HISTORICAL ECOLOGY

Evaluating the Purpose, Extent, and Ecological Restoration Applications of Indigenous Burning Practices in Southwestern Washington

by Linda Storm and Daniela Shebitz

ABSTRACT

Understanding the historic fire regime is essential before restoring fire to an ecosystem. Historical ecology provides a means to use both quantitative and qualitative data from different disciplines to address questions about how the traditional ecological management (TEM) practices of indigenous peoples influenced prairie and savanna ecosystems in the past. In this article, we evaluated paleoecological, archaeological, ethnographic, and ethnobotanical information about the Upper Chehalis River basin prairies of southwestern Washington to better understand the extent to which TEM influenced prairie distribution, composition, and availability of wild plant food resources. We also surveyed areas that had been burned at differing frequencies to test whether frequent fires increase camas (*Camassia quamash*) productivity. Preliminary results support the hypothesis that camas productivity increases with fire-return intervals of one to two years.

Keywords: prairie restoration, historical ecology, traditional ecological management (TEM), fire, camas, *Camassia quamash*, Coast Salish subsistence

A number of anthropologists, ethnobotanists, and ecologists now believe that indigenous peoples contributed to the long-term maintenance and distribution of prairie and savanna ecosystems in pre-European western Washington through traditional management techniques, such as burning (Norton 1979a, 1979b; Kruckeberg 1991; Agee 1993; Dunn and Ewing 1997; Boyd 1999a; Leopold and Boyd 1999; Wray and Anderson 2003). Following the decline of indigenous cultures and the subsequent absence of low-intensity, high-frequency fires, areas in western Washington that were once prairies and savannas have naturally succeeded to conifer-dominated forests (Lang 1961). Today, there are efforts underway to restore the fire-dependent prairies and savannas of western Washington and the many now rare, threatened, and endangered species that continue to exist in those degraded ecosystems (Dunn and Ewing 1997, Chappell and others 2001, Peter and Shebitz 2006).

In this paper, we use a historical ecology methodology to evaluate both the reasons why indigenous peoples in the Upper Chehalis River basin managed prairie and savanna ecosystems and the extent of those practices through time and space. We believe it is important to understand the motivations of the people who used fire in order to reconstruct the ecological patterns and effects of such practices. Key questions to understand past indigenous burning include:

- When did indigenous people first start to use burning on a regular basis to manage the land?
- What were their purposes and reasons to burn?
- What were the ecological effects of such burning practices on the spatial extent of vegetation communities and plant composition?
- What are the implications of these practices for present and future ecological restoration projects?

Background: Ecological and Cultural History of the Pacific Northwest

The climatic history of the Pacific Northwest can be reconstructed by using pollen data (Tsukada and others 1981, Barnoski 1985, Brubaker 1991), glacial geology (Porter and Swanson 1998), dendrochronology (Agee 1993), global climate model predictions (Hebda and

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Whitlock 1997), and charcoal evidence (Clark and Royall 1995, Hallett and Walker 2000, Pellatt and others 2001). From these sources, scientists have confirmed that the Pacific Northwest experienced an "early post-glacial" period between 16,000-11,300 years ago. They describe this period as cool and moist with a characteristic vegetation of grasses and sedges along with some boreal conifers (*Picea* spp. and *Pinus* spp.). A warmer and drier period, from 11,200-9,500 years ago, led to an open forest with an increase in spruce and pine pollen and the first occurrence of Douglas fir (*Psuedostuga menseizii*). The maximum warming period from 10,000-6,000 years ago, which is estimated to have been about 3.6°F (2°C) warmer than modern climate conditions, produced a vegetation complex of Douglas fir, Garry oak (*Quercus garryana*), and alder (*Alnus rubra*). Spruce, pine, and boreal species declined in this period and fire, as indicated by increases in charcoal remains, became more prevalent (Brubaker 1982). From 6,000-5,000 years ago, western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*) and Pacific yew (*Taxus brevifolia*) increased (Tsukada and Sugita 1982, Hebda and Mathewes 1984), and charcoal inputs decreased (Brubaker 1991), reflecting a transition to a wetter, cooler time period. However, scientists also confirm that prairie and savanna ecosystems persisted in southwestern Washington from the maximum warming period until the time of European contact and that they coincide with evidence of a short fire-return interval (Leopold and Boyd 1999).

The human history of western Washington extends back at least 10,000 years (Ames and Maschner 1999) with sedentary village life beginning after 3,800 years ago. Human populations increased as plank house village sites were established, salmon harvest intensified, and winter storage developed in some locales after this period. Some researchers postulate that during this period inland, up-river groups of indigenous peoples in southwestern Washington began using fire to maintain prairie and savanna habitats and subsequently increased their production and storage of important plant food resources (Ames 2005, Storm dissertation in progress).

