments. In coniferous trees, there may be a small amount of cambial and photosynthesis activity through the winter months, but there is not substantial secondary growth occurring at this time (Marchand, 1996).

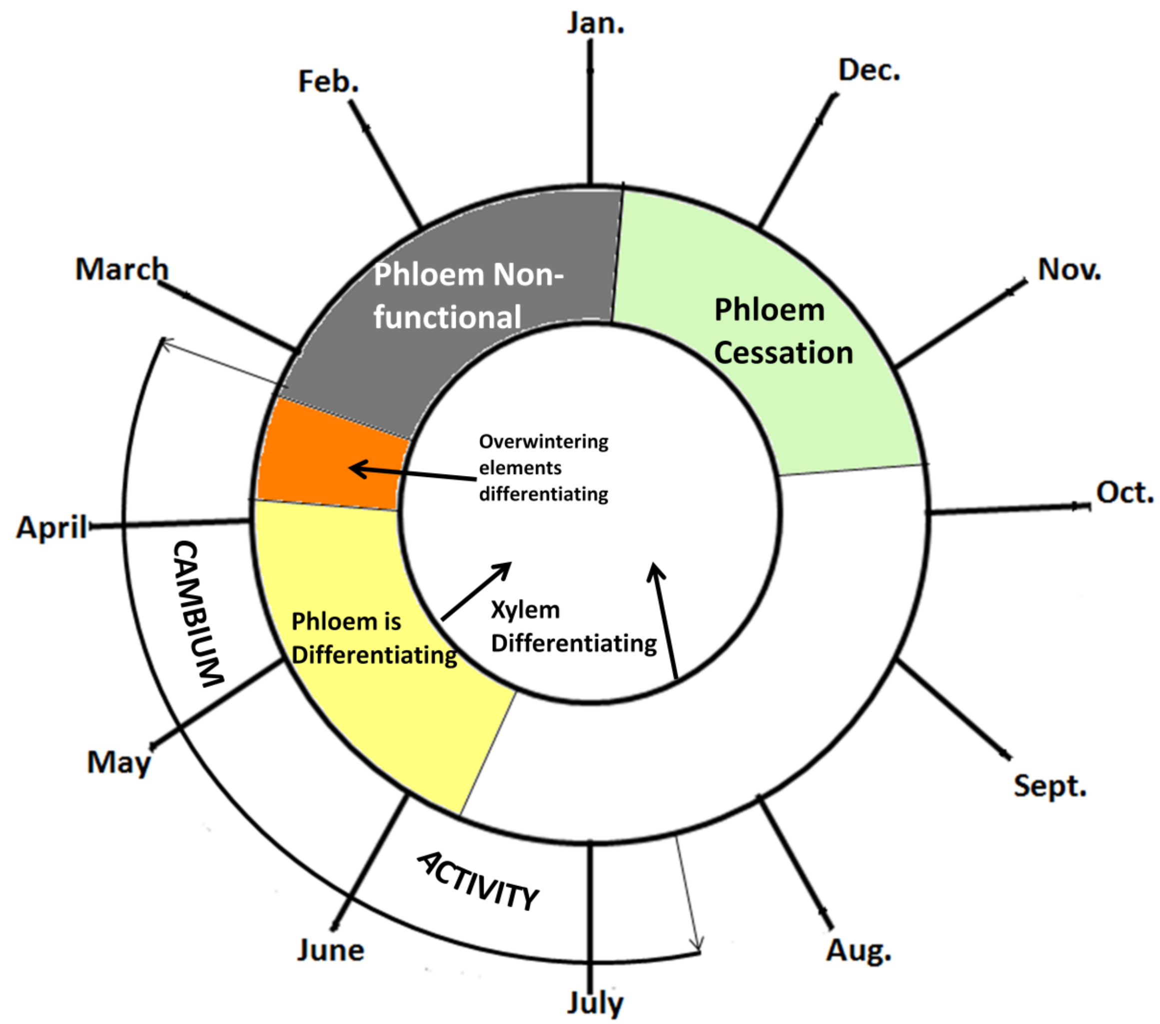

Figure 9. Seasonal cycle of cambial activity and xylem and phloem production (modified from Larson, 1994: 614).

3.3.1 Cambium Activation

The vascular cambium is active in the spring. This occurs, for example, in late March or early April in Madison, Wisconsin (Murmanis, 1971; Alfieri and Evert, 1968). A change in appearance of the thin row of overwintering cambial cells marks the initial activation of the vascular cambium. These cells undergo a change in color, becoming more translucent. Then they swell (Alfieri and Evert, 1968; Wilcox et al., 1962; Kramer and Kozlowski, 1979). This time period is also associated with increased ease of outer bark peeling, since the cambial cells are expanding and are loosely arranged, rather than compact (Wilcox et al., 1962).

At the time of spring activation, partially mature sieve tube cells from the previous year continue developing to maturity. These sieve tubes are believed to be used for sugar transport before new cellular divisions begin, although the situation is not always this clear-cut. The studies of Rees (1929) and Alfieri and Evert (1968) did not find immature cells present during the winter; rather, they found two to four layers of mature vascular tissue that had overwintered into the spring (Murmanis, 1971; Alfieri and Evert, 1968). There seems to be varying levels of not only winter activity but of spring preparation prior to new growth. New cell division does not generally start until the end of April/beginning of May in a study conducted in Madison Wisconsin (Murmanis, 1971). The initiation of the vascular cambium is influenced by a flush of hormones from the apical meristem, but the "timing of reactivation of the cambium and budburst are mainly functions of spring temperature" (Rensing, 1992: 4).

3.3.2 Cambium Growth

Following the initial activation of the vascular cambium, division and growth of vascular tissues occurs, producing new layers of secondary phloem and xylem. In gymnosperms, phloem production can precede xylem production by several weeks. This time span can range from about six weeks to 1.5 months (Alfieri and Evert, 1968; Kramer and Kozlowski, 1979). In a study conducted on white pine trees (*Pinus monticola* Douglas ex D. Don) in Central Wisconsin, phloem production began in April, with early phloem production completed by late May or early June, followed by steady production of late phloem until the end of September (Alfieri and Evert, 1968; Alfieri and Evert, 1973). At the time the early phloem was laid down, the over-wintered sieve cells began to die. By the end of October all early phloem cells were dead in the white pine trees studied and by the beginning of December in central Wisconsin all but the overwintering sieve cells were dead (Alfieri and Evert, 1968).

According to Alfieri and Evert (1968) once early phloem production has ended around the first week in May, the initiation of xylem differentiation begins in pine trees. The cambium divides rapidly creating a large number of xylem initials. The "grand period" is a time of vast xylem expansion. In a span of about four weeks, the vascular cambium rapidly divides to produce one-half to three-quarters of the total xylem increment for the year. The production of early wood/ xylem starts to diminish in late June or early July. By late July and early August, early xylem production ceases altogether and late xylem production begins simultaneously with the production of late phloem. Even though xylem production begins after the initiation of the phloem divisions, by the end of the growing season the layers of xylem cells far exceed those of phloem cells produced (Alfieri and Evert, 1968).

Cambial activity is not continuously uniform along or around the entire trunk of the tree. Cambial division may be localized only in certain regions of a tree, depending on the climate conditions, health of the tree, and other variables. The thickness of cambial growth can vary on different sides and at different heights along a tree trunk. One side of the tree can be in dormancy while the other is actively dividing (Kramer and Kozlowski, 1979; Kozlowski et al., 1962; Pallardy, 2008). While this phenomenon has been observed in several studies as well as observed by some harvesters of edible tree cambium, there appears to be no pattern in this phenomenon. Growth patterns vary by individual tree according to intricate interactions of environment, water stress, light conditions, and health. Temperature is one factor that causes differential growth of the vascular cambium. In one study by Leikola (1969) on Scots pine grown in Finland, thermometers were installed in the cambial layer on all sides of the trees. From April 24th to August 31st the south side of the tree was 4°C warmer at noon than the north side. They concluded that it may be possible to distinguish north-south orientation from the cross-section of tree trunks based on asymmetric growth patterns. However, there was not clear consistent asymmetrical growth pattern on north-south sides of all the trees studied (Creber and Chaloner, 1984). This reasoning could account for some reports by First Nations harvesters who prefer a specific side of the tree trunk for the best edible cambium harvest.

3.3.3 Cambium Dormancy

The onset of dormancy and slowing of divisions in the cambial zone varies with location and climate (Smith and Hinckley, 1995). In general, this stage of the cycle usually starts with the onset of fall, in the months of September and October. Cambial activity does not completely cease until as late as February. When the vascular cambium is inactive it is around six to ten cells thick. Partially developed xylem and phloem cells stop their expansion. Maturation continues later once spring begins (Murmanis, 1971).

Temperature apparently has little effect on the cambial activity at the end of the growing season, since the vascular cambium ceases activity at the end of the growing season even when the temperature is well above the minimum temperature for spring activation (Rensing, 1992; Creber and Chaloner, 1984). Vascular cambium dormancy seems to be a product of some internal factor and/or of shortening photoperiods (Creber and Chaloner, 1984). Some researchers speculate that the tissues themselves become desensitized to hormone levels and temperatures that promote cellular divisions earlier in the year; perhaps shortened days trigger this desensitization (Savidge et al., 1982; Bonga and Clark, 1963; Wodzicki and Wodzicki, 1973; Egierszdorff, 1981). The timing of production of edible tree cambium is cyclical and consistently ends in the fall and starts in the spring under influence of changing temperatures, hormone levels, and photoperiods.

3.4 Internal and external controls of the vascular cambium

An intricate interaction of external environmental factors and internal physiological functions (marked by hormone stimulation) spurs the reactivation of the vascular cambium and secondary growth each year. The primary external factors at play include temperature, light, water, oxygen, carbon dioxide, and mineral nutrition (Smith and Hinckley, 1995). Growth, while limited by the availability of carbohydrates and water, is also regulated by naturally occurring plant hormones and genetic interactions.

3.4.1 Hormonal Control: Indol-3-acetic acid

Indole-3-acetic acid (IAA), originally identified from urine as well as fungal cultures of *Rhizopus*, is the primary form of auxin found in plants (Davies, 2004). IAA has a wide array of functions beyond regulating cellular division in the vascular cambium. In this thesis I will not be discussing any of these subsequent functions. Research on IAA control of vascular divisions has resulted in almost a century of work focused in experimental plant physiology and more recently genetics. However, even with the evolution of precise analytical methods and advanced technology, questions are still unresolved which are essential for understanding the actual mechanism of IAA influence and the control of vascular cambium divisions and dormancy. Specifically, we still do not understand the mechanism of local IAA production, transport mechanisms, and whether this hormone functions as a positional signal in the vascular cambium (Davies, 2004).

Early explorations of IAA control of cambial divisions established key concepts about IAA mechanism and vascular growth. When apical buds are removed the tree is essentially decapitated. The flow of IAA decreases or disappears, stopping divisions of the vascular cambium. When endogenous forms of IAA are then applied to decapitated trees, the vascular cambium reactivates (Avery et al., 1937; Hoad, 1995; Little and Bonga 1974; Little and Wareing 1981; Sandburg and Ericsson, 1987; Digby and Wareing, 1966). These manipulation experiments led scientists to conclude that apical shoots, buds, and leaf primordia were the primary source of IAA synthesis during bud break in the spring. IAA originates at the apex of the tree and is transported from the crown downwards.

3.4.2 Methods of IAA quantification

Methods of extraction, purification, and quantification of IAA are extremely important and can create false, unreliable results if not preformed with precision. Purification and quantification of IAA used to require "tens or even hundreds of kilograms of plant material" in order to detect IAA while today analysis can be performed on milligrams of material (Davies, 2004: 3). As plant hormones are present in minute amounts, 0.1-50 ng g^{-1} fresh weight, instruments must be highly sensitive (Ljung et al., 2004). The most common and reliable methods of IAA analysis today are high performance liquid chromatography for purification followed by gas chromatography-mass spectrometry (GC-MS) for quantification (Davies, 2004; Edlund et al., 1995; Uggla et al., 1996). These methods are extremely sensitive to low IAA concentrations. They are also sensitive to other impurities that may be present in the sample which can skew the actual IAA concentrations.

The actual units of IAA quantification are important when presenting IAA results. IAA is expressed as total amount (ng cm^{-2}) or in units of concentration (ng g^{-1} fresh weight). Each unit provides a different perspective for discussion. Some believe it is of little relevance to just report the total hormone amount because IAA directly affects vascular tissues, so it is best to express IAA as a concentration of the environment which it influences (Davies, 2004; Sundberg et al., 1991; Sunberg et al., 1990).

For example in a study conducted by Sundberg et al. (1990) different conclusions were made when expressing the same study in total volume and concentration. In this study free IAA was quantified using chromatography-selected ion monitoring and mass spec in four designated zones along the radius of Scots pine (*Pinus sylvestris* L.) tree trunks. Results were expressed in both total amounts and concentration. The highest concentration of free IAA was found in the fraction including the vascular cambium, while the highest total amount of free IAA was found in the fraction within the phloem. Which result is the most important? It really depends on the interpretation of the authors. If they would just like to address IAA levels independently of the cells they influence, then IAA levels are the most important but if they want to speak about the IAA influence, then concentration is the only relevant unit.

3.4.3 Radial and Longitudinal gradients

Studies have presented contradictory conclusions about longitudinal IAA gradients which decrease from the crown to the base of the tree. The following studies found a strong to medium longitudinal IAA gradient: Aloni, 1987; Aloni, 1983; Rishiksh and Bennett, 2003. In contrast, IAA remained steady from crown to base in studies by Sundberg et al., 1991, Sundberg et al., 1990, and Wodzicki and Wodzicki, 1973. Since the primary IAA production occurs at the apical shoot it would make sense for there to be a distinct decrease of IAA from top to bottom unless there is either localized IAA production or storage along the trunk.

Studies which reported no longitudinal gradient, often blame faulty methods for the results of the contradictory studies. One study by Sundberg et al. (1991) claimed there may be a false gradient reported if IAA concentration is only reported at times of high cambial activity and vascular tissue expansion. Since the vascular cambium at this time is thicker at the bottom of the trunk this will result in lower concentrations of IAA in the bottom section of the trunk compared to the top.

There is also evidence of IAA gradient along radial stem sections which include xylem, vascular cambium, and phloem tissues. Tuominen et al. (1997), Sundberg et al. (1990), and Uggla et al. (1996), found the cambial zone to contain the highest concentration of IAA along a radial cross section. In hybrid aspen trees, from the cambial zone to the mature xylem, IAA decreased 32 fold over a 300 micrometer radius. From the cambium to the phloem, IAA decreased 85 fold over a 300 micrometer radius (Tuominen et al., 1997). A similar pattern was reported along the radius of Scots pine trunks. Levels of endogenous IAA peaked in the cambium and steeply decreased on both sides towards maturing xylem and phloem. Over a 250 micrometer distance, IAA decreased 50 fold (Uggla et al., 1996). Both studies used microscale gas chromatography-mass spectrometry to quantify IAA. These results show that cambial cells may either be a site of IAA transport, localized IAA production, or both. One study, by Savidge et al. (1982), reported contrasting results to the above studies with the highest levels of IAA being formed in differentiating xylem of lodgepole pine (*Pinus contorta*) trees. While they did use reliable methods, gas chromatography, these results stand in sharp contrast to the other studies.

The study of IAA gradients is important because IAA communication at a cellular level may be based on localized concentrations of the hormone along a gradient (Uggla et al., 1998; Little and Sundberg, 1991). The goal of these studies is to ultimately determine if IAA communicates in this manner with cells in the vascular cambium. However, based on the current studies, there is no conclusive evidence that IAA has the ability to communicate at all through concentration gradients. The exact mechanism of communication between IAA and cambium cells is still unexplained. However, it may well be explainable in a few years of technology advances (Uggla et al., 1998; Little and Sundberg, 1991).

