The Population Ecology and Ethnobotany of Devil's Club (*Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq.; Araliaceae)

by

Trevor Charles Lantz

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We accept this thesis as conforming to the required standard

[redacted]
Dr. Geraldine A. Allen, Co-Supervisor (Department of Biology)

[redacted]
Dr. Nancy J. Turner, Co-Supervisor (School of Environmental Studies)

[redacted]
Dr. Don S. Eastman, Departmental Member (Department of Biology)

[redacted]
Dr. Nan C. Vance, External Examiner (Dept. of Forest Science, Oregon State University)

Co-Supervisors: Drs. Geraldine A. Allen and Nancy J. Turner

ABSTACT

Devil's club (*Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq.) has recently become an important non-timber forest product (NTFP) harvested from the understory of temperate forests in western North America. This research focuses on several aspects of the population ecology and ethnobotany of devil's club as a means of addressing ecological and cultural concerns associated with this harvesting.

To provide additional autecological data and investigate the importance of clonal reproduction in population persistence, I sampled populations of devil's club in three classes of forest stand development. A number of population characteristics examined were significantly ($P < 0.05$) related to stand development class. Sexual recruitment appears to be un-important in existing devil's club populations, which are maintained in the early stages of forest succession by stem sprouting following disturbance and continual layering and clonal fragmentation.

To examine the cultural significance of devil's club, to assess the potential of traditional harvesting practices in developing sustainable management approaches and to explore potential cultural concerns associated with harvesting I reviewed the literature and conducted interviews with several knowledgeable plant specialists. Traditional knowledge of specific practices and cultural protocols associated with harvesting and use has significant potential to aid in the development of management practices. However, the depth of the cultural significance of this plant, evidenced by data on traditional use and cultural significance, make it unlikely that commercialization itself is compatible with the cultural importance of this plant.

To assess potential population level impacts of various harvesting intensities on devil's club, and to test the hypothesis that specific traditional management practices can aid in developing harvesting guidelines, I established six replicates of three experimental harvesting treatments and a control. Post harvest data in the most intense treatment indicates that harvesting practices removing large portions of decumbent stem and roots are detrimental to long-term population maintenance. Such practices deplete the bud bank, hindering regeneration and recruitment. Data from treatments emulating traditional harvesting practices, including selective harvesting and stem replanting, suggest that harvesting practices ensuring the maintenance of a functional bud bank are more conducive to long term sustainability and provide additional evidence that traditional knowledge, associated with specific harvesting practices, is integral to efforts to responsibly manage NTFPs.

Examiners:

[redacted]

Dr. Geraldine A. Allen, Co-Supervisor (Department of Biology)

[redacted]

Dr. Nancy J. Turner, Co-Supervisor (School of Environmental Studies)

[redacted]

Dr. Don S. Eastman, Departmental Member (Department of Biology)

[redacted]

Dr. Nan C. Vance, External Examiner (Dept. of Forest Science, Oregon State University)

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DEDICATION

For mom and dad, my greatest teachers.

CHAPTER 1. INTRODUCTION

> *"I'm afraid that if we do not really look at this situation the devil's club ... It's too precious a plant to just let it disappear"* Dr. Mary Thomas, Secwepemc Elder and Plant Specialist.

Overview

Devil's club (*Oplopanax horridus*) is a spiny, understory shrub common on moist, well-drained sites in forested ecosystems across northwestern North America (Howard 1993; Klinka et al. 1989). It is one of the most culturally significant plants to the First Peoples that live within its range, and is used medicinally to treat a variety of ailments and in a number of spiritual capacities, to purify, protect and cleanse (Turner 1982).

Recently, interest in devil's club as a medicinal Non-Timber Forest Product (NTFP) that is wild-harvested for the herbal, pharmaceutical, and nutraceutical industries has increased (Wills and Lipsey 1999). A shrub whose habitat is already declining in the face of industrial logging (Small and Catling 1999), devil's club may also be susceptible to over-harvesting of the commercially valuable roots and decumbent stems. However, since much of the autecological data for devil's club is descriptive, and information on its population ecology limited, it is difficult to predict what impact intensifying extraction will have on populations of this plant.

Given the cultural importance of devil's club, large scale commercial harvesting, and population declines associated with logging are also of great concern to First Peoples (Lantz 2001). Since the commercial use of devil's club has been driven largely by traditional medicinal knowledge of this plant, intellectual property rights and the cultural appropriateness of the commercialization of a plant of extreme cultural significance are also issues that need to be addressed.

The aims of the research described in the following chapters are to: (1) provide additional data on the autecology and population ecology of devil's club in order to better predict the population-level responses to harvesting; (2) examine the traditional uses and cultural significance of devil's club; (3) assess specific techniques and cultural protocols associated with devil's club harvesting for the development of sustainable harvesting practices; (4) explore potential cultural concerns associated with commercialization; and (5) experimentally evaluate the population-level impacts of different harvesting techniques and intensities.

The remainder of this chapter provides some background information on the taxonomy, nomenclature, distribution, morphology, and phenology of devil's club. Chapter two focuses on devil's club clonal structure, growth and development, and population ecology. Chapter three discusses the traditional use and cultural importance of devil's club in the context of commercialization and potential cultural conflicts. Chapter four contains the results and conclusions from devil's club experimental harvesting trials. Chapter five provides a synthesis and discussion of the data presented in the preceding three chapters, in light of the ecological and cultural concerns associated with commercial harvesting.

Taxonomy and Nomenclature

Devil's club is a member of the Araliaceae, or ginseng family. This family includes approximately 70 genera and 700 to 900 species, with its center of diversity, and probable place of origin, in southeast Asia (Cronquist 1981; Zhuralev and Kolyada 1996). Traditionally, the Araliaceae has been most closely aligned with the Apiaceae (carrot family), both of which are commonly placed in a single order within the subclass Rosidae (Cronquist 1981; Takkhtajan 1987). However, recent molecular data have strongly suggested that the Araliaceae should be included in the Apiaceae, and that both belong within an expanded Asteridae (Plunkett et al. 1996, 1997). Cronquist (1988) notes that this family's most distinctive ecological adaptation is its means of 'chemical warfare,' and the production of secondary metabolites including: monoterpenes, sesquiterpenes, triterpenoid saponins, polyacetylenes, and phenyl propanoids. Not surprisingly, the Araliaceae contains a number of familiar medicinals including: Korean or Chinese ginseng (*Panax ginseng* Meyer), American ginseng (*P. quinquefolius* L.), eleuthero (*Eleutherococcus senticosus* Maxim.), and wild sarsaparilla (*Aralia nudicaulis* L.).

The genus *Oplopanax* Torr. & A. Gray ex. Miq. is made up of three species: *Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq. from North America, *Oplopanax elatus* Nakai in Russia, Korea, and China, and *Oplopanax japonicus* (Nakai) Nakai in Japan. Although some authors (Hultén 1968; Scoggan 1979) consider all three as subspecies of *Oplopanax horridus*, most regard them as distinct species (Hitchcock et al. 1973; Ohwi 1965; Skiskin 1950; Voss 1929).

Devil's club was first described in 1819 by J.E. Smith as *Panax horridum* Sm. based on a type from Nootka Sound on Vancouver Island. In 1844, Decaisne and Planchon created the genus *Echinopanax* Decne. & Planch to establish Smith's 1819 type as distinct from *Panax* L. The genus *Oplopanax* Torr. & A. Gray ex. Miq., in common usage today, also based on this type, was not established until 1863. However, since Miquel's *Oplopanax* was based on Torrey and Gray's earlier (1840) subgeneric name Oplopanax, this name is generally accepted as having precedence. Technically though, since the International Code of Botanical Nomenclature stipulates that taxa never take precedence outside their own rank, the earliest, and thus legitimate, name is *Echinopanax,* as it has been treated by Hultén (1968) and Shiskin (1950).

Taxonomic synonyms of devil's club include *Echinopanax horridus* (Sm.) Decne. & Planch, ex. H.A.T. Harms, *Fatsia horrida* (Sm.) Benth. & Hook, *Panax horridum* Sm., *Riconophyllum horridum* (Sm.) A. Nelson & Macbride, and *Aralia erinacea* Hook. The specific epithet for devil's club has also commonly been spelled as *horridum*, to accord when the generic names *Oplopanax* or *Echinopanax* are treated as neuter. However, since *panax* is masculine in both Latin and Greek, to avoid further confusion the International Code of Botanical Nomenclature stipulated that all generic names ending in *panax* be treated as masculine (*horridus*), irrespective of the manner in which they were originally treated.

Geographic Distribution and Ecology

Devil's club is found from coastal Alaska southward to the mid Oregon Coast Range and Cascade Mountains, and eastward to the southwestern Yukon, the Canadian Rockies, Montana and Idaho. Devil's club has also been collected at a number of localities in northwestern Alberta (Moss 1985), and several disjunct populations of devil's club also occur on Isle Royale, Porphry Island, and the Slate Islands, in northwestern Lake Superior (Fig. 1.1).

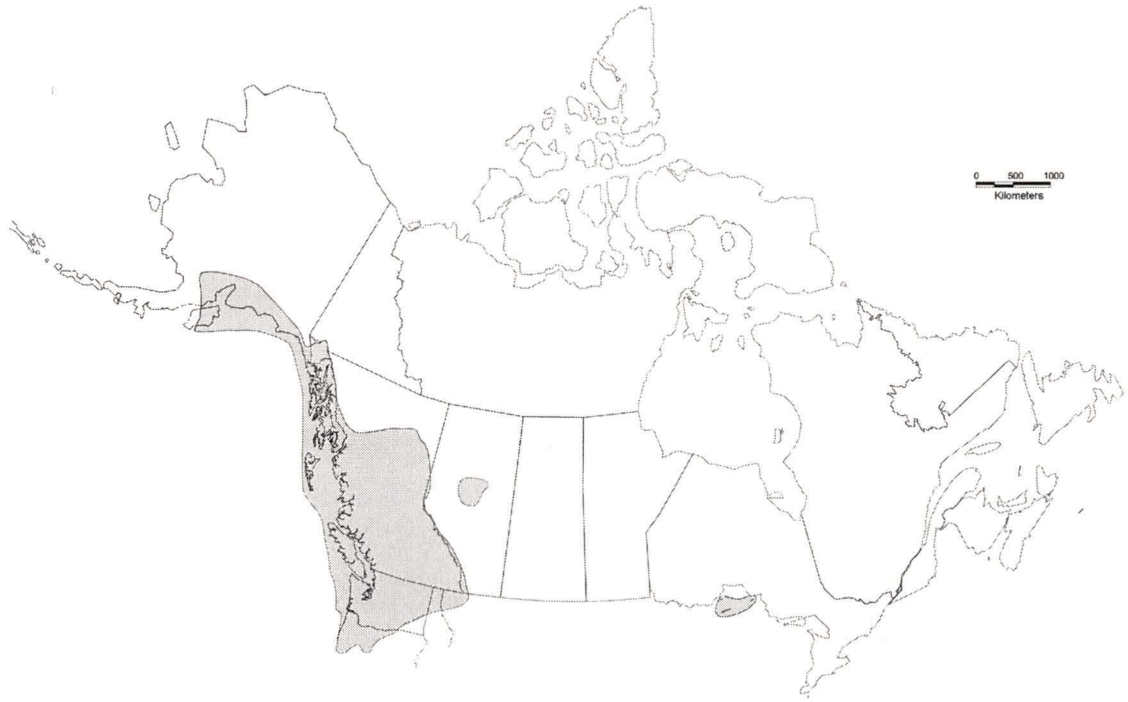


Figure 1.1. Geographic distribution of devil's club (*Oplopanax horridus* (Sm.) Torr. and A. Gray ex. Miq.). Map is based on data from: Booth and Wright (1959); Cody (1996); Hultén (1968); Moss (1985); Scoggan (1979); N. Vance, (pers. comm. 2001), W.H. Parker (pers. comm. 2001), and D. Fabijan (pers.comm 2001).

Throughout this region, devil's club can be found in a number of forest types (see Howard 1993), with its abundance generally increasing with higher precipitation and continentality (Klinka et al. 1989). It is a common member of the understory on moist to wet, well-drained soils along stream edges, floodplains and seepage sites (Klinka et al. 1989; Howard 1993). Devil's club is considered shade tolerant (Howard 1993; Klinka et al. 1989), and on nutrient rich sites can be quite dominant, but also commonly occurs in a mixed understory.

Figure 1.2 Large maple-shaped leaves of devil's club, long petioles and terminal infructescence of ripening berries. Photo: R.D. Turner.

Morphology and Phenology

An erect to sprawling deciduous shrub, devil's club can reach heights exceeding 5 meters (Fig. 1.3). Its thick woody stems typically bear a single crown of large (20-50cm) palmately lobed leaves, with irregularly toothed margins (Figs 1.2-1.3). These maple-shaped leaves are borne on long basally swollen petioles, and begin to emerge in late May to early June (Figs. 1.3a-1.3b). Devil's club is perhaps most infamous because of the stiff slender spines that cover the stems, leaf petioles and abaxial leaf surfaces, which according to Anderson (1937: 89) "behoove one to be wary" (Fig. 1.3a). Once they have entered skin, these spines can fester and cause severe discomfort for several weeks. Apparently, while building the transcontinental railway that brought British Columbia into confederation, the Canadian Pacific Railway changed the route several times in order to avoid "virtually impenetrable large patches" of devil's club (Small and Catling 1999: 106).

Figure 1.3 Morpological features of devil's club (left to right). **Figure 1.3a** Terminal crowns of emerging leaves, note spines on stem, leaves and petioles. **Figure 1.3b** Understory dominated by large upright stems of devil's club, note yellow raincoat-clad field assistant (C. Jacobsen) at the base of the tallest stem. **Figure 1.3c** Single umbel covered in small brown beetle pollinators and single larger Cerambycid beetle; note greenish corolla and inflexed stamens of individual flowers. Photo: Markku Savela.

Devil's club inflorescences are terminal umbelliferous racemes (Fig. 1.2). Individual flowers are small (5-6mm) and made up of a greenish white corolla of 5 petals (Fig. 1.3c). Flowers can be perfect, consisting of 5 inflexed stamens and two central stigmas, but are also commonly staminate (Fig. 1.3c). On Western Vancouver Island, flowering occurs in late July. Pollination appears to be carried out by beetles at the time of anther dehiscence, when virtually every inflorescence is covered in a small species of brownish beetle (Fig. 1.3c). Flattened berries with persistent style tips ripen to bright scarlet in late August (Fig. 1.2).

CHAPTER 2. CLONAL EXPANSION AND PERSISTENCE OF DEVIL'S CLUB DURING FOREST SUCESSION

Abstract

To examine clonal development and the ability of devil's club (*Oplopanax horridus*) to persist throughout stages of forest succession, I sampled populations in three classes of stand development: clearcuts (1-10 years old), young stands (11-50 years old), and maturing stands (51-200$^+$ years old). I completely excavated and mapped all clonal fragments in a plot at each site, and determined ramet and clonal fragment age using annual growth rings on stem cross sections. Clonal fragment density and size, ramet density and age, decumbent stem length, annual stem elongation, annual ramet recruitment, lateral meristem formation and the number of persistent dead ramets were significantly ($P < 0.05$) related to stand development class. Clonal fragments in clearcuts were large, predating the year of stand establishment, with many dead, old ramets, but many young stems. Ramet recruitment and lateral meristem formation were highest in clearcuts, which contributed to replacement of older ramets lost to the disturbance. Clonal fragments in young stands were few and small, consisting of a few ramets and short decumbent stems. In maturing stands, clonal fragments were numerous, but consisted of few ramets with extensive decumbent stem connections. No devil's club seedlings were observed in any of the stands sampled. Recruitment via seed appears to be unimportant in devil's club populations, which are maintained by prolific basal stem sprouting following disturbance and continual layering and clonal fragmentation throughout stand development.

" ... Behold! there was a devil's club tree larger than any other tree in the whole world. He [the son of devil's club] took his stone axe and felled the great devil's club tree; and after it was down, he took all the sap and bark; and ... he carried it to his town ... then he started to wash his body with the bark of the devil's club and its sap, and he ate some to purify himself. He did so for forty days ..." Excerpt from a Tsimshian Myth recorded by F. Boas (1916: 175).

Introduction

In many forested ecosystems, understory shrubs form an important component of the plant community, contributing to forest structure, nutrient cycling, soil stabilization, and provision of food and cover for wildlife (Balogh and Grigal 1988; Perry et al. 1987; Tappeiner and Alaback 1989). Many understory shrubs also have a long history of use by First Peoples for foods, medicines, and materials (Turner 1995, 1997, 1998b). Recently, many of these species have become economically important as Non-timber Forest Products (NTFPs) (De Geus 1995; Mitchell 1998; Wills and Lipsey 1999). Thus although forest-understory shrubs are critical components of forest ecosystems, very little is known about the ecology of most species. The economic, cultural, and ecological importance of many of these understory species, once considered primarily as silvicultural weeds (Haeussler and Coates 1986), necessitates study of their autecology, population dynamics and response to forest management.

Many understory shrub species of coastal temperate forests of western North America can persist in all stages of forest development after logging or other disturbances, from stand initiation through canopy closure, stem exclusion and self-thinning stages to climax forest. Many of these species qualitatively classified as shade tolerant (Haeussler et al. 1990; Klinka et al. 1989), once established, can survive under low light levels. However, because seedling establishment and survival in the low light environments of closed canopy forests is uncommon for many clonal species (Cook 1979, 1983; Eriksson 1989, 1993; Tappeiner and Alaback 1989; Tappeiner and Zasada, 1993), vegetative production of new ramets (via root suckering, rhizome extensions, basal-stem sprouting and layering) represents an important way of ensuring population persistence (Huffman et al. 1994; O'Dea et al. 1995; Tappeiner et al. 1991).

Clonal expansion is typical of forest understory plants, including both shrubs and herbs, and may be critical to their survival. In coniferous forests of western North America, understory plants vary greatly in growth form, but most are clonal and many can maintain large clonal fragments (Antos 1988; Antos and Zobel 1984; Huffman and Tappeiner 1997; Lezberg et al. 1999; Tappeiner and Alaback 1989; Tappeiner et al. 1991). Clonal expansion places ramets in new locations, which allows exploration of patches with favourable resources without the difficulties associated with seedling establishment (Hutchings and de Kroon 1994). Furthermore, the maintenance of large clonal fragments (systems of interconnected ramets) can contribute to resource integration in the spatially heterogeneous forest understory (Jonsdottir and Watson 1997; Pitkella and Ashmun 1985). However, the growth of long rhizomes or stolons and the maintenance of connections among ramets require resources and may not necessarily be advantageous in low resource environments (Jonsdottir and Watson 1997; Stuefer et al. 1996), such as dense forest understories.

Characteristics of clonal expansion are thus likely to vary considerably in relation to the major changes in environment occurring during forest succession. However, few studies have addressed how characteristics of clonal development are altered as stands develop (e.g., Cain and Damman 1997; Lezberg et al. *in press*; Tappeiner and Alaback 1989). These studies indicate substantial changes in clonal development and the characteristics of clonal fragments during succession, suggesting that a key feature of clonal development is the flexibility it allows for growth in the variable forest understory and for coping with the drastic environmental changes occurring during disturbance-succession cycles. One possibility is that clonal development is not so much an asset to survival during especially adverse periods, but rather a means by which new ramets can be rapidly produced when conditions improve (Lezberg et al. *in press*). However, there is inadequate information about changes in clonal development during stand development to effectively generalize; more case studies are needed.

Devil's club (*Oplopanax horridus*) is an understory shrub that ranges from coastal Alaska southward to central Oregon, and eastward to the south-western Yukon, the Canadian Rockies, Montana and Idaho (Scoggan 1979). Devil's club is common in semi-open forests on moist to wet, well-drained soils along stream edges, on floodplains and in seepage sites (Klinka et al. 1989; Howard 1993). Across its range, devil's club occurs in the understory of many forest types, most commonly under canopies of western redcedar (*Thuja plicata* Donn.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), red alder (*Alnus rubra* Bong.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.), and amabilis fir (*Abies amabilis* (Dougl.) Forbes) (Howard 1993; Green and Klinka 1994). Where devil's club occurs, it often dominates the shrub layer, but also commonly grows in mixtures with other shrubs, including salmonberry (*Rubus spectabilis* Pursh), red elderberry (*Sambucus racemosa* L.), red huckleberry (*Vaccinium parvifolium* Smith), oval-leaved blueberry (*V. ovalifolium* Smith), Alaska blueberry (*V. alaskense* Howell), salal (*Gaultheria shallon* Pursh), and thimbleberry (*Rubus parviflorus* Nutt.) (Green and Klinka 1994; Howard 1993).

Devil's club is considered shade tolerant (Howard 1993; Klinka et al. 1989), and in mature forest it recruits additional ramets through basal stem sprouting, and expands clonally by layering (Howard 1993; Roorbach 1999; Small and Catling 1999). However, information on devil's club's response to clearcutting and its ability to persist throughout stand development is largely descriptive. Moreover, reports are often conflicting, and include suggestions that it is an obligate climax species intolerant of canopy removal (Howard 1993; Mason 1989), that it is reduced in cover and constancy in clearcuts (Eis 1981; Hamilton and Yearsley 1988; Roorbach 1999), but also that it can thrive on clearcut sites (Alaback 1986; Burton et al. 1998).

One of the culturally important plants, both medicinally and spiritually, to the First Peoples who that live within its range (Gottesfeld-Johnson 1992; Turner 1982), recently devil's club has emerged as a medicinal NTFP marketed by the herbal and nutraceutical industries (Lantz 2001; Wills and Lispey 1999). The potential for commercial overharvesting of devil's club and habitat destruction associated with industrial logging have raised concerns regarding their potential impact on devil's club populations (Lantz 2001; Small and Catling 1999).

Consequently, ecological studies of devil's club are urgently needed to help assess the potential for negative effects of harvesting and forest management on this species. The primary goal of this study is to examine change in clonal structure and growth of devil's club during forest development following clearcut logging. Specific objectives include determining: (1) the size and age structure of clonal fragments at different stages of forest development, (2) characteristics and rates of clonal expansion, (3) size distributions, growth rates and ages of ramets, and (4) if and when seedlings are important in contributing to population persistence.

Materials and Methods

Study Sites

For this study I selected 34 sites on southern Vancouver Island (Fig. 2.1; Table 2.1) representing three stages of forest stand development: (1) clearcuts (1-10 years old), (2) young stands (11-50 years old) and (3) maturing stands (51-200$^+$ years old). Stand ages were obtained from forest cover maps (1: 20 000) using the date of stand establishment after clearcutting. For several young and maturing stands the date of stand establishment given on the timber company's maps was verified by coring several trees in the stand and counting annual growth rings. Stands were located in the very dry maritime (CWHxm), moist maritime (CWHmm), very wet maritime (CWHvm) and very wet hypermaritime (CWHvh) subzones of the coastal western hemlock biogeoglimatic zone (Green and Klinka 1994). This zone has a mean annual temperature of approximately 8°C and a high annual rainfall of approximately 2200 mm (Pojar et al. 1991). In young and maturing stands, the overstory included western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), red alder (*Alnus rubra*), Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco), big-leaf maple (*Acer macrophyllum* Pursh), and amabilis fir (*Abies amabilis*). Canopy closure (measured using a spherical densiometer and averaging two readings taken at the centre of the plot) averaged 84.5 percent in maturing stands and 83.6 percent in young stands. In contrast, clearcuts, which had been recently restocked with conifers, had open canopies averaging 7.3 percent closure (Table 2.1).

All sampling occurred in stands at low-mid elevations on sites that were in close proximity to creeks or in seepage areas. Common understory species in young

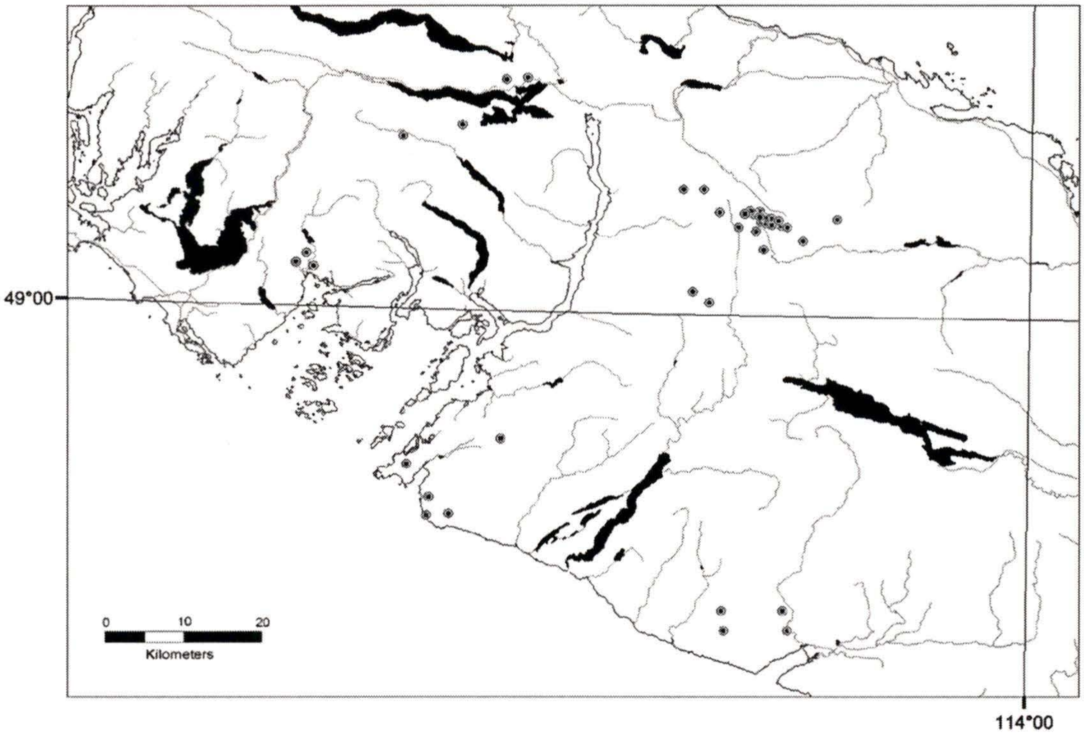


Figure 2.1 Location of stands sampled for *Oplopanax horridus* populations (black dots) on southern Vancouver Island.

and maturing stands included salmonberry (*Rubus spectabilis*), sword fern (*Polystichum munitum* (Kaulf.) Presl.), Alaska blueberry (*Vaccinium alaskense*), spiny wood fern (*Dryopteris expansa* (Presl.) Fraser-Jenikins & Jermy), vanilla leaf (*Achlys triphylla* (Smith) DC.), and false bugbane (*Trautvetteria caroliniensis* (Walt.) Vail). Clearcuts had many of the same species, but were characterized by the presence of early seral and dry-site indicator species (Klinka et al. 1989), including trailing blackberry (*Rubus ursinus* Cham. & Schlecht.), and fireweed (*Epilobium angustifolium* L.). Soils were characterized by digging a soil pit at each site using the methodology outlined by Green and Klinka (1994). Soils in all stands were rich to very rich humoferric podzols with moder or mull humus forms, and were mesic to subhygric. Sites on medium bench floodplains typically had less developed organic horizons.