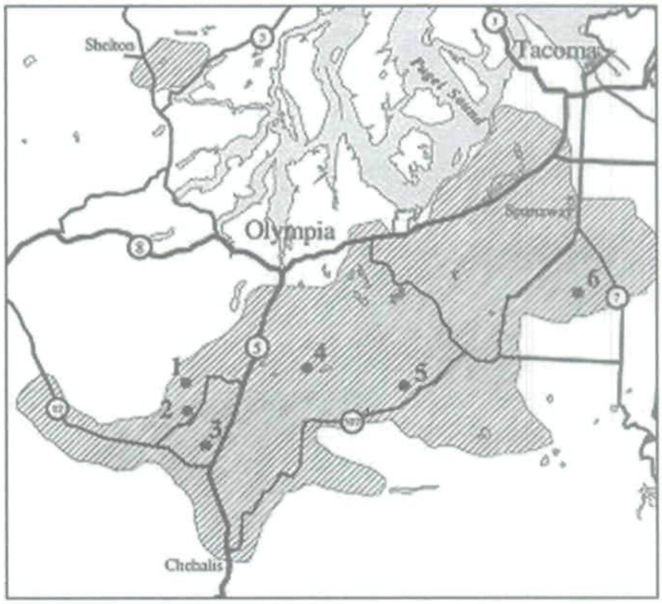

Figure 1. The Glacial Heritage Preserve (identified by the number 2 on the map) was the site of experiments to determine the most effective fire-return interval for maximizing camas production. The site is located south of Olympia, the capitol of the Washington State, in the Black River Drainage of the Upper Chehalis River Basin, which drains westward into the Pacific Ocean.

Native American Burning in the Pre-European Pacific Northwest and Western Washington

Historic fire return intervals in pre-European Pacific Northwest were a function of both natural and anthropogenic fires (Boyd 1999a). Prescribed burning enabled the management of large landscapes and promoted greater abundance of useful species and habitats. For example, fire was used to create forest openings and maintain expansive prairies, keeping plant communities in early to mid-seral stages, and enhancing the diversity and yield of useful plants and game (Norton 1979a, 1979b; Connelly and others 1997, Leopold and Boyd 1999; Connelly 2000; Storm 2002, 2004). Beyond those purposes, indigenous burning reduced insect pests, improved basketry materials, helped clear areas for home sites and safe travel corridors, reduced the risk of wildfire, and improved grazing for game and (later) horses (Lewis 1993, Anderson 1996, Boyd 1999a). Robin Kimmerer and Frank Lake (2001:38) contend that for indigenous peoples "[m]aintaining a diversity of habitats buffers the impact of natural fluctuation in a single food species and increases overall productivity."

By using fire for millenia, indigenous people developed a set of TEM practices that were grounded in an understanding of how fire travels across a landscape or slope, how to use fire to maintain trails that in turn serve as firebreaks, how to set backfires, and how to wet conifer boughs to control fires (Turner 1999). They used seasonal cues—plant phenologies (Lantz and Turner 2003), local climate, weather conditions, moisture levels of soils and fuels—to determine the time to burn.

Patterns of burning by indigenous peoples varied both between and within a given region, the effects of which would differ depending on soil type, moisture regime, and plant assemblages present. The effects of such practices have been well described for other western grassland and oak woodland savannas (Blackburn and Anderson 1993), but have only been partially described for western Washington (White 1975; Norton 1979a, 1979b; Leopold and Boyd 1999; Norton and others 1999).

Western Washington ecosystems that were indigenously maintained by frequent burning include open bunchgrass prairies, associated oak woodlands, oak/ash (*Quercus garryana*/*Fraxinus latifolia*) riparian corridors, beargrass (*Xerophyllum* spp.) savannas, and low (600–800 ft, 183-244 m) to mid-elevation (1000–2500 ft, 305-762 m) patches of open grasslands and berry grounds (Lang 1961, Giles 1970, Agee 1993, French 1999, Peter and Shebitz 2006). There is also some evidence for burning peat-dominated wetlands, such as bogs and fens (Shebitz 2005).

Until recently, little has been written about the extent and effects of TEM on Upper Chehalis River basin prairie and oak woodlands (Storm 2004). Despite this paucity of literature, evidence of indigenous land management is apparent in the presence and diversity of culturally significant, shade-intolerant plants of remnant prairies and savannas.

Case Study: Evidence for Long-term Indigenous Peoples' Management of the Upper Chehalis Prairies

While it is clear from archival records that the Upper Chehalis prairies were maintained by indigenous burning (Cooper 1859, Gibbs 1877, Tolmie 1963), it is unclear to what extent indigenous fire management influenced the distribution and availability of wild plant food resources—in both space and time. To address this question, one must consider both ecological and anthropological evidence.