3.4.4 Localized IAA production

IAA travels slowly at a rate of 1 cm/hour (Sundberg and Uggla, 1998). At this rate of travel, particularly in large trees, it would take IAA weeks to travel from the top to the bottom of the trunk. Thus it would make sense for the area of most cambial activity (the bottom) to have a supplementary source of IAA. Based on this logic some studies have explored the possibility of localized IAA production or localized IAA storage with interesting results and conclusions.

The most notable study on localized cellular IAA production is by Sundberg and Uggla (1998). Sundberg and Uggla (1998) specifically looked at IAA biosynthesis from areas other than the apex of Scots Pines. They first quantified the total endogenous IAA at the apical shoot and then added a pool of exogenous IAA. As the total pool of IAA traveled from crown to base, they monitored the ratio of externally applied IAA to the endogenous pool of IAA. Using mass spectrometry, Sundberg and Uggla found that the pool of externally applied IAA decreased from 90% to 80% of the total IAA pool. This suggests that some form of alternate internal IAA production was taking place in cells along the trunk.

Another view on this particular subject is that IAA supplies are stored over the winter in cellular compartments in order to supplement apical supplies in the spring. Studies supporting this theory report high levels of IAA in lower reaches of the trunk during the winter. These IAA levels are thought to be storage pools (Savidge and Wareing, 1982; Bonga and Clark, 1963; Wodzicki and Wodzicki, 1973; Egierszdorff, 1981). Researchers theorize that the stored IAA is used to initiate cambial activity in the spring before new IAA production has started or has reached the lower portion of the trunk. One study even reports cambial divisions in the spring below a girdle made during the winter (Egierszdorff, 1981). The cells produced were smaller in diameter than normal, suggesting the divisions were spurred by limited IAA stores which alone were not enough to complete development. This same study also reports that IAA levels were higher in the lower part of the trunk than in the crown during early spring. The author also attributes this to stored IAA supply that declined until refreshed by the apical source (Egierszdorff, 1981).

In conclusion, it is important to note that while it may be evident that some IAA is produced locally or stored over the winter, this does not dispute the fact that IAA from the apical shoot is the major source of new IAA each spring. When the apical shoot is decapitated the pool of free IAA produced drastically decreases (Sandburg and Ericsson, 1987). The other means of production are supplementary to the apical source in areas which are far away from the source or in times when the apical source has yet to be activated in the spring.

The mechanism of production at various locations, transport mechanisms, and the ultimate signal transduction and influence IAA has on individual cells is still not understood (Davies, 2004). Today IAA research, while using highly sensitive and developed methods in most cases has yielded a wide range of results and different conclusions. Genetics, age, environment, health, and other interacting variables can cause trees to function differently over time. Consequently, debates such as where, why, when, how IAA is produced, how it is transported, how is it stored, where local production occurs and how it affects the annual cycle of cambial activity and concentration dependency are all yet to be answered conclusively.

3.5 Environmental controls

The initiation, development, and dormancy of the vascular cambium can be suppressed or accelerated by external environmental influences. Climate, water stress, light, and pests can all influence and alter the annual cycle of secondary thickening (Oleksyn et al., 2000). The consequences of environmental influences change remarkably throughout the year depending on the combination of other influences present, the time of year and cycle of growth. Kramer and Kozlowski (1979) reiterate this point saying**,** “A problem in studying environmental effects on growth is that the relative importance of an environmental factor can change during the growing season. A given amount of precipitation early in the growing season, when the soil is fully charged with water, will have little effect on cambial growth, whereas one half that amount later in the season will affect cambial growth markedly ” (636).

3.5.1 Temperature

Temperature influences secondary growth by controlling cambial activation as well as rates of photosynthesis, respiration, and transpiration (Oleksyn et al., 2000). Warming and cooling patterns highly influence cambial activity and secondary growth in trees. Variation in location, climate, and temperature patterns deviating from the normal warming and cooling cycles can easily affect cambial development. In a study by Gricar et al. (2007) portions of a Norway spruce (*Picea abies* (L.) Karst.) tree trunk were heated and cooled in localized sections throughout the 2005 growing season. Localized elevation in temperature increased cell division at the first part of the growing season but not towards the end of the growing season. Lower temperatures shortened the cambium cycle and slowed down cellular divisions. Gricar et al. (2007) concluded that temperature change only affected areas in the direct site of action and did not travel along the stem.

Cambial growth only initiates when a temperatures are warm enough. If the ambient temperature remains too low after bud break, a delay in vascular divisions will occur in the spring, even with the presence of IAA (Creber and Chaloner, 1984). A forestry study of trees in the Adirondack region of New York found that bark peeling, and thus initiation of cambium activation, started in eight different tree species in a single week period after the weekly mean temperature surpassed 40° F (Wilcox, 1956). The rate of cambial growth usually increases directly with the increase of temperature and then begins to decrease after a critical high temperature is reached. However, it is often difficult to discern if this decline in growth is due to temperature increase or water stress.

A warm spring can speed up the initiation of secondary growth, while a drop in temperature in the middle of the growing season can halt secondary growth altogether (Kozlowski et al., 1962; Mikola, 1962). Early in the growing season when soil moisture levels are high, temperature is likely to be a limiting factor, but later in the season when temperatures are high, available water and evaporation become limiting (Kozlowski et al., 1962; Mikola, 1962).

3.5.2 Water stress

The supply of water is very important for the increase of woody girth in trees. Water makes up 80 to 90% of fresh weight in actively growing tissue and 50% of the entire fresh weight of a tree (Kramer and Kozlowski, 1979). Eighty- ninety percent of trunk diameter expansion and compression is due to variation in rainfall and water stress (Kramer and Kozlowski, 1979). Water is needed to maintain photosynthesis and turgidity of cellular tissues as well as provide the medium for transport of materials between cells. Kramer and Kozlowski state, "Internal water deficits do not appear to play an important role in the initiation of seasonal cambial growth, probably because water stress is rare in the spring. However, once seasonal cambial growth has begun, water deficits play a major role in subsequent control" (1979: 555).

Trees under water stress are more susceptible to fungal and pest attacks on the vascular system. Trees which have a sufficient water supply are able to maintain high pressure in their oleoresion glands which help stop the invasion of beetles boring into the inner bark system (Kramer and Kozlowski, 1979). Water shortage during the day causes shrinkage in the cambial sheath, and this shrinkage can last for as long as the drought continues (Kramer and Kozlowski, 1979). Even in the presence of IAA, without an adequate supply of water the cells cannot maintain turgidity, expand, complete cell wall deposition, or ultimately completely mature (Smith and Hinckley, 1995).

3.6 Carbohydrate Metabolism

Carbohydrates make up three-fourths of the dry weight in woody plants and can be placed into three classes: monosaccharides, oligosaccharides, and polysaccharides (Hoch et al., 2003). Carbohydrates are the unit of energy which supports tree growth as well as the predominant component of nutritional energy in edible tree cambium (Chapter 5). Structural and non-structural carbohydrates provide support for cell wall formation (Hoch et al., 2003). They are also the starting point for the synthesis of proteins and fat, which fuel respiration and provide food reserves.

In living cells of trees, monosaccharides occur in large amounts in the form of glucose and fructose (Hoch et al., 2003). These simple sugars rapidly incorporate into polysaccharides, such as cellulose and starch (Hoch et al., 2003). Cellulose, built from the monosaccharide, glucose, is the most abundant organic compound in trees. Each molecule of cellulose contains about 3,000 glucose molecules linked together by oxygen bridges, forming long straight chains which maintain the structural integrity of a tree (Pallardy, 2008).

Starch is the most abundant carbohydrate reserve in woody plants (Hoch et al., 2003). Starch is formed from the condensation of glucose and is produced and stored locally to be later broken down and transported. It occurs in living cells of sapwood and in living phloem cells of the inner bark; more specifically it is stored in ray parenchyma cells. In conifers, starch storage fluctuates seasonally (Hoch et al., 2003).

Oligosaccharides are sugars that form from linkages between two or more monosaccharides. Sucrose is a disaccharide which is very important in metabolic processes and is the primary sugar form in phloem sap. In fact, sucrose can make up to 95% of the dry weight of material transported by sieve tubes (Kramer and Kozlowski, 1979).

3.6.1 Annual cycle of carbohydrate demand

Sources of carbohydrate fluctuate with seasonal availability. A large carbohydrate supply is needed to support the onset of growth in the spring. The movement of sap occurs from the source (one-year-old needles and new needles in conifers) to the sink (Smith and Hinckley, 1995). Sinks compete for the source depending on the time of year and availability of carbohydrates at any given time. The vascular cambium is a weak sugar sink, and does not compete well with stronger sinks associated with new shoot growth, developing needles, and developing roots around the same time of year (Pallardy, 2008). Due to this cyclic competition over the span of the growing season and year, the carbohydrate pool available for cambial growth fluctuates (Smith and Hinckley, 1995). Such fluctuations of available carbohydrate reserves are caused by this ongoing competition as well as by effects from climatic changes, insect attacks, diseases, mycorrhizas, and other external influences that affect photosynthate production (Pallardy, 2008). Carbohydrates are, however, essential to fuel the expansion of the cambium and production of vascular tissues, so the ability for the vascular cambium to act even as a weak sugar sink is important.

According to Kramer and Kozlowski (1979), in temperate zone gymnosperms, the roots are the dominant sugar sink before the buds are open. After the bud burst at the beginning of spring, expanding shoots take over the role as the dominant sugar sink. Around the same time, the vascular cambium activates and forms a secondary sink in competition with new green growth; however, as noted, the vascular cambium is a relative weak sink. Upon the completion of shoot growth, the vascular cambium takes over as the dominant sugar sink until it shuts down in the fall/winter. During the later fall and winter the roots once again get priority as a sink. The roots are able to utilize the trickle of photosynthate production that continues through the winter due to added protection by soil coverage from harsh elements (Hansen, 1994). This seasonal pattern is greatly altered in the years of heavy fruiting and reproduction. During such years, reproductive tissues trump all and are the dominant sugar sink (Kramer and Kozlowski, 1979; Drossopoulos and Niavis, 1988; Hansen, 1994). Depending on the demand of other sinks and environmental conditions the sugar content of edible tree cambium could fluctuate with degrees of competition and times of reproduction.

3.7 Conclusion

The production of edible tree cambium and timing of harvest are governed by physiological processes and the environment. Through this literature review of vascular cambium development it is evident the quality and quantity of cambial tissues are variable with environment, location, climate changes, health, age, and multiple other factors. Many of these factors are also considered by First Peoples when harvesting edible tree cambium in order to harvest from locations and trees which produce the best edible cambium. While the discussed physiological interactions can be interrupted by internal and external stresses, trees are adaptable and resilient organisms which strive to achieve secondary growth and reproduction each year. First People's subsistence, technology, and ultimately their lives depended on their ability to read the timing of such predictable biological signals described in this chapter in order to harvest prime pine cambium. Not only can this biological knowledge explain the importance of harvest timing in the spring and summer, it also helps clarify nutrient concentrations based on carbohydrate and mineral transport in phloem tissues. Understanding the physiology of gymnosperm growth and function of vascular tissues provides an important aspect to understanding First Peoples harvesting patterns and preference for pine cambium as a traditional food.

4 Chapter 4 –Learning and Re-learning about edible lodgepole pine cambium

September 5, 1875 letter to Margaret M. Dawson while in the Chilcotin (Tatlayoko Lake): "the woods all through this part of the country consist largely of a small species of pine which I believe to be P. Contorta; and almost everywhere the natives have peeled great slabs of bark off the trees to get the soft cambium layer beneath. In spring this is scraped off and eaten" (G.M. Dawson in Cole and Lockner, 1989 page: 80).

4.1 Introduction

In this chapter I present my personal experiences harvesting lodgepole pine cambium at two major locations in British Columbia, during the spring and early summer of 2010. I also incorporate other qualitative data gathered through interviews and observations with Tsilhqot'in people, drawing connections with secondary data available through literature sources.
My first harvesting experience took place at Kalamalka Seed Orchard near Vernon in British Columbia (Figure 10). Thank you to Mike Carlson and others at the orchard for allowing me to harvest from their genetic selections of lodgepole pine. Based on my literature reviews, I expected the cambium to be in season in the Okanagan during the last weeks of May and first week in June. A section of the orchard contains stands of genetic selections of lodgepole pines from various regions of British Columbia. One such grouping includes trees from the Chilcotin. This initial harvesting session was meant to help familiarize myself with methods of harvest, and physical characters of optimal trees. The orchard also guaranteed some healthy trees for sampling purposes.

Following my initial harvests in the Okanagan, I traveled to the Chilcotin where I spent the month of June, the prime cambium month, camped near Puntzi Lake in Chilanko Forks, British Columbia. I also harvested cambium at Horn, Pyper and Eagle Lakes (Figure 11). By visiting lodgepole pine forests on a daily basis and harvesting cambium a few times a week over the course of a month, I was able to develop a better understanding of seasonal cycles and physical characteristics of the trees producing the greatest volume and best quality of cambium. I was also able to confirm some of my observations through conversations with Tsilhqot'in people from the Chilcotin region as well as from interview data collected by other researchers. The most notable secondary source data is drawn from the work of Amanda Marshall with the Dakelh (Carrier) people just north of the Chilcotin, and from the work of Douglas Deur with the

Klamath in Oregon. In the end I did not conduct formal interviews with Tsilhqot'in knowledge holders, as I had planned. My time in the field was simply too short to permit the type of interaction and relationship building necessary for effective interviewing. The distances are great between communities and personal communication is often necessary. The time needed to find and get to know Tsilhqot'in knowledge holders was not possible. Furthermore, Tsilhqot'in people were fully occupied in efforts to combat a proposed mine development at Teztan Biny (Fish Lake)[10], and much of the energy and efforts of people were focused on this land and resource dispute, further challenging my efforts to meet with people during the interval of time I was in the area.

[10] On November 10, 2010, the Canadian federal government rejected the Taseko Mines Ltd. Project as it stood at the time of the first proposal. Prosperity mine would destroy Teztan Biny and affect connecting waterways. The government deemed the mine too detrimental to the environment and people which have used the area for generations as fishing, hunting, and gathering sites (1 B.C. Mine, 2010). However at the beginning of the new year, Taskeko announced they would be addressing the governments environmental concerns and resubmitting the proposal for a second evaluation (Taseko, 2011).