Table 2.1 Characteristics of overstory stands sampled for *Oplopanax horridus* populations.

STAND TYPE	STAND AGE	DOMINANT OVERSTORY SPECIES	BIOGEO-CLIMATIC UNIT	CANOPY CLOSURE (%)
Maturing stands	58	Alder, Hemlock	CWHmm2	75
	58	Alder, Cedar	CWHmm2	81
	58	Hemlock, Alder	CWHmm2	81
	58	Alder, Hemlock	CWHmm2	84
	58	Alder, Cedar	CWHmm2	91
	58	Hemlock, Douglas-fir	CWHmm2	92
	60	Alder, Cedar	CWHxm2	71
	74	Cedar	CWHmm2	74
	74	Alder, Cedar	CWHmm2	79
	74	Hemlock, Alder	CWHmm2	80
	74	Alder, Cedar	CWHmm2	84
	74	Hemlock, Cedar	CWHmm2	96
	200^+	Cedar, Hemlock	CWHvm1	77
	200^+	Maple, Alder	CWHvm1	88
	200^+	Cedar, Hemlock	CWHvm1	96
	200^+	Maple, Alder	CWHvm1	96
Young stands	14	Alder, Hemlock	CWHvh1	95
	19	Cedar	CWHvm1	86
	19	Alder, Hemlock	CWHvm1	94
	21	Alder, Hemlock	CWHvh1	75
	36	Alder, Cedar	CWHmm2	70
	37	Douglas-fir, Hemlock	CWHvh1	91
	37	Cedar, Alder	CWHxm2	92
	38	Cedar, Alder	CWHvh1	39
	38	Hemlock, Fir	CWHmm2	98
	39	Alder, Cedar	CWHvh1	76
	40	Fir, Cedar	CWHvh1	98
	49	Douglas-fir, Alder	CWHxm1	88
Clearcuts	3	/	CWHmm2	0
	3	/	CWHmm2	5
	3	/	CWHxm2	37
	6	/	CWHvm1	0
	6	/	CWHvm1	0
	7	/	CWHmm2	1

Ramet and Clonal Fragment Sampling

From April to August 2000 and April to May 2001, I mapped a randomly selected a patch of devil's club in each stand using a 16m^2 quadrat with an internal grid of 0.5m. In each quadrat, I mapped the location of each ramet, the interconnections among ramets, and the spatial distribution of all clonal fragments. Clonal fragments were mapped by selecting a ramet, removing the soil around it and tracing its connections to other ramets, inside and outside the plot, until reaching the end of a given clonal fragment, sometimes well outside of the quadrat. In most cases it was impossible to determine if a system of connected stems contained a seedling source, and thus was a genet, or whether it was a clonal fragment of a larger, and likely much older, genet that had fragmented. Thus I classified them as clonal fragments, which I define here as 'aggregations of aerial stems (ramets) interconnected by a common system of rooted decumbent stems and not obviously connected to other clonal fragments.' Ramets are defined here as rooted, and thus potentially physiologically independent, stems attached to a clonal fragment.

To age the plants I collected stem sections at all below-ground branch points within each clonal fragment and counted annual growth rings on the dried and sanded stem discs. For all clonal fragments and associated ramets I obtained: (1) the size (height and basal diameter) of each ramet, (2) ramet condition class (upright, partially decumbent, or dead), (3) lengths of the last three annual stem increments (using terminal bud scale scars) for each ramet, (4) the number of ramets per clonal fragment, (5) the number of new ramets (rooted vegetative shoots < 2 years old, attached to an existent clonal fragment), (6) the number of lateral meristems per ramet, and (7) the age of all ramets and clonal fragments. I also determined ramet and clonal fragment density and the number of seedlings in each plot. I digitized field maps using OCAD (Steinegger 1999) and estimated the length of the decumbent stem network for each clonal fragment based on these maps.

Data Analysis

I used one way analysis of variance and Hochberg's GT2 method for multiple comparisons among groups with unequal sample sizes (Sokal and Rohlf 1995) to test the null hypothesis that stand class had no effect on clonal fragment density, clonal fragment age, ramet density, ramet age, the number of lateral meristems per ramet, ramet annual growth increment, decumbent stem length, number of ramets per clonal fragment, vegetative ramet recruitment, and the number of dead ramets per clonal fragment. All pair-wise comparisons between stand types are based on means of plot characteristics. To normalize the distribution and improve homogeneity of variances, clonal fragment density, the number of ramets per clonal fragment, the number of lateral meristems per clonal fragment, and decumbent stem length were log transformed. Additionally, to explore the relationship between stand age and several ramet characters, including ramet age, number of ramets recruited/m^2, and the number of dead ramets per clonal fragment, I used regression analysis. Regression lines were fit using residual analysis and coefficients of determination (Sokal and Rohlf, 1995). Inverse functions were chosen because in all cases they displayed the best fit to the data.

Results

Patterns Clonal Structure and Expansion

Devil's club populations throughout all stages of stand development were characterized by clonal fragments of various sizes, but seedlings were absent. Although seed was produced in all stand types, no seedlings were observed in any of the stands, or at any location over the course of two field seasons. Thus clonal development appears to be of primary importance in population maintenance.

Individual clonal fragments were made up of various numbers of ramets interconnected by a branching network of rooted decumbent stems (Fig. 2.2). For example, one clonal fragment in a maturing stand was 36 years old and consisted of 6 ramets interconnected by a network of decumbent stems that extended for 3.1 meters (Fig. 2.2c). Stems of individual ramets varied in growth habit from upright, through partially decumbent, to decumbent, but unrooted. Clonal expansion in devil's club occurs through layering as upright stems become horizontal and produce adventitious roots along their axes, and attached branches become potentially physiologically independent (Fig. 2.3). Additional recruitment of ramets can also occur through sprouting from decumbent stems. Most rooted, decumbent stems were shallowly buried in the upper soil horizons, often only lightly covered in duff and moss. In some cases when I excavated decumbent stems I found rotting, but persistent portions of decumbent stem, which provide evidence of a former connection between adjacent clonal fragments (Fig. 2.2c). However, it is likely that these represent only the most recent former connections.

Figure 2.2 Sample plot maps from *Oplopanax horridus* populations characteristic of the 3 stand types sampled: (a) Clearcuts (1-10 years old), (b) Young stands (11-50 years old) and, (c) Maturing stands (51-200$^+$ years old). Maps show ramets (solid black lines) of a clonal fragment attached through a common network of decumbent stems (hatched black lines). Doubly hatched lines accompanied by numbers indicate points along decumbent stems of new ramet recruitment. Clonal fragments connected to other clonal fragments at some time in the past are indicated by a dotted line connecting them. The age of the oldest portion of a clonal fragment is shown inside a black circle. Ramets are indicated by white circles at their distal end; the ages of live ramets are given inside the circle; dead ramets are indicated by a "D" inside the circle. Scale bar = 1 meter.

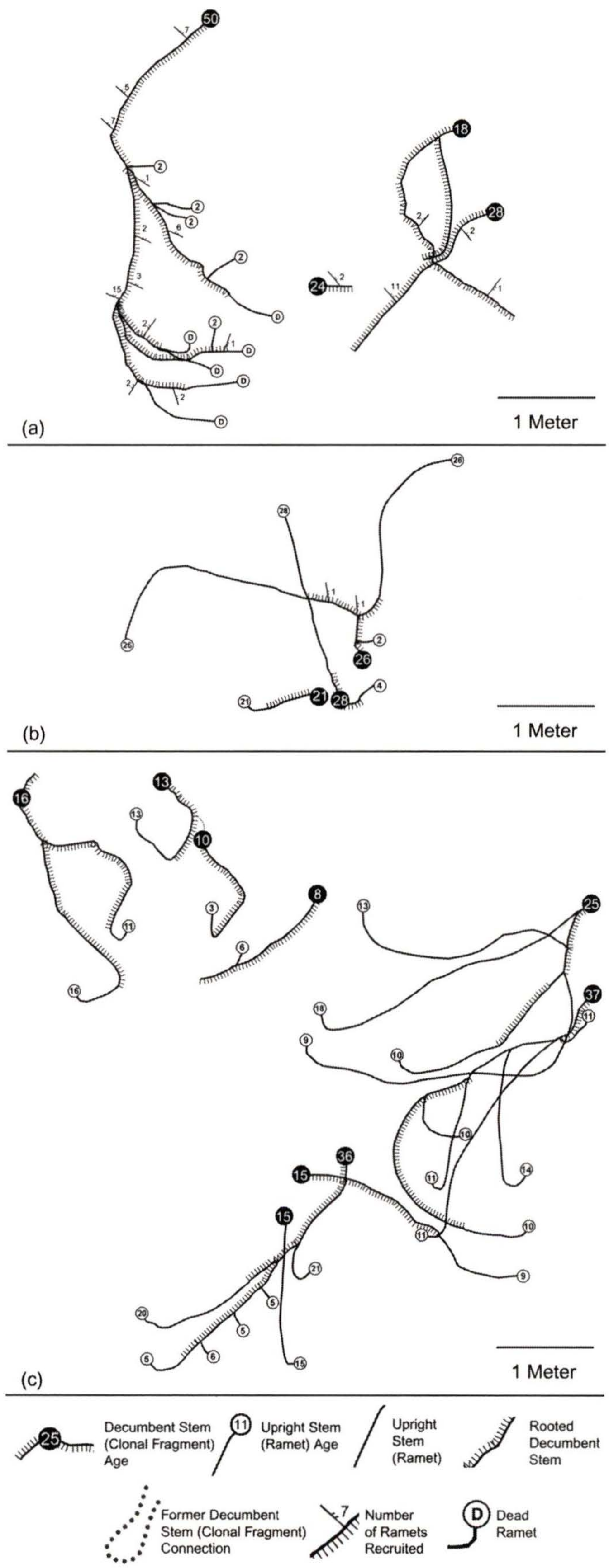

(a)
1 Meter
(b)
1 Meter
(c)
1 Meter
Decumbent Stem (Clonal Fragment) Age
Upright Stem (Ramet) Age
Upright Stem (Ramet)
Rooted Decumbent Stem
Former Decumbent Stem (Clonal Fragment) Connection
Number of Ramets Recruited
Dead Ramet

Figure 2.3 Vegetative reproduction by layering in devil's club (*Oplopanax horridus*). Line drawings prepared by Catherine Jacobsen.

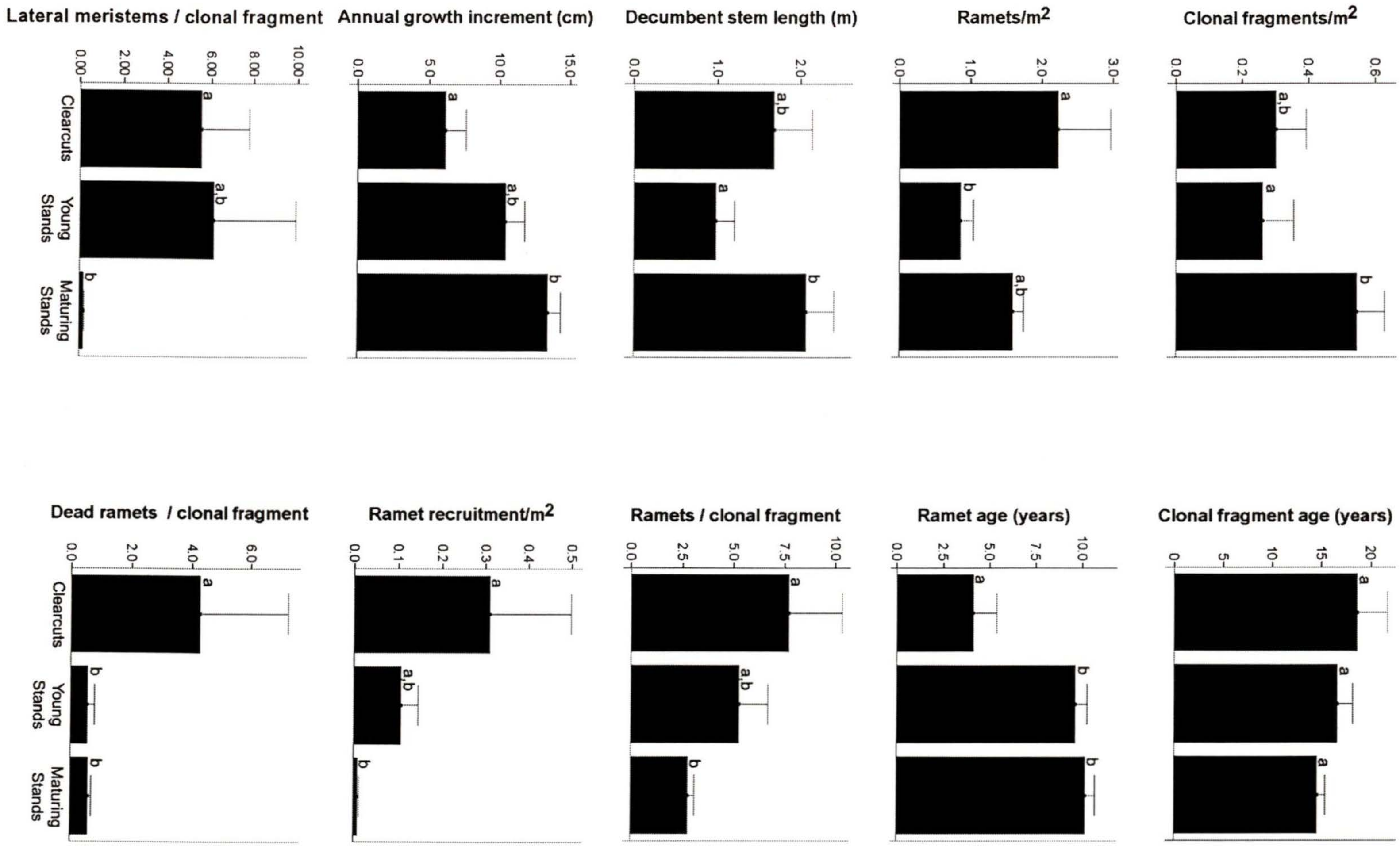
Clonal structure of devil's club populations differed among the stages of stand development (Fig. 2.2). In clearcuts (1-10 years) clonal fragments were large and extensive, with a mean decumbent stem network of 1.7 m and an average of 7.7 ramets per clonal fragment, and consistently predated the year of stand establishment (Fig. 2.2a). However, many of the individual ramets making up these clonal fragments were either dead, or quite young, and rooted decumbent stems tended to show prolific sprouting (ramet recruitment) along their axes (Fig. 2.2a). Leaves in clearcuts also tended to be smaller, lighter green (sometimes yellowing), more strongly angled, and more cup-shaped than those in more shaded conditions. Roorbach (1999) made similar observations of devil's club leaf morphology in high and low light conditions in Oregon. Clonal fragments in young stands (10-50 years) were smaller, consisted of fewer dead ramets, and showed less ramet recruitment than those in clearcuts (Fig. 2.2b). In maturing stands, clonal fragments were similar in size to those in clearcuts, but there were few dead ramets and little ramet recruitment (Fig. 2.2c).

Clonal Fragment Characteristics

Clonal characteristics of devil's club populations differed among stages of stand development (Fig. 2.4; Tables 2.2-2.3). Clonal fragment density, ramet density and age, decumbent stem length, the number of ramets per clonal fragment, annual growth, annual recruitment of ramets, axillary bud formation and the number of persistent dead ramets differed significantly ($P < 0.05$) among stand development classes. Clonal fragment densities in clearcuts and young stands were similar and lower than in maturing stands; the difference between young and maturing stands was significant ($P < 0.05$, Fig. 2.4a). Clonal fragments in all three stand types had similar mean ages, ranging from 18.6 years in clearcuts to 14.5 years in maturing stands (Fig. 2.4b). Most (96%) of all individual clonal fragments in clearcuts were older than the date of stand initiation. Ramet density varied considerably among stand types, being highest in clearcuts, lowest in young stands (difference significant at $P < 0.05$) and intermediate in maturing stands (Fig. 2.4c). In clearcuts mean ramet age was less than half the value, and significantly lower ($P < 0.05$), than on the other two stand types (Fig. 2.4d).

Clonal fragments in all three stand types were quite extensive, with a maximum decumbent stem length ranging from 7.7 m in clearcuts to 12.3 m in maturing stands. Mean decumbent stem length was similar in clearcuts and maturing stands, but significantly lower in young stands compared with maturing stands ($P < 0.05$, Fig. 2.4e). Conversely, clonal fragment size (number of ramets) decreased uniformly with increasing stand age (Fig. 2.4f) and was significantly higher ($P < 0.05$) in clearcuts than in maturing stands (Fig 4f).

Figure 2.4 Clonal fragment and ramet characteristics of *Oplopanax horridus* populations in stands representing three different age classes following clearcut logging: (a) clonal fragment density, (b) clonal fragment age, (c) ramet density, (d) ramet age, (e) decumbent stem length per clonal fragment, (f) clonal fragment size (number of ramets), (g) mean annual growth increment, (h) ramet recruitment/m^2, (i) number of lateral meristems per ramet, and (j) number of dead ramets per clonal fragment. Bars represent means for each stand type (n = 6 for clearcuts, n = 12 for young stands, and n = 16 for maturing stands). Error bars are ±1 SE. Bars sharing the same letter are not significantly different ($P \leq 0.05$, ANOVA and Hochberg's GT2).



Lateral meristems / clonal fragment
Annual growth increment (cm)
Decumbent stem length (m)
Ramets/m2
Clonal fragments/m2
Dead ramets / clonal fragment
Ramet recruitment/m2
Ramets / clonal fragment
Ramet age (years)
Clonal fragment age (years)
Clearcuts
Young Stands
Maturing Stands

Table 2.2 Summary statistics for clonal fragment and ramet characteristics of *Oplopanax horridus* populations in stands representing three different age classes following clearcut logging. Means with different superscripted letters are significantly different ($P \leq 0.05$).

Variable	N	Mean	Standard Deviation	Standard Error
Clonal fragments density (number / m^2)				
Clearcuts	6	.30208^{a,b}	.221559	9.04512E-02
Young stands	12	.260417^{a}	.326214	9.41699E-02
Maturing stands	16	.542969^{b}	.334414	8.36035E-02
Clonal fragment age (years)				
Clearcuts	6	18.5729^{a}	7.5281	3.0733
Young stands	12	16.5638^{a}	5.4003	1.5589
Maturing stands	16	14.5477^{a}	3.2099	.8025
Ramets density (number / m^2)				
Clearcuts	6	2.2292^{a}	1.8013	.7354
Young stands	12	.8594^{b}	.6188	.1786
Maturing stands	16	1.5898^{a,b}	.6291	.1573
Ramet age (years)				
Clearcuts	6	9.6325^{a}	2.2563	.6513
Young stands	12	10.1592^{b}	2.0487	.5122
Maturing stands	16	8.9086^{b}	3.1867	.5465
Decumbent stem length (m)				
Clearcuts	6	1.6793^{a,b}	0.462255	0.0036
Young stands	12	0.9765^{a}	0.135702	0.597986
Maturing stands	16	2.0714^{b}	0.01301	0.003067
Annual growth increment (cm)				
Clearcuts	6	6.1188^{a}	3.581262	1.462044
Young stands	12	10.441^{a,b}	4.674120	1.349302
Maturing stands	16	13.455^{b}	3.547980	.886995
Ramet recruitment (number / m^2)				
Clearcuts	6	0.3102^{a}	1.125954	0.0036
Young stands	12	0.1061^{a,b}	0.796476	0.597986
Maturing stands	16	0.0088^{b}	1.351727	0.003067
Lateral meristems / clonal fragment				
Clearcuts	6	5.5332^{a}	5.5565	2.2684
Young stands	12	6.1216^{a,b}	12.5567	3.7860
Maturing stands	16	.1821^{b}	.1997	4.993E-02
Dead ramets / clonal fragment				
Clearcuts	6	4.2579^{a}	7.2564	2.9624
Young stands	12	.5518^{b}	.8077	.2332
Maturing stands	16	.5782^{b}	.4900	.1225

Table 2.3 Anova table for clonal fragment and ramet characteristics of *Oplopanax horridus* populations in stands representing three different age classes following clearcut logging.

Variable	Sum of Squares	df	Mean Square	F	P
[1]Clonal fragments density (number / m²)					
Between groups	6.154E-02	2	3.077E-02	4.221	.024
Within groups	.226	31	7.289E-03		
Total	.287	33			
Clonal fragment age (years)					
Between groups	77.249	2	38.624	1.578	.222
Within groups	758.715	31	24.475		
Total	835.964	33			
Ramets density (number / m²)					
Between groups	8.141	2	4.070	4.784	.015
Within groups	26.373	31	.851		
Total	34.514	33			
Ramet age (years)					
Between groups	168.562	2	84.281	15.687	.000
Within groups	166.550	31	5.373		
Total	335.112	33			
[1]Decumbent stem length (m)					
Between groups	.245	2	.122	3.705	.036
Within groups	1.024	31	3.303E-02		
Total	1.269	33			
[1]Ramets / clonal fragment					
Between groups	.638	2	.319	4.055	.027
Within groups	2.440	31	7.872E-02		
Total	3.079	33			
Annual growth increment (cm)					
Between groups	242.820	2	121.410	7.630	.002
Within groups	493.271	31	15.912		
Total	736.091	33			
Ramet recruitment (number / m²)					
Between groups	.398	2	.199	4.846	.015
Within groups	1.274	31	4.108E-02		
Total	1.672	33			
[1]Lateral meristems / clonal fragment					
Between groups	1.744	2	.872	6.140	.006
Within groups	4.261	30	.142		
Total	6.006	32			
Dead ramets / clonal fragment					
Between groups	67.323	2	33.661	3.808	.033
Within groups	274.053	31	8.840		
Total	341.376	33			

[1] Log Transformed

Several clonal characteristics of devil's club were strongly related to its ability to persist throughout stand development. In clearcuts, clonal fragments produced an average of 0.31 new ramets/m^2, significantly higher ($P < 0.05$) than in maturing stands, where mean recruitment was less than 0.01 ramets/m^2 (Fig. 2.4h). However, mean annual growth increment of ramets was significantly lower in clearcuts than in maturing stands ($P < 0.01$, Fig. 2.4g). The number of lateral meristems per clonal fragment was also significantly higher in clearcuts than in maturing stands ($P < 0.05$, Fig. 2.4i). Mortality, as evidenced by the number of persistent dead ramets per clonal fragment, was significantly higher in clearcuts than in either young or maturing stands ($P < 0.05$, Fig. 2.4j). Although it was not possible to accurately age dead ramets using annual ring counts, the height and basal diameter of persistent dead ramets, at least in clearcuts, dates them to before canopy removal. On some sites, where the disturbance associated with logging was higher, the number of persistent dead stems was undoubtedly an underestimate of ramet mortality.

Clonal fragments in all stands could be quite long-lived (up to 30 years), but most were intermediate in age (Fig. 2.5). The age distribution of clonal fragments in all stands was unimodal with peak abundance between 10 and 20 years (Figs. 2.5a-2.5c). In most cases it was impossible to determine accurately whether clonal fragments were of sexual or vegetative origin. Many of the clonal fragments that I excavated had decumbent stems with either persistent but decaying connections to other stems (20%), or completely decayed interconnections as indicated by the abrupt termination of the broken or decaying ends of rooted decumbent stems (24%). The remaining clonal fragments, although not obviously once connected to other plants, could not be unequivocally classified as genets. Consequently, clonal fragment ages are generally an underestimate of genet age. The age distribution of ramets in clearcuts had an reverse j-shape with a large number of young ramets (Fig. 2.5d), whereas in young stands the age distribution of ramets showed a much more gradual decline with age, and the percentage of ramets in the younger age classes was much reduced (Fig. 2.5e). In maturing stands the ramet age distribution was unimodal (Fig. 2.5f). In all stands, clonal fragments were small, with half or more consisting of only one ramet. The distribution of clonal fragment size (number of ramets) resembled an reverse j-shaped distribution with very few clonal fragments having > 5 ramets (Figs. 2.5g-2.5i).