Methods

To reconstruct long-term indigenous burning practices in Upper Chehalis River basin prairies, we evaluated paleoecological, archaeological, ethnographic, ethnohistoric, ethnobotanic, and ecological data. From these sources, we used several questions and types of evidence to reconstruct the historic patterns and purposes of indigenous burning (Table 1). Taking a historical ecological approach (Crumley 1994, Swetland and others 1999, Anderson 2001, Egan and Howell 2001) allowed us to better understand the pre-European landscapes of southwestern Washington at a number of temporal and spatial scales.

A field experiment was used to test the hypothesis that fire increases the productivity of camas. This experiment took place at the Glacial Heritage Preserve—a Thurston County owned property that is managed by The Nature Conservancy (TNC)— located about 15 miles (24 km) south of Olympia, Washington (Figure 1). TNC staff burn the prairies at the preserve as part of their regular management efforts. In terms of this experiment, each burn treatment was conceptualized as representing a different length of "time since burn" (that is, the number of years since the area was burned: 0-control, 1 year, 2 years, and 3 years since burned).

Camas productivity was defined as the number of mature (harvestable) camas plants. Camas abundance was measured both in space (the number of mature camas plants within a patch) and in time (the length of time that plants were flowering and fruiting within a growing season).

In May 2004, the primary author sampled three transects within each of three burn treatment areas and a control site along a mound-intermound gradient. The gradient represented by each transect was divided into five strata—south intermound = SI, south flank = SF, top = T, north flank = NF, and north intermound = NI. Samples were collected at 0.5-m intervals using a 1.0-m x 0.5-m quadrat. Transects were oriented on a southwest-northeast axis (Figure 2). All mature camas plants were counted and the dominant phenological stage of each plant (budding, flowering, fruiting) was recorded. The average number of mature camas plants from each burn treatment area and the no-burn control were then compared.

The primary author created a maturity index (MI) to describe the phenological state of each sample. The index was computed by assigning each mature plant in a sample a dominant phenological stage (bud, flower, fruit). Each stage was numerically weighted (1 for buds, 2 for flowers, and 3 for fruits) according to its

Table 1. Methods for reconstructing indigenous prairie management

Form of evidence	Questions addressed	Methods used
A Paleoecology and archaeology: Fire history reconstruction	How long into the past were prairies burned? Is there paleoecological or paleoethnobotanical evidence for prairie management?	Review paleoecological and archaeological data Use analog for antiquity of burning in Upper Chehalis prairies
B Ecology, history, and ethnohistory: Physical extent of historic prairie	What were the historical extent and types of prairie prior to Euro-American settlement? How has the landscape changed since Euro-American settlement?	Review ethnohistorical data, including historical and archival records/observations of Indian burning practices
C Ethnography and ethnobotany: Traditional uses of fire to manage plant and animal species	How frequent were prairies burned? What was the timing of burns? What were the reasons for burns? What/where were the ethnobotanically significant plants and culturally significant places?	Review native testimony, place names, linguistics, and stories Evaluate ethnohistoric, ethnographic, and ethnobotanical data
D Field experiment: Fire effects on camas productivity	Does camas productivity increase with burning as reported in the archival and ethnographic records?	Perform burn treatment experiment at Glacial Heritage Preserve, Thurston County, Washington

relative maturity. The weighted sum was normalized in each sample by dividing by the total number of plants in the sample as follows:

$$MI = \frac{buds + 2(flowers) + 3(fruits)}{buds + flowers + fruits}$$

The mean MI per stratum per mound (transect) within each burn treatment area was then calculated and the stratum means were compared across burn areas using a three-factor mixed-effects ANOVA (stratum, time since burn, stratum x burn area interaction as fixed effects, mound as a random effect within burn area). When a factor was significant, post hoc Tukey tests were used to determine which treatment levels were different. Analyses were all run in SPSS, version 11.5.