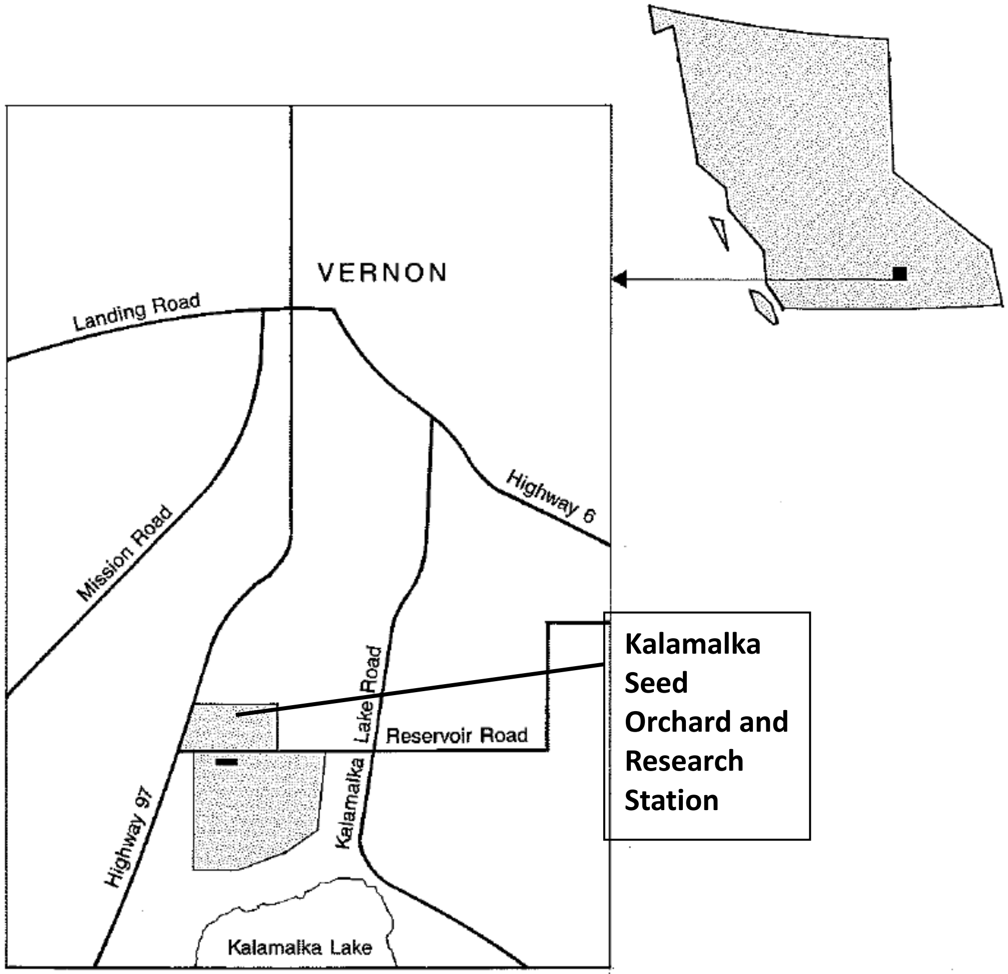

Figure 10. Map showing location of Kalamalka seed orchard outside Vernon, BC. Kalamalka (British Columbia Ministry of Forests, 1988).

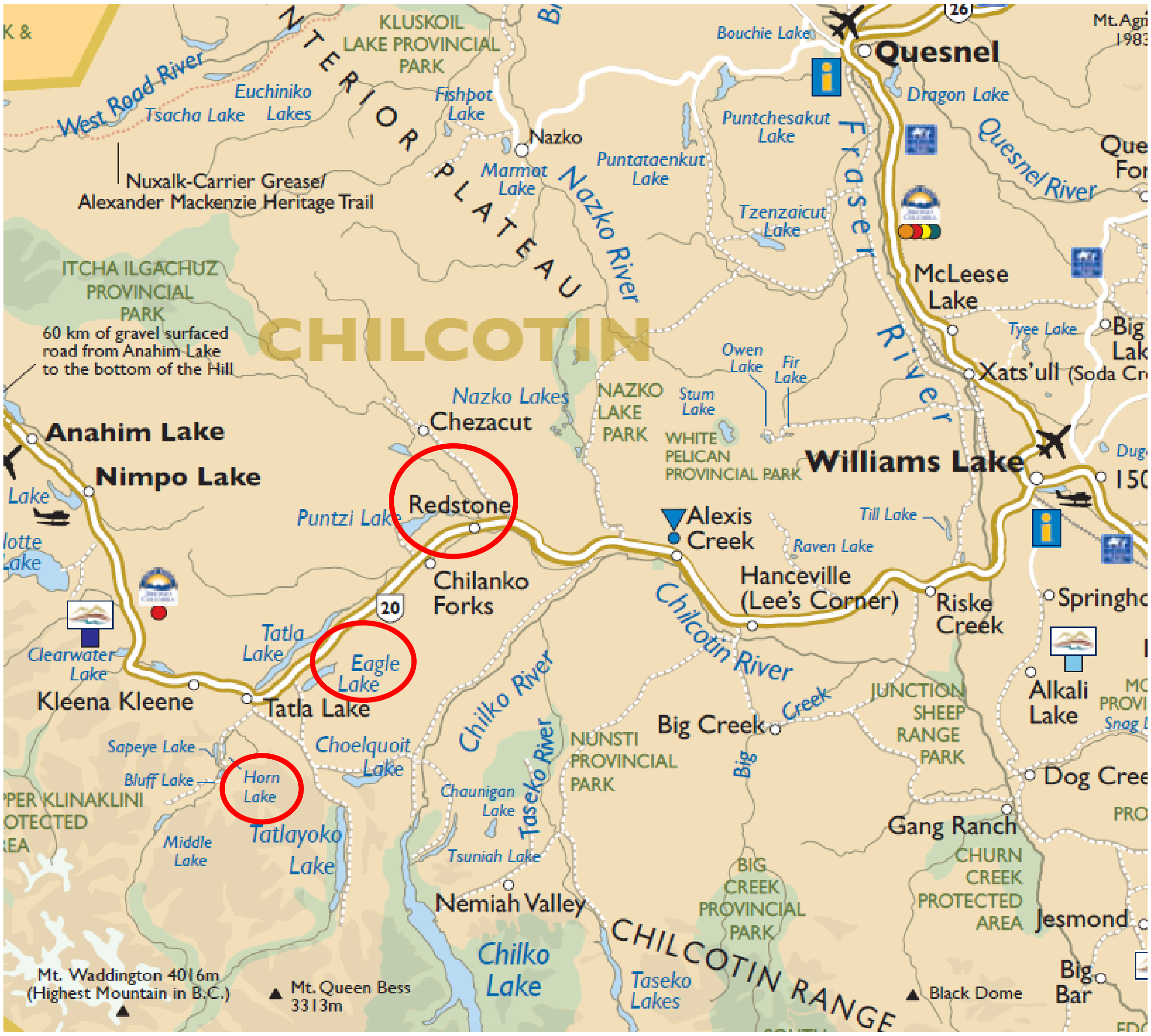

Figure 11. Map of British Columbia west of Williams Lake, showing primary locations of field work in the Chilcotin [11] (Cariboo Chilcotin Coast Tourism Association, 2008).

[11] Pyper lake is not pictured on the map as it is relatively small and less traveled. It is located 5 minutes West of Chilanko Forks, before the Eagle Lake turnoff.

4.2 Background: The Tsilhqot'in People and Their Land

There is a great sense of pride and beauty reflected in the landscape and inhabitants of the Chilcotin plateau. This pride is related not only to present day but heavily related to the past of the Tsilhqot'in people. A highly commemorated historical event in the territory of the Tsilhqot'in people is the Chilcotin War of 1864. According to John Lutz in *Makuk*, "You cannot spend too long in Tsilhqot'in country before you hear of the Chilcotin War. To hear people discuss it, it might have happened a few years back instead of in 1864, so vivid are the memories, so precise the details" (Lutz, 2008: 119). The events of this war are present in many people's minds today and still are on the minds of people when it comes to protection of their territories, resources, and rights. Ironically many battles and conflicts which were disputed in the Chilcotin War over land and resource use are still in dispute today.

Residential schools in Canada have impacted Tsilhqot'in people. Experiences, memories, and colonizing philosophies from residential schools are still fresh in conversation or thought processes. Residential schools are part of a system dating back to the 1870s in Canada, funded by the government and run by the church, to "stop parental involvement in the intellectual, cultural, and spiritual development of Aboriginal children" (Wadden, 2008) Children were forbidden to speak their language and practice their own culture. The last of these schools closed in 1996; in all, it is thought that over 150,000 First Nations, Métis, and Inuit children were forced to attend residential schools. Of this group of people 80,000 are still living today. Experience and memories from residential schools continue to impact the mental health and social problems of First Nations people and communities today (Wadden, 2008).

The residential school in Williams Lake was established in 1891. Chilcotin children first attended in 1907. Parents did not want to send their children there but at the time it was the only education offered. However, the incentive to educate their children in a corrupt system was low. In the 1940s missionaries at the Anaham Reserve established the first school local to the Chilcotin. Not until the 1960s were day schools established in most communities or were children integrated into provincially run schools off reserve. Only in the last two decades has Chilcotin been spoken secondary to English. Many Tsilhqot'in elders today only speak their native language of Tsilhqot'in (Chilcotin) (Lutz, 2008). All of these events and circumstances contributed to the reduced use of lodgepole pine cambium as other traditional foods. Other factors have also been at play, however, not the least of which has been an attack on the trees themselves.

4.2.1 Mountain pine beetle (Dendroctonus ponderosae)

"A conifer forest in which none of the trees is diseased or pest-ridden probably doesn't exist. Forest pests and diseases are as much as part of the natural scene as the trees they afflict, and to judge them in human terms as evils is as anthropocentric as believing that the earth is at the center of the universe" (Pielou, 1988: 78).

British Columbia is currently suffering from the largest mountain pine beetle infestation in North America to date, affecting 8 million hectares of forest in Canada (McGarrity and Hoberg, 2005). Beetles number into the trillions. Some have reported outrageous observations of heaps of beetles, 10 cm deep, littering lakes and beaches, literally hearing the sound of beetles munching through bark, and seeing a large flight of beetles on airport radar (Nikiforuk, 2007). Whether these reports are truth or exaggeration, the point is the impact and scale of mountain pine beetle attack in British Columbia has gone beyond a natural role of one disturbance in the forest ecosystem. Beetle outbreaks have reached epidemic proportions in the past but eventually were contained by cold weather, a winter low of -40 degrees Celsius or a cold period in early fall or late spring of -25 degrees Celsius will stop a beetle epidemic (Nikiforuk, 2007). It was assumed that the same would happen with this current infestation but temperatures have not dipped low enough to kill the beetles. British Columbia is experiencing, with climate change, hotter summers and warmer winters, increasing the optimal beetle habitat in the area by 75% (Nikiforuk, 2007).

The mountain pine beetles have impacted pine forests of the Caribou-Chilcotin area. Beatles feast on the same tissues that make up edible bark "noodles"; cambium and phloem. Infested trees are not viable for inner bark harvest, thus infestation highly affects access to viable bark stripping pine trees. The preferred hosts for mountain pine beetles are mature lodgepole pine trees (80 years or older), although they also feed on secondary hosts (ponderosa pine, whitebark pine, western white pine, younger lodgepole pines, and some spruce) when the prime trees run out (Westfall and Ebata, 2009). Significantly, these are all trees used for inner bark stripping and other traditional practices for food and medicine by Canadian First Peoples.

It is estimated that by 2013, 80 percent of mature lodgepole pine in British Columbia will be killed. The current outlook of the mountain pine beetle in BC is that it will stop once the beetle has run out of preferred hosts, in the process destroying almost all of the mature lodgepole pine trees. We see this cycle beginning to play out in the Chilcotin area, where areas of highest infestation have begun to decline in intensity as the beetle runs out of host trees and the pest runs its course (Westfall and Ebata, 2009).

4.3 Methods of Interviews and Observation

It is the context of these immense changes that my own research on Tsilhqot'in use of edible lodgepole pine cambium began. While I was aware of the possible obstacles to harvesting and learning about this often times rare and environmentally threatened traditional food, I still hoped to find some people who were willing to teach me about edible pine cambium through distant memories or present day harvesting activity. The initial goals during my field season of 2010 were to talk with as many people as I could who were willing to share information with me about the lodgepole pine tree. This was a harder task than I expected. Many elders spoke minimal English and preferred to communicate in their first language, Chilcotin. I was not prepared to conduct interviews in Chilcotin nor did I have the funds to hire a translator. In order to communicate with people and form relationships takes more time than I had in one field season. The time I spent in the Chilcotin was just barely breaking the ice with meeting people and learning about the new surroundings.

I was able to talk to four people and gather some information about the edible bark of the lodgepole pine, but did not talk to nearly enough people to perform any type of quantitative analysis on the data collected. I also found that a lot of elders are often shy or hesitant to share information and knowledge associated with traditional foods and medicines. This is true even with sharing knowledge with people from their own community. Historically, many people in the elder age bracket had attended residential schools. Associations with their language, food, culture, and family were discouraged and the school officials attempted to clear traditional knowledge from their memory by replacing it with knowledge deemed appropriate by European settlers and colonial and church officials. Reliving history and memories brings up frustrations regarding the Chilcotin War, which I found is still fresh in many people's minds. These two events in the past often diminish willingness of knowledge sharing that may still be associated with fear or other bad memories.

4.3.1 Interviews

Open-ended casual conversations were the best way for me to get to know people during my initial field season. If I expected to learn more about traditional uses of pine trees and to truly know a place and a people, it would take many visits, and extensive communication with people throughout the years. Unfortunately, the scope of an ethnobotany project as a two-year master's thesis does not allow for this. Consequently my qualitative data can only be presented as a limited number of anecdotal accounts. The interviews I did conduct were based on a predetermined set of questions (Appendix III). While the order and preference given to specific questions were dictated by the flow of conversation, I had key points I wanted to discuss, and did control the flow of conversation to some extent in order to stay on topic.

4.3.2 Material probes

During the semi-structured interviews I used material probes (Cotton, 1996) in the form of photographs of lodgepole pine trees, of me harvesting the inner bark, and of the actual inner bark material (Parker, 2006). These visual probes were very important in my interviews with many Chilcotin elders who spoke broken or no English. I could use the Tsilhqot'in word for lodgepole pine (*chendee*) but the Tsilhqot'in words for the edible cambium and bark was unknown to the people I spoke with. Using the English words for cambium and bark posed a problem but once I showed the pictures, understanding was gained.

4.3.3 Record keeping

I recorded my interviews through notes and writing down direct quotes, and with a thorough written debrief immediately after the interview. Although, I do believe the best way for record keeping during an interview is voice recording I did not attempt to use a recorder since, unlike in some other situations, most people in the Chilcotin-Caribou region were not used to speaking to students or other people conducting research.

4.3.4 Observation and Participant-observer

During my time in the field I spent a day harvesting with three women and a young child from Redstone. Two of the women (Edna and Ulysses) had harvested pine cambium before as children and adults, while the third woman, Lenore, was just learning about this traditional food. This was a really great way to conduct informal conversations about plant foods while harvesting food and medicines. A great deal can be learned, just by watching and listening. This outing confirmed some methods for bark harvesting from the literature and thus the methods I had been following when collecting my cambium samples at Kalamalka and then in the Chilcotin. It is definitely something I would like to build on and do many more times in the future as it offers opportunity to learn about the primary study subject plus many others. It also spurs local planning of subsequent outings. A large logistical hurdle is literally getting people out into the field and establishing a common meeting time and place. Once an interest group has been established, information may spread through word of mouth and through pictures of prior outings, spurring more people to join and come into the field.

4.3.5 Photos

Photographs are is very important when documenting food plants. They provide visual representation beyond what textual description can offer (Pink, 2001), and serve as images that can be used later to return to the community in the form of posters and presentations. I plan to present my work to the community this coming summer (2011) in the form of slide presentation, photo posters, and a condensed version of my paper.

4.4 Limitations and Scope of qualitative information

As I mentioned above a major constraint on this project was time. This particularly affected my qualitative date collection as it did not give me time to build relationships, establish some kind of identity in the community, and naturally progress to a level, which would be deemed appropriate to speak to people in a comfortable manner, openly through recorded interviews. I plan on working further with people in the Chilcotin and have maintained contact via email with one particular woman who has great enthusiasm for medicinal and edible plants. Although, this thesis is the culmination of my masters, I do not to think about it as the culmination of my work in this community; really it is just the beginning.