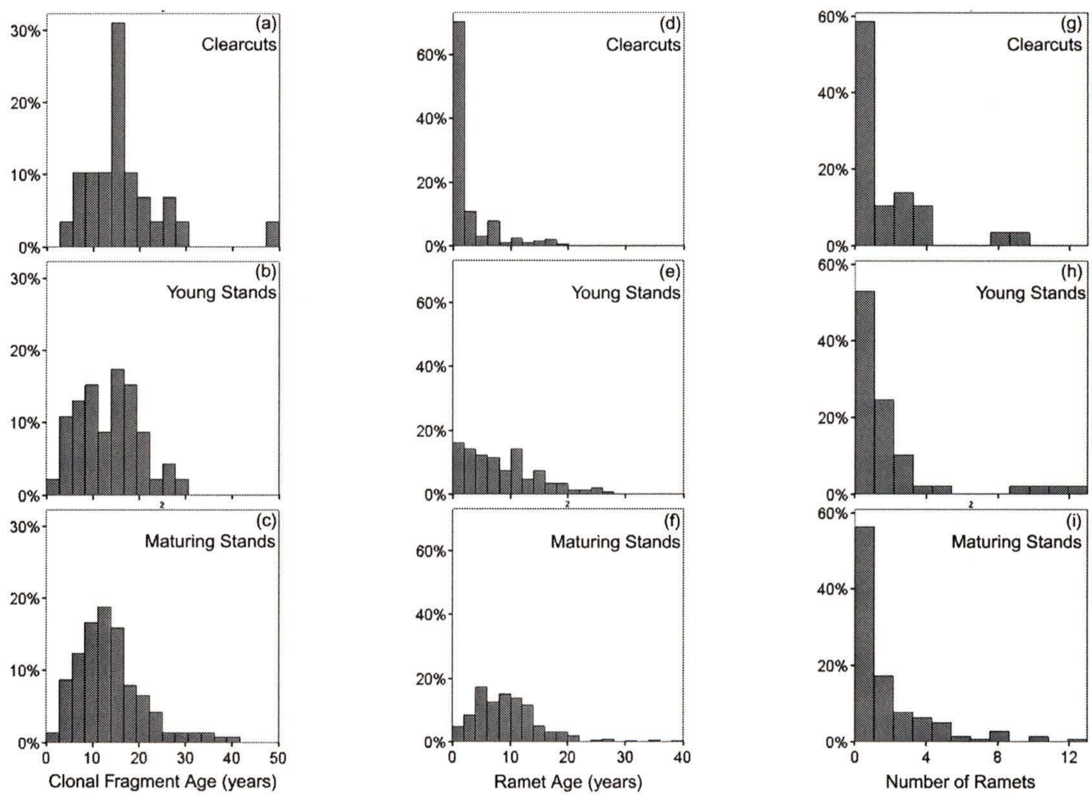


Figure 2.5 For *Oplopanax horridus*, age distribution of clonal fragments in: (a) clearcuts, (b) young stands, and (c) maturing stands; age distribution of ramets in: (d) clearcuts, (e) young stands, and (f) maturing stands; size (number of ramets) distribution of clonal fragments in: (g) clearcuts, (h) young stands, and (i) maturing stands. For a-f, data are percent contribution of each age class. For g-i, data are percent contribution of each size class among all clonal fragments in stands of the given stand type.

Relationship of clonal fragment characters to stand age

Several clonal characteristics were related to stand age; non-linear regressions of stand age (years since stand establishment) with ramet age, ramet recruitment, and the number of dead ramets per clonal fragment (Figs. 2.6 a-2.6c), were statistically significant ($P \leq 0.01$), but weakly supported. Mean ramet age was generally very low in stands < 10 years old, but varied little among older stands. Ramet recruitment averaged highest after cutting, but remained high in a few stands up to 40 years old; it was consistently very low in all stands > 40 years old (Fig. 2.6b, $r^2 = 0.288$). The number of dead ramets per clonal fragment also tended to decrease with stand age (Fig. 2.6c. $r^2 = 0.358$), indicating that after cutting a large number of ramets die. However, their parent clonal fragments appear to survive and initiate a flush of vegetative recruitment.

Discussion

Clonal Expansion and Development

Like many understory shrubs of coastal temperate forests of western North America (Hauessler et al. 1990; Huffman et al. 1994; O'Dea et al. 1995; Tappeiner et al. 1991; Tappeiner and Alaback 1989), devil's club can develop large clonal fragments. These groups of ramets, interconnected by rooted decumbent stems, can be large and persist for many years. One 26-year old clonal fragment that I sampled covered an area of approximately 14 m^2 and consisted of 8 ramets that were interconnected by a 9-meter network of rooted decumbent stems. Much like vine maple (O'Dea et al. 1995), devil's club clones eventually break into smaller fragments, which continue to spread by layering (Fig 2.7).

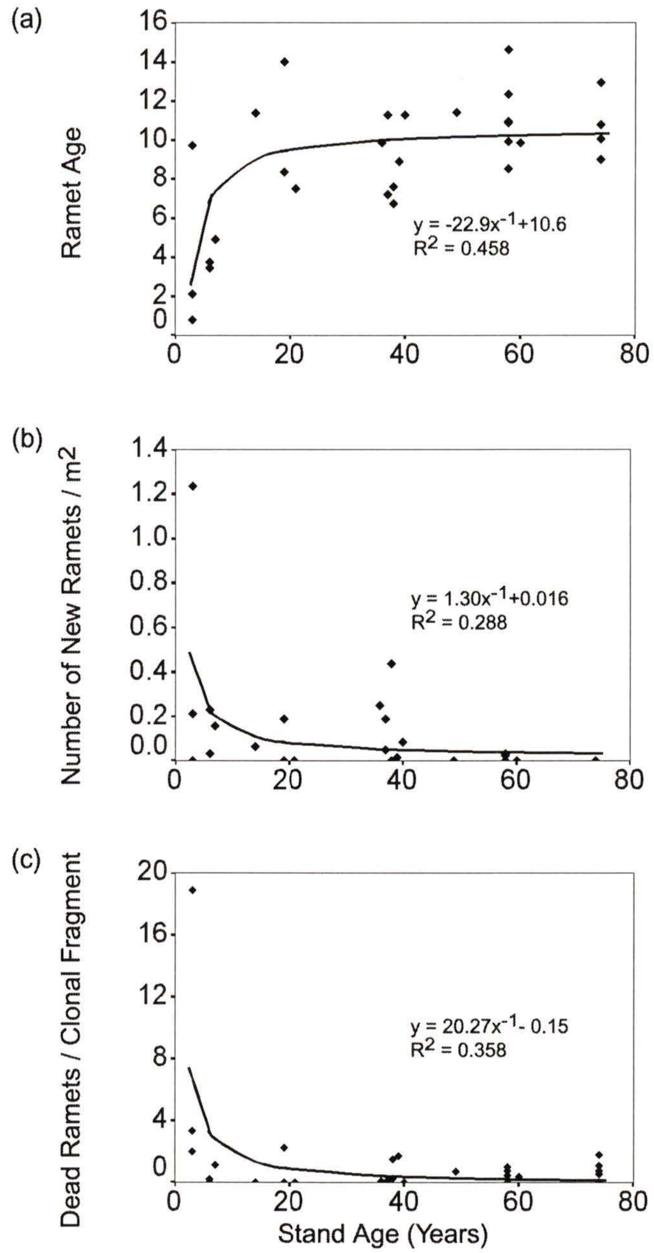


Figure 2.6 Relationship between stand age and selected clonal characteristics of *Oplopanax horridus*: (a) ramet age, (b) ramet recruitment, and (c) dead ramets per clonal fragment. Data points represent means for each stand (stands > 100 years omitted). All regressions are significant at $P \leq 0.005$.

For example, excavation showed that this same 26-year old clonal fragment had been recently connected to an adjacent 30-year old clonal fragment; similar connections were found on 40% of the clonal fragments I excavated. The size distribution of clonal fragments was also consistent with continual clonal fragmentation (Fig. 2.5g-5i). Similarly, the oldest clonal fragments that I excavated were not the largest, but tended to belong to medium or smaller size classes. Because even the oldest clonal fragments that I sampled were probably formerly connected to much older but now absent parts of clones, it was impossible, based on my approach, to identify the size and age of devil's club genets. However, the persistence and formation of new clonal fragments in clearcuts and young stands, the absence of seedling recruitment on these sites, and the similarity in clonal fragment age structure in different stand classes suggest that regeneration following disturbance is vegetative and that genets are much older than my estimates of clonal fragment age.

Reinartz and Popp (1987) characterized two general strategies of clonal development in woody plants: clones whose ramets remain physiologically integrated and connected throughout the life of the clone, and clones whose ramets become separated and physiologically independent about ten years after their formation. Devil's club clonal fragments, which do not persist without fragmentation but also do not fragment into independent ramets, are perhaps best seen as intermediate in this classification. This strategy may be advantageous because it allows devil's club to exploit and integrate resources over the entire area occupied by a clonal fragment (Cook 1983; Hartnett and Bazzaz 1985; Pitelka and Ashmun 1985) while periodic fragmentation spreads the risk of genet mortality amongst separate clonal fragments (Cook 1979, 1983).

Figure 2.7 Layering devil's club stem that has been knocked flat by a red alder branch on a floodplain.

Devil's club clonal fragments are intermediate in size compared to other shrubs occupying similar habitats, such as salmonberry (*Rubus spectabilis*), whose clonal fragments can occupy areas over 50m^2 (Tappeiner et al. 1991), salal (*Gaultheria shallon*), whose clonal fragments can cover 29m^2 (Huffman et al. 1994), vine maple (*Acer circinatum* Pursh), with clonal fragments up to 85m^2 (O'Dea et al. 1995), and black huckleberry (*Vaccinium membranaceum* Dougl.) and Alaska blueberry (*Vaccinium alaskaense*) whose clonal fragments occupy areas of approximately 5m^2 (Minore 1975;

Tappeiner and Alaback 1989). Clonal fragment ages for devil's club are only minimum estimates of genet ages, but compared with shrubs of similar habitats, clonal fragments of devil's club (up to 50 years old) are older than most. Although it is generally equally difficult to estimate the age of other clonal shrubs, some minimum estimates for other species based on clonal fragment ages include: speckled alder (*Alnus incana* ssp. *rugosa* (DuRoi) Clausen), 10-25 years (Huenneke 1987); vine maple (*Acer circinatum*); 40 years (O'Dea et al. 1995); and salal (*Gaultheria shallon*), 25 years (Huffman et al. 1994).

Seedling Recruitment

The lack of evidence of seedling recruitment in any of the plots, or in any of the stands I sampled in this study, in conjunction with the observation that 96% of the clonal fragments in clearcuts were older than the clearcut, suggests that regeneration of devil's club after clearcutting, and potentially after other disturbances, is primarily vegetative. It is not clear whether or not seedling recruitment becomes more important in maintaining populations of devil's club in stands older than those studied. However, the absence of seedlings in all stand development classes sampled and the age distribution of clonal fragments suggests that seedling recruitment does not play an important role in maintaining established populations. Conversely, clonal fragment size distributions (Figs. 2.5g-2.5i) imply that layering and clonal fragmentation contribute to population stability.

However, because I sampled only in established populations, these results do not preclude the possibility that seedling recruitment is important in the establishment of new populations. Devil's club fruit is frequently eaten in large quantities by bears that could transport seed away from existing populations (Pojar and MacKinnon 1994; Small and Catling 1999), and might also contribute to chemical and mechanical breaking of seed dormancy as the fruit passes through their gut. However, in an examination of the germination rates of devil's club seed that had passed through the guts of several vertebrate frugivores, Traveset and Willson (1997) found extremely low (< 0.5% for brown bears) germination rates, which were not significantly different from controls. Additionally, intensive searching in the second field season, not restricted to sample plots, did not reveal any devil's club seedlings, further indicating that establishment of devil's club seedlings occurs rarely. This is supported by the horticultural literature, which indicates that propagation of devil's club from seed can be quite difficult (Kruckeberg 1982; Pettinger 1996), and by Roorbach's (1999) observation (throughout the course of two field seasons) of only two devil's club seedlings in Oregon populations.

Following initial population establishment from seed, Erikson (1993) describes two possibilities for the further development of clonal plants: those that exhibit only initial seedling recruitment (ISR) and those that demonstrate repeated seedling recruitment (RSR). Devil's club, like most clonal plants (Erikson 1989), does not appear to exhibit repeated seedling recruitment, but maintains populations vegetatively, under disturbance conditions and under a range of light environments in young to maturing forests (Figs. 2.5d-2.5f, 2.6b).

Unlike devil's club, many clonal understory shrubs of similar habitats, including salmonberry (*Rubus spectabilis*), (Tappeiner and Zasada 1993), vine maple (*Acer circinatum*) (O'Dea et al. 1995; Huffman and Tappeiner 1997), and Oregon grape (*Berberis nervosa* Pursh) (Huffman and Tappeiner 1997) exhibit at least some continued seedling recruitment in established populations. Although these species also maintain populations through vegetative spread, seedling recruitment contributes to population persistence in this species. In the case of salal, however, such recruitment can be quite infrequent and restricted primarily to decaying logs outside of established populations (Huffmann et al. 1994; Huffman and Tappeiner 1997; Tappeiner and Zasada 1993). For devil's club, like speckled alder (*Alnus incana* ssp. *rugosa*) (Huenneke 1987), continued vegetative recruitment but little or no seedling establishment appears adequate to ensure long-term persistence. Given the ability of this species to persist in different stages of stand development, it is possible that established populations of clonal fragments are the vegetative progeny from only a few seedlings, and thus make up a few, very old genets.

Persistence and Stand Development

Leaf morphology of devil's club observed in clearcuts appeared qualitatively different (leaves were smaller and more sharply angled) than leaf morphology of plants in young and maturing stands (Fig. 2.8). Additionally, when selecting sites to sample in clearcuts and young stands a considerable amount of searching for this species was nessecary. It was absent in many of the stands where I would have expected to find it, based on topographic and hydrographic characteristics. Similarly, both Burton et al. (1998) and Roorbach (1999) indicate that sampling devil's club populations in clearcuts required some perseverance. In the white spruce (*Picea glauca* (Moench) Voss) - subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) forests of north-central British Columbia, Eis (1980) found that on sites where devil's club had been dominant before canopy removal, it remained only as a few individual plants of low vigour 6 years after logging. Similarly, on many site types in the white spruce - subalpine fir forests of northeastern British Columbia, Hamilton and Yearsley (1988) observed that devil's club cover and constancy were markedly lower on sites that were clearcut and burned or clearcut and mechanically site prepared (<10 years previously) than in mature forest.

Despite the stress associated with clearcut environments, clonal fragments do persist on at least some sites. When I excavated some of these populations, I found extensive decumbent stem interconnections between sometimes distant individual ramets, and I uncovered a large number of new shoots that were just emerging through slash and debris, or were etiolated and had not yet emerged. Apparently, the removal of the overstory initially causes high ramet mortality (Figs. 2.2a; 2.4j). However, many of the clonal fragments persist, and recruit a large number of new ramets through sprouting and layering (Fig. 2.2a; 2.4h; 2.5d; Fig 2.8). The increased formation of lateral meristems (Fig. 2.4i), which have the potential to become stem branches and ultimately ramets via layering, also appears to contribute to population persistence.

Although ramet recruitment on clearcuts was high (Fig. 2.4h), the continued stress of the clearcut environment would likely cause decreased growth (Fig. 2.4g) and continued mortality (Fig. 2.6c), resulting in the reduced ramet densities (Fig. 2.2b; 4c) in young stands. Many sections of decumbent stem that I excavated were so deeply buried that they did not produce any new ramets, and these portions of a clonal fragment probably would have senesced, resulting in reduced decumbent stem connections (Fig. 2.4e), and thus more, but smaller clonal fragments. As stand development progresses, clonal fragment age and age distribution stay relatively constant (Figs. 2.5a-2.5c), implying that initial population maintenance is driven by basal sprouting, evidenced by high initial recruitment and the reverse-j-shaped age distribution of ramets in clearcuts (Figs 2.4h; 2.5d). However, after an initial increase, ramet recruitment through basal sprouting slows (Fig. 2.4h), and recruitment continues primarily through layering. In populations in maturing stands, most ramets are between 4 and 14 years old (Fig. 2.5f), suggesting that continued ramet recruitment occurs primarily through layering of upright stems that are at least 4 years old.

Figure 2.8 Prolific ramet production from devil's club decumbent stems in a recent clearcut. Prior to sampling most of the ramets shown here were partially to completely buried in slash and debris.

Much like devil's club, vine maple (*Acer circinatum*) persists through all stages of Douglas-fir (*Pseudotsuga menziesii*) forest development in coastal Oregon, by vigorous basal sprouting in openings, clearcuts and burns, and through layering under closed canopy (Anderson 1969; O'Dea et al. 1995). Salmonberry (*Rubus spectabilis*) persists under dense canopies by both rhizome extensions and basal bud sprouting on senescent aerial stems (Tappeiner et al. 1991). Similarly, salal (*Gaultheria shallon*) and Oregon grape (*Berberis nervosa*) appear to persist in closed canopy forests through the production of aerial stems from new rhizomes and limited seedling establishment which appears somewhat more frequent in Oregon grape than salal (Huffman et al. 1994; Huffman and Tappeiner 1997).

Vegetative growth, through layering and basal stem sprouting, allows devil's club to persist through stages of stand development under light levels ranging from high light intensity in open clearcuts, through extremely low light beneath the canopies of young stands, to intermittent and reflected light in canopy gaps of maturing forest. In the low light environments of maturing and young stands, resources appear to be allocated primarily to incremental growth and not ramet recruitment (Figs. 2.4g-2.4i), whereas in the more open light environments of clearcuts, allocation to ramet recruitment and lateral meristem formation appear to occur at the expense of ramet growth (Figs. 2.4h-2.4i). It is possible that rapid recruitment through basal sprouting and increased lateral meristem development is in part a light-dependent response, similar to that of striped maple (*Acer pensylvanicum* L.) (Wilson and Fischer 1977). De Kroon and Kwant (1991) propose a similar mechanism to explain patterns of bud development in populations of *Carex flacca* Schreber.

Under low light levels, devil's club seems to forage for light by actively growing, often sprawling, towards canopy gaps and sunflecks (Fig. 2.9). In Oregon, Roorbach (1999) found the highest stem elongation in the lowest light environments. Roorbach (1999) speculates that increased incremental growth, in addition to altered stem and petiole orientation, allows devil's club in low light environments to overtop other shrubs and maximize light capture. Using proxies that probably more accurately reflect total biomass accumulation, Burton et al. (1998) found that in northwestern British Columbia devil's club growth is higher at intermediate light intensities. Reduced clonal fragment size (ramet number) in maturing forest may also be a product of lower light levels, because stems that sprawl are more likely to layer and subsequently fragment. Sprawling ramets and layering facilitate increased access to the patchy resources by increasing the area of ground covered. Decumbent stems may also be a means by which devil's club can horizontally explore the understory for light (Pickett and Kempf 1980; Roorbach 1999), and potentially maximize the area of active corticular photosynthesis, a phenomena which has been described in other shrubs (Coe and McLaughlin 1980).

Flexibility in growth can be an important characteristic contributing to the survival of clonal understory plants during the changing conditions related to disturbance and forest succession, and especially survival in dense young stands with very low resource levels (Lezberg et al. 1999, *in press*). This may be especially true for species like devil's club that appear to rarely start from seed, making persistence of clonal fragments critical to population maintenance on a site. Devil's club exhibits characteristics allowing considerable flexibility in growth, including formation of decumbent stems, layering to varying degrees, sprouting of basal buds, and maintenance of clonal fragments of variable size and thus various degrees of integration. Persistence through major disturbances, such as clearcutting and fire, survival in dense young stands, and the ability to effectively utilize resources in old forests largely structured by patch dynamics are all necessary for the maintenance of devil's club on many sites.

Figure 2.4 Devil's club stem in a maturing forest 'foraging' for light in a canopy gap.

It seems likely that flexibility in clonal development is a key to the survival of devil's club through these changing conditions, which contributes to the generalization that the ability to vary clonal development is an important attribute of many forest understory plants.

CHAPTER 3. ETHNOBOTANY OF DEVIL'S CLUB: TRADITIONAL KNOWLEDGE, CULTURAL SIGNIFICANCE, AND PROBLEMS ASSOCIATED WITH COMMERCIALIZATION

Abstract

Devil's club (*Oplopanax horridus*), one of the most culturally important plants to the First Peoples living within its range, has recently been marketed by the herbal and nutraceutical industries as a medicinal Non-Timber Forest Product (NTFP). Although still at an early stage in commercialization, devil's club will probably continue to increase in popularity. There are several concerns associated with commercial growth including: potential population declines associated with over-harvesting in the wild; commercially inappropriate use of a culturally important plant; and lack of protection and compensation for traditional medicinal knowledge about devil's club. To assess potential cultural concerns, this chapter presents information from interviews and the literature on the traditional medicinal, spiritual, technological, and food uses of devil's club, its linguistic recognition, and its importance in oral tradition. Traditional knowledge of specific practices and cultural protocols related to harvesting is also examined for its potential to inform attempts to sustainably manage the commercial use of devil's club. Accounts of traditional practices and cultural protocols associated with harvesting appear to have significant potential to aid in the development of strategies to sustainably manage devil's club. Conversely, data on the traditional use of devil's club highlight the extreme cultural importance of this plant and suggest that the depth of its significance makes commercialization itself problematic.

"Then you again bathe yourself with the bark, rubbing it all over your body. Then you leave for your hunting grounds. Be sure of the number of days and do not lessen or increase these, as these are your days. You must do the same with all your hunting paraphernalia. I am returning and I am devil's club and it is the bark of me that you will use." Excerpt from a Tsimshian Story recounted by Mrs. Harriet Hudson to W. Benyon (Barbeau and Benyon, 1987: 28).

Introduction

Devil's club is often cited as one of the most culturally important plants, both medicinally and spiritually, to the First Peoples within its range in northwestern North America (Compton 1993; de Laguna 1972; Gottesfeld-Johnson 1992; Smith 1973; Turner 1982). The first ethnographic record of devil's club use dates to 1842, when Eduardo Blaschke reported the application of devil's club ash as a treatment for sores amongst the Tlingit (Blaschke 1842). Subsequently, medicinal, spiritual and technological uses of devil's club have received widespread mention in ethnographies, ethnobotanies, historical accounts, and medical journals from within (as well as outside) its geographical range. In a 1982 review, Turner reports over 30 categories of medicinal, spiritual and technological uses by over 25 different linguistic groups across western North America. Recently, the roots and inner bark of devil's club's decumbent stems have become a popular commercial herbal remedy and nutraceutical product (Fig. 3.1). Although devil's club is in its infancy as a commercial medicinal, many authors point to its long history of traditional use, cultural significance, commercially alluring common name, and botanical relationship to other medicinal members of the Araliaceae (e.g. *Panax ginseng* Meyer, *P. quinquefolius* L., *Eleutherococcus senticosus* Maxim., and *Aralia nudicaulis* L.) as factors which contribute to its commercial appeal and potential for growth (Small and Catling 1999; Wills and Lipsey 1999).

Figure 3.1 Devil's club medicinal products. Dried devil's club true roots being sold as 'root bark' (upper left), tincture of devil's club root bark in grain alcohol (lower left), and green inner bark peeled from de-spined aerial stems (right).

Devil's club is also currently marketed as a ginseng substitute (although it is unclear to what extent) under the common names: Pacific ginseng, Alaskan ginseng, and wild-armoured Alaskan ginseng (Awang *in press*; Small and Catling 1999). Marketing devil's club as a wild-ginseng substitute is reminiscent of the commercial sale of another shrubby member of the Araliaceae, eleuthero (*Eleutherococcus senticosus*), which is sold in large quantities in North America as a ginseng substitute under the name Siberian ginseng (Foster, 1996; Blumenthal 2000). Currently the quantity of devil's club harvested from British Columbia is not of the same magnitude as quantities of Siberian ginseng extracted in Russia, and harvesting itself currently does not represent a threat to the persistence of this species across the province. However, habitat loss associated with logging may be responsible for devil's club population declines (Small and Catling 1999; Tilford 1997), as has been observed by Mary Thomas, a Secwepemc Elder:

> Those creeks where the devil's club used to be plentiful, there is nothing there. It all gone, it just all dried out. There is no doubt in my mind we are destroying their habitat.

Potential for increased marketing of devil's club as a ginseng substitute, escalation in popularity as a herbal and nutraceutical product, and growing interest in devil's club as potential pharmaceutical (Kobaisy et al. 1997; McCutcheon et al. 1993; 1994; 1995; 1997; Wigwod 1997) suggest that wild harvesting of devil's club is likely to increase in the future. At present, it is unclear how devil's club populations, which are maintained primarily through vegetative reproduction (Chapter 2; Roorbach 1999), will respond to increasing harvesting pressure. This raises concerns that, in addition to habitat loss, over-harvesting may also negatively impact populations. Some plant specialists already express fears that wild harvesting of devil's club, in conjunction with logging, is responsible for observed declines in abundance. According to Arvid Charlie, a Halkomelem plant specialist:

> Many areas, where there used to be devil's club, there isn't any more, because of over-harvesting. Or clear-cut. We see areas just disappearing, just, you know, we're able to get there [before] and grab a few plants, and now there's, there's nothing there.

The cultural significance of devil's club also raises a number of concerns regarding current and future exploitation of this plant. Given the nature and long history of traditional use, commercial growth and production of devil's club may conflict with the cultural and spiritual importance of this plant. Tedder et al. (2000: 37) predict that the harvest of many culturally sensitive NTFPs on ***Haida Gwaii*** (Queen Charlotte Islands) "for commercial exploitation may conflict with Haida heritage and/or cultural values and lead to open conflict if left unresolved." Additionally, since knowledge of devil's club's medicinal properties appears to be derived primarily from ethnographic documentation of traditional use, commercial exploitation of this medicinal knowledge is in opposition to articles 1 and 8j of the Convention on Biological Diversity, which call for fair and equitable sharing of any benefits resulting from the sustainable use of biodiversity, and traditional and local knowledge (Baker et al. 1995; Reid et al. 1993).

Recently, Traditional Ecological Knowledge (TEK) of peoples long resident to an area has been acknowledged as commensurate and complementary to scientific knowledge and has been presented as a means of informing and improving ecosystem-based management practices, aiding restoration practices, and developing sustainable resource management practices (Berkes 1999; Hunn 1999; Huntington 2000; Turner et al. 2000a). In many parts of North America and for a large number of culturally important plants (many of which are now harvested as NTFPs), there is compelling ethnographic and historical evidence that traditional management practices actually increased the productivity and ensured the continued availability of these resources. Traditional management included specific practices such as: partial, selective and precisely timed harvesting, replanting, transplanting, pruning, coppicing, weeding, tilling, and controlled burning to stimulate growth and maintain more open habitats (Anderson 1996; Anderson

1997; Bandringa 1999; Loewen 1998; Peacock 1998; Peacock and Turner 2000; Turner 2001b; Turner et al. 2000a), as well as numerous broader cultural protocols associated with resource use (Anderson 1996; Berkes 1999; Turner and Atleo 1998; Turner et al. 2000a). Such traditional knowledge, derived from generations of observation and experimentation, has frequently been presented as information that can effectively be integrated with and augment conventional scientific approaches to sustainably manage NTFPs (Davidson-Hunt and Berkes 2001; Turner 2001a, 2001b).