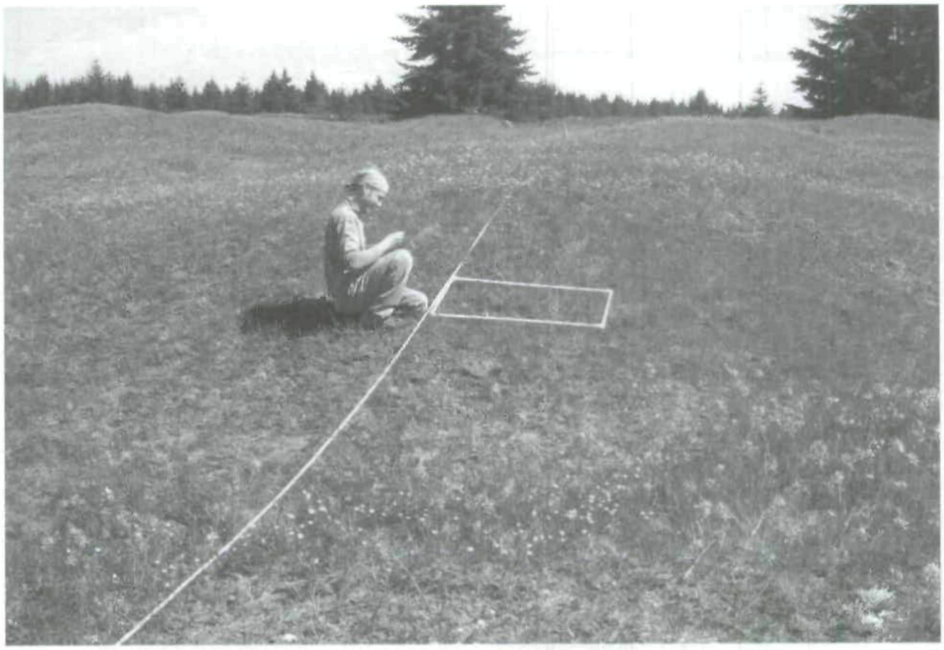

Figure 2. Sam Terpstra sampling camas along mound-intermound gradient on a southwest-northeast axis at the Glacial Heritage Preserve. *Photo by Linda Storm*

Results

Multiple lines of evidence support the overall hypothesis that indigenous burning contributed to the maintenance of prairies in the Upper Chehalis River basin. They include 1) paleoecology and fire history reconstruction, 2) Contact Period conditions, 3) ethnohistoric and ethnographic evidence of prairie burning, 4) ethnological evidence of the cultural significance of prairies and woodland edges, and 5) results of the field experiment.

Paleoecology and Fire History Reconstruction: When Did Indigenous People First Start to Use Burning on a Regular Basis to Manage the Land in Southwestern Washington?

Recent high-resolution vegetation histories and charcoal accumulation rate analyses in British Columbia support the hypothesis that indigenous burning and factors other than climate were responsible for the persistence of oak savanna and associated grassland environments during the past 2,000 to 3,800 years (Pellatt and others 2001, Brown and Hebda 2002). These data provide a strong analog for the persistence of ethnobotanically rich prairie and oak ecosystems in southwestern Washington. However, no similar long term, high-resolution fire history studies exist for southwestern Washington. While we do know that fire frequencies were higher during the early Holocene (between 10,000 and 6,000 years ago) when prairie and oak savannas became dominant in southwestern Washington (Brubaker 1991), we do not have explicit evidence in the form of high resolution charcoal analysis tied to prairie pollen signatures to explain the persistence of prairies after 6,000 years ago when climate shifted to a cooler and moister period. On the other hand, though paleoethnobotanical records from archaeological sites in western Washington are sparse, there is evidence—charred bulbs from a hearth feature—that camas was processed 3,800 years ago in the Upper Chehalis River basin (Schalk and others 2005). High-resolution fire history studies are needed for southwestern Washington to truly test the hypothesis that frequent, localized human-ignited fires were responsible for maintaining open prairies and savannas during the cooler, moister neoglacial period. Without such regionally specific paleoecological analyses, one must compare prairie extent and distributions at the time of Euro-American contact to establish a baseline for the extent to which indigenous peoples managed these systems with fire.

Contact Period Conditions: What Were the Historic Extent and Types of Prairie at the Time of Euro-American Contact?

"The Indians, in order to preserve their open grounds for game, and for the production of their important root, the camas, soon found the advantage of burning." (Cooper 1859:23)

Early explorer accounts describe the open landscape of the lowland Puget Trough prairie region (Douglas 1840:3-11, Wilkes 1845, Cooper 1859, Gibbs 1877, Tolmie 1963). In 1840, James Douglas drew a map (Leopold and Boyd 1999:149) depicting a "string of prairies" along the route from Cowlitz Landing through Grand Mound that led to the Nisqually Plains at Steilacoom. This route was an Indian trail, which was later adopted as the best inland route between the Columbia River and Puget Sound region (Douglas 1840). Douglas notes two distinct types of prairie soils in this "string of prairies": deep, wet soils with "rivulets" running through them, and the "shingly plains" of glacial, gravel outwash prairies.