4.5 Results - Josephine Gregg Interview

I had the opportunity to speak with Josephine Gregg on June 9, 2010 at Scout Island nature sanctuary in Williams Lake, BC. Her grandson, Skip, accompanied Josephine during the interview. Josephine was born in 1925 to Lucy Dagg and Baptiste Dester in Klinaklini Valley in the West Chilcotin. Both her parents had white fathers and Tsilhqot'in mothers. Growing up, her father did not recognize his native status, in order to own crown land and to protect his children from the residential school system. Josephine spent part of her childhood in Kleena Kleen with her grandmother but has spent most of her life in Anahim Lake. She attributes her good memories of living off the land and old time stories to the preservation of her own language in oral histories and stories. Her only formal schooling came when she attended school for two years (1931-32) in Tatla Lake. She learned English at home once her seven children started attending school. Josephine is very talented in tanning buckskin and making hand sewn moccasins, gloves and other articles of clothing, a skill she learned from her mother and grandmother (Birchwater, 2009). Today Josephine lives off reserve, outside of Williams Lake.

Below are some key points from my conversation with Josephine Gregg:
Josephine described the inner bark of lodgepole pine as “their sugar”. When it was available in the spring, pine cambium was collected in a similar manner to that of picking berries. She talked about it fondly and said it was eaten like candy. It was so good that she never really worried about getting sick. She just ate as much as she wanted when this candy was in season. Most commonly, people consumed pine cambium raw – sprinkled with sugar or plain. She reported that it was sometimes dried in a similar process to smoking meat over a fire. If the bark is harvested too late in the season it does not taste as good. She said you can taste the pitch then. When it is just right it is very sugary and good to eat right away. The supply was limited and did not last very long when it was available.

She mentioned briefly that animals such as bears and porcupines use the bark in the same manner as humans, tearing into the outer bark. However, she was perplexed as to how they scraped off the actual inner bark tissue and did not think they used their claws at all. She also said that she has not seen a porcupine for ages and last time she did it was getting shot at. She believes they are not here (around Williams Lake) anymore.

When looking for a tree to harvest, Josephine says the best way to tell if the tree is good for inner bark is by cutting a test strip. She doesn't believe you can really tell anything by looking at the outside of the tree or the outer bark. The trees she selected for testing are youngish, she thought about 50 years in age, about two arms around (approximately 50-60 cm). A signal that the trees are in season, she reported, is when the pollen cones are releasing their pollen into the air.

Josephine said, they didn't harvest from the same tree multiple times nor did they go back to the tree to collect other materials. They just let it be. She believed that the tree died after the initial peeling. She said "that is a fact". It is unclear if she actually peeled around the entire tree, but it seems possible since Josephine thought the peeled trees did not survive after the harvest. One tree offered a lot of cambium. She said it often filled up a large bucket or collection basket. In order to harvest the bark, a cut was made with a knife in the outer bark and it was pulled down in strips to expose the inner bark. She used part of a tin can which was cut up and slightly flattened but still had some natural curvature. Josephine said, everyone knew how to make these tools – men, women, and children all took part. Before tin cans were used, she believes that the bone of caribou was used as a scraping tool.

Josephine and her family stopped harvesting pine cambium when people in forestry and doctors discouraged this practice. She said they did not know what they were talking about because pine cambium made them healthy and not sick. These forestry officials and doctors threatened to put them jail if they did not stop stripping the trees. To this day she associates negative consequences with stripping trees. Another issue she mentioned is "the beetle killer". Josephine said she tried harvesting pitch around Williams Lake and Nimpo Lake and she was not able to. She said, "All the trees around here are too skinny, they are not good. I think this is because of the beetle." She compares the little ones to that of a "broomstick – can't get anything out of them."

After talking about the cambium of the lodgepole pine, Josephine mentioned other uses of the pine and talked briefly about a few other species. Another popular material collected from the pine is pitch. She talked about using pitch one time to remedy an extremely sore and swollen throat. It was so sore she could not even open her mouth. Before she went to bed, she soaked a warm cloth in pitch and tied it around her neck. She slept like this. They also used pitch to heal cuts and as chewing gum. Back in the old days Josephine says, “They had no store back then. Today there are many stores but not back then. Then just went to the tree for gum.” The pitch chewing gum is supposedly pretty good, once you get past the initial strong taste.

Josephine is talented in tanning hides and creating items from buckskin. In the tanning process, lodgepole pine cones are used to smoke the hide. I am still unclear on the details of this process but what I did gather is as follows- A pit is dug in the ground, a fire lit in the pit, then a bucket of pine cones is placed in the pit and the hide is wrapped around the cone area. The hide is then cooked slowly for a long time. The smoke from the pinecones is absorbed by the hide and it gets dark tan in color. This is something that seems to be still happening and the knowledge is being passed on to younger generations. Skip, Josephine’s grandson, said he was hoping to learn from her that weekend when they went to smoke some hides. Josephine recalls using the end tip of a pine branch covered in needles as a pot scrubber and cleaning item while she was in the bush. She also said a hollowed out spruce tree could be used to wash clothes.

4.5.1 Group harvesting at “Punky” Lake Camp

On June 16th, I went cambium and pitch harvesting with four ladies from Redstone Reserve. Lenore Case and her daughter, Dacy, and Edna, and her mother Ulysses took me to a harvesting site off an old logging road near Punky Lake Youth Camp (Figure 12). The area is swampy, with a small stream running through it. There was a high diversity of useful plants in a small area. Lenore had never harvested the inner bark of the lodgepole before but had eaten the inner bark of the spruce. She recalls that spruce inner bark is “sweet like candy, better than candy.” Lenore is very interested in ethnobotany and medicinal uses of plants. Edna is a language teacher for the community and is very knowledgeable about speaking Tsilhqot'in and plant knowledge learned from her mother, Ulysses. Ulysses is the eldest member of the community at 90 years of age.

Figure 12. Site at Punky Lake camp. Lenore and Edna harvesting pitch from lodgepole pine (personal photo, June 16, 2010).

At the Punky Lake camp, Edna instructed me to find a pine tree with smooth bark and not "peeley" bark. She said she usually cuts a diagonal cut with a knife at the start and then strips the outer bark downward. The inner bark is then scraped off the exposed wood in upward motions. June is considered the pine month; that is when it is ready to eat. Edna said the inner bark was consumed as a delicacy and candy, and eaten raw right after it was harvested. She did not mention processing or drying, nor combining it with other foods. The bark we harvested that day was very juicy and sweet. After that day, Lenore informed me through email communication that her cold was cured over night. Eating the inner bark that day worked as a medicine (L. Case, personal email communication, July 10, 2010).

While at Punky Lake, we also harvested pine pitch. The pine pitch is scraped off the tree with a knife or hands and collected for later use. Pine pitch is good medicine for cuts, scars, chapped lips, eczema, and throat ailments. Lenore instructed me on how to make a pitch salve, combining melted pine pitch and Vaseline (used to be bear grease or other animal fat). When heated, pine pitch readily melts to a liquid. People warned me to be sure to heat the pitch in an old pot or disposable tin can. Pitch in large quantities will stick on things like cement. When the pitch has turned to liquid, the grease is mixed in. The salve should be stored in a closed container. As it cools it will firm up, but will not revert to solid form if kept covered. Pitch in salve form is more easily removed and not sticky if the right proportion of pitch to grease or Vaseline is used. I made my own salve; below are the pictures from the process (Figure 13):

Figure 13. Collecting pine pitch from Puntzi Lake in June 2010. The pitch can then be heated, melting it for a salve.

4.5.2 Other plants collected

Lenore and Edna also collected Laborador tea (*Ledum groenlandicum* Oeder) leaves while we were at Punky Lake. The leaves are dried and used to make hot tea. Other plants we talked about briefly that day were common juniper (*Juniper communis* L.), soapberry (*Shepherdia canadensis* (L.) Nutt.), and kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.). The juniper berries are not eaten but could be dried and used as beads. Juniper has a pleasant smell and can be used to smoke or steam areas to rid them of certain spirits. The soapberry plants we saw were not in fruit. In July, when the berries are red, they are harvested and used to make "Indian Ice cream," a whipped confection that is somewhat better tasting. Kinnikinnick is a common ground covering. The leaves from kinnikinnick are dried and smoked like tobacco and the berries can be fried in grease for eating. Lenore says when the berries are fried "they pop like popcorn."

4.6 Discussion

As discussed in the introduction to this chapter, a majority of the lodgepole pines in the Chilcotin are greatly affected by the epidemic of mountain pine beetle. The Chilcotin is the hardest hit area of British Columbia by this epidemic. Pine beetle infestation is often fatal, causing large stands of dead or dying trees (Figure 14). These beetles are after exactly the same material I was: the sweet, juicy cambium. Overall, because of the epidemic, the majority of the lodgepole pine population in the interior plateau is not suitable for cambium harvesting. Finding healthy trees of suitable age with a healthy secondary growth cycle was a challenge. My greatest success was near and around the lakes that characteristically dot the Chilcotin plateau.

Figure 14. Lodgepole pine trees killed by mountain pine beetle, Caribou-Chilcotin region off highway 20 summer 2010.

As I spent more time harvesting both from good trees and from trees producing little or no cambium, I began to notice patterns which assisted me in choosing trees more likely to be good producers. Some of these observations had been supported in the literature or through informal conversations I had with local knowledge holders. These traits are not fool proof, however. I encountered trees which failed to follow the usual trends. Overall, though, using these traits, I was able to select good trees from large stands quite readily. The general trends based on my established decision-making process is displayed in Figure 15 which is followed by further explanation and discussion of how I came to the conclusion of these trends.

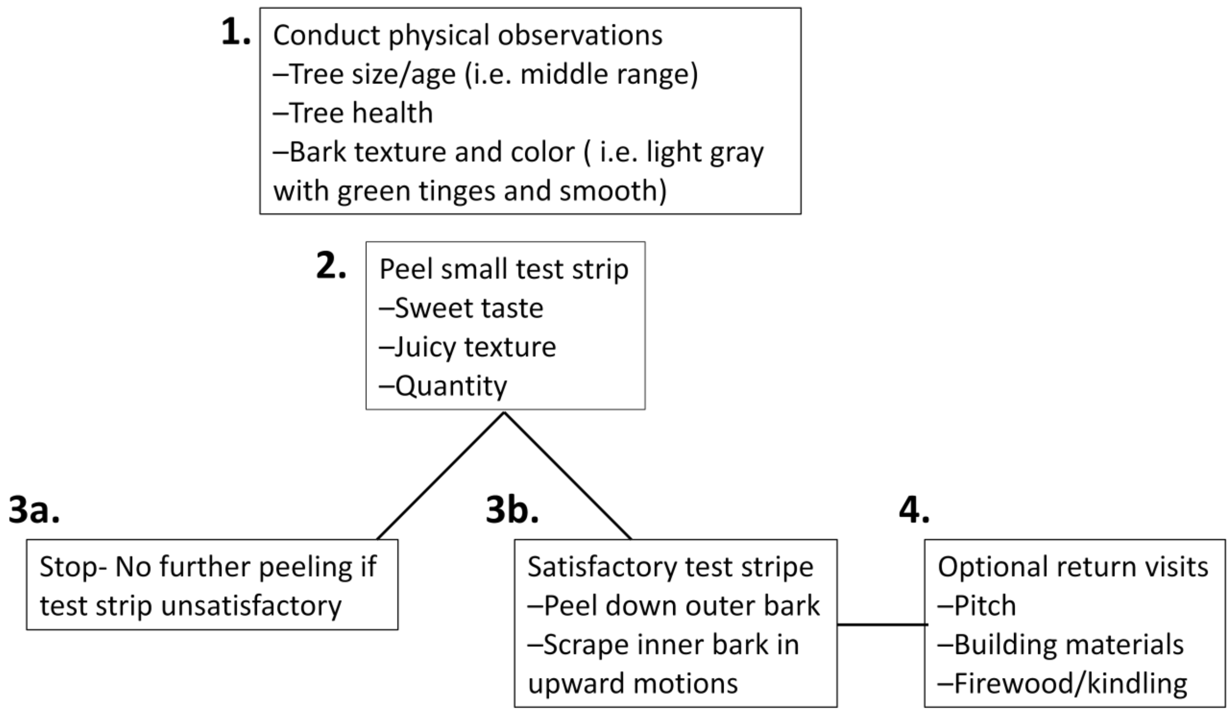

Figure 15. Decision making process for harvesting lodgepole pine cambium based on my own harvesting, harvesting with Tsilhqot'in people, and literature review information.

I found the most successful time for harvesting of lodgepole pine cambium in the Chilcotin to be the first two weeks of June. My first visit to Horn Lake was on June 3rd. It was not a successful visit in terms of harvesting because the cambium was not ready yet but I did identify the area as a place with large, healthy lodgepole pine stands. Just, three days later, on June 6th , when I returned to Horn Lake, the trees were producing thick, juicy inner bark (Figure 16). I was able to collect my largest sample of inner bark at this time. I harvested successfully from 13-15 trees and collected approximately 1.5-2 cups of material altogether. Overall that day, I attempted harvesting from 20-25 trees total but some did not yield inner bark at all. For most, though, the outer bark peeled off easily in long continuous strips: an indicator of a prime harvest opportunity. This allowed me to scrape substantial strips of cambium from the exposed wood. My tools of choice for harvesting were a Gerber knife for peeling off the outer bark and a cheese slicer for scrapping the cambium noodles (Figure 16). Some other people I harvested with preferred to use a knife for both tasks but I found the flat edge of the cheese slicer far superior to a knife for scrapping thick and long noodles.

Figure 16. Fresh bark "noodles" harvested at Kalamalka Seed Orchard (May 20, 2010) and Horn Lake, Chilcotin (June 13, 2010). The top two photos show the cheese slicer that turned out to be a superior cambium scrapper. The bottom two photos show the translucent and delicate characteristics of freshly harvested pine cambium.

I harvested at Horn Lake again on June 10th, and successfully gathered from another 8-10 trees. It was not until the 17th of June that the lodgepole pine trees producing pollen - a phenological stage cited as an indicator that the cambium is ready to harvest (Kuhnlein and Turner, 1991). I found by this time, however, the trees were actually towards the end of their harvesting stage. Most were not readily producing cambium, and only a few trees were left that were in season. From around June 11th onward, I found it more difficult to find large numbers of trees at the right stage. I would successfully peel a tree here and there but nothing like the good success I found in the early part of June. This situation could have been a result of the dwindling tree population due to the beetle epidemic, as the whole population of trees did not represent the true pool of trees that could potentially be used for harvest; only a small sector were healthy and mature enough for this study.

Figure 17 shows lodgepole pine trees with characters that often correlate with high cambium production and examples of lodgepole pine trees with characters that indicate poor cambium production are displayed in Figure 18.

Figure 17. Lodgepole pine trees at Horn Lake with physical characteristics that are often indicators of quality cambium production.

Figure 18. Lodgepole pine trees at Horn Lake with physical characteristics that are often indicators of trees which do not produce edible cambium.

I found medium-sized trees to be best for inner bark production. The average girth used was a tree just bigger than I could fit my hands around. In trees any bigger than this, the outer bark tended to be too thick and rough. The best visual indicator for revealing the interior contents I found to be the texture and thickness of the outer bark. A tree with smooth, thin outer bark almost always was hiding a juicy delicacy underneath and another indicator correlated with smooth bark is a tinge of a green border along the edge of a sliced outer bark strip. Smooth bark tends to be lighter in color, indicating new growth (light gray). Trees with bumpy, scaly, and fissured outer bark that is darker in color often produce little or no cambium. The texture and color of the bark is ultimately a product of age. In the book *Bark* Schwankl and Edlin (1956) write, “On young trees the bark is still smooth, but as they grow older it nearly always becomes rugged or scaly” (1956: 11). The continuity and ease of peeling of the outer bark is also an indicator for a tree at the right stage of harvesting. If the cambium is bitter or the outer bark is brittle and tough to peel the tree is not suitable for harvest.