The purpose of this chapter is twofold: (1) to explore traditional harvesting practices associated with devil's club, including specific harvesting techniques and spiritual and cultural protocols governing its harvest, as potential sources of information to inform attempts to sustainably manage the commercial harvest of devil's club; and (2) to examine the traditional medicinal, spiritual, and technological uses of devil's club, as well as cultural practices associated with these uses, as a means of grappling with concerns about cultural propriety and intellectual property rights associated with devil's club commercialization.

Methods

To explore the traditional uses and spiritual significance of devil's club, and specific traditional and cultural practices associated with harvesting, I reviewed ethnographic, ethnobotanical, and historical literature and I interviewed[2] a number of knowledgeable plant specialists. A preliminary examination of the literature revealed that a great deal of information on the traditional use of devil's club had already been recorded. Consequently, interviews were focused on the spiritual importance of devil's club and specific traditional harvesting and cultural practices associated with use. All information from interviews and the literature is organized according to a cultural-linguistic classification. However, since 36 languages were encountered in the literature consulted, no attempt has been made to standardize orthographies, and the orthography used for those languages follows that of the source publications (Tables 3.1-3.4).

Interviews were semi-structured and relatively open ended. Conversations were recorded on audiocassette and subsequently transcribed. The plant specialists interviewed are from communities across British Columbia, and are listed alphabetically below. Their initials, in parentheses, are used throughout the text to indicate the source of information.

Arvid Charlie (AC): Halkomelem Plant Specialist, Duncan, B.C. Interviwed by Nancy Turner and Trevor Lantz, December 13, 1999, Duncan, B.C.

Captain Gold (CG): Haida Elder and Plant Specialist, Skidegade, B.C. Interviewed by Nancy Turner, June 10, 2001, Skidegate, B.C.

Desmond Peters, Senior (DP): Stl'atl'imx Elder and Plant Specialist, Pavilion, B.C. Interviewed by Trevor Lantz and Kimberlee Chambers, September 30, 2000, Pavilion, B.C.

Dr. Mary Thomas (MT): Secwepemc Elder and Plant Specialist, Salmon Arm, B.C. Interviewed by Trevor Lantz, February 26, 2001, Victoria, B.C.

[2] The research methodology used in the interview process, and this research project as a whole, was approved by the University of Victoria's Tri-Council Ethical Review Board (Project Number 077-00).

The relatively small number of plant specialists interviewed over the course of this study undoubtedly does not reflect the diversity of perspectives on devil's club traditional use that exist across this plant's range. However, all of the individuals interviewed are recognized in their communities as being particularly knowledgeable concerning plants, and much of the knowledge they shared is previously unrecorded and undoubtedly augments the information available in the literature.

Results and Discussion

Ethnobotanical Records of Traditional Plant Use

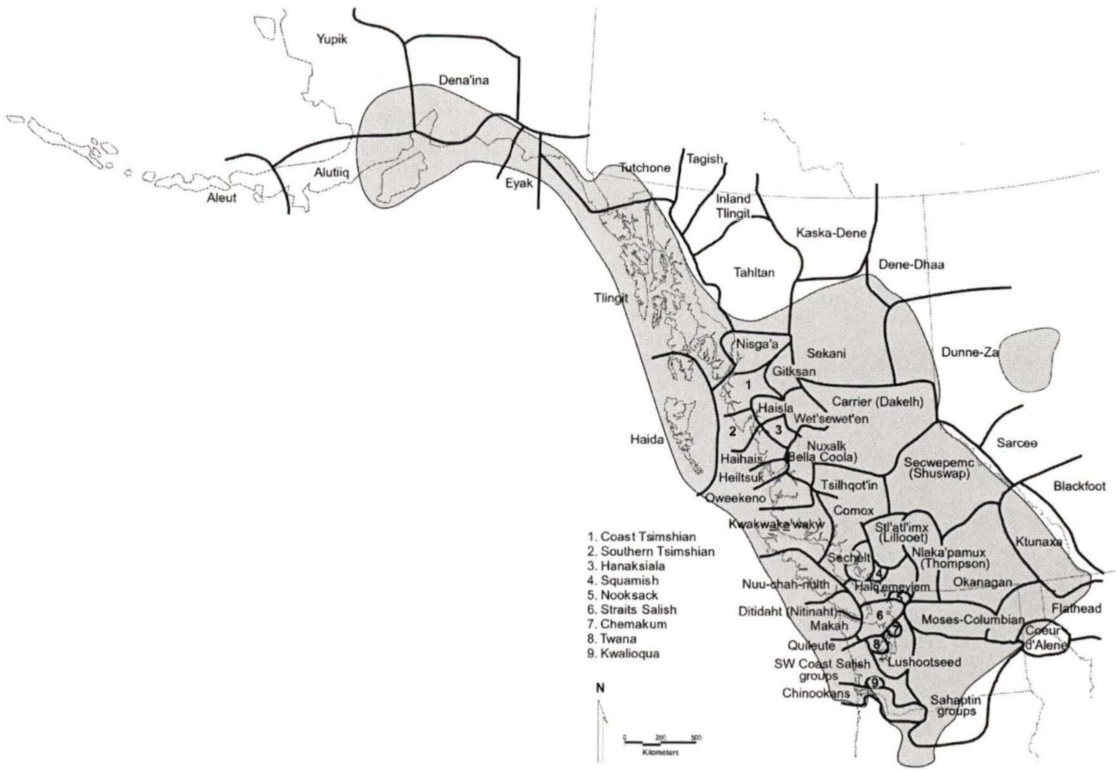
A review of published and unpublished ethnographic sources reveals an enormous diversity of devil's club uses amongst cultural groups from across this plant's geographic range. These uses are summarized here in 34 broad categories of medicinal use (Table 3.1), 8 categories of spiritual use (Table 3.2), and 2 categories of material and food use (Table 3.3). Thirty-eight linguistic groups from across Northwestern North America use devil's club (Tables 3.1-3.3). The region delineated by this cultural usage almost directly parallels the geographic distribution of devil's club (Fig. 3.2) and underscores the cultural importance of this plant across its range. Devil's club is used well outside of its geographic range, and so the few areas where cultural use is not recorded from within the area of its distribution more likely represent gaps in the ethnobotanical literature, and not in usage.

Traditional Medicinal Uses

Amongst all of the medicinal uses of devil's club, examples common to many cultural groups include: treatment for arthritis, rheumatism, diabetes (late onset type 2), respiratory ailments, coughs, colds, sores, swellings, cuts, and boils, and as an emetic, purgative and cathartic (Table 3.1). Devil's club is also used traditionally as a laxative, an aid in childbirth (post-partum), for internal hemorrhaging, as an analgesic, to treat stomach and digestive tract ailments, broken bones, fever, dandruff, lice, headaches, and a number of internal infections, and as a treatment for cancer (Table 3.1).

Several plant parts, including leaves, whole stems, berries, inner bark, inner bark ash, and roots, are used in a variety of ways to effect these treatments. However, the most common means of preparing devil's club are as infusions or decoctions of the inner bark (Table 3.1). The efficacy of many of the treatments is undoubtedly related to devil's club's significant antimicrobial [antibacterial (Kobaisy 1997; McCutcheon et al. 1993), antimycobacterial (Kobaisy 1997; McCutcheon et al. 1997), antifungal, (Kobaisy 1997; McCutcheon et al. 1994), antiviral (McCutcheon et al. 1995; Wigwod 1998)], and hypoglycemic properties (Large and Brockesby 1938; Justice 1966). However, most of the traditional applications of devil's club, which have been classified here as 'medicinal,' cannot realistically be separated from 'spiritual' applications of devil's club such as for cleansing and purification. Although this spiritual and medicinal dichotomy is useful for the purposes of this paper, it should be stressed that it does not reflect traditional conceptions of health and healing (de Laguna 1972; Johnson 1997; Turner 1982).

Figure 3.2 Geographic distribution of devil's club (light grey, upper map) in relation to the area of cultural use and linguistic recognition (dark grey, lower map) in Western North America. Figure modified from Turner and Loewen (1998).


Yupik
Dena'ina
Alutiiq
Aleut
Eyak
Tutchone
Tagish
Inland Tlingit
Kaska-Dene
Tahltan
Dene-Dhaa
Tlingit
Nisga'a
Sekani
Dunne-Za
Gitksan
Carrier (Dakelh)
Haisla
Wet'sewet'en
Haida
Nuxalk (Bella Coola)
Haihais
Heiltsuk
Secwepemc (Shuswap)
Sarcee
Blackfoot
Tsilhqot'in
Oweekeno
Comox
Kwakwaka'wakw
Stl'atl'imx (Lillooet)
Ktunaxa
Sechelt
Nlaka'pamux (Thompson)
Nuu-chah-nulth
Halq'emeylem
Okanagan
Ditidaht (Nitinaht)
Makah
Moses-Columbian
Flathead
Coeur d'Alene
Quileute
Lushootseed
SW Coast Salish groups
Chinookans
Sahaptin groups
1. Coast Tsimshian
2. Southern Tsimshian
3. Hanaksiala
4. Squamish
5. Nooksack
6. Straits Salish
7. Chemakum
8. Twana
9. Kwalioqua
N
Kilometers

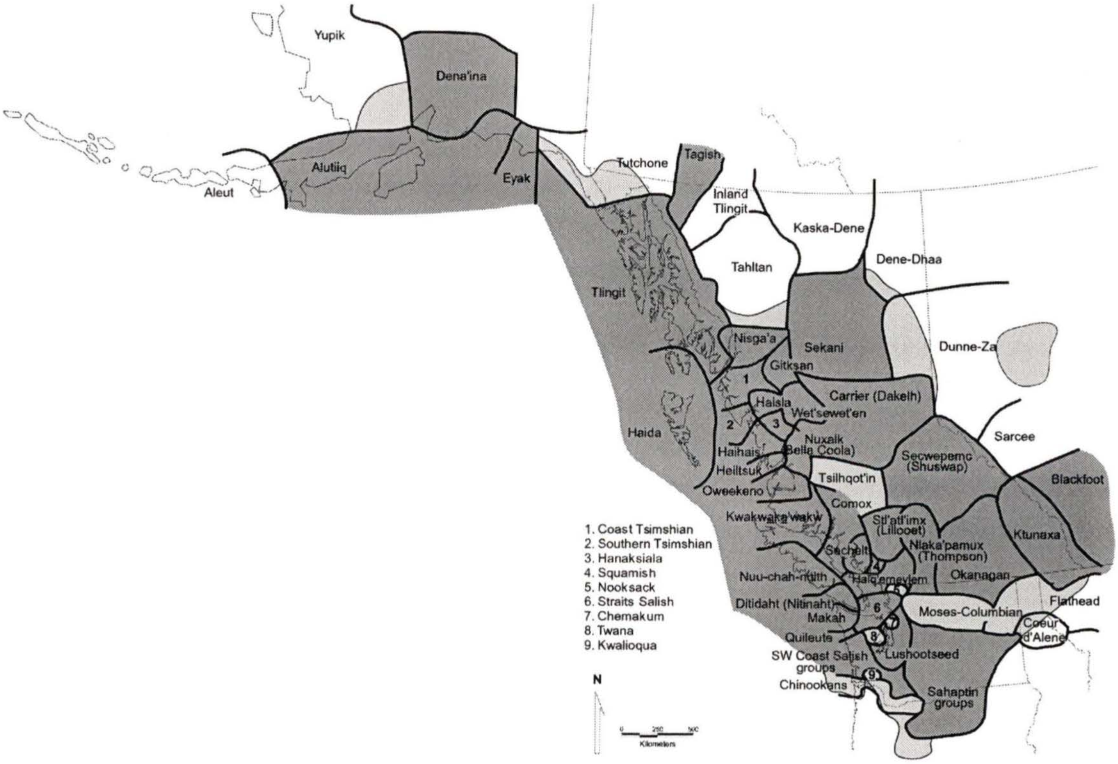

Yupik
Dena'ina
Alutiiq
Aleut
Eyak
Tutchone
Tagish
Inland Tlingit
Kaska-Dene
Tahltan
Dene-Dhaa
Tlingit
Nisga'a
Sekani
Dunne-Za
Gitksan
Carrier (Dakelh)
Haisla
Wet'sewet'en
Haida
Nuxalk (Bella Coola)
Haihais
Heiltsuk
Secwepemc (Shuswap)
Sarcee
Blackfoot
Tsilhqot'in
Oweekeno
Comox
Kwakwaka'wakw
Stl'atl'imx (Lillooet)
Ktunaxa
Sechelt
Nlaka'pamux (Thompson)
Nuu-chah-nulth
Halq'emeylem
Okanagan
Ditidaht (Nitinaht)
Makah
Moses-Columbian
Flathead
Coeur d'Alene
Quileute
Lushootseed
SW Coast Salish groups
Chinookans
Sahaptin groups
1. Coast Tsimshian
2. Southern Tsimshian
3. Hanaksiala
4. Squamish
5. Nooksack
6. Straits Salish
7. Chemakum
8. Twana
9. Kwalioqua
N
Kilometers

Table 3.1 Summary of medicinal uses of devil's club (*Oplopanax horridus*).

MEDICINAL USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
APPETITE STIMULANT Infusion of inner bark.	**Nlaka'pamux** (Turner et al. 1990); **Secwepemc** (Turner et al. 1998); **Squamish** (Bouchard and Turner 1976)
ARTHRITIS / RHEUMATISM Infusion or decoction or inner bark, pounded leaves and sometimes roots, inner bark used in bath/steam bath, inner bark chewed, crushed root used as poultice, and whole stems used to beat rheumatic limbs as counter-irritant.	**Alutiiq** (Stanek 1985; Wennekens 1983; 1985; Russell 1991); **Carrier** (Hebda et al. 1996); **Ditidaht** (Rollins 1972; Turner et al. 1983); **Gitxsan** (Gottesfeld and Anderson 1988; Johnson 1997; Oates 1994); **Haida** (Deagle 1983; Justice 1966; Turner 1970; Turner 1973; Harrison 1925; Smith 1928; McGregor 1981); **Halkomelem** (Galloway 1979); **Hanaksiala** (Compton 1993); **Makah** (Gill 1983); **Oweekeno** (Compton 1993); **Nuu-chah-nulth** (Rollins 1972); **Stl'atl'imx** (Turner 1998a); **Nuxalk** (Turner 1973; Harrison 1925; Smith 1928); **Sahaptin** (Gunther 1973); **Sechelt** (Turner and Timmers 1972; Bouchard 1977; Rollins 1972); **Sekani** (Davis 1993); **Squamish** (Rollins 1972; Bouchard and Turner 1976); **Stl'atl'imx** (Turner 1972; Turner 1998a); **Tlingit** (Justice 1966; McGregor 1981); **Tsimshian** (McGregor 1981); **Unspecified** (Graham 1985)
BIRTH CONTROL Decoction of roots.	**Metis** (Marles et al. 2000)
BLOOD PURIFIER Decoction of inner bark.	**Carrier** (Hebda et al. 1996); **Nlaka'pamux** (Steedman 1930; Turner et al. 1990)
BROKEN BONES Decoction of inner bark.	**Alutiiq** (Russell 1991); **Gitxsan** (Smith 1997); **Haida** (Justice 1966)
CANCER Infusion of inner bark.	**Alutiiq** (Russell 1991); **Gitxsan** (Johnson 1997); **Haida** (Deagle 1983; Justice 1966); **Tlingit** (Justice 1966); **Tsimshian** (McGregor 1981)
CHILDBIRTH / MENSTRUATION Inner bark mashed and swallowed, or decoction of inner bark taken as purgative to expel afterbirth, to start post-partum menstrual flow, regulate menstruation and for cramps.	**Alutiiq** (Birket-Smith 1953); **Carrier** (Morice 1893; Smith 1928); **Hanaksiala** (Compton 1993); **Lushootseed** (Gunther 1973); **Makah** (Gunther 1973); **Secwepemc** (Teit 1909); **Tlingit** (de Laguna 1972)
DIABETES Infusion or decoction of inner bark and sometimes roots, both alone and in mixtures.	**Cree** (Marles et al. 2000); **Haida** (Deagle 1983); **Halkomelem** (Turner and Hebda 1989); **Heiltsuk** (MacDermott 1949); **Metis** (Marles et al. 2000); **Nlaka'pamux** (Turner et al. 1990); **Nuxalk** (Thommasen 1995); **Sechelt** (Bouchard 1978); **Secwepemc** (Turner et al. 1998); **Squamish** (Bouchard and Turner 1976); **Stl'atl'imx** (Turner 1998a); **Straits Salish** (Turner and Hebda 1989, Turner et al. 2000b); **Tsimshian** (Large and Brocklesby 1938)
DIPTHERIA Infusion of roots applied externally.	**Sekani** (Davis 1993)
EMETIC PURGATIVE CATHARTIC Decoction or infusion of inner bark prepared in water or seal oil, both alone and in mixtures, roots chewed and the inner bark sometimes swallowed.	**Alutiiq** (Russell 1991; Wennekens 1985); **Carrier** (Morice 1893; Smith 1973); **Eyak** (Birket-Smith and de Laguna 1938; Smith 1973); **Gitxsan** (Smith 1997; Turner 1973); **Haisla** (Compton 1993); **Haida** (Harrison 1925); **Makah** (Gunther 1973); **Nuxalk** (Smith 1928; Turner 1973; Thommasen 1995); **Tlingit** (Smith 1973; de Laguna 1972; Emmons 1991); **Tsetsaut** (Smith 1973); **Unspecified** (Vogel 1970); **Wet'suwet'en** (Smith 1997)
FERTILITY Unspecified.	**Unspecified** (Vogel 1970)

Table 3.1 - Continued

MEDICINAL USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
FEVER Decoction of inner bark.	**Tanaina** (Kari 1977); **Unspecified** (Vogel 1970)
FLU Infusion of inner bark, alone and in mixtures, and the inner stem bark chewed.	**Alutiiq** (Wennekens 1985; Russell 1991); **Gitxsan** (Johnson 1997); **Haida** (Deagle 1983; McGregor 1981); **Nlaka'pamux** (Turner 1982; Turner et al. 1990); **Tanaina** (Garibaldi 1999); **Tsimshian** (McGregor 1981); **Tlingit** (de Laguna 1972; McGregor 1981); **Wet'suwet'en** (Johnson-Gottesfeld 1993)
GALL STONES Infusion inner bark.	**Haida** (Justice 1966); **Tlingit** (Justice 1966)
HAEMORRHAGING AND BLOOD DISORDERS Infusion of inner bark, alone and in mixture, and berries pounded into paste taken internally.	**Comox** (Bouchard 1976); **Hanaksiala** (Compton 1993)
HEART DISEASE Berries pounded into paste taken internally.	**Alustiiq** (Russell 1991); **Hanaksiala** (Compton 1993); **Wet'suwet'en** (Johnson-Gottesfeld 1993)
INSANITY Introduced into the system by beating with stems.	**Haida** (McGregor 1981); **Tsimshian** (McGregor 1981); **Tlingit** (McGregor 1981)
INTERNAL INFECTIONS Infusion of inner bark.	**Haida** (McGregor 1981); **Tanaina** (Garibaldi 1999); **Tsimshian** (McGregor 1981); **Tlingit** (McGregor 1981); **Unspecified** (Graham 1985)
LAXATIVE Infusion or decoction of inner bark prepared both alone and in mixtures.	**Gitxsan** (Wilson et al. 1984); **Haida** (Justice 1966; McGregor 1981); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993) **Heiltsuk** (Turner 1982); **Kwakwaka'wakw** (Turner and Bell 1973); **Nlaka'pamux** (Steedman 1930; Turner et al. 1990); **Nuxalk** (Smith 1928); **Tanaina** (Kari 1977); **Tlingit** (Justice 1966; McGregor 1981; Emmons 1991); **Tsimshian** (Garfield and Wingert n.d.; McGregor 1981); **Unspecified** (Graham 1985)
LICE AND DANDRUFF Pounded berries rubbed on hair and scalp.	**Haida** (Turner 1970); **Oweekeno** (Compton 1993)
LYMPH TROUBLE (DROPSY) Ash of inner bark.	**Alutiiq** (Birket-Smith 1953)
MEASLES Decoction of inner bark.	**Halkomelem** (Rollins 1972); **Tlingit** (Garibaldi 1999)
PAIN RELIEF ANALGESIC Decoction of inner bark, inner stem bark mixed with oil and eaten, dried inner bark laid into tooth cavity, steam bath with inner bark.	**Alutiiq** (Stanek 1985; Wennekens 1983); **Gitxsan** (Oates 1994); **Haida** (Justice 1966); **Kwakwaka'wakw** (Boas 1930; 1966; Compton 1998; Turner and Bell 1973); **Nuxalk** (Thommasen 1995); **Oweekeno** (Compton 1993); **Tlingit** (Justice 1966); **Tsimshian** (Justice 1966)
PERFUME, BABY TALC Unspecified.	**Makah** (Gunther 1973)
PNEUMONIA Decoction or infusion of inner bark, and inner bark used in steam baths with a variety of additional plants.	**Alutiiq** (Wennekens 1985); **Squamish** (Bouchard and Turner 1976); **Tlingit** (de Laguna 1972)

Table 3.1 - Continued

MEDICINAL USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
RESPIRATORY AILMENTS, COUGHS, COLDS Decoctions and infusions prepared from inner stem bark, whole stems and sometimes roots, inner bark also chewed, used in sweat baths, and burned and dampened and worn around the neck.	**Alutiiq** (Russell 1991; Wennekens 1983; 1985); **Eyak** (Birket-Smith and de Laguna 1938); **Gitxsan** (Gottesfeld and Anderson 1988; Johnson 1997); **Haida** (Deagle 1983; Justice 1966; McGregor 1981); **Halkomelem** (Rollins, 1972); **Hanaksiala** (Compton 1993); **Okanagan** (Ray 1932); **Oweekeno** (Compton 1993); **Nlaka'pamux** (Turner 1982); **Okanagan** (Turner et al. 1980); **Sahaptin** (Gunther 1973); **Secwepemc** (Turner et al. 1998); **Squamish** (Bouchard and Turner 1976); **Tagish** (McClelan 1975); **Tanaina** (Kari 1977); **Tlingit** (Justice 1966; McGregor 1981); **Tsimshian** (McGregor 1981); **Unspecified** (Graham 1985; Vogel 1970; Gottesfeld-Johnson 1992) **Wet'suwet'en** (Johnson-Gottesfeld 1993)
SKIN WASH Infusion or decoction of roots used a general wash for acne, skin disease, dandruff, etc.	**Alutiiq** (Russell 1991; 1994); **Comox** (Bouchard 1976); **Gitxsan** (Wilson et al. 1984); **Sechelt** (Rollins 1972); **Sekani** (Davis 1993); **Tlingit** (de Laguna 1972)
SORES (SWELLINGS, CUTS, BOILS, BURNS AND EXTERNAL INFECTIONS) Inner bark, or infusion of, used externally as a poultice or wound dressing or rubbed over sore, dried inner bark pulverized with pitch or burnt to ash and mixed with oil or grease (sometimes salmonberries and dog feces) and applied externally, berries pounded into a paste and applied externally, decoction of root applied externally, and sliver of bark placed in wound to prevent infection.	**Alutiiq** (Birket-Smith and de Laguna 1938; Birket-Smith 1953; Russell, 1991; Wennekens 1983; 1985); **Carrier** (Hebda et al. 1996); **Eyak** (Wennekens 1985); **Gitxsan** (Gottesfeld and Anderson 1988; Wilson et al. 1984; Johnson 1997); **Haida** (Smith 1973; Justice 1966); **Hanaksiala** (Compton 1993); **Kwakwaka'wakw** (Boas 1966); **Makah** (Gill 1983); **Nlaka'pamux** (Steedman 1930); **Nuxalk** (Thommasen 1995); **Sechelt** (Bouchard 1978); **Tanaina** (Kari 1977); **Tlingit** (Justice 1966; de Laguna 1972; Emmons 1991; Krause 1956; Blashke 1842; Smith 1973); **Tsimshian** (McGregor 1981); **Unspecified** (Graham 1985; Macdermot 1949); **Wet'suwet'en** (Gottesfeld and Anderson 1988)
STOMACH TROUBLE/PAINS, ULCERS Infusion or decoction of inner bark or paste made from berries taken internally.	**Gitxsan** (Johnson 1997); **Haida** (Harrison 1925; Smith 1928; Justice 1966; Oates 1995); **Hanaksiala** (Compton 1993); **Kwakwaka'wakw** (Boas 1966; Compton 1998; Turner and Bell 1973); **Nlaka'pamux** (Steedman 1930; Turner et al. 1990); **Nuxalk** (Turner 1973, Harrison 1925, Smith 1928); **Squamish** (Bouchard and Turner 1976); **Tanaina** (Kari 1977); **Tlingit** (Justice 1966); **Unspecified** (Graham 1985; Macdermot 1949)
TONIC Infusion or decoction of inner bark, or sometimes roots, inner bark chewed, and bark ash infused.	**Ditidaht** (Turner et al. 1983); **Gitxsan** (Gottesfeld and Anderson 1988; Johnson 1997); **Haida** (Justice 1966; Turner 1970); **Halkomelem** (Rollins 1972); **Nlaka'pamux** (Steedman 1930; Turner et al. 1990); **Nisga'a** (Oates 1994); **Nuu-chah-nulth** (Scientific Panel 1995; Turner and Efrat 1982); **Oweekeno** (Compton 1993); **Tlingit** (Justice 1966; de Laguna 1972); **Sechelt** (Bouchard 1978); **Unspecified** (Graham 1985; Vogel 1970); **Wet'suwet'en** (Johnson-Gottesfeld 1993)
UNSPECIFIED USE, GENERAL SICKNESS Unspecified.	**Alutiiq** (Wennekens 1983); **Carrier** (Carrier Linguistic Committee 1973); **Ktunaxa** (Hart et al. 1981); **Gitxsan** (Oates 1994); **Nlaka'pamux** (Turner 1982); **Nuxalk** (Bouchard 1977); **Oweekeno** (Compton 1993); **Quileute** (Reagan 1934); **Sechelt** (Bouchard 1978); **Tahltan** (Turner pers. comm. 2001); **Tlingit** (Greene 1896); **Tsimshian** (Smith 1973)

Table 3.1 – Continued

MEDICINAL USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
VENEREAL DISEASE Decoction prepared from inner bark and whole stems both alone and in mixtures with a variety of other plants.	**Gitxsan** (Smith 1997); **Haida** (McGregor 1981); **Tlingit** (McGregor 1981; Emmons 1991; de Laguna 1972); **Tsimshian** (McGregor 1981); **Unspecified** (Graham 1985)
VISION / BLINDNESS Infusion of inner bark taken internally, inner bark applied externally with pitch, and decoction used an eyewash to reverse the effects of cataracts	**Haida** (McGregor 1981); **Hanaksiala** (Compton 1993); **Tsimshian** (McGregor 1981); **Tlingit** (McGregor 1981)
WEIGHT LOSS Infusion of de-spined stems.	**Nlaka'pamux** (Turner 1982; Turner et al. 1990)

Spiritual Uses

In addition to ethnographic records of medicinal uses, there are also numerous descriptions in the literature of spiritual uses of devil's club. These uses include: for purification and cleansing; for protection against supernatural entities; epidemics, and evil influences; for the acquisition of luck; to combat witchcraft; for ceremonial and protective face paint; and for attaining supernatural powers by shamans and others in rituals (Table 3.2). Two of the most widespread spiritual uses are bathing with devil's club inner bark for personal protection and purification, and its use, as an amulet for protection against a variety of external influences, particularly the spiny aerial stems (Table 3.2). External and internal cleansing, commonly involving the use of devil's club, "was of paramount importance" to many of the cultural groups throughout devil's club's range (Turner 1982: 27). Devil's club was also often used to wash down fishing boats and nets, to purify a house after a death, and to prepare protective face paint for ceremonial dancers (Table 3.2). John Thomas explained to Nancy Turner (1982: 27) that amongst the Ditidaht, and many other neighbouring groups, devil's club is considered sacred and "along with red ochre paint is considered to be a link between the ordinary, or profane world, and the supernatural, or spirit world" (Turner 1982:27).