The deep-soil prairies were quickly converted to agriculture following Euro-American settlement. For instance, Newaukum, Fords, Jackson, Lincoln, Lacamas, and Boisfort prairies were settled early by Euro-Americans and these prairies later became the towns of Centralia, Chehalis, and Boisfort (Smith 1942). Each prairie has a native place name (Kinkade 1991:329-335) and was part of the inhabited landscape that was managed for subsistence by Cowlitz and Upper Chehalis descendants (Marr and others 2001). Very little wetland and deep-soil prairies remain today.

The dry, gravel outwash prairies of Pierce and Thurston counties are the most familiar to ecologists (Dunn and Ewing 1997). They are what remain of historically more extensive and diverse types of prairie including the rich, silt-loam soil wetland prairies (Caplow and Miller 2004, Easterly and others 2005). More than 97 percent of native prairies in Thurston and Pierce and 99 percent of prairies in Clark, Cowlitz, and Lewis counties have been lost (Chappell and others 2001, Caplow and Miller 2004). The Washington State Natural Heritage Program (WNHP) estimates that the historic extent of South Puget Sound gravel outwash prairies was 150,000 acres (60,000 ha) at the time of Euro-American settlement (Chappell and others 2001). About 23,000 acres (9,200 ha) remain today, with only 3,000 acres (1,200 ha) comprised of native prairie plants (Chappell and others 2001). The extant gravel outwash prairies persist because they were not easily converted to agriculture, except for grazing.

One of the largest gravel outwash soil prairies was Grand Prairie (also called Mound Prairie) at Grand Mound, just north of where the Chehalis River bends westward to make its way to the Pacific Ocean (Figure 3). North of Grand Mound, in the Black River drainage, Mima Mounds and Glacial Heritage Preserves (now only 500 acres or 250 ha are prairie) are all that remain of the once contiguous 3,200-acre (1,280-ha) "Mima Prairie," which was mapped during the 1855 cadastral land surveys (Figure 4). Mima Prairie and Grand Mound Prairie were two of several mounded prairies, representing a fraction of the historic extent of prairies at the time of Euro-American contact. Recently, these prairies have been the subject of extensive ecological restoration efforts.

Ethnohistoric, Ethnographic and Ethnobotanical Evidence for the Frequency, Timing and Purposes of Prairie Burning

The process of forest encroachment was already underway in the 1850s (Cooper 1859), reflecting 60 or more years of decline in indigenous populations due to introduced diseases and the subsequent decline of their TEM (Boyd 1999b). Fortunately, ethnohistoric and archival records provide important and useful qualitative evidence for the purposes, timing, and frequency of indigenous burning. For example, Cecelia Carpenter (1986:17-18), a Nisqually tribal member and historian, describes prairie burning by the Nisqually people:

> *The information has been passed down to us by our Nisqually ancestors that for as many years as they could remember that during the fall of each year the vast prairie areas that lay on both sides of the lower segment of the Nisqually River were burned. By burning in the fall of the year at a time when the fall rains had begun, the likelihood of the fire getting out of hand and moving into the forests was minimal.*
>
> *The main purpose [sic] of burning the thick layer of rich prairie grass was twofold. These prairies . . . , were each fall covered with a thick carpet of prairie grass, that, if left during the winter, would lay as a heavy carpet over the land prohibiting the spring crop of camas plants from pushing up to the sunlight. . . . The camas bulbs, as well as the tender shoots of the bracken ferns, which also thrived on the burned-over land, were two main sources of food of the traditional Nisqually people.*

This account reflects both on the seasonality and purposes of burning. Early fall burning also corresponded with the acorn harvest (Gibbs 1877:168-170, 194; Haeberlin and Gunther 1930:21-22), facilitating acorn collection, while simultaneously stimulating the following season's root food and berry production.

The organized practice of prairie landscape burning at the end of berry harvest season (and beginning of acorn harvest season) is described in detail in an unpublished oral account recorded by the anthropologist, Franz Boas (1927). This ethnographic account describes how the Upper Chehalis people (*q!waya'elq*) "had houses everywhere along the banks of the Chehalis River" and how they hunted, gathered, and prepared food for winter storage. Most importantly, it states that the people collectively organized "to burn dry grass everywhere on all the prairies" after the berry picking season:

> *They always burned the whole prair [sic] and also the mountains. They burned the heather to make berry patches just like making gardens for blackberries. The [sic] always burned the prairies to plant camas and strawberries. The chiefs said, 'When the earth burns it burns all the badness of the earth and after it has burned it begins to be good.' Before they burned the land all the q!waya'elq assembled. Everyone prepared to watch all the houses . . . The young men and the children and the girls went and scattered all along the Chehalis River down river and up to the head of the Chehalis River. Then they burned all the prairies and some mountains. After they finished burning the land they assembled and had a great feast which lasted many days. They and the Nisqualli were happy . . . Everywhere they did this after they finished picking berries. When the grass was over all the prairies then they first burned the land of the q!waya'elq.*