I noted that trees, which are branchless on the lower half of the trunk, were easier to harvest and yielded more scraping area than trees with many branches along the entire trunk. A bare lower trunk creates an undisrupted scraping medium. Chopping off a few small branches leaves behind buttons of wood to scrape around, but a tree covered in many little branches makes it nearly impossible to harvest discrete sheets of bark and create a surface from which to scrape the cambium (Figure 19).

Figure 19. Lodgepole pine tree at Horn Lake with branch stubs which obstruct the cambium scraping surface.

The most reliable way to determine the potential of a tree to produce good edible cambium is to take a small test strip. By peeling away a 7-13 cm (3-5 inch**)** strip of outer bark and testing the material underneath, one can determine the quantity quality and taste of the material. This is a method employed by First Nations harvesters in order to minimally injure the tree and ensure the trees, which are wounded further are put to good use. I undertook this test in my own harvesting and found it worked well. While testing for potential of cambium quantity people also tested for quality, specifically if the bark was sweet and good tasting. If the cambium was not sweet enough, the tree would be left alone. In the test strip, taste did not play as much of a role as did the volume and thickness of the cambium produced by a tree.

The samples harvested from Pyper Lake were dried as individual strips. The cambium strips were set out on a flat surface in the open sun to dry. When the sun is bright and hot it takes about 1.5- 2 hours to completely dry out a cambium strip. Once the cambium is dried out completely, the strips peel off easily like fruit leather. The texture of the dried cambium is papery and brittle. I found it less substantial and satisfying than the fresh cambium. I preferred the fresh cambium to the dried bark in both taste and texture. Dried cambium may be good to garnish a dish in cooking, like fried skinny onion rings.

As a test, I attempted to cook a small amount of cambium in water. The goal was to steam the cambium in a manner similar to that in pit-cooking. However, I found that the water tended to leach out the taste-producing compounds particularly the sugars. While steaming may be an advantage for cambium containing high levels of tannins and resins, it also depletes the desirable nutrients, making the pine cambium relatively limp and bland.

4.6.1 Timing of lodgepole pine cambium harvesting

Synchronizing harvesting with the optimal stage of prime cambium production is an important part of harvesting. The cambium must be thick enough in order for it to be scraped off in long strips, and the sap must be running for enough sweetness to tantalize the taste buds. Through my own experience, reading transcripts of interviews with Carrier elders, and speaking to people in the Chilcotin, it is clear that the month of June is the right time for bark harvesting in the Chilcotin and a bit further north into Carrier territory. I found the most success in the span of the first two weeks in June, even before the trees were releasing their pollen. Many sources and people cite the pollination stage as an environmental indicator of ripe cambium (Kuhnlein and Turner, 1991; Marshall, 2002; Josephine Gregg, personal communication June 6, 2010). I do not doubt this indicator, as pollination does happen around that time of year, but I do believe it to be only an approximation of the optimal timing.

As mentioned in the previous section, the ultimate measure of timing can be tested by taking a small test strip of cambium, to test the quality and quantity of the cambium. Another possible measure of timing is based on the concept of degree-days. Degree-days are based on the accumulation of heat units in a plant or a tree above or below a certain threshold of growth. Trees have a cumulative memory of temperature and heat increments over time. They are thermal integrators. Once there have been enough warm days and growing temperature increments, trees can perform specific physiological tasks which are cued by temperature. Degree-days are based on the accumulation of heat units in a plant or a tree above or below a certain threshold of growth. Thresholds of growth based on temperature exist in lower limits and for some also upper limits of biological processes. Developmental rates increase with air temperature to a certain point (Snyder et al., 1999; Seo et al., 2008). Above and below these thresholds no further development can be expected (Snyder et al., 1999). Heat accumulation above a certain temperature threshold can keep track of the long term effects that temperature has on triggering the timing of certain biological processes in trees (Seo et al., 2008). According to Wang (1960) the heat unit/degree day approach were used for over two centuries to study plant-temperature relations.

Lodgepole pine trees cannot grow below 5 degree Celsius (Deslauriers et al., 2008; Schmitt et al., 2004, Seo et al., 2008). Therefore, when calculating the degree days for edible bark development in the Chilcotin, I used 5 degrees as my temperature threshold (Deslauriers et al., 2008; Schmitt et al., 2004, Seo et al., 2008). As the temperature rises above 5 degrees Celsius, degree days are accumulated, and eventually hit a threshold number for heat accumulation to trigger certain biological processes. The graph of degrees days relative to my harvesting cites in the Chilcotin is presented in Figure 20. Degrees days do vary with longitudinal and latitudinal movements, and must be applied only locally to similar climates and then re-evaluated when moving to different environments with different diurnal temperature fluctuations. There are also variation among individuals in the same climatic zone and among the same individuals in differing growing years, thus the degree-day appropriation is often a range (Seo et al., 2008). Based on this initial data, degree-days could be charted in subsequent years to determine timing of pine cambium harvest. This is a system that can help with broken traditional knowledge pathways and lack of familiarity with lodgepole pine annual cycles of growth, if people wish to resume harvesting pine cambium.

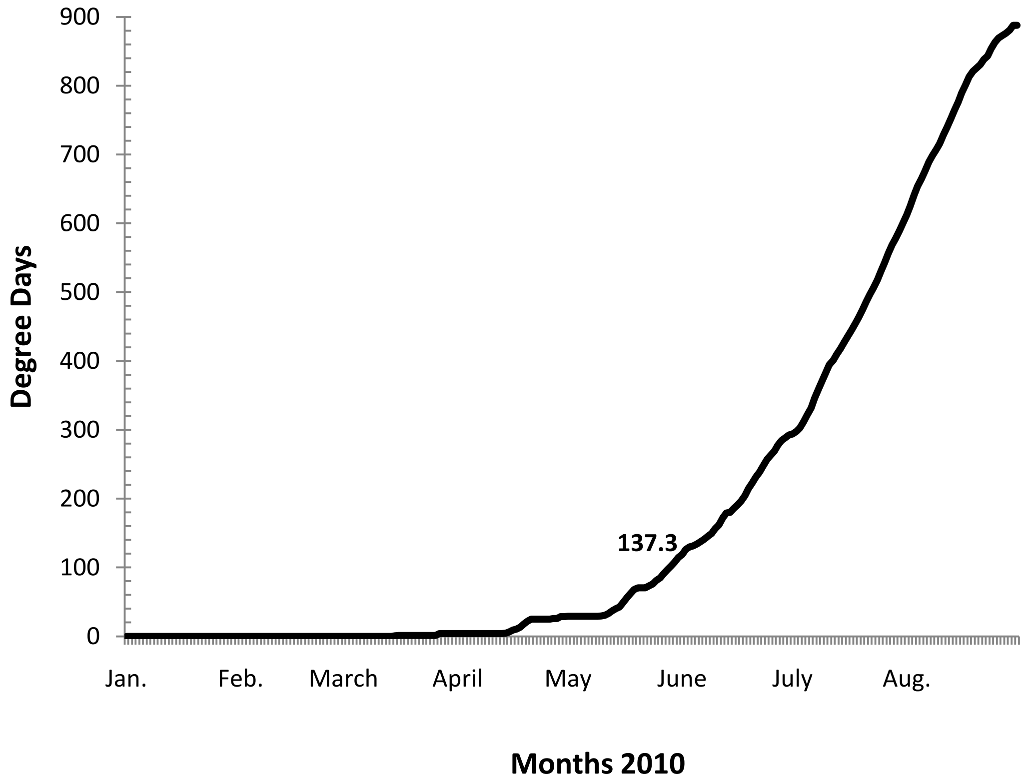

Figure 20. Accumulation of degree days based on temperature averages from Tatlayoko weather station (2010) based on a growing threshold of 5 degrees Celsius. Based on one harvesting season 137.3 degree days indicate a level of thermal integration which is prime for cambium harvesting at this location.

4.7 Conclusion

By conducting my own literature reviews and harvesting experiments and then having the opportunity to talk with First Nations people who have experiencing pine cambium, I am able to present a clear picture of the major methods of harvesting, tree selection, and processing and consumption of lodgepole pine cambium, some of which were presented in this chapter. Through these three mediums of research, information in all sources can be checked and validated, however, this can also reveal discrepancies and areas in this subject matter, which remain unclear. These found areas of affirmations (Table 2) and discrepancy are presented in Table 3.

Table 2. Topics of affirmation based on my own qualitative data, observations, literature sources, and secondary interview sources.

Affirmations
Spring time treat, candy, dessert, not a primary form of subsistence for First Nations in British Columbia
Methods of peeling and scraping
Dual purpose of medicine and food
Importance of pine pitch, maintaining of tradition
Decline in use and knowledge due to discouragement by forestry officials in the 1900's
Tools made from horn and bone and then transitioned into metal
Peeled by everyone. Great pleasure involved in consumption

Table 3. Showing the areas needing further research based on my own qualitative data, observations, literature sources, and secondary interview sources.

Further Research Required
Concept of pit cooking and drying cambium
Theory that a specific side of a tree can produce the best cambium or communication ripeness
Volume harvested from each tree
Specific environmental indicators of timing other than pollen
Use of pine products after the trees were peeled, multiple visits to the same area.
Vitamin C contents and scurvy
Anatomy and Nutritional Value of other tree species used for tree cambium

Further qualitative research must be conducted in order to learn more about these areas of discrepancy, specifically developing questions that are less open ended to touch on missing information. It is always valuable to continue the interview process and learn from traditional knowledge holders. You never know what information will turn up or when memories will be jogged in specific contexts or settings. People are often difficult subjects of studies, as their behaviour is not predictable. It cannot be placed in a box or controlled, thus interview data should be treated as something that has the potential to evolve and grow over time as people develop thoughts, untangle memories, and trust in relationships.

5 Chapter 5 - Nutrition of Lodgepole Pine Cambium

5.1 Introduction

Pine cambium is a timely delicacy available each spring. Almost everyone gathered it, and almost everyone ate it (personal communication, 2010. Pine cambium is often described simply as a sweet, snack or treat, eaten in the spring during the short interval of availability in May or June. Through nutritional analysis and knowledge of winter and summer dietary conditions, this perceived function of a "sweet treat" does not reveal the complete story. Nutritional analysis results, which are presented further in this chapter, show pine cambium literally to be a healthy dessert that provides more than pleasure to the consumer.

In general, few constituent analyses of edible cambium tissues have been conducted. The nutritional analyses that have been completed often do not have comparable units or comparable constituents. Thus overall conclusions about the nutritional value of edible cambium as food from multiple tree species cannot be made (Eldridge, 1982). In 1938, Yanovsky and Kingsbury published a general constituent analysis of lodgepole pine cambium harvested from Alaska and Oregon. They tested for percentage of "reducing" sugar, "non-reducing" sugar[12], protein, ash, and hemicelluloses present in fresh and dry weight cambium. Specifics of harvest timing, methods, or drying processes were not reported. The results were very general and did not reflect any great insight or details of what sugars and other nutrients were present. This study did show, however, minimal difference in sugar concentrations between fresh and dry cambium (Yanovsky and Kingsbury, 1938).

This chapter provides a complete nutritional analysis of lodgepole cambium collected in early June 2010. It provides data for proximate analysis (fat, protein, carbohydrate, moisture, crude fibre, and calories), as well as selected minerals, vitamins, and individual sugar concentrations. The nutritional results for lodgepole cambium reveals an array of mineral and vitamin

[12] Sugars are classified as reducing and non-reducing based on reactivity with Tollens', Benedicts or Fehlings reagents. If the sugar is oxidized by these reagents then it is considered reducing, otherwise the sugar is considered non-reducing. Reducing sugars are monosacharides (glucose) and some disaccharides (lactose and maltose) (Zumdahl and Zumdahl, 2010).

constituents that are also found in fruits and vegetables, vitamin supplements, sports drinks and electrolyte supplements. There is also an indication that the cambium possesses antioxidant properties. I also present my work on the anatomical structure of edible pine cambium. Lastly, I discuss the implications of the nutritional value of lodgepole cambium with emphasis on the primary constituents. I also address health implications related to wild food consumption and the possibilities for this food in the future.

5.2 Methods

I collected lodgepole pine cambium samples from two different locations in British Columbia: Kalamalka Seed Orchard in the Okanagan, and at a few separate locations in the West Chilcotin. Nutritional analysis was conducted for a range of minerals, vitamins, protein, fat, carbohydrates, and specific sugars. Anatomical analysis was conducted on samples taken from Kalamalka Seed Orchard as well as from a shore pine on Vancouver Island during dormancy.

5.2.1 Nutrient Sampling

Cambium samples were collected on May 20, 2010 from Kalamalka seed orchard. I collected lodgepole pine cambium from 11 different Chilcotin genotypes and from 4 different Thompson-Okanagan genotypes. At this point in the season the outer bark was be easily peeled away (in most cases), revealing the inner woody trunk. The cambium was then scraped off in long white ribbons. Cambium samples from each tree were collected in separate Ziploc bags. Some of the trees did not yield enough tissue to sample. None of the trees was girdled during sampling; only one side was peeled. Four of the Chilcotin genotype samples were cooked for 45 minutes with ¼ cup of water over medium heat; the rest of the samples remained raw. Each sample was stored in a Ziploc freezer bag and frozen shortly after collection. The samples remained frozen until September 2010, at which time I conducted enzymatic sugar analysis for sucrose, glucose, and fructose concentrations, in Peter Constabel's Lab in the Centre for Forest Biology of the University of Victoria with assistance from Dr. Lynn Yip. Raw samples, cooked samples, and dried samples were all analyzed for these sugars (Appendix I).

Lodgepole pine cambium was also sampled from three locations in the Chilcotin: Horn Lake, Pyper Lake, and Eagle Lake. The largest sample was harvested from Horn Lake on June 13th, 2010. I combined cambium from 17 different trees at Horn Lake to make a composite sample of pine cambium. This sample was stored in a Ziploc freezer bag and frozen on the same day. The composite sample was sent on dry ice to Silliker labs in Burnaby, British Columbia for full nutritional analysis.

The lodgepole pine cambium sampled from Pyper Lake and Eagle Lake, in mid-June 2010, was all sun dried. I dried the sample by laying out individual strips on a flat metal or plastic surface in full sun. It was on a sunny day and the cambium strips completely dried in 1.5-2 hours. The cambium was dry when it peeled off in papery strips which were no longer gummy or sticky. The dried cambium was analyzed using enzymatic sugar analysis.

5.2.2 Anatomy Sections

Cubed sections of phloem, vascular cambium, and young xylem were harvested from trees at Kalamalka on May 20, 2010, which produced the best quantity of pine cambium. The initial sections were placed in buffer for transport and placed in fixative after sectioning. Similar cubed sections were also harvested from a shore pine on Vancouver Island in November 2010. There samples were also placed in buffer initially and then in fixative after sectioning (appendix II). SEM pictures were taken of both the dormant and active sections with the expert assistance of Brent Gowan and Elaine Humphrey. I am very thankful for the work they contributed for the SEM photos. I could not have done this portion of my project without their knowledge.

5.3 Results

The results for the full analysis of the cambium composite sample from Horn Lake are presented in Table 4-8. The results show high sugar concentrations in cambium, as expected, along with a range of vitamins and minerals and almost equal amounts of protein and carbohydrate. The primary minerals were: aluminum, calcium, magnesium, manganese, phosphorus and, potassium, with trace amounts of other minerals. There were no significant levels of vitamins present; the only notable value is a low level of Niacin. Hardly any Vitamin C, was present. There were also no significant levels of toxins present.