Table 3.2 Summary of spiritual uses of devil's club (*Oplopanax horridus*).

SPIRITUAL USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
END BAD WEATHER Unspecified.	**Eyak** (Birket-Smith and de Laguna, 1938); **Tlingit** (de Laugna, 1972);
LUCK Wood retained for luck, bark used in bath, and rubbed on body, and fresh bark chewed.	**Eyak** (Birket-Smith and de Laguna 1938); **Gitxsan** (Wilson et al. 1984; Johnson 1997); **Haida** (Deagle 1988; Newcombe 1901; Barbeau 1953); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Tlingit** (de Laguna 1972); **Tsimshian** (Boas 1916; Compton 1993); **Wet'suwet'en** (Gottesfeld and Anderson 1988)
PAINT Charcoal, sometimes mixed with bear grease used for face paint used in ceremonies and for protection. Bark also used as medium for paint mixed with berries	**Ditidaht** (Turner et al. 1983); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Nuu-chah-nulth** (Scientific Panel 1995; Turner and Efrat 1983); **Secwepemc** (Turner et al. 1998); **Squamish** (Bouchard and Turner 1976); **Straits Salish** (Turner et al. 2000b)
PERSONAL PURIFICATION Infusion or inner bark and inner bark used in bath.	**Eyak** (Birket-Smith and de Laguna 1938); **Gitxsan** (Gottesfeld and Anderson 1988; Johnson 1997; Wilson et al. 1984); **Haida** (Newcombe 1901; Barbeau 1953); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Tlingit** (Krause 1956; Smith 1973); **Tsimshian** (Turner 1982; Compton 1993); **Wet'suwet'en** (Gottesfeld and Anderson 1988; Johnson-Gottesfeld 1993);
PROTECTION Bark and stems used as an amulet, charcoal used for protective face paint, bark used in bath for protection, hoop of stem steeped through for protection against supernatural entities, epidemics, evil influences, love charms and shamans spells, and inner bark sewn into pouch as an amulet worn around neck	**Alutiiq** (Russell 1991); **Ditidaht** (Turner et al. 1983); **Eyak** (Birket-Smith and de Laguna 1938); **Gitxsan** (Johnson 1997); **Haida** (Turner 1970); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Nisga'a** (Oates 1994); **Nuu-chah-nulth** (Scientific Panel 1995; Turner and Efrat 1982); **Nuxalk** (Turner 1973); **Sekani** (Davis 1993); **Tagish** (McClellan 1975); **Tlingit** (de Laguna 1972); **Tsimshian** (Compton 1993)
PURIFICATION OF HOUSE Inner bark burnt as a fumigant, placed in pouches, under pillows, or used with other plants to prepare an infusion to purify a house, often following a death	**Eyak** (Birket-Smith and de Laguna 1938); **Gitxsan** (Johnson 1997; Oates 1995); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Nuxalk** (Bouchard 1977); **Sekani** (Davis 1993); **Wet'suwet'en** (Gottesfeld and Anderson 1988; Johnson-Gottesfeld 1993)
SHAMANIC Infusion of inner bark or roots, and roots chewed.	**Blackfoot** (Johnston 1970); **Eyak** (Birket-Smith and de Laguna 1938); **Haisla** (Compton 1993); **Hanaksiala** (Compton 1993); **Oweekeno** (Compton 1993); **Sekani** (Jenness 1937); **Tlingit** (de Laguna 1972; Greene 1896); **Tsimshian** (Compton, 1993)
WITCHCRAFT Prophylactic against witchcraft.	**Alutiiq** (Schwatka 1892); **Hanaksiala** (Compton 1993); **Tlingit** (Krause 1956; de Laguna 1972)

Food and Material Uses

Although not nearly as common as its spiritual and medicinal uses, the spiny stems and wood of devil's club were also used in traditional fishing technology to make a variety of lures (Fig. 3.3; Table 3.3). Other uses of devil's club include the consumption of spring buds (before the spines have become bristly) as a green vegetable (Table 3.3). Apparently, others species of *Oplopanax* are also eaten in Asia and Russia, and recently a British Columbia company has marketed devil's club buds as food on the internet.

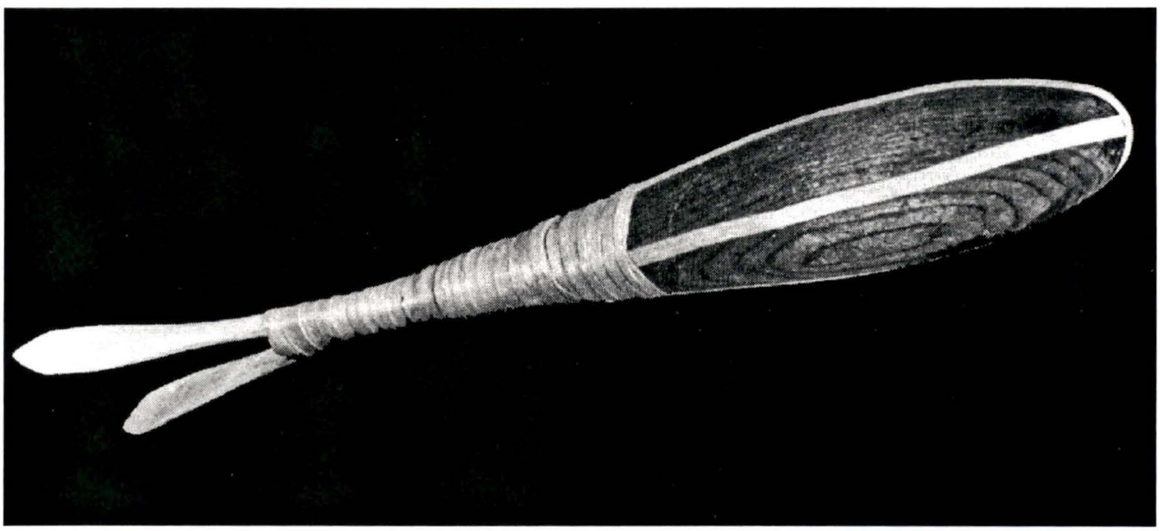


Figure 3.3 Cod-fish lure made from western redcedar (*Thuja plicata*) and devil's club (*Oplopanax horridus*). Photo: Ethnology Division, B.C. Provincial Museum.

Table 3.3 Summary of material and food uses of devil's club (*Oplopanax horridus*).

MATERIAL AND FOOD USES	CULTURAL LINGUISTIC GROUP (AND REFERENCES)
FISHING Wood carved into fishing lures and hooks, and thorny stems used for catching octopus. Used as a charm to ensure good fishing.	**Clallam** (Fleisher 1980); **Ditidaht** (Gill 1983; Turner et al. 1983); **Kwakwaka'wakw** (Compton 1998); **Makah** (Gill 1983; Gunther 1973); **Nuu-chah-nulth** (Gill 1983; Fleisher 1980; Gunther 1973; Turner 1998b; Turner and Efrat 1982; Scientific Panel 1995)
FOOD Spring buds and young stems eaten.	**Oweekeno** (Compton 1993); **Tlingit** (Greene 1896)

Linguistic Recognition

Names for devil's club have been recorded in over 35 distinct western North American languages, representing 9 language families, and including almost every language spoken within its geographic range (Table 3.4). A brief inspection of the words in Table 3.4 reveals at least 20 etymons, or words of a unique origin not derived from words in related languages. In addition to stressing the cultural importance of this plant, Turner (1982) has suggested that the large number of etymons, particularly in closely related languages (e.g. Makah, Ditidaht, and Nuu-Chah-Nulth), which otherwise share many words of common origin, implies that devil's club use is quite ancient in many of these cultures (Turner 1982). Additionally many of the names for devil's club do not have any obvious meaning or derivation, implying that the words origins have been forgotten or obscured with time (Turner 1982).

Stories Associated with Devil's Club

The cultural importance of devil's club is also evidenced by the traditional mythology and oral tradition of several cultural groups. Among the myths and stories that make reference to devil's club, one theme that is common in Gitxsan (Oates 1994), Haida (Swanton 1908), Oowekeno (Compton 1993), and Tsimshian (Barbeau and Benyon 1961) oral traditions involves the appearance of the human form of devil's club to individuals who have been extremely unlucky. In these stories, the male or female form of devil's club provides explicit instruction in the use of devil's club bark for bathing, purification or attaining luck. After sufficient instruction, the ill-fated individual carries out the exacting protocols specified by the human form of devil's club and the unlucky curse is broken and the individual becomes extremely successful at whatever he does. In a story recounted to Nancy Turner (1982: 28), Willie Matthews (Haida) described how one of:

> His ancestors had been fasting out in the forest for several days [when] he came across a giant devil's club plant with a trunk about 0.5 meters in diameter and leaves about 2 m across. He ate the inner bark from it and immediately lost consciousness. Upon awakening he saw a supernatural being similar to a "fairy," who was thenceforth his guardian spirit.

A number of other ethnographic sources include reference to the use of devil's club in stories about purification and rituals to obtain supernatural power (Barbeau 1953; Barbeau and Benyon 1961; Boas 1912; Compton 1993; Krause 1956; Oates 1994; Swanton 1905; 1909; Turner 1982).

Overall, the extremely widespread and diverse medicinal usage of devil's club, the depth of its spiritual significance, the large number of names for devil's club and the role of devil's club in mythology, highlight the extreme cultural importance of this plant to the First Peoples in northwestern North America.

Table 3.4 Names for devil's club (*Oplopanax horridus*) in western North American languages.

NAME	LANGUAGE	FAMILY	REFERENCES
cukilanarpak	Alutiiq	Alutiiq	Garibaldi 1999; Wennekens 1985
hoolhghulh*; *whuscho	Carrier	Athapaskan	Carrier Linguistic Committee 1973; Kay 1995
heshkeghka'a*; *heshkegh	Dena'ina	Athapaskan	Kari 1977; Garibaldi 1999
whus cho	Sekani	Athapaskan	Davis 1993
khos choo*; *xwvs choo	Tahltan	Athapaskan	Turner pers. comm. 2001
s!Axt*; *áchta*; *s'áxt'	Tlingit	Athapaskan	Swanton 1909; Krause 1956; Emmons 1991; de Laguna 1972
whisco	Wet'suwet'en	Athapaskan	Johnson-Gottesfeld 1993
che-chah-pulth	Quileute	Chimakuan	Reagan 1934
t'siihllnjaaw*; *t'siihlanjaaw;	Haida	Haida	Turner 2001c
nałiyɕaxawuʔk	Ktunaxa	Ktunaxa	Hart et al. 1981
***shk̲apk̲ápnuwash*;**	Columbia River Sahaptin	Sahaptin	Hunn 1990
x'našwaakuł*; *sqaipqa'ipas	Northwest Sahaptin	Sahaptin	Turner 1982; Gunther 1973
ch'í7t'ay	Comox	Salish (Coast)	Turner 1982
qʷáʔpəɬ*; *qpó:pelhp	Halkomelem	Salish (Coast)	Turner and Bell 1971; Galloway 1979
xaxadī'a'ts*; *xadī'ats*; *tcitca'tcily''I	Lushootseed	Salish (Coast)	Gunther 1973
ch'é7at'ay*; *ch'á7at'ay	Sechelt	Salish (Coast)	Turner 1982
ch'átiyay'	Squamish	Salish (Coast)	Bouchard and Turner 1976
qʷáʔpʌłp	Straits Salish	Salish (Coast)	Turner and Bell 1971
puqłč*; *pōkłtc*; *qwu'n'numpł	Straits Salish (Clallam)	Salish (Coast)	Fleischer 1980; Gunther 1973
k'étyeʔ	Nlaka'pamux	Salish (Interior)	Turner et al. 1990
x̲ax̲ag̲áy'lhp*; *x̲wux̲wug̲ay'lhp	Okanagan	Salish (Interior)	Turner et al. 1980
xwuxwalek̲w	Secwepemc	Salish (Interior)	Palmer 1975
k'átlaz'	Stl'atl'imx	Salish (Interior)	Turner 1972, 1998a
wooms	Coastal Tsimshian	Tsimshian	Boas 1912
wa'uumst*; *hu'ums*; *wo'oms*; *wu'ums	Gitksan	Tsimshian	Turner 1982; Oates 1994; Gottesfeld and Anderson 1988
wa'ums; wu'ums	Nisgha	Tsimshian	Turner 1982; Oates 1994
ST wɔ·'ms; ST wɔ· ʔms	Southern Tsimshian	Tsimshian	Compton 1993
ʕayxʷqʷapt	Ditidaht	Wakashan	Gill 1983; Turner et al. 1983
HA h'uìq'as	Haisla	Wakashan	Compton 1993
HA h'uìq'as	Hanaksiala	Wakashan	Compton 1993
wiq'ás	Heiltsuk	Wakashan	Turner 1982
i'x̲w'm'í*; *i'x̲w'min; t'ła'x̲suli	Kwakwaka'wakw	Wakashan	Turner and Bell 1973; Compton 1998
ʔa· ʔałbap	Makah	Wakashan	Turner 1982; Gill 1983
n'a·p'a·łmapt*; *n'aap'aalhmapt	Nuu-chah-nulth	Wakashan	Turner and Efrat 1982; Scientific Panel 1995; Gill 1983
tsk'alhkw	Nuxalk	Wakashan	Turner 1973
OO wìq'as	Oweekeno	Wakashan	Compton 1993

Harvesting Practices and Cultural Protocols Associated with Devil's Club

In contrast to the numerous ethnographic records of traditional uses of devil's club, very little information exists on other aspects of devil's club usage. In particular, references to specific practices and cultural protocols associated with harvesting for devil's club are quite rare.

Given that an emphasis on the specific, often medicinal, uses of plants has shaped much of ethnobotanical inquiry in the last century (Ford 1994), this is not entirely surprising. It seems likely that ethnographers, focusing primarily on utilitarian aspects of cultural knowledge, simply did not record specific details relating to harvesting. Plant medicines were not typically gathered in the same quantity and with the same degree of group coordination as plant foods and materials (Johnson-Gottesfeld 1993; McIlwarith 1948; Thorton 1999; Turner 1995, 1997, 1998b), but were collected by individuals and often surrounded by a great deal of secrecy (Turner et al. 1982; 1983; Turner and Hebda 1989). Consequently, it is also possible that this type of information, which may have varied considerably within families or even between individuals within the same family, was simply never disclosed. Additionally, much of the knowledge associated with harvesting devil's club and other medicinal plants may also have been lost through acculturation, the disruption of traditional life ways, and historical events that have imperiled the link between people and the natural world.

Given the paucity of information on the traditional harvesting of devil's club and the limited number of interviews conducted, this section is a preliminary assessment of practices that can potentially contribute to the development of sustainable management practices for devil's club. To that end, information is categorized according to harvesting practice, and the potential population level impacts of each traditional practice are considered. These categories include: partial or selective harvesting; transplanting and propagation; timing of harvesting; plant parts harvested; spiritual practices associated with harvesting; and secrecy and ownership of medicinal knowledge.

Partial or Selective Harvesting

A number of the plant specialists interviewed in this study described selective harvesting practices for devil's club. In general these practices appear to reflect a belief that leaving behind some stems within a patch will allow for, or expedite, devil's club regeneration. For example, Mary Thomas (Secwepemc) explained:

> If you don't disturb the root it will come back. If it's a real thick area, [and] there is lots of it, you can afford to thin it out, take just certain ones … cut it out and eventually it will grow back again.

Similarly, Captain Gold (Haida) described harvesting only the vegetative secondary stalks of devil's club when it was for routine medicinal use, noting that if a particularly strong and important medicine was required, then the larger flowering stalks could be taken, after the proper protocols for asking permission from the plant and thanking and honouring it in some way had been followed. However, he also stressed that this intensity of harvesting (taking the main stalk) was only carried out in extreme circumstances, when someone was really sick. Several other Haida plant specialists (Maude Moody; Agnes Moody; and George Young) explained that flowering and fruiting stems were generally not harvested for routine use, because they are too 'oily' (Turner pers. comm. 2001). According to Marilyn Walker (2000), traditional harvesting of devil's club on the Northwest Coast involves the selective removal of individual aerial stems or sections of the decumbent stems. Two of the plant specialists interviewed by Walker (2000), Bob Sam of Sitka, Alaska and Paul Sam of Saanich, British Columbia, spoke about particular patches that they had harvested in this way for 25 and 50-60, years respectively. The belief that selective harvesting will permit or speed up regeneration is a perception consistent with evidence that clonal expansion in devil's club produces networks of interconnected aerial stems. Clonal population structure may enable devil's club to respond quickly to disturbance, and harvesting, via resource sharing between members of the same clonal fragment (Chapter 2). Consequently, selective harvesting probably does accelerate regeneration because it protects some stems in a clonal fragment that are often older and more vigorous.

Transplanting and Propagation

There is no substantial evidence that propagation and transplanting of devil's club has ever been a widespread traditional practice, but there are a number of interesting references to such practices. Arvid Charlie (Halkomelem) described his recent adoption of this practice, in response to observed local reductions in devil's club abundance:

> So, myself, I've gone to when I harvest them, I'll cut a long stem in several pieces and poke them into the mud, or some, I'll just put some kind of a weight on it, maybe a piece of wood. And, I've taken some from other places and just moving them. I'm in the process of moving some closer, 'cause there's a need for them. I'd cut it, oh, about four pieces, three or four pieces, five pieces for a longer plant, cut them into lengths.

According to Marilyn Walker (2000: 8), "Theresa Thorne [Halkomelem] said she never passed by devil's club without pinching off a top and pressing it into the soil so another plant would grow." Conversely, according to Mary Thomas (Secwepemc), devil's club was never transplanted or replanted:

> Our people never did. You always protected the area where certain plants grow; they would never ever think of transplanting any bushes, trees, or shrubs, or roots.

Despite uncertainty regarding the origin and extent of transplanting practices, evidence from greenhouse experiments (Roorbach 1999) and the horticultural literature (Kruckeberg 1982; Pettinger 1996) indicate that such techniques can be an effective means of establishing new populations of devil's club or hastening regeneration after harvesting. The ease with which devil's club can be propagated from stems (Kruckeberg 1982; Pettinger 1996; Roorbach 1999) suggests that many of the stems replanted in the manner described by Arvid Charlie and Theresa Thorne would indeed survive. Additionally, observations that broken devil's club stems often root naturally, made by Arvid Charlie, Roorbach (1999) and myself (Chapter 2), reinforce the potential effectiveness of these propagation practices.

Timing of Harvesting

Although several cultural groups harvest devil's club at a specific time of year, generally the timing of harvest is extremely variable, and amongst many groups can be carried out in any season. Mary Thomas (Secwepemc) described devil's club as among those medicines that are best when fresh material was used, and consequently it was gathered year round. "They took it right off the tree, I never seen them dry it" (MT). Similarly, the Ooweekeno (Compton 1993) and Stl'atl'imx (DP) apparently also gather devil's club at all times of the year. Amongst the Tlingit, Tsimshian, and Haida, devil's club is harvested year round, but is perceived as most potent when collected in the spring (Justice 1966; McGregor 1981). The Hanaksaila and Haisla harvest devil's club aerial stems in the spring and summer, and throughout the winter use stored devil's club roots (Compton, 1993). Conversely, the Gitxsan prefer to gather devil's club "after the leaves senesce or when the plant is dormant, but not in the spring when it is just leafing out" because it is "not ripe or ready" then (Gottesfeld and Anderson 1988: 16). In those cases where harvesting was limited to specific times of year, timing seems to reflect a belief that devil's club is more or less potent at different times of the year (Moore 1993; Willard 1992), and to be largely unrelated to potentially differing impacts of harvesting on actively growing vs. dormant plants. However, as is the case for many shrubs, that harvesting during times of dormancy probably has a smaller impact on regeneration in the next growing season.

In addition to seasonal timing, some information in the literature indicates that devil's club was harvested by some cultural groups at a specific time of the day and in a specific location. According to Elsie Pierre (Davis, 1993) devil's club plants selected for harvesting must receive morning sun. Similarly, Turner and Hebda (1990:68) note that: "for maximum effectiveness, tree bark medicines are usually harvested in the early morning, before the harvester has eaten, and the bark is cut from the side of the tree on which the first rays of the morning sun shine." This practice is common to many Northwest Coast and some Interior First Peoples (Turner et al. 1983; Turner et al. 1990), and is applied when harvesting many woody medicinal species including cascara (*Rhamnus purshiana* DC), red alder (*Alnus rubra* Bong.), and bitter cherry (*Prunus emarginata* Dougl. ex Hook.). This practice reflects a belief that the bark heals faster on the sunny side of the tree (Turner and Hebda 1989). Interestingly, although there is no other reference to such a practice, Arvid Charlie noted that many individuals prefer devil's club harvested from:

> A heavy patch [with a large number of aerial stems], while others will see that patch and they'll walk until they get to a place where there's only a stem here and there, and that's the one they prefer.

Apparently the practice of harvesting more isolated plants, not growing in a large thicket, comes from the belief that these plants constitute stronger medicine; as Arvid described "something about the strength to the ones that stand by themselves."

<u>*Plant Parts Harvested*</u>

One of the most notable differences between the traditional and commercial use of devil's club is the part of the plant harvested. Unlike the commercial use of devil's club, which utilizes the inner bark of decumbent stems and the true roots produced along these horizontal stems, the plant part most commonly used traditionally is the inner bark of upright aerial stems. Several of the plant specialists interviewed in this study indicated that they too harvested the true roots and decumbent stems (AC and DP), and some of the records in the literature describe the traditional use of the true roots and decumbent stems (Table 3.1; Bouchard 1973; Johnson-Gotteseld 1993; Kari 1977; Turner et al., 1980).

However, the most common plant part referred to is the inner stem bark (Table 3.1; MT; Carrier Linguistic Committee 1973; de Laguna 1972; Emmons 1991; Gottesfeld and Anderson 1988; Hebda et al. 1996; Jones 1914; Johnson 1997; Justice 1966; MacDermot 1949; Turner 1982; Wennekens 1983). In Moerman's (1998) summary of devil's club uses, less than one fifth of his entries refer to the use of true roots. Additionally, most of the protocols for preparing devil's club medicines in the literature describe the removal of spines, and outer bark (Birket-Smith 1953; de Laguna 1972; Emmons 1991; Gottesfeld and Anderson 1988; Hebda et al. 1996; Johnson 1997; Turner 1982; Wennekens 1983), implying that the inner bark of the spiny aerial stems is far more widely used than the roots.

The more common usage of devil's club aerial stems may be largely related to the strong association between the prickly characteristic of devil's club stems and this plant's ability to "provide immunity against witchcraft, evil spirits, or people with malicious intent, and to provide luck and power to the user of the plant" (Turner 1982: 27). Many spiny plants, including wild roses (*Rosa* spp.), gooseberries (*Ribes* spp.), black hawthorn (*Crataegus douglasii* Lindl.), trailing wild blackberry (*Rubus ursinus* Cham. & Schlecht.), and Oregon grape (*Berberis aquifolium*) are also considered to have strong protective powers (Turner 1982). According to Arvid Charlie, "for certain kinds of illnesses, people want the pokey stuff on there." As John Thomas explained to Nancy Turner (Turner et al. 1983: 96), people use devil's club wood charcoal as face paint for ceremonial dancers: "because its sharp. When you see somebody with that kind of paint, you couldn't look them in the eye, their power is so strong." Similarly, a Tlingit informant interviewed by de Laguna (1972: 659) explained the power associated with devil's club spines, saying "nothing like[s] devil's club. Everybody is careful when they go among devil's club. They think the things in the world is scared of them."