Cultural associations between prairies, the plants they host, and the role of fire for maintaining them are further illustrated by the diversity of terms used to describe prairies, fire, and plant communities burned. As examples, the Upper Chehalis word for prairie is *máqʷm* (camas place). The word for camas is *qá·um'*. There are terms for

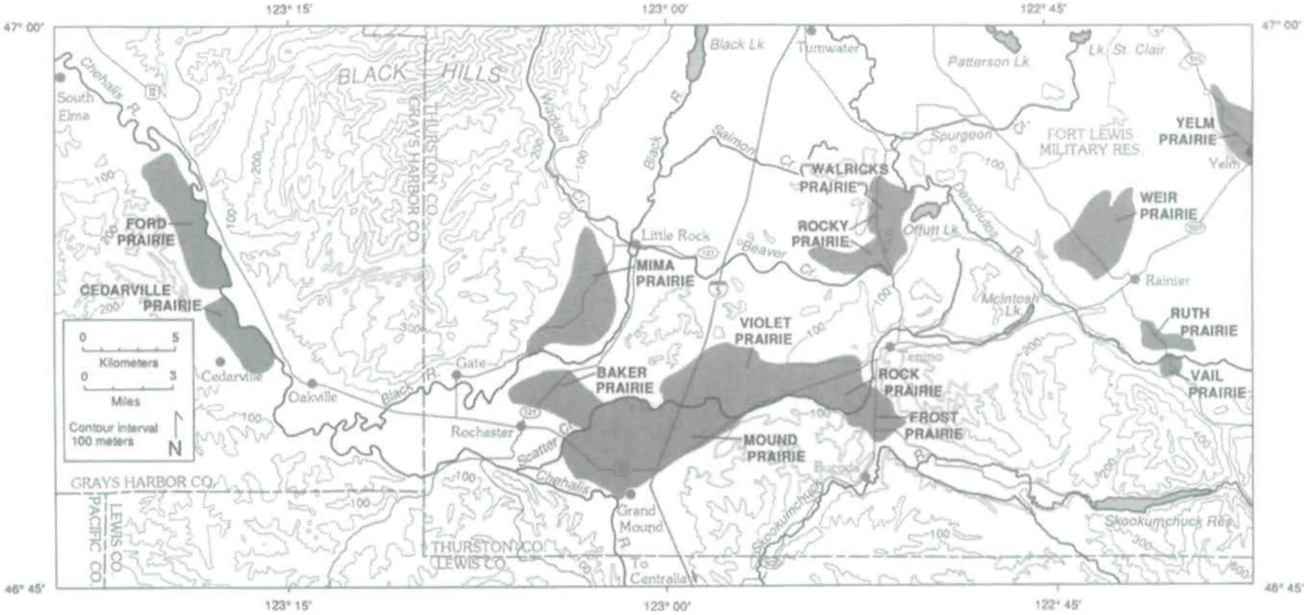

Figure 3. A map of South Puget Sound prairies with mima mounds. *From Washburn 1988 after J. Harlan Bretz 1913*

"prairie fire" (*sʔaxálaqʷm*), "burned land" or "land on fire" (*qʼwʔtʼáytmš*) and for "place burned over for berries" (*słəx*). Almost an entire page of words or terms in *The Upper Chehalis Dictionary* is devoted to fire (Kinkade 1991:194, 221), and more than 20 words specifically relate to parts or aspects of prairie (Kinkade 1991:273), and each plant species used is specifically named (see Table 2 for examples).

Forty three (27 percent) of the 157 Upper Chehalis place names recorded by Kinkade (1991) are prairies. *Náwaq ʷm* is the name of several prairies in Upper Chehalis territory. The word means "big prairie." One of these lies at the confluence of the Newaukum and Chehalis rivers, and is where both camas and wild carrots (likely yampah, *Perideridia gairdneri*) were harvested (Kinkade 1991:332). Another is located farther up-river in the Boisfort Valley. Unfortunately, none of the original vegetation of either "big prairie" remains, but the names and stories tied to them record critical ecological and cultural knowledge about these important gathering sites and indigenous village locations (Adamson 1934).