The results for enzymatic sugar analysis of raw and cooked samples of pine cambium from Kalamalka Seed Orchard as well as from dried samples from the Chilcotin are presented in Figure 21. Based on one standard error, there is no difference in sugar concentrations between

Chilcotin genotypes and Thompson-Okanagan genotypes. This suggests that production of edible inner bark is not genetically specific but a process that any lodgepole tree has the potential to create under the right environmental conditions. The total sugars were consistently lowest in the cooked samples and did not show variation between the dried and raw samples. Sucrose had the lowest sugar concentration consistently, followed by fructose, and then glucose, with the highest concentration. This pattern of sugar concentration was the same in the Chilcotin raw samples.

Table 4-Table8. Nutrient report by Sillker Labs of pine cambium from 17 trees at Horn Lake, British Columbia, harvested on June 13th, 2010.

Table 4. Proximate nutrient profile

Proximate Profile	**Per 100g fresh weight**
Crude Fibre	1.41%
Ash	.47g
Fat	.61g
Protein	6.25g
Total Carbohydrates	10.64g
Calories	51 Cal
Moisture	87.64g

Table 5. Carbohydrate profile

Carbohydrate profile	**Per 100g fresh weight**
Starch	0.26%
Sucrose	<.1g
Maltose	<.1g
Lactose	<.1g
Glucose	2.8g
Fructose	4.0g
Total sugars	6.7g

Table 6. Vitamin profile

Vitamins	**Per 100g fresh weight**
Retinol (Vit A)	0 IU
Beta Carotene (Vit A)	0 IU
Riboflavin (B2)	<.1 mg
Thiamine (B1)	<.1 mg
Niacin (B3)	.30 mg
Vitamin C	<1 mg
Vitamin D (D3)	<10 IU
Total Vitamin A	<20 RE

Table 7. Dominant minerals present, > 1 mg/100g

Dominant Minerals	**mg/100g fresh weight**
Aluminum	0.989
Calcium	1.110
Magnesium	19.400
Phosphorus	33.700
Potassium	191.000

Table 8. Trace minerals, <1mg/100g

Trace Minerals	mg/100g fresh weight
Cadmium	Trace amounts
Beryllium	<0.001
Chromium	<0.001
Cobalt	<0.001
Lead	<0.001
Lithium	<0.001
Mercury	<0.001
Thallium	<0.001
Vanadium	<0.001
Bismuth	0.002
Nickel	<0.002
Silver	<0.002
Molybdenum	0.003
Arsenic	0.004
Antimony	0.005
Tin	0.005
Uranium	0.009
Selenium	<0.010
Titanium	0.016
Barium	0.019
Thorium	0.038
Copper	0.041
Strontium	0.069
Zirconium	0.109
Boron	0.162
Zinc	0.267
Iron	0.273
Sodium	0.360
Manganese	0.684

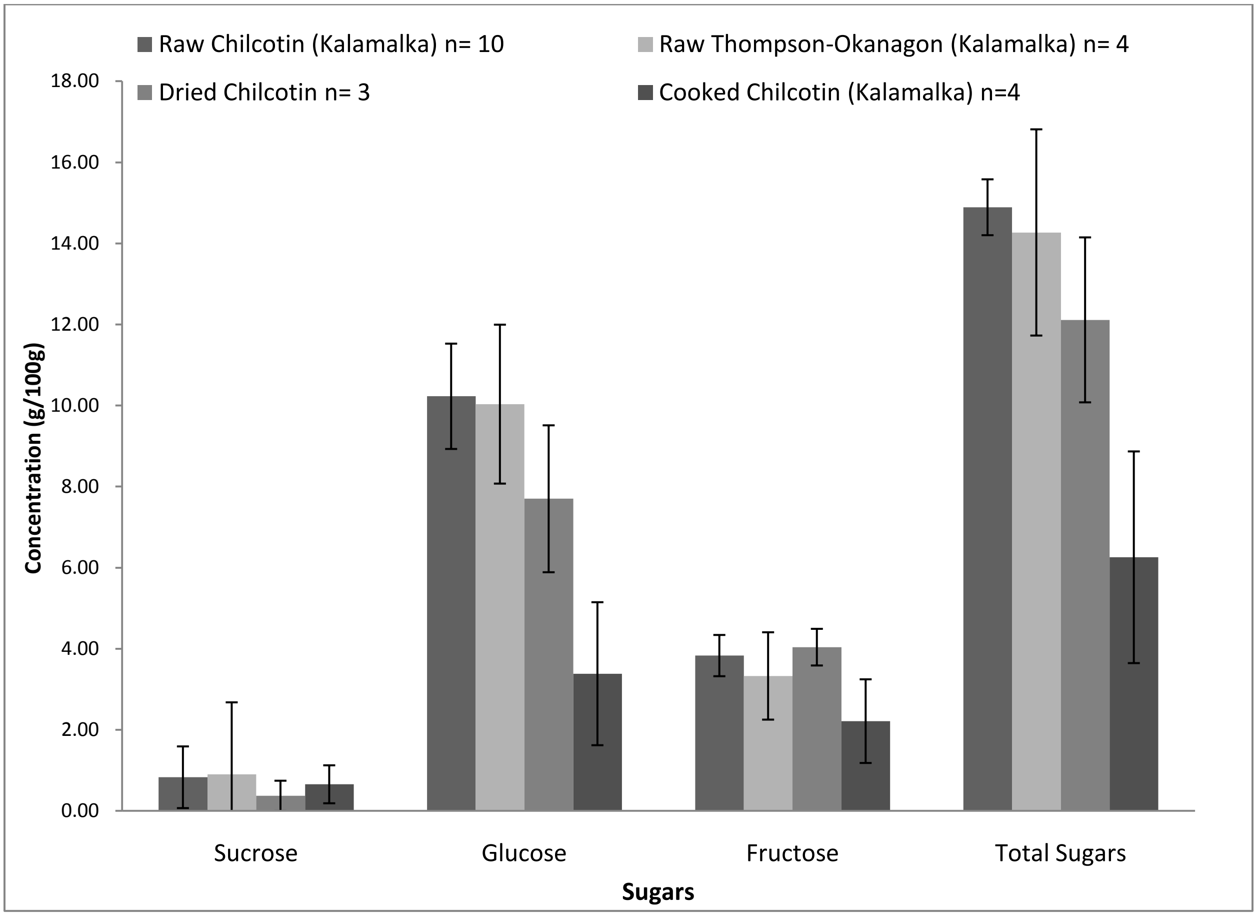

Figure 21. This graph shows sucrose, glucose, fructose, and total sugar concentrations (mg/100g) of raw, dried, and cooked lodgepole pine cambium samples. The raw and cooked samples were harvested from trees at Kalamalka Seed Orchard on May 20, 2010. The dried samples were harvested from Pyper Lake, British Columbia in mid June 2010. Based on 95% confidence interval.

5.4 Anatomy Results

The scanning electron microscope (SEM) pictures of cube samples taken during the fall and then again during the spring did not clearly identify fluctuations in the vascular cambium based on seasonal change. I was not able to clearly identify the vascular cambium layers separate from the xylem and phloem tissues. The samples were not able to be embed in plastic, thus smaller sections could not be cut. The following figures (22-24) are results of my SEM work.

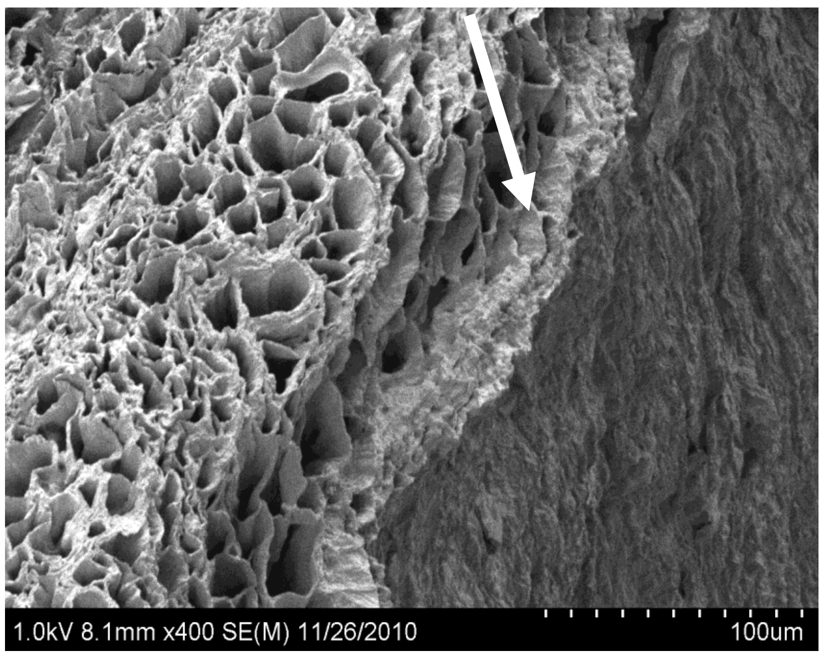

Figure 22. Pine cambium harvested on May 20, 2010 from Kalamalka Seed Orchard in Vernon BC. The arrow indicates vascular cambium cells with sieve tubes to the left of the arrow and xylem cells starting to the right.

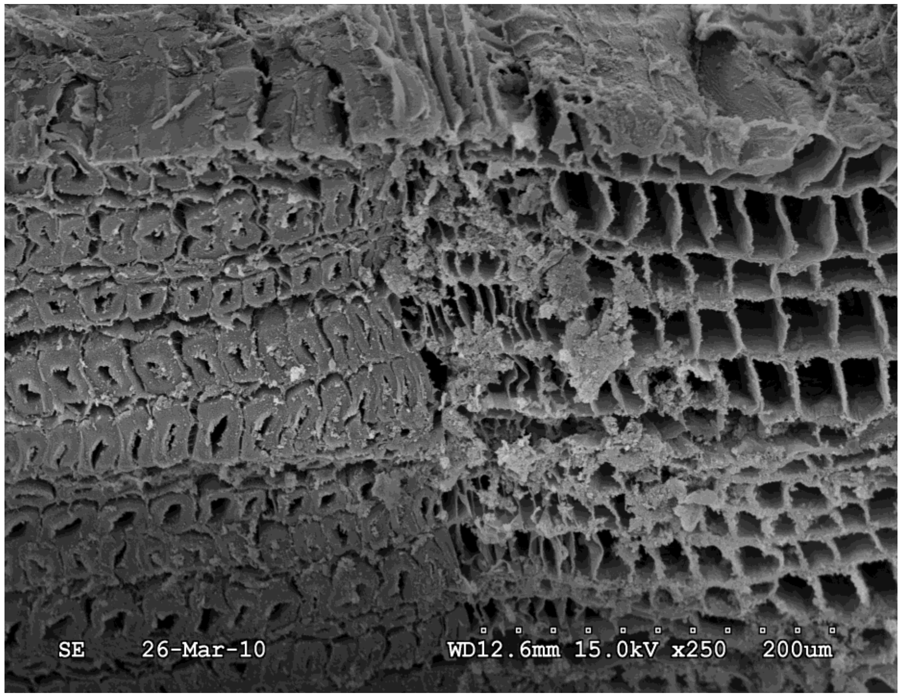

Figure 23. Sample taken in November 2009 from shore pine (*Pinus contorta* var. *contorta*) growing in Victoria, BC. Shows the separation of phloem (right) and xylem (left) at the region where the vascular cambium is present between the two tissue layers.

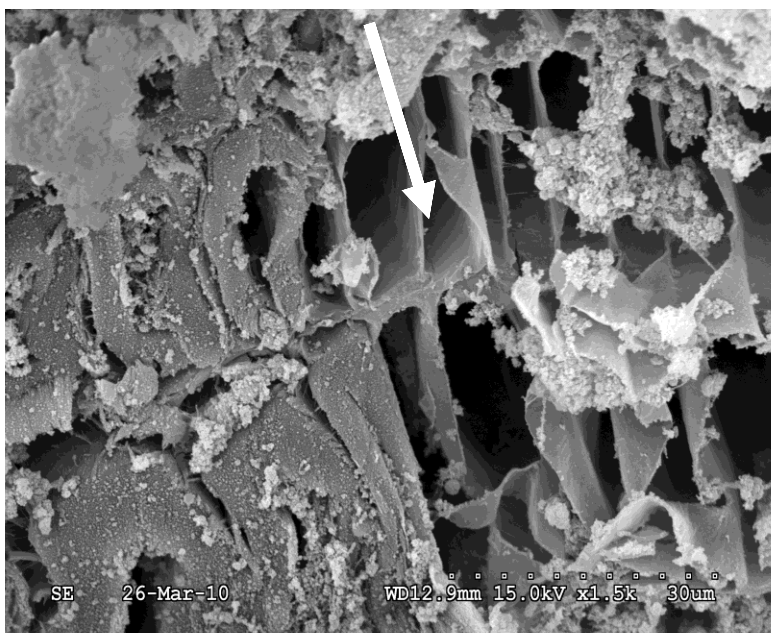

Figure 24. Sample taken in November 2009 from shore pine (*Pinus contorta* var. *contorta*) growing in Victoria, BC. This slide shows the transition area from xylem (left) to phloem (right). This transition zone is the area of the vascular cambium, thus the thin wall cells in this transition area are cambium cells.

5.5 Discussion

The mineral content in plants and trees is controlled by physiological mechanisms and minerals are transported by both vascular tissues (xylem and phloem). Phloem transports sugars, minerals, vitamins, hormones, proteins, and ATP. This vascular tissue is the most nutritionally rich tissue in plants. It is also a primary site of storage and transport of nutrients including carbohydrates, amino acids, and minerals. Potassium, phosphorus, magnesium and sulphur are minerals of highest concentration transported in sieve tube elements (Marschner, 1995). My nutritional results show that potassium, phosphorous, and; magnesium were the minerals of highest concentration in lodgepole pine edible cambium (Table 7).

5.5.1 Vitamin C component and pine products

Studies of pine products, needles, outer bark, and some inner bark tissues report higher levels of vitamin C (Ostlund et al., 2009; Swetnam, 1984). Specifically, studies of Scots pine (*Pinus sylvestris* L.) cambium consumed by the Sami, report high concentrations of vitamin C or ascorbic acid, translated from Latin to mean "without scurvy". Humans (as well as other primates, guinea pigs, and some birds) are not capable of making vitamin C, thus, obtaining this vitamin from dietary sources has been important throughout history (Frankenburg, 2009). They are termed 'a-scorbutic' animals. A study done by a Norwegian doctor in 1979 concerning Scots pine bark as a scurvy remedy, reported Scots pine cambium to contain 38 mg/kg vitamin C in May and 54 mg/kg vitamin C in June Hansson, 1995). Other authors maintain that the inner bark of Scots pine was responsible for keeping sailors scurvy free for long seaboard journeys and that consumption of this food was the reason why people did not get scurvy in the northern most parts of Scandinavia (Hansson, 1995; Ostlund et al., 2009, Zackrisson et al., 2000). I therefore expected to find substantial levels of Vitamin C in lodgepole pine cambium, but the nutritional results reported quite the contrary: less than 1 mg per 100 g fresh weight. This amount is not substantial enough to provide meaningful amounts, as adults need 75-90 mg daily (Higdon, 2003). Further research is needed to determine why vitamin C would be high in some pine products and not others.

5.5.2 Carbohydrate components

In the Chilcotin samples and Kalamalka samples sucrose was the form of sugar in the lowest concentration, with some trees having zero sucrose concentration. Both glucose and fructose concentrations were well above sucrose levels in all samples. This is contrary to what I expected because sucrose is the primary transport sugar in phloem sap, sometimes compromising up to 90% of sieve tube contents (Kramer and Kozlowski, 1979; Marschner, 1995).