Even though the more common usage of devil's club stems may have more to do with the power associated with the spines than with perceived differences in the sustainability of each practice, stem harvesting is still probably far less disruptive and damaging to devil's club populations. As Mary Thomas speculated:

> I don't know about the root, I've never seen them do that. They are so sensitive; I'd be really worried about digging the root and destroying the root.

Indeed research on clonal development and spread in devil's club and its mechanism for persistence throughout forest succession population (Chapter 2) suggests that decumbent stems, which must be removed when harvesting roots, are critical for ramet recruitment and regeneration following disturbance.

Spiritual Practices Associated with Harvesting

Unlike the relatively rare descriptions of specific harvesting strategies, spiritual practices associated with harvesting are often described in some detail in the literature. Plant specialists interviewed over the course of this study also shared information regarding spiritual practices associated with harvesting and use. In addition to general cultural protocols associated with resource utilization that demand respect for all life forms and for the land itself, and distain wastefulness (Anderson 1996; Turner and Atleo 1998; Turner et al. 2000a), devil's club, like other medicinal plants, was harvested, prepared, and used with extraordinary care and ritual, often following specific protocols (de Laguna 1972; Turner et al. 1983; Turner et al., 1990; Turner and Hebda 1989). Like many cultural groups on the Northwest Coast, amongst the Halkomelem and Straits Salish there, is "a strong link between medicines and the supernatural world. The Saanich and Cowichan respect medicinal plants and their curative powers" (Turner and Hebda 1989:68). Devil's club, like many medicinals, is thought to possess special powers, and when harvested, it is entreated to cure the sick person (Boas 1966; Turner and Bell 1971). Marilyn Walker (1999: 3) has described harvesting medicinal plants as an activity that "was both spiritual and corporeal, integrating intent and action." According to Walker (1999: 3), for many peoples harvesting medicinal plants required preparation including: "emptying one's heart of all bad thoughts, [and] perhaps fasting or cleansing." This type of practice is extremely well exemplified in the Kwakwaka'wakw words of praise and thanks[3] spoken by a man to devil's club before harvesting it to treat his wife's lingering illness:

> He walks up the river and when he arrives at a patch of devil's club plants he sits down and, looking at the devil's club plants, he prays and says, "Now look at me, for I come trying to come to you, great Supernatural Ones, being sent by my poor wife and I come and ask you for mercy that you please take out her sickness; that is the reason that she has been lying in bed for a long time sick with pains in her body. Now I come to call you, Supernatural Ones, that you may go please, and save her, you, Life Giver; and you also, Healing

[3] Daisy Sewid-Smith (Turner and Atleo 1998) notes that Boas' original description of this and similar passages as prayers is inaccurate. According to Sewid-Smith "Words of praise, acknowledgement, and thanks" are more accurate translations.

> Woman, that you, please, may set right my poor wife, please, that you wash off her sickness with your waters of life, that, please, she may live, please," says he as he stands up and takes his small axe and chops down the devils club bush (Boas, 1930: 240-241).

Mary Thomas (Secwepemc) remembers, as a child watching her grandmother harvest devil's club, the spiritual protocol that she followed:

> I could just hear my granny, … getting close to where the plants were, she'd do a little chant. She'd be chanting as she's walking towards the plant, and when she'd get there, she would actually talk to the plant like it was a live person. 'I came to you for help, Mother Nature has created you to help me … I need this medicine, I need to take it home, with respect I come to you to help me' and in return she'd put something back in the ground when she'd finished cutting what she needed. … before the tobacco, it was another plant that they used that was really close to them, like kinnikinnick or any plant that they'd have in a little bundle.

Bob Sam, interviewed by Walker (1999: 5), indicated, "when harvesting devil's club, you have to ask if a plant may be taken." Similarly, Captain Gold (Haida) stressed that when harvesting devil's club the plants must be asked permission and thanked and honoured. Proper acknowledgement of devil's club often consists of placing an offering back in the ground after harvesting as Elsie Pierre (Davis 1993: 63), Mary Thomas and Frederica de Laguna (1972) have described.

In addition to protocols for honouring and thanking devil's club when harvesting, there are also strict protocols for handling medicines. According to Martin Louie (Turner et al. 1980:73), in the summer, devil's club "was put down by the creek" both so that the medicine would be kept cool and so that "the shadow of another person wouldn't pass over it" shaming the medicine and "causing it to lose it's powers." According to Martin Louie, if this happened, the devil's club's had no power as a medicine and "you might as well drink water" (Turner et al. 1980: 73). Similar precautions were taken in preparing all medicines, but particularly in the case of devil's club, which is perceived as "extremely sensitive" (Turner et al. 1980: 73). Amongst the Gitxsan and Wet'suwet'en similar protocols were followed when collecting false hellebore (*Veratrum viride* Ait.). Like devil's club, this medicinal plant had enormous spiritual importance, was treated with great respect and caution, only gathered by certain individuals, only handled and looked at by a small number of people, and never left unattended (Johnson 1993; 1997; Gottesfeld and Anderson 1988). If these protocols were not followed, false hellebore was believed to lose its medicinal value, nullifying "the good power of the plant" and in some cases causing "harm to the user." (Johnson 1997: 119).

Although it is difficult to speculate about the specific impacts that spiritual practices associated with harvesting may have had on plant populations, it seems clear that the respect and care embodied in these practices would act as a cultural interdiction to prevent the overconsumptive and unsustainable use of devil's club. As Anderson (1996: 55) has argued, many spiritual beliefs on the Northwest Coast act to "sanction conservation and teach environmental knowledge."

Secrecy and Ownership of Medicinal Knowledge

Like many medicinal plants, information relating to devil's club preparations, particularly specific recipes that include a number of additional plants, are often closely guarded family secrets (Turner et al. 1982; 1983; Turner and Hebda 1989). This secrecy indicates the immense spiritual importance of many medicinal plants and is strongly tied to the spiritual belief that once knowledge of plant medicines is shared publicly it loses its power (Craig 1993; Johnson, 1997; Turner et al. 1980, 1983). According to Arlene Paul (Nuu-chah-nulth), people "never spoke of [medicinal knowledge]. They'd call it ***nuumak*** because it loses its potency for healing" when spoken about (Craig, 1993: 200). Secrecy about medicinal knowledge is also tied directly to the sacredness of the plants and medicines themselves. According to Arlene Paul:

> "These things [medicines] were kept silent because it was a sacred thing … like if a person had something for cancer they weren't going to go broadcasting it around, I get it [medicine] from here. They never did that. That was a silent tradition" (Craig 1993: 199).

Secrecy surrounding medicinal plants is also directly related to family ownership of specific medicinal knowledge and particular recipes. According to Luke Atleo (Nuu-chah-nulth), medicinal knowledge is:

> "Not public knowledge because it's owned knowledge, owned by the families. Just like songs are owned by families … There are some that are certainly commonly known … but there are some that are very strict secret family knowledge taught only within each family" (Craig, 1993: 199).

Amongst the Haida medicinal knowledge is also closely guarded within a family. According to Deagle (1988: 1589) "certain individuals are known to possess the recipe for medicines for certain types of ailments, and the exact ingredients of such medicines are well guarded secrets." Similarly, Halkomelem medicinal preparations were also regarded as family property (Turner and Hebda 1989). For the Gitxsan, medicinal knowledge was also transferred along family lines, often from grandparents to grandchildren, who might collect and prepare a specific medicine for a grandparent. Typically patients were from the same clan or were affinal relatives (Johnson 1997). Amongst the Blackfoot, the gathering of medicinal plants also appears to have been an individual task and "according to elders, individuals with spiritual curing powers are prohibited from revealing those powers to other members of the community" (Peacock 1992:69).

Like spiritual practices associated with harvesting, the reverence embodied in the secrecy surrounding the use and preparation of medicinal plants seems likely to have discouraged overuse. Additionally, limiting the transmission of medicinal knowledge through the cultural protocol of secrecy also may have itself prevented overconsumption, or at least restricted harvesting to only those with the greatest knowledge of the plant itself.

Conclusions

The diversity of traditional medicinal, spiritual, technological, and food uses for devil's club (Tables 3.0-3.2; Figure 3.1), the large number of etymons for devil's club in northwestern North American Languages (Table 3.4), and devil's club's importance in traditional mythology and oral tradition clearly demonstrate that devil's club is one of most the culturally significant plants throughout its range. Additionally, a number of specific practices and cultural protocols associated with harvesting, that are borne out of a deep spiritual reverence for this plant, reiterate this cultural significance. Paradoxically, the depth of this cultural importance provides significant insights into possible approaches to sustainably managing the commercial harvest, and many indicators that commercialization itself may conflict with the cultural value of devil's club.

The Report of the Royal Commission for Aboriginal Peoples (1996) describes several collective concerns of First Peoples relating to the commercialization of traditional knowledge that are relevant to the case of devil's club. These include "assurance of appropriate use of indigenous knowledge, portrayal of the authentic originators of this knowledge, … [and] the prevention of inappropriate imitation of indigenous practices which are a misinterpretation of Aboriginal culture and weaken its teachings" (as cited in Bannister 2000: 131-132). Although the bulk of devil's club use by the herbal industry parallels its traditional uses, and are amongst the most common uses described in the ethnographic literature, it is unclear if the commercialization of these uses would be considered culturally appropriate. Without consultation, of which there is little evidence in the commercialized use so far, it seems unlikely that commercialization of devil's club would be viewed as appropriate. Like many traditionally important medicinal plants, devil's club is thought to lose its power to heal if spoken about or shared with too many people. One of the most striking examples of an inappropriate commercial use of devil's club is the sale of ready made devil's club 'spirit paint'. Given the spiritual importance, and sacredness, of devil's club / red ochre paint, its sale would undoubtedly be seen by many First Peoples as an 'inappropriate imitation of indigenous knowledge.'

The adoption of devil's club by the herbal and nutraceutical industries, as well as research interest in pharmaceutical applications, has been driven primarily by ethnobotanical records of the traditional use. Consequently, the intellectual property rights of the First Peoples who collectively own this knowledge is another potential source of conflict. First Nations concerns that relate to intellectual property rights described in The Report of the Royal Commission for Aboriginal Peoples (1996) include: "proper protection of collective rights as opposed to individual rights, including [indigenous knowledge] that might otherwise be defined to be in the public domain, [and] … fair compensation for appropriate commercial use of intellectual and cultural property" (as cited in Bannister 2000: 131-132).

In 1992, signatories to the United Nations Convention on Biological Diversity formally recognized the intellectual property rights of indigenous and traditional peoples in Articles 1 and 8j by calling for fair and equitable sharing of any benefits resulting from the sustainable use of biodiversity, and traditional and local knowledge (Baker et al. 1995; Reid et al. 1993). Since Canada is a signatory to this treaty, it is legally and morally bound to uphold all of its 40 articles. However, despite the obvious conflict between the commercialization of devil's club in the absence of compensation, and articles 1 and 8j of the convention, there are currently no effective legal means to ensure that the compensation called for in the declaration is received. The concept of copyright and patent protection fundamental to western intellectual property rights law is designed to protect corporations and individual entrepreneurs. Thus far it has been inadequate in addressing intellectual property rights that relate to knowledge held in common by one or several cultural groups. Additional difficulties, discussed in more detail by Bannister (2000) and Posey and Dutfield (1996), include conflicts between indigenous world-views regarding ownership of knowledge and the monopolistic and exclusionary axioms inherent in the western concept of intellectual property rights (Posey and Dutfield, 1996), and the incapacity of current intellectual property rights law to protect traditional knowledge which has been published in the ethnographic literature and become part of the public domain.

To ensure that devil's club is used in a culturally appropriate manner and that the intellectual property rights of the cultural groups who collectively own the medicinal knowledge associated with this plant are protected, it is vital that First Nations control the growth and direction of any further commercialization of this plant. One current initiative in British Columbia, which includes an attempt to address some of these potential concerns, is described by Mitchell (2001). In many ways, specific harvesting practices that have significant potential for the development of systems of sustainable commercial use, many of which are strongly linked with broader spiritual and cultural practices, should only be implemented with the collaboration of the peoples that have used devil's club for millennia.

CHAPTER 4. EXPERIMENTAL HARVESTING OF DEVIL'S CLUB POPULATIONS: APPLYING TRADITIONAL KNOWLEDGE IN THE DEVELOPMENT OF HARVESTING GUIDELINES

Abstract

To assess potential population level impacts of commercial harvesting of on devil's club (*Oplopanax horridus*) and to examine the potential of traditional management practices in developing harvesting guidelines, I established six replicates of three harvesting treatments and a control, two of which partially emulated traditional harvesting practices. Post-harvest, I monitored all plots for survival, regeneration, recruitment, and growth in 2000 and 2001. Post-harvest data from the most intense treatment, in which regeneration and recruitment were close to zero, indicate that harvesting practices that remove large portions of decumbent stem and roots are probably detrimental to long-term population maintenance. Such practices deplete the bud bank, preventing regeneration and subsequent recruitment. Data from treatments emulating traditional harvesting strategies suggest that those practices that ensuring the maintenance of a functional bud bank are more conducive to long term sustainability. In intensively harvested plots where aerial stems were horizontally replanted to replenish the bud bank, regeneration and subsequent recruitment was significantly higher than in controls. Similarly, selective harvesting of clonal fragments may ensure population persistence by leaving part of the bud bank intact. These results also provide additional evidence that Traditional Ecological Knowledge, associated with specific harvesting practices, is integral to efforts to responsibly manage NTFPs.

"He walks up the river and when he arrives at a patch of devil's club plants he sits down and, looking at the devil's club plants, he prays and says, 'Now look at me, for I come trying to come to you, great Supernatural Ones, being sent by my poor wife and I come and ask you for mercy that you please take out her sickness; that is the reason that she has been lying in bed for a long time sick with pains in her body. Now I come to call you, Supernatural Ones, that you may go please, and save her, you, Life Giver; and you also, Healing Woman, that you, please, may set right my poor wife, please, that you wash off her sickness with your waters of life, that, please, she may live, please,' says he as he stands up and takes his small axe and chops down the devils club bush." Kwakwaka'wakw words of thanks spoken to devil's club as recorded by F. Boas (1930: 240-241).

Introduction

In the last decade in Canada and the United States, interest in commercial development of Non-Timber Forest Products (NTFPs) has increased considerably (Davidson-Hunt et al. 2001; De Geus 1995; Emery and McLain 2001; Thomas and Schumann 1993; Vance and Thomas 1998; Wills and Lipsey 1999). As the quantities of such plant materials harvested from forested ecosystems increase, researchers have expressed concerns about the ecological consequences and long-term sustainability of widespread extraction (Duchense et al. 2001; Turner 2001a; Turner and Cocksedge 2000; Vance 1999). For most species producing NTFPs, autecological data are largely descriptive, and little is known about their population ecology and potential responses to harvesting (Davidson-Hunt et al. 2001; Duchense et al. 2001; Schlosser et al. 1992; Turner and Cocksedge 2000; Wills and Lipsey 1999). The continual growth of this industry and potential for over-harvesting necessitates additional research on the autecology, population dynamics, and population level responses to harvesting of many NTFP species.

Devil's club (*Oplopanax horridus*), an understory shrub common in moist habitats in many forested ecosystems in western North America (Howard 1993; Scoggan 1979), is rapidly becoming a marketable medicinal NTFP (Small and Catling 1999; Wills and

Lipsey 1999). Due in part to the rich tradition of use of devil's club by the First Nations throughout its range (Turner 1982; Gottesfeld-Johnson 1992; Chapter 3), devil's club has become a relatively common commercial herbal medicine in western North America. Devil's club is also marketed, although it is unclear to what extent, as a substitute for ginseng (*Panax ginseng* C.A. May and *P. quinquefolius* L.) under the common names of Pacific ginseng, Alaskan ginseng, and wild-armoured Alaskan ginseng, in much the same way as Siberian ginseng (*Eleutherococcus senticosus* Maxim.; Araliaceae) (Awang *in press*). Devil's club has antibacterial (Kobaisy 1997; McCutcheon et al. 1993), antimycobacterial (Kobaisy 1997; McCutcheon et al. 1997), antifungal, (Kobaisy 1997; McCutcheon et al. 1994), and antiviral (McCutcheon et al. 1995; Wigwod 1998) properties and these findings have generated interest in the pharmaceutical industry (Wills and Lipsey 1999). Although it is difficult to assess the size of the annual harvest of devil's club, Wills and Lipsey (1999) estimate that in 1997 more than 3000 kg of bark were harvested from British Columbia. The market for devil's club as a ginseng substitute is undoubtedly in its infancy; however, Wills and Lipsey (1999) have suggested that devil's club has significant potential as a ginseng substitute in global markets.

Devil's club is a clonal shrub that maintains populations primarily through layering of decumbent stems and basal sprouting, but rarely through seedling recruitment (Chapter 2; Roorbach 1999). Thus it may be susceptible to over-harvesting of decumbent stems and roots, particularly if devil's club becomes a widely-consumed ginseng substitute, and is harvested on the same scale as Siberian ginseng. Because devil's club is also one of the most significant and revered of plants, both medicinally and spiritually, for many First Nations of British Columbia, its commercial exploitation and the potential for over-harvesting greatly concerns First Nations (Lantz 2001; Chapter 3).

One approach that has received considerable attention for its potential to improve resource management practices (Berkes 1999; Hunn 1999; Huntington 2000; Turner et al. 2000), including those for NTFPs (Turner 2001a; 2001b, Davidson-Hunt and Berkes 2001), is the inclusion of Traditional Ecological Knowledge (TEK) of peoples long resident to an area. For many culturally important plants compelling ethnographic and historical evidence suggests that traditional management practices actually increased their productivity and ensured their continued availability (Anderson 1996; Anderson 1997; Bandringa 1999; Chapter 3; Loewen 1998; Peacock 1998; Peacock and Turner 2000; Turner 2001b; Turner et al. 2000). In North America, the hypothesis that traditional management practices increase plant productivity has received only limited investigation (Anderson 1993). In one of the few rigorous tests of this hypothesis, Anderson and Rowney (1999) showed that traditional management practices including partial harvesting and replanting of propagules for blue dicks [*Dichelostemma capitatum* (Benth.) Keator], a root food important to indigenous peoples in California, can increase productivity and ensure a sustainable harvest.

Evidence from traditional management practices for devil's club, including partial and selective harvesting, replanting, and transplanting (Chapter 3), suggests that emulating traditional harvesting techniques may be an effective means to sustainably harvest devil's club. The goals of this study are: to provide a rapid assessment of the potential impacts of harvesting devil's club at different intensities, to assess the potential benefits of traditional harvesting practices, and to explore potential alternatives to wild harvesting. Specific objectives include assessing the impact of experimental harvesting treatments on: (1) clonal fragment survival, regeneration, and recruitment; (2) ramet survival, regeneration, recruitment, and growth; and (3) ramet size distributions, clonal fragment size, and overall biomass. Survival and growth of devil's club outplanted in propagation trials are also assessed.

Methods

Harvesting experiments

To investigate the potential population level impacts of harvesting devil's club and to examine the potential benefits of traditional harvesting practices, I established six replicates each of three harvesting intensities (two of which were partially based on traditional practices [Chapter 3]) and a control, using 24 (16 m^2) permanent plots located throughout the China Creek drainage on southwestern Vancouver Island (Fig. 4.1, Table 4.1). From March to April, 2000, prior to harvesting I mapped, using a 16 m^2 quadrat with an internal grid of 0.5m, the size, spatial distribution and interconnections of all clonal fragments and ramets that originated in the plot by partially excavating clonal fragments until reaching their termini, sometimes well outside the plot. Clonal fragments are defined here as aggregations of aerial stems (ramets) interconnected by a common system of rooted decumbent stems and not obviously connected to other clonal fragments (Chapter 2). I tagged and numbered all clonal fragments and ramets, and recorded: (1) the size (height and basal diameter) of each ramet; (2) ramet condition class (upright, partially decumbent, or dead); (3) a three-year ramet growth history (using terminal bud scale scars); and (4) the number of ramets per clonal fragment. I digitized field maps using OCAD (Steinegger 1999) and estimated the length of decumbent stem networks for each clonal fragment based on these maps (Fig. 4.2). All permanent plots were located at elevations between 400 and 440 m and represented the range of moisture and nutrient conditions present throughout the drainage (Fig. 4.1; Table 4.1). In general, all permanent plots were in close proximity to creeks or in seepage areas and were characterized by a dense overstory (mean canopy cover = 83.5%) of red alder (*Alnus rubra* Bong.), western redcedar (*Thuja plicata* Donn.), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) (Table 1). Percent canopy closure was estimated using a spherical densiometer and by averaging two measurements taken at the centre of the plot. Common understory species included salmonberry (*Rubus spectabilis* Pursh), sword fern (*Polysticum munitum* (Kaulf.) Presl.), lady fern (*Athyrium filix-femina* (L.) Roth), vanilla leaf (*Achlys triphylla* (Smith) DC.), and false bugbane (*Trautvetteria caroliniensis* (Walt.) Vail.). Soils were examined between May 12th and 15th, 2000 by digging a soil pit at each site. Soil nutrient and relative moisture regimes were determined using the methodology outlined by Green and Klinka (1994), where VR=very rich, R=rich, and M=medium. The relative moisture classification system outlined by Green and Klinka (1994) uses 8 moisture classes to categorize the soil from the driest (0) to wettest (7) (Table 4.1). Soils were rich to very rich humoferric podzols with moder or mull humus forms, and were mesic to subhygric. Medium bench floodplains sites typically had less developed organic horizons.

After mapping, I randomly assigned plots to one of the three treatments or control and carried out harvesting from May 12th-15th, 1999. In the least intense harvesting treatment (traditional stem harvesting [TSH], partially emulating a traditional harvesting strategy; Chapter 3), I harvested approximately half of all aerial stems attached to each clonal fragment, and half of the single-stemmed clonal fragments (Figs. 4.2a-4.2b).

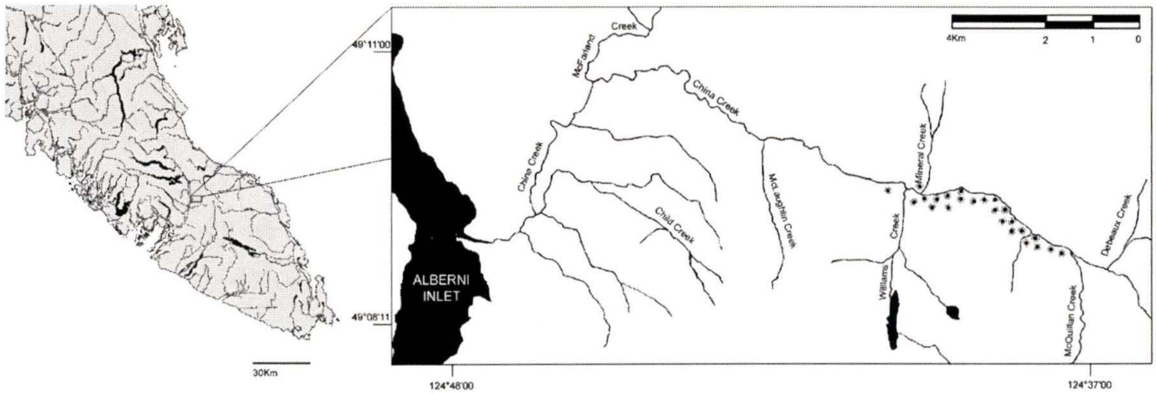


Figure 4.1 Location of the China Creek Drainage on Southern Vancouver Island (at left). Inset map (at right) shows the China Creek drainage and the location of permanent plots.

Table 4.1 Site characteristics of harvesting plots.