For southwestern Washington prairies, about 83 percent of 153 native prairie plant species have cultural uses. At least 35 percent of these are food plants (Norton 1979a, Leopold and Boyd 1999, Storm 2004). The

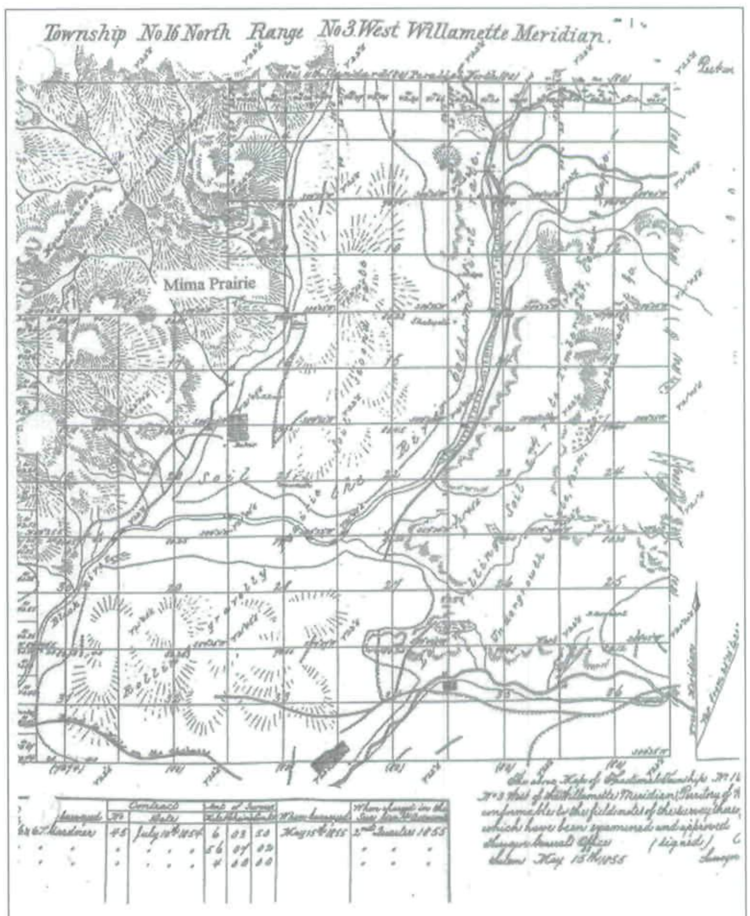

Figure 4. Mima Prairie, which is situated just to the southeast of the mountainous area in the northwest sector of this 1855 General Land Office Survey map. The surveyor wrote about this prairie, "Rolling, gravelly prairie soil, second rate." The area to the east is wooded or brushy with hazel, ferns, maple, fir, and cedar.

Table 2. Edible prairie and prairie woodland edge species with Upper Chehalis names

Common name	Scientific name	Upper Chehalis name
Shoots/Greens		
salmonberry leaves	*Rubus spectabilis*	*Yán'c*
wild celeries:		
Indian celery, wild parsnip	*Lomatium nudicaule,*	
wild parsnip	*Lomatium triternatum*	
cow parsnip	*Heraculum lanatum*	*Yalp* (?)
water parsley	*Oenanthe sarmentosa*	*Qw&l. m ts*
Roots		
common camas	*Camassia quamash* ssp. *azurea*	*qá·wm'*
common camas	*Camassia quamash* ssp. *maxima*	*qá·wm'*
cooked camas, partly cooked, and dried and stored for winter		*qé?q, sxic'áwql, ts'v x*
giant camas	*Camassia leichtlinii*	*?ukwíla* (oqulia)
prairie sunflower	*Balsamorhiza deltoidea*	*p'alíw'*
button camas, biscuitroot	*Lomatium utriculatum*	*tS'lsnó·´*
tiger lily, tiger lily root	*Lilium columbianum*	*masílč'l, c'aqwé?*
wild carrot, yampah	*Perideridia gairdneri*	*sx̣ák'wm*
small sweet carrot		*sa'wt*
wild onions & false wild onions	*Allium* spp. and *Brodiaea* spp.	*maxál'u?, qiwálqs*
bracken fern	*Pteridium aquilinum*	*patákwn'ɬ*
bracken fern root to make bread		*s?əq or x&qc*
Fruits & Berries		
Juneberry, serviceberry, saskatoon	*Amelanchier alnifolia*	*ć́əšš, q'wəlástm*
prairie huckleberry	*Vaccinium caespitosum*	*K'ap&nt* (?)
bearberry (kinnikinnick)	*Arctostaphylos uva-ursi*	*sq'iwán', kaya´nɬ*
blue elderberry, blue elderberry bush	*Sambucus cerulea*	*c'kwíkw, c'kwíkwnɬ*
Indian plum, Indian plum bush	*Osmaronia cerasiformis*	*c'axwá?, c'axwán'ɬ*
wild blackberry	*Rubus ursinus*	*Sxwás*
blackberry vines	"	*sxwásnɬ, xwásnɬ*
eat blackberries	"	*?íɬssxwástn*
wild raspberry/blackcap	*Rubus leucodermis*	*máckw*
salmonberry	*Rubus spectabilis*	*yátwa?*
thimbleberry, thimbleberry patch	*Rubus parviflorum*	*q'wá?xw, q'wá?xwn ɬ*
crabapple, crabapple bush	*Malus fusca*	*scúm', scúm'n'ɬ*
wild strawberry	*Fragaria virginiana*	*Čatsa?*
wild strawberry patch	"	*c˘atísanɬ, c˘atísa?nɬ*
Nuts & Seeds		
oak tree	*Quercus garryana*	*swísɬ, Lū .k*
acorns or "oak berry"	"	*Swís*
hazelnut, hazel	*Corylus cornuta*	*k'ap'úx̣w, k'ap''úx̣wníɬ*
prairie sunflower	*Balsamorhiza deltoidea*	*p'alíw' stálx*