Marschner (1995) suggests that potassium and magnesium concentrations affect sucrose ratios. He found that sucrose uptake into vacuoles was highest in red beet (*Beta vulgaris*) tissues when magnesium and potassium were both present. Shifting levels of potassium can control phloem sap movement to sugar sinks. In transporting potassium ions into vacuoles, the turgor pressure of sieve tubes increases, moving the sap quickly away from the source and towards the sink, and maintaining a consistent gradient of sucrose demand from source to sink (1995). This might also explain why magnesium and potassium have two of the highest mineral concentrations in lodgepole pine cambium.

Lastly, low sucrose concentration could be a result of a sucrose gradient, decreasing from top to bottom to motivate continuous transport from source to sink. Pine needles are the primary photosynthesizing bodies, producing sugar, which then must be transported in the form of sucrose to sugar sinks for growth. During the springtime, cambial growth and the “grand” period of xylem expansion and secondary growth creates a substantial sugar sink. In order for a tree to maintain the demand for sugar transport, especially in an area, which is far from the source (pine needles are often limited to the top half of lodgepole pine trunks), a steep gradient must be maintained. By deconstruction of sucrose into components of glucose and fructose at the sink, a sucrose gradient is created from top to bottom of the tree trunk.

5.5.3 Cooking

Cooking of foods can result in the breakdown of some sugars into a more digestible form (e.g. in the case of inulin), increased palatability and digestibility, and leaching of tannins, resins, lignins, terpenes, waxes, and other secondary metabolites which are distasteful (Etkin, 2006; Ostlund et al., 2009). When I cooked lodgepole pine cambium, however, it turned into a tasteless clump with a mushy consistency. Cooking with a small bit of water did leach out distasteful components but it also leached the sweetness and, I assume, micronutrients into the cooking liquid. The sugar concentrations for my cooked samples were consistently lower for all three sugars (glucose, fructose, and sucrose). Scots pine, hemlock and perhaps ponderosa pine edible cambium are commonly pit cooked for increased palatability. However, pit cooking of lodgepole pine edible cambium does not seem to be common practice (Ostlund et al., 2009). There is no evidence to suggest that lodgepole cambium was cooked in any manner other than smoking for drying. There really was no need to cook a food, which was delicate in form and already palatable, raw, with no indigestible sugars. Cooking does leach out tannins, which may be present in some edible cambium samples. However, tannin-heavy lodgepole pine trees were eliminated from the beginning by taste testing before a large portion of the cambium was harvested.

5.5.4 Medicinal Contributions of Pine Cambium

Pine cambium was not just utilized as a food in the spring but was also consumed by First Peoples for various medicinal reasons (See Chapter 2 and 4). Bark is often rich in medicinal secondary plant chemicals and antioxidants (Cunningham, 2001), particularly flavonoids. Flavonoids are a class of naturally occurring polyphenols which are found in fruits, vegetables, grains, bark, tea, and wine. They are proven to have free radical "scavenging" properties and may be involved in prevention of cancer and heart disease (Ostlund et al., 2009; Shand et al., 2003). Anti-oxidants found in pine tree bark have been tested and found to be 50 times more effective than Vitamin E and 20 times more effective than Vitamin C at combating free radicals in human bodies which can lead to colds and allergies (Marshall, 2002). Presently, phloem powder is used as a supplement in some foods due to its known potential health benefits from polyphenol concentrations (Shand et al., 2003; Ostlund et al., 2009; Vanharanta et al., 2002; Mursu et al., 2005).

One specific flavonoid, marketed and patented as Enzogenol, is found in the Montery pine (*Pinus radiate* D. Don) native to the central coast of California. Enzogenol has immune boosting powers and possibly other health benefits related to prevention of cancer and cardiovascular disease which are still being explored (Shand etal., 2003). Another example of a flavonoid from pine is pycnogenol, a strong antioxidant compound, found in Maritime pine (*Pinus pinaster* Aiton), a pine native to western and south-western Mediterranean (Marshall, 2002). I can only speculate if the same or similar compounds occur in lodgepole pine bark. More analysis is needed.

Studies have shown that increased consumption of traditional foods can help prevent the incidence of diabetes and some other chronic diseases. First Nations people in Canada are 3-4 times more likely to get Type 2 diabetes than other Canadians, with an increasing incidence of Type 2 diabetes among the younger generations (Health Canada, 2009). Traditional plant foods tend to be low in energy, high in micronutrients and fiber, and slowly digested. Pine cambium is high in sugar but it is also high in protein and plant fibre (Milton, 2000, Eldridge, 1982). Fibre is indigestible plant tissue which takes some time to pass through the digestive tract; thus, sugars bound up in fibre release slowly, providing a slow seep of energy that can sustain over a period of time (Gottesfeld, 1992; Ostlund et al., 2009). Protein also has similar effects in the digestive process when combined with sugar (Jenkins et al., 1981; Thorburn et al., 1987). When digestion rates of traditional and western foods were compared, 23 of 30 traditional foods consumed by Indigenous Australians were all digested more slowly than 7 western foods.

5.5.5 Anatomy

I assumed that I would observe changes in the anatomical structure of the phloem and vascular cambium based on seasonality. The vascular cambium is many cell layers thick in the spring (during prime pine cambium harvesting time) and only a few layers thick in the fall and winter, if even detectable. The SEM pictures from samples taken during dormant and active time periods of vascular divisions in lodgepole pine cambium did not show these fluctuations. This could be a result of a few factors. Sectioning cambium for microscopy is extremely difficult. This process has taken some people years to accomplish in itself (Rensing, 1992). Sampling the phloem, cambium, and xylem as a chunk creates a problem because the sample easily slips apart between the woody (xylem) and soft phloem tissues. Cutting even with a sharp knife, can easily crush or sever delicate cambium in the process. Another factor could be that the sample was too thick. The samples could not be embedded in plastic, so thinner sections were not available for analysis.

Based on what my SEM photos did show, I believe phloem is the primary edible tissue. This is also reflected in my nutritional results based on sugar levels and specific minerals present. Cambium tissues, beyond their role as a vascular tissue producer, may make up little of the actual edible portion of the pine cambium. Furthermore, based on the nutritional results for low crude fibre, it can be speculated that the edible portion contains little xylem (Table 1).

5.6 Conclusion

The nutritional analysis results confirm that lodgepole pine "cambium" is a healthy food, high in numerous minerals and macronutrients. Protein and sugar are the two most prevalent components in the edible tissues, with both glucose and fructose being higher in concentration than sucrose in lodgepole pine cambium. Magnesium, phosphorus, and potassium are the three minerals of highest concentration, with trace amounts of other minerals present. Collectively, lodgepole pine cambium contains a suite of nutrients which contribute to immunity, electrolyte balance, and stress relief in the human body. People enjoy lodgepole pine cambium for its sweetness but also for the contributions it can make to overall health and maintenance of the bodily systems.

However, it is also very important to mention that lodgepole pine cambium was considered by interior First Peoples as "their sugar", consumed as a dessert, candy, or delicacy. There is a strong case that this traditional food was eaten out of sheer pleasure for taste. Josephine Gregg and others that I spoke with mentioned pine cambium first in as a dessert and then as a medicine or trail food (personal communication, 2010). This is also consistent in the interviews conducted by Anne Marshall who often described lodgepole pine cambium in comparison with ice cream or candy (Marshall, 2002). It is imperative not to underestimate gathering motivated by pleasure, with no concern for nutritional value at all; as such delicacies were rarely as accessible and prevalent as lodgepole pine cambium in the spring.

Steaming lodgepole pine cambium in water substantially decreased all sugar concentrations, while processing through sun drying did not prove to affect sugar concentrations. When consumed, pine cambium slowly breaks down in the gut, providing a slow release of sugars over time, and serves as an energy source which could support low intensity endurance activity. Along with many other traditional foods, it has potential to alleviate the high incidence of diabetes and other diet-related chronic disease if consumed in combination with other or healthy food options.

While my anatomical investigations did not fully reveal the proportion of each vascular tissue present, based on the SEM photos I did evaluate and my nutritional analysis, I believe that edible lodgepole cambium consists mostly of phloem tissues, with minimal cambium or xylem. This suggests that the timing of harvest is not only important for increased sugar content but for the maximum proportion of thick tissues. Thicker secondary phloem forms when there is an increased need for transport in the spring and summer. During other times of the year the secondary phloem is not thick enough in volume to scrape from the surface of the wood. After the spring and summer growing periods, secondary phloem compresses into the outer bark, making it unsuitable for harvest (Pallardy, 2008).

These results begin to shed light on the nutritional value of cambium and the connections that can be made between the nutritional components and anatomical sections. This chapter leads into the concluding chapter which will further discuss the of nutritional value information of wild foods, possibilities of supplementing foods such as pine cambium into modern diets, diets and disease, and future research avenues for edible tree cambium.

Chapter 6- Summary and Conclusions

This study presented major findings of the nutrition and ethnobotany of lodgepole pine "cambium" as a traditional food based on edible tissues pine samples collected in Vernon, BC and in the Chilcotin, as well as some qualitative research. The qualitative information reported was based on three sources: informal interview data, personal observations, and expert literature sources. My primary area of study was in Tsilhqot'in First Peoples' traditional territory in British Columbia. During my time spent in the Chilcotin I was able to closely monitor and observe lodgepole pine stands, harvest pine cambium daily, and speak with local people who remember harvesting pine cambium. The interview information was collected in coordination with one of the Tsilhqot'in communities, Tsi Del Del (Redstone reserve). Through informal conversations and participant observations I was able to confirm practices of harvesting and consumption as described in the literature as well as learn some novel information concerning nutrition and medicinal use of lodgepole pine "cambium." I also was able to determine characteristics of pine trees producing prime "cambium" and the timing limitations of this food.

The major findings from nutritional analyses including sugar analyses of pine cambium samples are in Chapter 5. Based on a synthesis of learned information from knowledge holders and literature sources, as well as my own experiences, with harvesting and taste, it would be erroneous to claim that pine "cambium" was pivotal to First Peoples' existence historically or presently as a food or medicine (cultural keystone species[13]). Geologist and ethnographer, George Dawson makes consistent references to Indigenous use of pine cambium during his travels of the Chilcotin and interior B.C. On September 5, 1876 around Tatlyoko Lake, for example he wrote, "The Indians in general it may be said that they can eat many things which white men cannot. For example, the woods all

[13] Cultural keystone species as defined by Garibaldi and Turner (2004) is "the species most closely associated with indigenous and local peoples, wherever they reside, are the ones they depend upon the most extensively to meet their needs for food, clothing, shelter, fuel, medicine, and other necessities of life. These are the species that become embedded in a people's cultural traditions and narratives, their ceremonies, dances, songs, and discourse. These are also the species for which a people will have developed the most detailed names and associated vocabulary, and the ones on which they focus in their immediate activities and conversations" (2004: 1).

through this part of the country consist largely of a small species of pine which I believe to be *P. contorta* and almost everywhere the natives have peeled great slabs of bark off the trees to get at the soft cambium layer beneath. In the spring this is scraped off and eaten" (Cole and Lockner, 1989: 80).

Today, Tsilhqot'in and other First Peoples talk about pine "cambium" fondly and with great admiration, recounting memories of harvesting and eating it. I think affection is based on the sheer pleasure this unique food creates through the harvesting and consumption process. People I interviewed as well as those cited in other secondary literature sources compare pine cambium to ice cream or other sweet treats. No other food in traditional food systems is comparable in taste, consistency, or method of harvest. As people today relish ice cream in the summer or hot chocolate in the winter, the timing, taste, and functional enjoyment are all right for pine cambium. It is a food that fills a gap created by a long winter of general nutritional monotony. The unique method of harvesting "pine noodles" also adds to the pleasure of the process. Testing a pine tree for cambium is suspenseful, as only peeling away the rough outside will reveal whether a potential treat exists on the inside. From my own experiences it is a pure delight to peel a tree open and scrape away sweet, juicy, inner bark noodles and then eat them on the spot.

Nutritional analysis of the edible lodgepole pine "cambium" revealed that it is loaded not only with carbohydrates in the form of sugar but is also contains protein and micronutrients which could be said to be comparable to a low dosage multi-vitamin or electrolyte supplement. The most prevalent minerals were potassium, magnesium, and phosphorus, with trace amounts of other elements. In the conglomerate sample taken from the Chilcotin, about equal amounts of protein and carbohydrate were present. Pine cambium can thus be classified as a "health food" even though it is also perceived by many consumers as a sweet treat or dessert. Clearly it can be perceived as both a health food and sweet treat. In terms of the sugars, glucose and fructose are present in large quantities and sucrose in small quantities. Sugar concentrations in fibre matrixes – the dietary fibre present in this food – are proven in many instances to be beneficial in diabetes prevention and management as the fibre slows down digestion and release of sugars into the blood stream.

5.7 Wild Foods and Nutrition: the significance of this research

Presently, many traditional food systems are dwindling or disappearing from lack of maintenance, loss of knowledge, loss of land ownership, reorganization of social relationships, and changing economies and ecosystems (Kuhnlein and Turner, 1991; Kuhnlein et al., 2009; Turner and Turner, 2008). The spring and summer, times for harvest and feast, are challenged by other pressures to work and earn money as a functioning member of society. Social networks and knowledge transfer systems suffer and the purpose and responsibilities of men and women as providers and caretakers of their families are blurred. Such transitions and changes have been detrimental to the health of indigenous people, creating situations where people are torn between conformity to the larger governing body and social and economic constructs of Canada and adhering to their local social, cultural, and economic traditions (Kuhnlein and Turner, 1991).

However, there is large sector of Indigenous Canadians who are fighting to retain and continue their food traditions and relationships with their land. The 2010 fight to save Teztan Biny (Fish Lake) is a prime example of a community being empowered to save hunting, trapping, fishing, and gathering sites important to Tsilhqot'in traditions. If Teztan Biny were transformed into the proposed gold and copper mine (Prosperity mines), it would be poisoned with 700,000,000 tons of toxic tailings, killing not only the Teztan Biny ecosystem but affecting surrounding watersheds, freshwater supplies, and animals and people depending on the area. A nurse who works in the Xeni Gwetin community in Nemaiah offered a powerful testimony at the public court hearings about healthy changes going on in the community and the negative impact that the destruction of Teztan Biny would have on this positive momentum. She reported that in the past,“100% of the adult population in Nemaiah had addiction issues”. Over the past 20 years, this trend has decreased, with only 20% of the adult population and only 5% of Elders consuming alcohol today. The nurse credits maintenance of traditional lifestyles along with health, spirituality, nutrition, physical activities, and connection with the land for this remarkable improvement (unpublished letter for court proceedings, 2010). On November 2nd, 2010 the federal government of Canada officially rejected plans (as they stand currently) for mining development at Teztan Biny. This was a great victory and catalyst for continual growth of Tsilhqot'in people in ownership of their land and traditions.

By considering benefits of wild foods through nutritional analysis, credibility can be gained with specific audiences, programs, and land claims which require quantitative representation to portray the value of wild foods or traditional lifestyles. This specifically pertains to Indigenous health and food policy, funding, land agreements, and resource management. Nutritional results, such as those for lodgepole pine “cambium”, also can be used in educational workshops and alternative diet suggestions to spread awareness about health benefits of traditional foods (Kuhnlein et al., 2009).