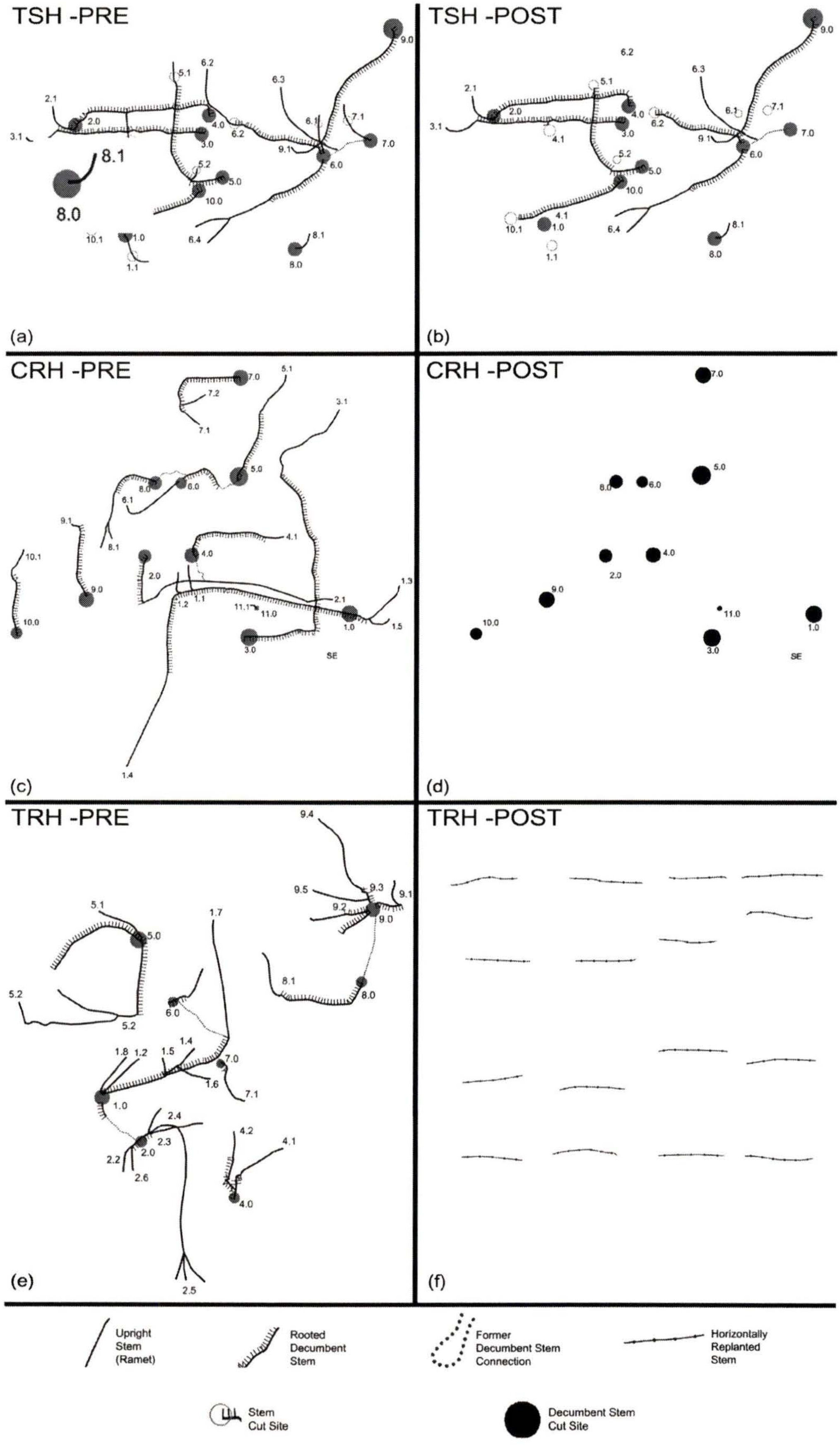
HARVESTING TREATMENT	NUTRIENT REGIME	DOMINANT OVERSTORY SPECIES	MOISTURE REGIME	CANOPY CLOSURE (%)
Control	M	Alder, Hemlock	5	85
(C)	VR	Cedar, Hemlock	5	85
	VR	Alder, Cedar	5	64
	VR	Alder, Hemlock	5	83
	R	Alder, Cedar	5	90
	VR	Alder, Cedar	5	76
Traditional Stem Harvest	VR	Alder, Hemlock	5	92
(TSH)	R	Alder, Cedar	4	82
	R	Alder, Cedar	4	83
	R	Alder, Cedar	4	83
	R	Alder, Cedar	4	79
	M	Alder, Hemlock	5	81
Traditional Root Harvest	VR	Alder, Hemlock	5	84
(TRH)	VR	Alder, Cedar	5	91
	VR	Alder, Cedar	5	89
	VR	Alder, Hemlock	5	75
	R	Hemlock, Alder	3	81
	M	Cedar, Douglas-fir	4	92
Commercial Root Harvest	R	Alder, Cedar	4	74
(CRH)	M	Cedar	5	79
	R	Hemlock, Cedar	5	96
	VR	Hemlock, Douglas-fir	5	94
	VR	Hemlock, Alder	5	80
	VR	Alder, Hemlock	5	84

In the second treatment (traditional root harvesting [TRH] partly emulating a traditional harvesting strategy; Chapter 3) I harvested all of the aerial and decumbent stems and replanted the plot with 16 (50 cm) sections of stem, each with at least two terminal bud scale scars. I replanted stem sections by burying them horizontally in approximately 1 cm of duff and moss (Fig. 4.2e-4.2f). In the most intense harvesting treatment (commercial root harvesting [CRH]: emulating intense commercial harvesting; Chapter 3), I removed all of the aerial and decumbent stems in the plot (Fig. 4.2c-4.2d).

Propagation Experiments

To assess the viability of cultivating devil's club under forest canopy in a low maintenance agroforestry system as an alternative to wild harvesting, I conducted out-planting trials. In these trials I planted 160 rooted apical cuttings in a third-growth forest in a moist riparian habitat along Kitsucksus creek (49° 16' 00" N - 124° 49'00" W) in habitat that appeared to be suitable for devil's club. The canopy along the creek was dominated by red alder (*Alnus rubra*), big-leaf maple (*Acer macrophyllum* Pursh), and western redcedar (*Thuja plicata*). Common understory species included salmonberry (*Rubus spectabilis*), red elderberry (*Sambucus racemosa* L.), stink currant (*Ribes bracteosum* Dougl. ex Hook.), sword fern (*Polystichum munitum*), wall lettuce (*Lactuca muralis* (L.) Fresen.) (introduced), and false bugbane (*Trautvetteria caroliniensis*). I established all plots within 10 meters of Kitsucksus Creek, half in areas with dense canopy cover and the other half in partially shaded areas with a less closed canopy. Cuttings were taken from three devil's club populations in the China Creek drainage in late April, before the leaves had flushed. These cuttings were placed in water for

Figure 4.2 Sample plot maps showing three treatment intensities including: (a) traditional stem harvesting pre-treatment; (b) traditional stem-harvesting post-treatment, (c) commercial root harvesting pre-treatment; (d) commercial root harvesting post-treatment; (e) traditional root harvesting pre-treatment; and (f) traditional root harvesting post-treatment. Maps show clonal fragments, attached ramets, decumbent stem connections, and former connections between clonal fragments, Scale bars = 1m.



TSH -PRE
(a)
TSH -POST
(b)
CRH -PRE
(c)
CRH -POST
(d)
TRH -PRE
(e)
TRH -POST
(f)
Upright Stem (Ramet)
Rooted Decumbent Stem
Former Decumbent Stem Connection
Horizontally Replanted Stem
Stem Cut Site
Decumbent Stem Cut Site

approximately three weeks until roots had developed along immersed portions of the stem. I outplanted cuttings by burying approximately one third of the stem in mineral soil, from June 7-8th, 2000. This protocol was also partially based on a traditional practice described by Halkomelem plant specialist Arvid Charlie (Chapter 3).

Monitoring

To monitor harvesting experiments I re-censused all plots including all controls, in August 2000 and May 2001 by recording: (1) stem incremental growth (2000); (2) the number of clonal fragments surviving harvest (2000); (3) the number of ramets surviving harvest (2000); (4) number of ramets recruited in 2000; (5) the number of ramets recruited in 2001; (6) the number of new clonal fragments (2001); and (7) the number of ramets per clonal fragment (2001). To assess the initial impact of harvesting on ramets and clonal fragments, I calculated (1) pre and post-harvest biomass based on regression equations developed by Alaback (1986) to estimate devil's club biomass in coastal Alaska, (2) percent clonal fragment survival, and (3) percent ramet survival. To separate regeneration and recruitment of new clonal fragments and ramets between August 2000 and May 2001 from survival in 2000 percent, I calculated (4) clonal fragment regeneration and recruitment (regeneration in the text), and (5) percent ramet regeneration and recruitment (regeneration in the text). I also calculated (6) percent change in clonal fragment size and the (7) mean change in stem growth increment.

(1) $Biomass_{(g)} = 8.9084 \ln (basal\ diameter_{(mm)}) - 16.8581,\ r^2=0.84.$

(2) *Percent clonal fragment survival [2000] = (post-harvest number of clonal fragments /pre-harvest number*[4] *[August, 2000])*100.*

(3) *Percent ramet survival [2000] = (post-harvest number of ramets /pre-harvest number*[6] *[August, 2000])*100.*

(4) *Percent clonal fragment regeneration and = (number of clonal fragments [May 2001] / pre-harvest number)*100 - percent survival (2000).*

(5) *Percent ramet regeneration and recruitment = (number of ramets [May 2001] / pre-harvest number)*100 - percent survival [2000].*

(6) *percent change in clonal fragment size [1999-2001] = (the average number of ramets per clonal fragment [2001] / the average number [1999])*100.*

(7) *mean change in stem growth increment = ramet growth increment (2000) – average growth increment (1997-1999).*

Propagation experiments were also monitored by census in August 2000 and May 2001 by recording the number of surviving rooted cuttings.

Data Analysis

I used one-way analysis of variance and least significant difference ($P < 0.05$) (Sokal and Rohlf 1995) to examine differences between treatments and to test the null hypotheses that harvesting treatments did not affect: (1) clonal fragment survival in 2000; (2) ramet survival in 2000; (3) clonal fragment regeneration in 2001; (4) ramet regeneration in 2001; (5) ramet recruitment /m^2 in 2000; (6) ramet recruitment /m^2 in

[4] The number of post-harvest clonal fragments or ramets does not include ramets or clonal fragments produced from stems re-planted horizontally in the traditional root-harvesting treatment.

2001; (7) post-harvest change in stem incremental growth; or (8) post-harvest change in clonal fragment size.

Results

Harvesting Experiments

Effects on Biomass and Survival of Clonal Fragments and Ramets

Treatments had a range of impacts on aboveground biomass and on the number of clonal fragments and ramets (present pre-harvest) surviving treatment (Figs. 4.3-4.4; Tables 4.2-4.3). In the traditional stem-harvesting treatment (TSH), a large number of partially harvested ramets and clonal fragments were left within the plot (Figs. 4.4a-4.4b) and average devil's club biomass was reduced by an average of 41 percent following treatment (Fig. 4.3a). In the commercial root-harvesting treatment (CRH) there were no clonal fragments left immediately post-harvest (Figs. 4.4c-4.4d), and all devil's club biomass was removed from the site (Fig. 4.3a). Similarly, in the traditional root-harvesting treatment there were no clonal fragments left intact post-harvest (Figs. 4.4e-4.4f) and all biomass was removed from the site (Fig. 4.3a). Since no harvesting was carried out in control plots, biomass was unchanged immediately following treatments.

Post-harvest survival of clonal fragments present before harvesting was significantly lower ($P < 0.001$) in all treatments than in the control (Fig. 4.3b), and post-harvest clonal fragment and ramet survival closely reflected changes in mean treatment biomass. However, treatments from which all visible decumbent stems and roots were removed (TRH and CRH) did show some clonal fragment survival. In these treatments, a

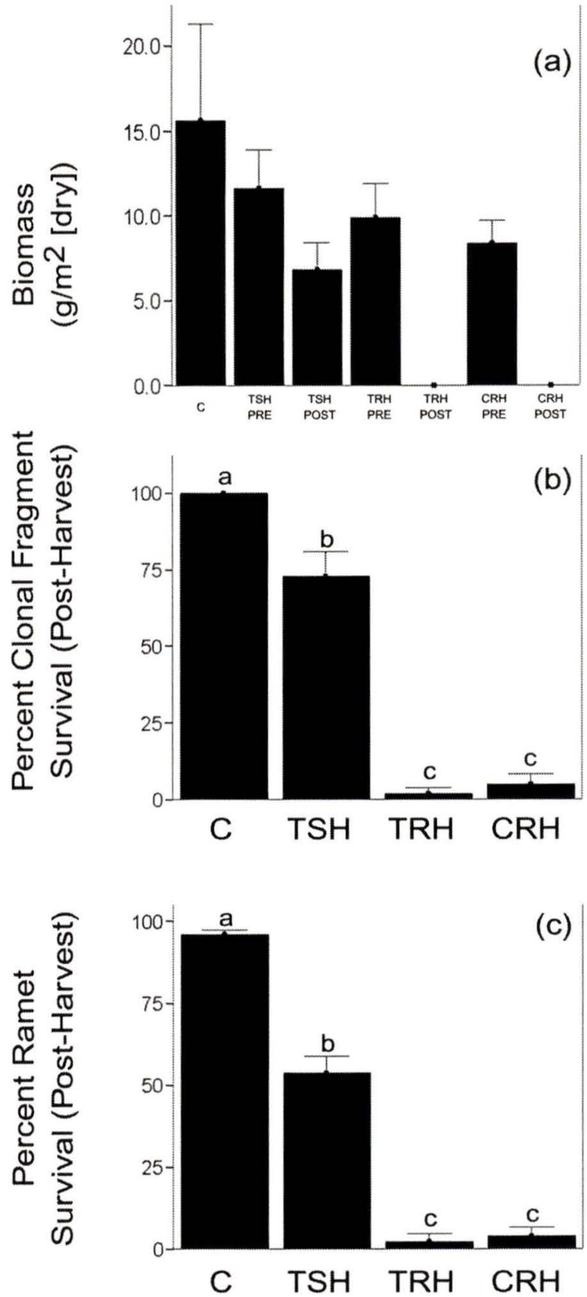


Figure 4.3 Intensity of harvest treatments. (a) Pre- and post-treatment devil's club biomass (dry weight in g/m^2). Bars show treatment means for: C=control, TSH PRE=traditional stem harvest pre-treatment, TSH POST=traditional stem harvest post-treatment, TRH PRE=traditional root harvest pre-treatment, TRH POST=traditional root harvest post-treatment, CRH PRE=traditional root harvest pre-treatment, and CRH POST=traditional root harvest post-treatment. Error bars represent ±1 SE. (b) Percent clonal fragment survival post-harvest, (c) percent ramet survival post-harvest, bars show treatment means for: C=Control, TSH=traditional stem harvest, TRH=traditional root harvest, and CRH=traditional root harvest. Error bars represent ±1SE.

few deeply buried clonal fragments present before harvesting survived and had produced new shoots by August of the same year. Overall however, survival of clonal fragments present before harvesting was very low in both the traditional and commercial root-harvesting plots (Fig. 4.3b). Although also lower than the control ($P < 0.001$), post-harvest clonal fragment survival in the traditional stem-harvesting treatment was much higher ($P < 0.001$) than in both root-harvesting treatments (Fig. 4.3b). Similarly, post-harvest survival of ramets present before treatment was significantly lower ($P < 0.001$) in all treatments compared with the control (Fig. 4.3c). In the traditional stem-harvesting treatment ramet survival in (2000) was higher than in both root-harvesting treatments ($P < 0.001$), but significantly lower ($P < 0.001$) than in the control (Fig. 4.3c).

Post-harvest Regeneration in 2001

Despite the initial survival of a few deeply buried clonal fragments in 2000, there was little or no additional regeneration or recruitment in the commercial root-harvesting treatment (CRH) in 2001 (Figs. 4.3b; 4.4c-d; 4.5a). In contrast, although clonal fragment and ramet survival in the traditional root-harvesting treatment was extremely low in 2000, most of the horizontally replanted stems rooted, and survived as clonal fragments that produced new ramets in both 2000 and 2001 (Figs. 4.3b; 4.4e-4.4f; 4.5a; 4.5c-4.5d). In contrast to other treatments, in which clonal fragment regeneration in 2001 was quite similar to the control (Fig. 4.5a), the traditional root-harvesting treatment showed significantly higher regeneration in 2001 ($P < 0.001$) than did the control (Fig. 4.5a).

Similarly, although only a few of those ramets present before harvesting survived either the traditional or commercial root-harvesting treatments (Fig. 4.3c), the regeneration of ramets in the traditional root-harvesting treatment was significantly higher

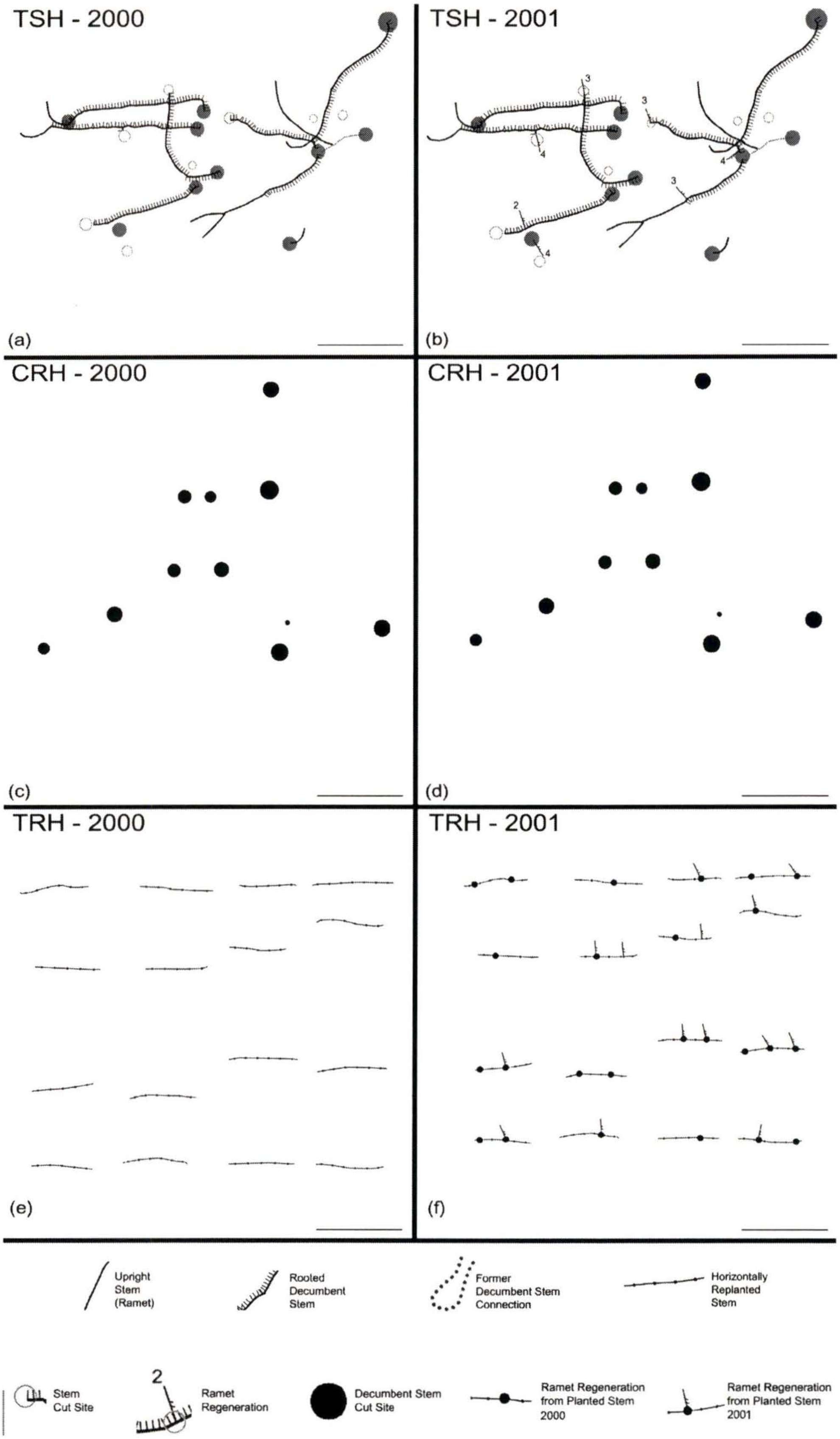
(P < 0.01) than in the control because of sprouting from horizontally replanted stems (Fig. 4.5b). The number of ramets produced per unit area was also significantly higher in 2000, but not 2001, in the traditional root-harvesting treatment compared with the control, (P < 0.05) and traditional stem-harvesting (P < 0.05) treatments (Figs. 4.5c). In the commercial root-harvesting treatment (P < 0.001), where no replanting was conducted, there was little additional ramet regeneration or recruitment (Fig 4.5d). In this treatment ramet regeneration was significantly lower than the control (P < 0.01) in 2001, but not in 2000, and significantly higher than in the TRH treatment (P < 0.001) in both 2000 and 2001 (Figs. 4.5c-4.5d).

In the traditional stem-harvesting treatment (TSH) many partially harvested clonal fragments sprouted prolifically from the base of cut sites, and harvested single stemmed clonal fragments sprouted from buried decumbent stems not removed from the site (Figs. 4.4a-b). Ramet regeneration from partially harvested clonal fragments was high in the traditional stem-harvesting treatment, and was not significantly different from recruitment in the unharvested controls (Fig. 4.5d). Similarly, ramet recruitment in the traditional stem-harvesting treatment was not significantly different from the control in 2000 and 2001 (Figs. 4.5c-4.5d).

Post-harvest Growth and Population Size Structure

Mean post-harvest growth in the traditional stem-harvesting plots was lower than for the control, but the difference was not statistically significant (Fig. 4.5e). Because the incremental growth of ramets produced in 2000 was generally less than 1 cm, and was

Figure 4.4 Sample plot maps showing post-harvest condition and survival and regeneration in 2001, including: (a) traditional stem harvesting post-treatment survival; (b) traditional stem harvesting recruitment and regeneration in 2001; (c) commercial root harvesting post-treatment survival; (d) commercial root harvesting regeneration in 2001; (e) traditional root harvesting post-treatment survival; and (f) traditional root harvesting regeneration in 2001. Maps show clonal fragments, attached ramets, decumbent stem connections, former connections between clonal fragments, stem cut sites, decumbent stem cut sites, and ramet regeneration sites. Scale bars = 1m.



TSH - 2000
TSH - 2001
CRH - 2000
CRH - 2001
TRH - 2000
TRH - 2001
(a)
(b)
(c)
(d)
(e)
(f)
Upright Stem (Ramet)
Rooted Decumbent Stem
Former Decumbent Stem Connection
Horizontally Replanted Stem
Stem Cut Site
Ramet Regeneration
Decumbent Stem Cut Site
Ramet Regeneration from Planted Stem 2000
Ramet Regeneration from Planted Stem 2001

often difficult to separate from the current year's (2001) growth, it was not measured in any of the treatments.

Harvesting treatments also had a range of effects on the clonal fragment size and the size distribution of ramets. The percent change in clonal fragment size from 2000-2001 (number of ramets per clonal fragment) was significantly higher ($P < 0.001$) in the traditional root-harvesting treatment than in all other treatments and the control (Fig. 4.5f). However, the number of ramets per clonal fragment remained largely unchanged in the commercial root-harvesting and traditional stem-harvesting plots and was not significantly different from the control (Fig. 4.5f).

In all treatments, the number of ramets in the smallest size class increased post-harvest (Fig. 4.6). In the control the numbers of ramets in larger size classes were similar before and after harvesting (Figs. 4.6a-4.6b). In the traditional stem-harvesting treatment the numbers of ramets in larger size classes were slightly reduced post-harvest (Figs. 4.6c-4.6d). In both the traditional and commercial root-harvesting treatments, only individuals in the smallest size classes remained post-harvest (Figs 4.6e-4.6h).

Propagation Experiments

At the time of the August 2000 census the leaves of all out-planted cuttings had senesced, and it was impossible to determine the survival status of all plants in the plots. I re-censused all plots in the spring of 2001 and no cuttings in any of the plots had survived.

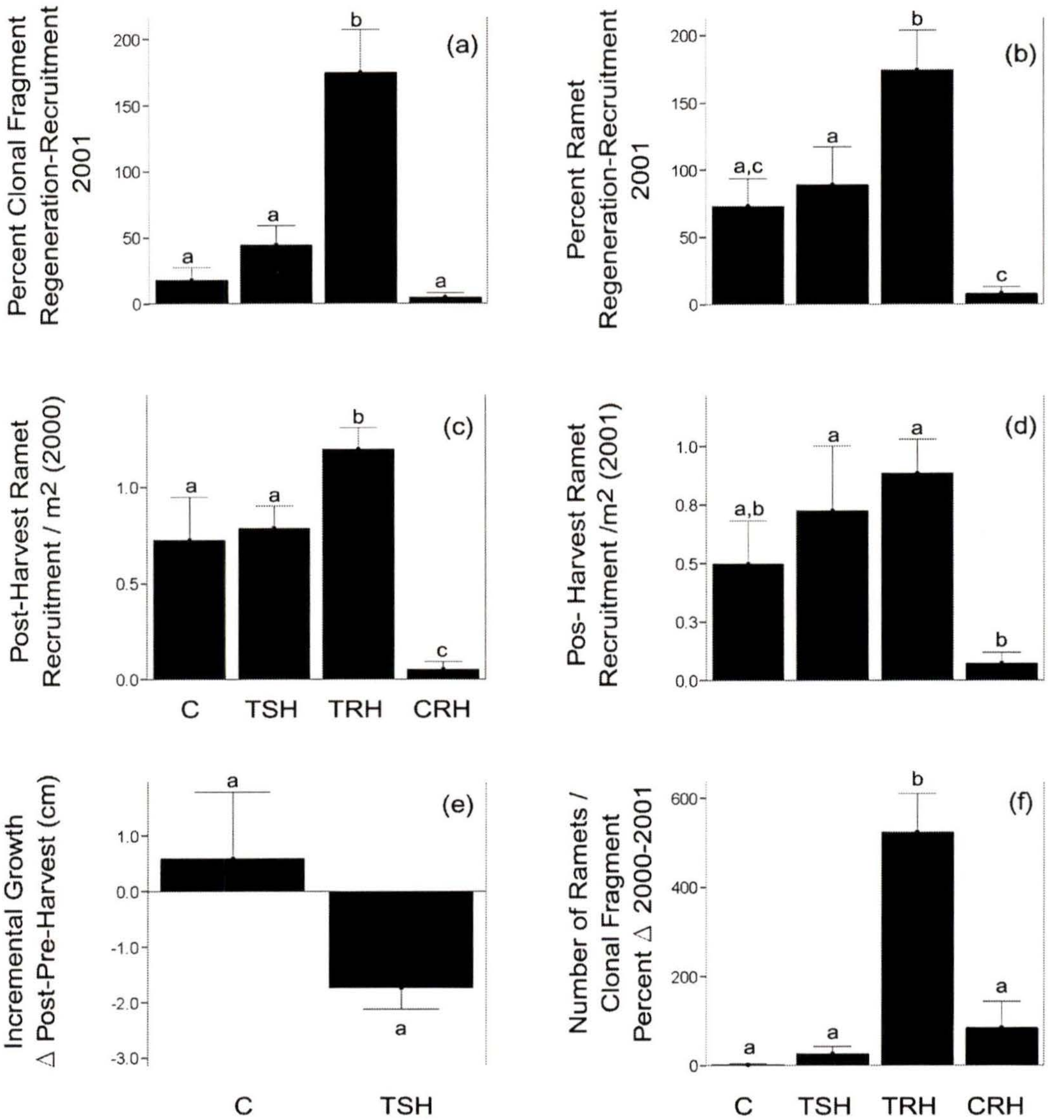


Figure 4.5 Post-harvest clonal population characteristics in 2000 and 2001. Bars show treatment means for: C=control; TSH=traditional stem harvest; TRH=traditional root harvest; and CRH=commercial root harvest. Error bars represent ±1SE. (a) percent clonal fragment regeneration 2000-2001; (b) percent ramet regeneration 2000-2001; (c) post-harvest ramet recruitment 2000; (d) post-harvest ramet recruitment 2001; (e) post-harvest change in incremental growth; and (f) post-harvest change in clonal fragment size Recruitment /m2 (2001).