5.8 Future potential of pine cambium

Throughout the winter, Indigenous people of British Columbia living traditional lifestyles were limited mostly to stored foods. Springtime often equated with exhausted winter food storages (Turner and Davies, 1993). The main form of subsistence during this time of year would have been lean sources of protein, resulting in a low carbohydrate, low fat, high protein diet High protein diets are common in traditional diets of Canadian First Nations. However, when the protein source is not supplemented by fat or carbohydrates this causes problems with energy metabolism. Highly lean protein diets make the body work harder to metabolize energy that is not as accessible or as easily stored as fat and carbohydrates, thus the act of actually metabolizing the meat expends more energy (Speth and Spielmann, 1983). This concept is referred to as “rabbit starvation” by Speth and Spielmann: a diet of lean protein with little fat and carbohydrates to burn as energy. In extreme cases it can be described as this:

> If you are transferred suddenly from a diet normal in fat to one consisting wholly of rabbit you eat bigger and bigger meals for the first few days until at the end of about a week you are eating in pounds three or four times as much as you were at the beginning of the week. By that time you are showing both signs of starvation and of protein poisoning. You eat numerous meals; you feel hungry at the end of

> each; you are in discomfort through dissention of the stomach with much food and you begin to feel vague restlessness. Diarrhoea will start in from a week to 10 days and will not be relieved unless you secure fat. Death will result after several weeks (Speth and Spielmann, 1983: 3).

Speth and Spielmann then go on to recount how, during times of low carbohydrate and low fat diets, bark, insects, seaweed, ptarmigan entrails, and caribou stomach contents could be consumed (1983). While today many traditionally based food systems of Canadian First Nations today are still high in protein, scarcity of carbohydrates sources is not an issue, since commercially sold processed sugar and flours are readily available. Today the situation is quite the opposite; carbohydrates and fats are over-consumed, leading to heightened cases of diet-related chronic disease. With decreased need for foraging and advent of other conveniences and practices, gathering of pine "cambium" does not often occur in by First Peoples' life ways; in fact many people do not even know about this traditional food.

Traditional knowledge and oral histories around pine "cambium" use are limited and fading. Limited use and knowledge of pine cambium resulted, at least in part, by discouragement of bark peeling from forestry and governmental officials in the mid 1800's and early 1900's, as well as from effects of residential school rules which forbid any practices related to First Peoples' identity. Along with dying cultural connections, pine cambium collection has also been hampered by the mountain pine beetle outbreak in the interior of British Columbia, in which lodgepole pines have been killed or seriously compromised in health, limiting the places where pine "cambium" can be harvested. The Chilcotin area pines were hit hardest by this epidemic. Even with the reintroduction of pine "cambium" into traditional food information pathways and annual harvests, the potential to harvest this food is limited by the existence of healthy lodgepole pine stands.

While there are obstacles for future and consistent use of edible pine "cambium", it is important not to become discouraged or to overlook the potential benefits of consuming and harvesting this traditional food. My nutritional results show that pine cambium is full of nutrients: vitamins, minerals, carbohydrates, and protein. While it does take time and effort to harvest, it is free to anyone as a service of Mother Nature. Foods which offer substantial vitamins and minerals can be expensive. Thus, taking advantage of the nutrients offered by foods that can be collected, virtually cost free, is important to many First Peoples. Overall, the process of harvesting is simple, once healthy trees are located. The tools for the process are inexpensive, and most likely already owned by most people. “Cambium” harvesting is a great activity to involve people of all ages, and there is no wait to consume the fruits of the collection. Eating pine cambium on the spot is recommended and encouraged, as long as traditional harvesting practices and constraints against excessive damage of pine stands are observed.

5.9 Future Avenues of Research

This project was conceived out of the need for further research specifically on tree “cambium” use as a traditional food. While I have reported on the nutrients found in lodgepole pine cambium, there is still considerable work needed in order to make conclusions about overall nutrients contributions of tree cambium of the Pacific Northwest. The most pressing need for future research is thus comprehensive nutritional analyses, using uniform units, and including samples from different growth stages and parts of the tree, for major tree species used for edible cambium by First Peoples of the region.

While I am convinced from my preliminary research that edible pine cambium is mostly phloem tissue, with some vascular cambium cells, and little or no xylem. To further explore the anatomical structure of edible tree cambium and associated tissues would be another avenue of future research. This is a challenging issue because the tissues, particularly the vascular cambium, are so thin and delicate. It is hard to isolate the cells and tissues without crushing them. At the same time, extracting tissues in one unit, as I did, this is not really answering the question about which layer of tissues actually comprise the edible portion.

Undertaking a project based on an uncommon traditional food, even among people who still utilize some parts of traditional food systems, is challenging yet rewarding. People must conduct more initiate more dialogues with knowledge holders to further explore and document knowledge from First Peoples who harvest tree cambium or who have harvested in the past. This will also help make connections about use across different groups and different tree species. However, the people that I did talk to seemed pleasantly surprised to focus on a subject which many people do not think about these days. Many are interested in renewing connections with their land and environment, and learning about traditional foods, such as pine cambium, is a great way to start this journey.

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APPENDIX A - Interview questions

This set of interview questions was developed for potential Tsilhqot'in interviewees which are knowledgeable about edible lodgepole pine cambium as a traditional food or medicine. The following sequence of questions are placed in order of possible presentation but were not necessarily kept in that order during conversation.

Have you ever eaten lodgepole pine (*chendee*) cambium or have your family members told you about it?

[The next questions would be asked only if the person knows about this food and has either eaten it themselves, or has been told about it]

What time of year would people harvest this food?

- Timing of harvest
- Place in seasonal rounds, importance in relation to other foods

How did people know when it was time to harvest this food?

- Environmental signals
- Other things ready to harvest at the same time

Where would people go to harvest this food?

How would a person decide which trees to pick for inner bark harvesting?

- Not all trees make good bark
- Characters of a good tree
- Particular places better than others?

Was pine inner bark of lodgepole considered a medicine? Or is it particularly healthy as a food?

Was this food consumed and harvested routinely or only at certain times?

- Importance in relation to other foods.

Did people go to harvest this food from the same trees or places each year?

Was a certain side of the tree preferred for the best bark?

If yes, why do you think this was?

Did everyone harvest it or only certain people? Did children help?

How did people harvest it? Were there certain tools that were used, or certain types of baskets or containers?

How was it eaten? (Was it cooked, or eaten raw? Was it eaten with certain other foods?)

Was it an important part of rituals or ceremony?

Do animals eat it too?

Were there other kinds of trees that gave similar inner bark food? (if so, what were they, and what were they called?)

Is there anything else you could tell me about this food, or the lodgepole pine tree?

APPENDIX B - Carbohydrate Analysis - Enzymatic Sugar Assays (by colorimetric measurement of conversion of NAD to NADH at 340 nm) used for glucose, fructose, and sucrose concentrations of lodgepole pine cambium

The following procedure was written by Lynn Yip, 2009 (modified from Campbell et al. 1999, *J Sci Food Agric*) for enzymatic sugar assays. I used these methods for sugar analysis of fresh, dry, and cooked pine cambium collected in the Chilcotin region and Kalmalka Seed Orchard in the Okanagan. I conducted the methods under the tutelage of Dr. Lynn Yip and Dr. Peter Constabel in the Centre for Forest Biology at the University of Victoria.

Sample Extraction

Weigh 10 mg of lyophilized plant tissue in powder form into eppendorf tube with locking lid.

Add 1 mL of 80% ethanol. (Mark level of liquid, in case of evaporation, can top back up to level, or parafilm to avoid this). Vortex 2 x 5 sec

Incubate at 75^{0}C ~4-6 hr. (Use hybridization oven for incubation. Original protocol did two 6 hr incubations, adapted to 2nd incubation O/N, but evaporation sometimes occurs with this long incubation even with locking lid tubes.)

Vortex and spin down (2 min 10,000 rpm), decant extract (use pipettor).

Repeat extraction 1 mL of 80% ethanol, incubate O/N.

Vortex and spin down (4 min 10,000 rpm).

Decant extract completely. Combine with 1st extraction.

Speed-vac extracts to less than 20% volume to remove ethanol. (Do not dry down completely; it may not all re-dissolve.)

Add water to bring extract volume up to 200 µL for each sample.

Extract concentration is 50 mg plant material /mL.

Enzymatic sugar assays

Make only volume of enzymatic reagent mixture necessary for number of samples, including blank and a little extra. (To conserve enzymes.)

For reactions of one 96 well microtitre plate, assay volume **200 µL** per well:
(Use non-stick microtitre plates.)

Sucrose assay Invertase Method (2009):

Sucrose is hydrolyzed to D-glucose and D-fructose with the enzyme invertase. Concentration is measured by determining resulting glucose concentration.

To obtain actual sucrose concentration, a separate glucose assay is done to measure the constitutive glucose content in the sample.
Subtract this glucose value from the sucrose assay value.

Buffer and ATP solution as for Glucose Assay below.

Use the following proportions to make enough enzyme solution to have 100 µL per sample.
Include blanks.

Dissolve 11.3 mg invertase (Sigma I4504) in 1 mL dH$_2$O (= 4000 U enzyme units/mL)

Add the invertase to 3 mL glucose assay buffer and 6 mL dH$_2$O (= 10 mL at 400U/mL)

Put 10 µL of sample in microtitre well. Add 100 µL reagent mixture to each and mix well.

Incubate at room temperature 15 min.

Dissolve 15.3 mg NAD in 3.5 mL buffer (4.36 mg/mL buffer),
add 7 mL H$_2$O and 700 µL ATP solution. (11.2 mL)

Add enzymes: 40 U HK = 33 µL (Sigma H5625)

21 U G6PDH = 3.5 µL (Sigma G8404)

Add 100 µL reagent mixture to each invertase well and mix well.

Incubate at room temperature 15 min.

Measure absorbance at **340 nm** on Tecan to determine total NADH concentration.

Hexokinase (HK) phosphorylates D-glucose to G-6-P and D-fructose to F-6-P.
In an oxidation-reduction reaction with G-6-P, NAD is reduced to NADH with glucose-6-phosphate dehydrogenase (G6PDH). Amount of NADH correlates with amount of glucose.

Sucrose standards: 0, 0.1, 0.2, 0.35, 0.5, 0.75 mg/mL

Glucose and Fructose assays

Buffer: 50 mM triethanolamine, 5 mM $MgSO_4$, 0.02% BSA
0.5 mM DTT (dithiothreitol, Cleland's reagent)
adjust pH to 7.6 wth HCl

Dissolve 300 mg ATP disodium salt and 300 mg Na_2CO_3 in 6 mL H_2O.
(Freeze in 1-2 mL aliquots)

For reactions of one 96 well microtiter plate, 200 µL per well:

Dissolve 15.3 mg NAD in 7 mL buffer (=2.18 mg/mL buffer),
add 14 mL H_2O and 700 µL ATP solution. (total volume 21.7 mL)

Add enzymes: 40 U HK = 33 µL (Sigma H5625)

21 U G6PDH = 3.5 µL (Sigma G8404)

Glucose assay:

Put 5 µL of sample or standard in assay well, add **200 µL** reagent mixture.

Mix well and incubate at room temp for 15 min.
Measure absorbance at 340 nm to determine production of NADH.

Continue with Fructose assay:

Dilute 110 U PGluI = 20 µL (Sigma P5381) in 500 µL H_2O, add **5 µL** to each well.

Mix well and incubate at room temp for 15 min.
Measure absorbance at 340 nm to determine total NADH.

Phosphoglucoisomerase (PGluI) converts F-6-P to G-6-P.
This value gives the fructose measured as more G-6-P in addition to the glucose content.
Fructose conc. is calculated as the difference from the glucose assay.

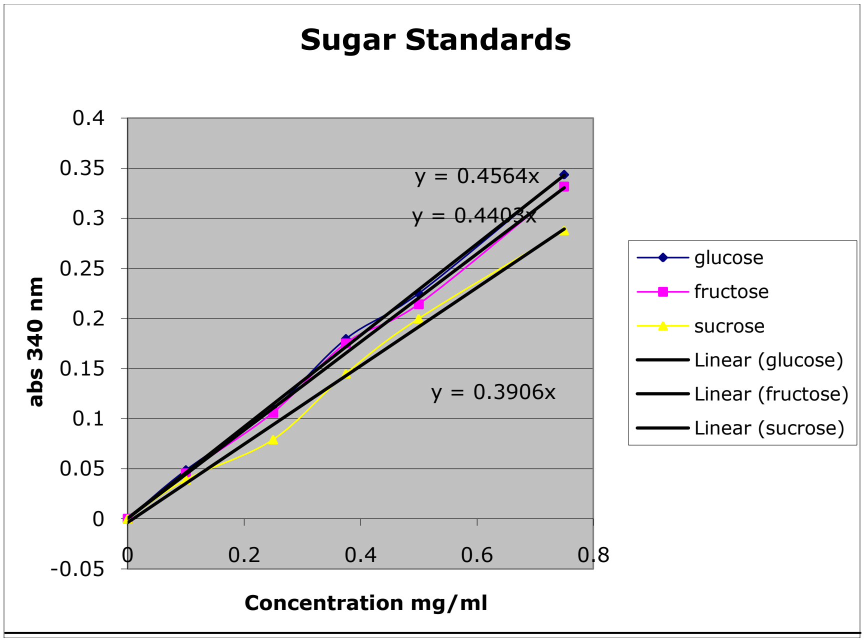
Glucose and fructose standards: 0, 0.1, 0.25, 0.35, 0.5, 0.75 mg/mL each

Result Calculation

The corrected absorbance value is obtained by subtracting the blank value of the reagent mixture without extract.

Sugar concentration in mg/mL is obtained with the absorbance from the standard curve.

The sugar concentration x 20 gives the value per gram plant material, as the concentration of the plant extract is 50 mg of dry plant material /mL.



Sucrose Phosphorylase Method (2007, from Campbell etal.):

Sucrose phophorylase (SucP) cleaves sucrose to G-1-P and fructose.
(In this reaction, constitutive D-glucose is not converted, and need not be accounted.)
Phosphoglucomutase (PGluM) then converts G-1-P to G-6-P.
In the oxidation-reduction reaction with G-6-P, NAD is reduced to NADH with G6PDH.

Assay buffer stock: mix solutions A and B to reach pH 7

Sol. A: 10 mM K_2HPO_4, 1 mM $MgSO_4$
Sol. B: 10 mM KH_2PO_4, 1 mM $MgSO_4$

Dissolve 6.64 mg NAD in 20 mL assay buffer (0.33 mg / mL buffer)

Add enzymes: 25 U PGluM = 17 µL (Sigma P3397)
60 U G6PDH = 11 µL(Sigma G8404)
50 U SucP = from frozen aliquots (Sigma S0937 powder) dissolved in phosphate buffer w/ BSA

Put 10 µL of sample in microtitre well. Add 200 µL reagent mixture to each well, mix well.

Incubate at room temperature 70 min. Measure absorbance at **340 nm** on Tecan.

APPENDIX C - Buffer and Fixative Preparation (Rensing and Owens, 1994)

The methods below were used for preserving lodgepole pine sections used for anatomical analysis. Sections taken in the field were immediately kept in buffer (0.075 M) until the samples were cut into small thin sections. Once this was done the final sections were preserved in fixative (6% glutaraldehyde in 0.15 M Severson's).

1) 10 mL Severson's phosphate buffer (0.5 M, prepared by E. Kruith on October 8, 2008) in 23.3 mL distilled water. Final volume: 33.3 mL (0.15 M)
2) Add .0216 g $CaCl_2$ to above buffer mixture. Final concentration: 0.006 M
3) Combine 1 mL 25% glutaraldehyde with 3.16 mL buffer from step two (above). **Final fixative product makes 6% glutaraldehyde in 0.15 M Severson's.**
4) Combine 10 mL buffer (product from step 2) with 10 mL distilled water. **Final buffer product: 0.075 M.**