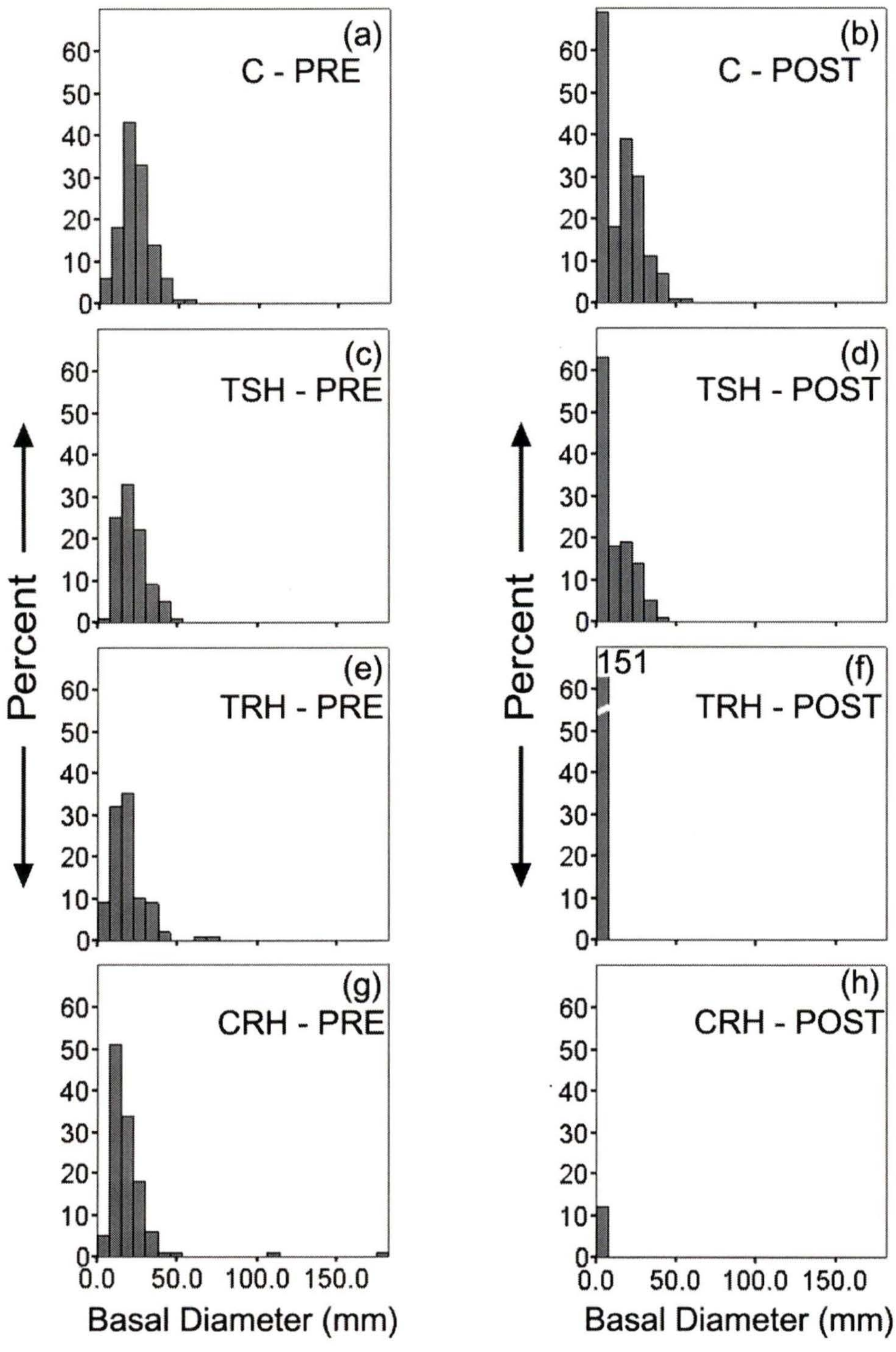
Table 4.2 Summary statistics for post-harvest clonal population characteristics in 2000 and 2001. Means with different superscripted letters are significantly different ($P \leq 0.05$).

Variable	N	Mean	Standard Deviation	Standard Error
Percent clonal fragment survival (post-harvest)				
Control	6	100.0000[a]	.0000	.0000
Traditional stem harvesting	6	72.8636[b]	17.7124	7.9212
Traditional root harvesting	6	1.8519[c]	4.5361	1.8519
Commercial root harvesting	6	5.0303[c]	8.0344	3.2800
Percent ramet survival (post harvest)				
Control	6	96.0076[a]	2.9237	1.3075
Traditional stem harvesting	6	53.8343[b]	11.3005	5.0537
Traditional root harvesting	6	2.2727[c]	5.5670	2.2727
Commercial root harvesting	6	3.9655[c]	6.2594	2.5554
Percent clonal fragment regeneration-recruitment 2001				
Control	6	18.2143[a]	21.2942	9.5231
Traditional stem harvesting	6	44.6364[a]	32.3788	14.4803
Traditional root harvesting	6	174.861[b]	78.9733	32.2407
Commercial root harvesting	6	5.0303[a]	8.0344	3.2800
Percent ramet regeneration-recruitment 2001				
Control	6	73.3409[a,c]	45.2183	20.2223
Traditional stem harvesting	6	89.0414[a]	62.5941	27.9929
Traditional root harvesting	6	174.333[b]	72.3877	29.5521
Commercial root harvesting	6	7.9310[c]	12.5187	5.1107
Post-harvest ramet recruitment - 2000 (number/m^2)				
Control	6	.7250[a]	.4953	.2215
Traditional stem harvesting	6	.7875[a]	.2562	.1146
Traditional root harvesting	6	1.1979[b]	.2750	.1123
Commercial root harvesting	6	5.21E-02[c]	.1001	4.088E-02
Post harvest ramet recruitment - 2001 (number/m^2)				
Control	6	.5000[a,b]	.4050	.1811
Traditional stem harvesting	6	.7250[a]	.6212	.2778
Traditional root harvesting	6	.8854[a]	.3567	.1456
Commercial root harvesting	6	7.29E-02[b]	.1147	4.682E-02
Incremental growth change – post-pre-harvest (cm)				
Control	6	.5889[a]	2.6762	1.1969
Traditional stem harvesting	6	-1.7432[a]	.8350	.3734
Traditional root harvesting	6	/	/	/
Commercial root harvesting	6	/	/	/
Number of ramets / clonal fragment percent change 2000-2001				
Control	6	2.2100[a]	3.0660	1.3712
Traditional stem harvesting	6	26.9068[a]	34.7606	15.5454
Traditional root harvesting	6	523.704[b]	211.4349	86.3179
Commercial root harvesting	6	84.9713[a]	143.3948	58.5407

Table 4.3 Anova table for post-harvest clonal population characteristics in 2000 and 2001.

Variable	Sum of Squares	df	Mean Square	F	P
Percent clonal fragment survival (post-harvest)					
Between groups	39439.243	3	13146.414	140.808	.000
Within groups	1680.553	18	93.364		
Total	41119.796	21			
Percent ramet survival (post harvest)					
Between groups	32575.966	3	10858.655	218.178	.000
Within groups	895.853	18	49.770		
Total	33471.819	21			
Percent clonal fragment regeneration-recruitment 2001					
Between groups	106952.654	3	35650.885	17.106	.000
Within groups	37513.996	18	2084.111		
Total	144466.650	21			
Percent ramet regeneration-recruitment 2001					
Between groups	84224.478	3	28074.826	9.941	.000
Within groups	50834.365	18	2824.131		
Total	135058.843	21			
Post-harvest ramet recruitment – 2000 (number/m^2)					
Between groups	4.043	3	1.348	14.506	.000
Within groups	1.672	18	9.290E-02		
Total	5.715	21			
Post-harvest ramet recruitment - 2001 (number/m^2)					
Between groups	2.204	3	.735	4.557	.015
Within groups	2.902	18	.161		
Total	5.106	21			
Incremental growth change – post-pre-harvest (cm)					
Between groups	13.596	3	4.532	.865	.509
Within groups	31.438	6	5.240		
Total	45.034	9			
Number of ramets / clonal fragment percent change 2000-2001					
Between groups	1037011.949	3	345670.650	18.786	.000
Within groups	331204.717	18	18400.262		
Total	1368216.666	21			

Figure 4.6 Pre- and post-harvest (May 2001) ramet size density (basal diameter [mm]) by treatment including: (a) control pre-harvest (C-PRE); (b) control post-harvest (C-POST); (c) traditional stem harvest pre-harvest (TSH-PRE); (d) traditional stem harvest post-harvest (TSH-POST); (e) traditional root harvest pre-harvest (TRH-PRE); (f) traditional root harvest post-harvest (TRH-POST); (g) commercial root harvest pre-harvest (CRH-PRE); and (h) commercial root harvest post-harvest (CRH-POST). Bars represent percent by treatment.


(a)
C - PRE
(b)
C - POST
(c)
TSH - PRE
(d)
TSH - POST
(e)
TRH - PRE
(f)
TRH - POST
151
(g)
CRH - PRE
(h)
CRH - POST
Percent
Percent
0
10
20
30
40
50
60
0.0
50.0
100.0
150.0
Basal Diameter (mm)
Basal Diameter (mm)

Discussion

Harvesting Experiments

Impacts of Harvesting on Vegetative Growth

One of devil's club's most striking responses to the harvesting treatments was its capacity for vegetative regeneration. No seedling recruitment was observed in any of the plots and all recruitment and regeneration observed was vegetative. In the traditional root-harvesting treatment, a large number of the stems that were replanted horizontally formed roots and prolifically recruited ramets from lateral meristems (Figs. 4.4e-4.4f; 4.5a-4.5d; 4.7; 4.9). The developmental plasticity of these stems is consistent with observations that devil's club maintains established populations vegetatively, primarily through layering of decumbent shoots and basal stem sprouting.

Figure 4.7 Single devil's club ramet growing from an aerial stem buried horizontally in the traditional stem-harvesting treatment, August, 2000.

As decumbent stems root, lateral branches and new shoots produced on the decumbent stem axis become potentially independent ramets (Chapter 2; Roorbach 1999). In Oregon, Roorbach (1999) observed that even small broken pieces of devil's club stem could layer and root. Devil's club's capacity for vegetative regeneration is reinforced by the commercial root-harvesting treatments. Although almost all of the decumbent stems and roots were removed in several of the plots, deeply buried fragments of decumbent stem or root did survive and produce new shoots, demonstrating devil's club's ability to regenerate vegetatively even from small pieces of clonal fragments.

In the traditional stem-harvesting treatment, many of the multi-stemmed and single stemmed clonal fragments from which the aboveground parts were partially or completely harvested (respectively) showed prolific vegetative recruitment at cut ends of sites and along the length of partially intact decumbent stems (Figs. 4.4a-b; 4.5a-4.5d; 4.8; 4.10). Prolific shoot production along decumbent stems from which some or all the aerial stems were removed suggests that devil's club responds to damage through increased formation of new ramets (Figs. 4.5c-4.5d) at little expense to incremental growth within the rest of the clonal fragment (Fig. 4.5e). These results are consistent with observations of increased ramet recruitment in devil's club populations in disturbed environments such as clearcuts (Chapter 2). Roorbach (1999) has concluded, on the basis of aerial stem-lopping experiments, that devil's club likely responds to other types of disturbances (including herbivory, flooding and sediment deposition, and avalanche) in a similar fashion, by increasing branching and lateral bud production. Like other clonal plants, devil's club may be particularly well adapted to these types of disturbance because it can quickly regenerate after disturbance by sharing resources within the clonal fragment and replacing damaged parts of the clonal fragment through recruitment (Cook 1983; Hartnett and Bazzaz 1985; Pitelka and Ashmun 1985; Roorbach 1999).

Figure 4.8 Prolific ramet recruitment along partially buried decumbent stems of devil's club partially harvested in the traditional stem-harvesting treatment.

Implications for Sustainable Harvesting

From a demographic standpoint, clonal shrubs are notoriously difficult organisms to study. The longevity of below-ground structures can make it impossible to determine the age or extent of genetic individuals (genets), and the modular iteration of ramets can make defining functional individuals in the population quite complicated. Furthermore, slow growth and infrequent seedling recruitment can make the observations of entire genet life cycles close to impossible (Harper 1977; Huenneke 1987). Short-term or static comparisons of such organisms in harvested and unharvested populations only document the immediate impact of harvesting on population structure. Because dynamic population characteristics, not revealed by in changes in the population structure, may be quite significant for long-lived clonal plants, short-term data on population structure cannot be used to extrapolate the long-term impact of harvesting, and ultimately cannot be used to reliably predict what constitutes a sustainable harvesting level (Boot and Gullison 1995). Therefore, based on the limited time series data presented here, it is difficult to speculate about the potential long-term population responses to the harvesting treatments.

In the case of devil's club, the rarity of seedling recruitment (Chapter 2; Roorbach 1999) implies that vegetative reproduction, and therefore decumbent and older aerial stems, are more critical to long-term population maintenance than seedling recruitment. However, at a longer temporal scale, periodic seeding recruitment, and consequently older flowering ramets, may make an essential contribution to long-term population stability. In order to critically assess longer-term impacts of these harvesting treatments, monitoring through annual census should continue for the next three to five years. Ultimately, these data can be used to construct stage-based matrices (life tables) (Caswell, 2001) to project the long-term impacts of harvesting on the population dynamics of devil's club, and formulate more reliable hypotheses about sustainable harvesting levels.

However, these results do provide a useful preliminary assessment of the impact of harvesting. Post-harvesting treatment data suggest that devil's club populations are most negatively impacted by harvesting treatments that remove decumbent stems and roots. This removal limits the potential for vegetative regeneration and continued recruitment, by reducing the functional bud bank. In the commercial root-harvesting treatment, in which most of the decumbent stems and roots were removed, clonal fragment survival was extremely low and consequently there was little to no subsequent recruitment of ramets (Figs. 4.5a-4.5d). Apparently, devil's club does not readily regenerate from a soil seed bank, and below-ground structures act as a vegetative bud bank essential to regeneration (Chapter 2; Roorbach 1999). This highlights the importance of below-ground structures for post-harvest regeneration and for continued population maintenance. It also suggests that some below-ground structures should be left intact to ensure population persistence.

In the traditional root-harvesting treatment, in which upright stems were replanted horizontally, prolific vegetative recruitment (Figs. 4.4e-4.4f; 4.5a-4.5d), reinforces the importance of the bud bank in regeneration. The ability of replanted stems to root and produce shoots demonstrates devil's club's impressive capacity for vegetative growth, and it suggests that leaving some decumbent stems on site, or replanting upright stems horizontally, may be critical to ensure regeneration. Because mortality of the ramets produced from replanted stems was low in 2000 and additional ramet recruitment occurred in 2001 (Figs. 4.5c-4.5d), these stems will likely be sufficient to maintain the population as long as intervals between harvesting are sufficiently long to allow for regeneration. Up to 16 clonal fragments survived in a plot, a significant increase in the number of clonal fragments per plot (Fig. 4.5f; 4.7). Thus enough clonal fragments will probably survive to maintain the population. Based on the unimodal age distribution of clonal fragments in mature devil's club populations, which showed peak abundance in age classes between 15 and 20 years, and a few clonal fragments in age classes greater than 40 years (Chapter 2), these clonal fragments may develop into a mature population of stems in 40-50 years. However, since all of the ramets in the traditional root-harvesting treatment post-harvest were in the smallest age class, it is unclear what impact mortality will have on continued growth and recruitment. Since recruitment most commonly occurs via layering and basal sprouting of older and larger stems, regeneration may be slowed considerably as these small ramets mature. Furthermore, despite the apparent rarity of seedling recruitment, it is not clear what impact the removal of reproductive size classes will have on the long-term population dynamics.

Figure 4.9 Additional ramet recruitment along stems horizontally replanted in the traditional root-harvesting treatment, June 2001.

Of all the treatments, the traditional stem-harvesting treatment was probably the least disruptive to the population structure and bud bank. In this harvesting treatment a large number of partially intact clonal fragments were left on site, and regeneration was not significantly different from the control (Figs. 4.4c-4.4d; 4.5a-4.5b). Additionally, incremental growth of ramets on partially harvested clonal fragments was not reduced relative to the control in 2001, as might be predicted from a reduced number of photosynthetically active aerial stems per clonal fragment (Fig. 4.5e). This suggests that partial stem-harvesting, which does not disturb decumbent stems or deplete the bud-bank important for clonal expansion and regeneration, is a more sustainable approach to harvesting than harvesting below-ground structures. Additionally, since selectively harvesting aerial stems preserves the population size structure (Figs. 4.6c-4.6d) and consequently some reproductive clonal fragments, continued seed production is ensured. In contrast to the traditional use of devil's club, which primarily involves the inner bark of aerial stems (Chapter 3; Turner, 1982), the commercial use of devil's club focuses on 'root bark.' It is unlikely that commercial harvesting of aerial stems would ever be adopted. In commercially available products, 'root bark' consists of both the inner bark of decumbent stems, and the bark of narrow adventitious roots produced along buried decumbent stems. Since harvesting of decumbent stems and attached roots necessitates the removal of large sections of a clonal fragment to obtain a relatively small volume of root material, this type of harvesting has serious long term implications for populations that persist through expansion and reiteration of these below ground structures.

Despite the negative impacts of decumbent stem and root harvesting and the improbability that aerial stems will be harvested commercially, it is possible that a low intensity of selective decumbent stem removal in conjunction with the horizontal replanting of aerial stems to maintain and replenish the bud bank and promote regeneration may provide a sustainable type of harvesting regime, if the time interval is long enough to allow sufficient regeneration. However, since the results described here are a short-term comparison of harvested and non-harvested populations, longer-term monitoring of population dynamics in harvesting plots is required to test this speculation.

Since clonal expansion is a relatively slow process, long-term data, obtained by monitoring of control and treatment plots in the harvesting experiments, is vital.

Figure 4.10 Devil's club sprouting directly below a stem cut site in the traditional stem-harvesting treatment.

Traditional Harvesting Practices and Sustainable Management

In general, the specific traditional harvesting practices that were incorporated in this experiment provided substantial insight into the development of sustainable management practices for devil's club. The traditional practice of replanting stems horizontally is an impressive means of encouraging regeneration or establishing populations post-harvest by replacing devil's club's functional bud bank. My results suggest that intensive harvesting of below-ground parts, conducted in conjunction with stem re-planting that mimics this traditional practice, may ensure continued population maintenance and productivity. Additionally, although it may never be carried out commercially, the traditional practice of selectively harvesting the aerial stems of some clonal fragments is another harvesting practice that maintains both the population structure and the functional bud bank, likely ensuring long-term sustainability. Overall, the preliminary results of this trial provides additional experimental data to support the hypothesis, derived from ethnographic data, that many traditional management practices ensure the long-term productivity of resources, and that these practices form an integral component of attempts to manage NTFPs.

Propagation Experiments

There are many factors that probably contributed to the mortality of all stems in the propagation experiments. Transportation of cuttings to sites in Kitsusksus Creek, both by vehicle from Victoria, and on foot in through dense bush to the outplanting plots, probably caused excessive desiccation and stress. By the time the last several plots were planted with cuttings on the second day, most of the leaves were wilted and the cuttings appeared stressed. Transplantation shock of these cuttings, many of which had quite delicate root systems, may have also caused mortality within a few days. Additionally, sparse root production on apical cuttings was probably insufficient to compensate for summer drought stress. Furthermore, in the summer of 2000, when I first re-censused these plots, it became apparent that Kitsusksus Creek was a hotter and drier drainage than China Creek, was lower in elevation, and may simply not be ideal devil's club habitat. Although these results are somewhat discouraging, data from the traditional root-harvesting treatment suggest that devil's club populations could probably be established with more success by replanting stem sections horizontally directly at the site. Planting aerial stems horizontally probably reduces drought stress by minimizing the surface area exposed. Planting untreated stem sections horizontally also avoids the stress and shock associated with transporting and transplanting rooted cuttings or established plants. Greenhouse rooting experiments conducted by Roorbach (1999) in Oregon, in which a large number of aerial stems with no shoots or roots survived, also suggest that outplanting devil's club horizontally *in situ* may prove to be a more successful approach to growing devil's club in an agroforestry setting as an alternative to wild harvesting.

CHAPTER 5. CONCLUSIONS

> *"Though devil's club was also medicinal, it was used for many purposes by our people and one of the plants that was very highly respected by our people. You didn't abuse it, you did not just chop it out to clear land, they always left it alone because it was a very high medicinal purpose in it."* Dr. Mary Thomas, Secwepemc Elder and Plant Specialist

Given current uncertainty about the quantity and locations of devil's club harvesting, it is difficult to speculate about the overall ecological impacts of commercialization. Wills and Lipsey's estimate that 3000 Kg of devil's club was collected from British Columbia in 1997 (based on information obtained from commercial harvesters) is likely quite conservative. Compared to other medicinals wild-harvested in British Columbia such as St. John's wort (*Hypericum perforatum* L.) and Oregon Grape (*Mahonia aquifolium* Nutt.), the amount of devil's club collected is quite low (Wills and Lipsey 1999) and probably does not represent a serious threat to the large scale persistence of this species, which can be quite abundant in many parts of its range.

Currently most commercial harvesting in British Columbia seems to be restricted to a few regions close to large urban centres. Wills and Lipsey (1999) estimate that over half of the devil's club harvested in 1997 was collected from the Chilliwack Forest District alone. Thus there are many areas of the province where devil's club harvesting probably does not have a large impact, or may not be occurring at all. Conversely, concentrated extraction in a few regions may have a much more significant impact and it is possible that intense or repeated harvesting could lead to local population declines or extirpations.

Devil's club, which relies on layering, sprouting of buried decumbent stems, and basal ramet reiteration as a means of persisting throughout early forest succession (Chapter 2), may be quite susceptible to intense or repeated harvesting that removes the below ground structures critical to this type of growth. Harvesting that removes most roots and decumbent stems from a site prevents vegetative regeneration, and may ultimately exclude devil's club until it can re-establish from seedlings. Since seedling recruitment is rare during the early stages of forest succession (Chapter 2) and was not observed after experimental harvesting (Chapter 4), it is unlikely that seedling establishment would occur frequently.

Short-term data from experimental harvesting reinforces the potential damage that can be caused by intensive harvesting (Chapter 4). However, long term population monitoring, field reconnaissance for seedlings at additional site types, and experimental work on devil's club's seed germination biology, is required to clarify the long-term impacts of harvesting. Given the potential for regional population declines or extirpations, the commercial growth of devil's club should be carefully monitored. Harvesting regulations for devil's club should be developed and implemented to minimize current impacts.

Traditional knowledge of specific practices and cultural protocols associated with devil's club harvesting (Chapter 3) and the experimental examination of the impacts of these practices (Chapter 4) generally support the hypothesis that traditional knowledge can aid in the development of sustainable harvesting strategies for non-timber forest products. Such knowledge, applied in conjunction with experimental investigations, and long term monitoring, represents an excellent foundation from which to develop harvesting regulations.

Specifically, the traditional practices of replanting stems horizontally and of selectively harvesting aerial stems present the means of replacing the functional bud bank of devil's club and maintaining the population structure, respectively.

Although specific harvesting practices for devil's club provide important insight into potential strategies for sustainable management, it should be stressed that traditional knowledge taken out of its cultural context can only provide a starting point for conventional approaches to resource management. Since the implementation of the specific management practices described here takes traditional knowledge in isolation from practices embodied in a larger cultural framework, caution is required. There are many additional ethical dilemmas associated with the commercialization of devil's club that conventional resource management cannot adequately address, even when it is informed by traditional knowledge. The cultural significance of devil's club, as evidenced by data on its traditional medicinal, spiritual, technological, and food use, linguistic recognition, spiritual significance, and importance in oral tradition provide compelling evidence that commercialization itself may be incompatible with the cultural importance of this plant (Chapter 3). If commercialization is incompatible with cultural use and significance, then the use of traditional knowledge to develop sustainable management practices is itself fraught with complexity.

Consequently, if attempts to manage devil's club using traditional knowledge are to be truly meaningful they must remain within the context of cultural knowledge and be controlled by First Nations. As Davidson-Hunt and Berkes (2001: 78) have noted, " the full contributions of Aboriginal people and their knowledge to managing for sustainable use will not be realized if traditional knowledge continues to be treated as just some other category of information to be inserted into, or merged with, western scientific knowledge." In the case of devil's club, the traditional knowledge of harvesting practices incorporated in the experiments described in Chapter 4 was taken out of a cultural context that demands respect and care for the plants being harvested (Chapter 3; Lantz 2001).

Ultimately, these harvesting practices can probably be more effectively implemented from within this context with the collaboration of the peoples that have used devil's club for millennia.

Figure 5.1 Unique perspective visible from below a canopy of devil's club.

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VITA

Lantz, Trevor Charles

Education

Université Laval	1993-1994
University of Alberta	1994-1998
University of Victoria	1999-2001

Degrees Awarded

B.Sc. (Honours) Botany	University of Alberta	1998

Honours and Awards

Natural Science and Engineering Research Council of Canada (NSERC)

PGS A Scholarship for Post-graduate Studies	1999- 2001

University of Victoria

Amelia Leith Memorial Fellowship	2001
Vice Presidents Scholarship	1999-2001

Botanical Society of America

Conant Travel Award	1999
Isabel Cookson Award	1998

University of Alberta

Organization of Botany Students, Achievement Award	1998
University of Alberta, First Class Honours	1998
Henry Hearn Memorial Award in Botany	1997

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Title of Thesis:

The Population Ecology and Ethnobotany of Devil's Club (*Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq.; Araliaceae).

Author [redacted]

Trevor Charles Lantz

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