testimonies of Upper Chehalis elders further illustrate the ethnobotanical importance of prairies (Duwamish and others v. United States of America 1933). In 1927 Arthur E. Griffin took oral testimonies to document the traditional use areas of western Washington non-treaty tribes. Mary Heck, then 92 years old and an Upper Chehalis Tribal member, identified the Upper Chehalis territory as a land of plenty (Duwamish and others 1933:529-541). When asked what kind of food the prairies supplied, she replied "we get the sunflower roots, for one kind. They take that up and bake it and use it for food." She goes on "a kind of wild onion, and lacamas [e.g., common blue camas, *Camassia quamash*] was the chief food they had, like bread or something like that. Then they had other roots that were three or four times bigger in size than the lacamas, but they were just the same, the same shape, same form, only they got another name to it. They called it, *?quilla*" [this is giant camas, *Camassia leichtlinii*] (see Figure 5 for the two camas species). Other foods produced on the prairie included "lots of wild rhubarb and spinach," (wild spinach refers to wild greens, most likely in the Chenopodiaceae Family) and "all kinds of berries." She said "they had kinikinik berries, black berries, wild raspberries, and crabapples, salmon berries, salal berries, and another kind of berry they call *kamotlk* . . . They had Juneberries, wild currents, blackcap raspberries and lots of blueberries," and "thimble berries grow along the edge of the prairies." When asked if they had strawberries, she said "there was so much strawberries you can smell it from a distance."

Marion Davis, a 76-year-old Upper Chehalis man in 1927, remembered "Berries; was just full of berries all over, strawberries on every prairie" and that the prairies were "stocked full of game" at the time of the treaties (Mary Heck and Marion Davis testimonies from Duwamish and others 1933:530-533, 544 respectively; see Table 2 for scientific and Upper Chehalis names of these plants).

Roots of wild sunflower (*Balsamorhiza deltoidea*), tiger lily (*Lilium columbianum*), wild carrots or yampah, camas (*Camassia quamash* and *C. leichtlinii*), Indian riceroot or chocolate lily (*Fritilaria affinis* syn. *F. lanceolata*), and false onions (*Brodiaea* spp.) were gathered from the prairies near Rochester and Grand Mound (Adamson 1926-1927, Miller 1999). Wild sunflower roots were mashed to make a root beer-like beverage. Strawberries (*Fragaria virginiana*), serviceberries or Juneberries (*Amelanchier alnifolia*) and other berries were gathered in June, and eaten fresh or dried and stored for winter. Acorns and hazelnuts were harvested in the fall. Acorns were either placed in mud banks for the winter to leach out the tannins or cooked overnight on hot rocks in a pit (Duwamish and others 1933:531, Miller 1999:20). Bracken fern (*Pteridium aquilinum*) rhizomes were also harvested, roasted in ashes and pounded into flour to make bread (Haeberlin and Gunther 1930, Norton 1979b). Large quantities of roots, berries, and acorns were processed and stored for winter along with smoked salmon and other meats, including deer, elk, bear, and small mammals.

Quantitative Field Experiment: How Does Burning Influence Camas Productivity?

Camas was one of the most abundant and culturally important prairie plants (Gunther 1974:24). Its role as a staple to the inland, up-river Salish people is well documented in archival and ethnographic records (Cooper 1859; Gibbs 1877:170, 193; Adamson 1926-27; Haeberlin and Gunther 1930; Smith 1940). The antiquity of camas processing from the Upper Chehalis River basin is in the form of two charred camas bulbs that date to 3,870 ^{14}C years ago (Schalk and others 2005). These charred bulbs were recovered from an intact hearth located at the historic prairie and Upper Chehalis village site named *tá·ʔn'c'šn'* (Ford's Prairie) at the site of the contemporary Centralia sewage treatment plant. This paleoethnobotanical evidence suggests that prairie ecosystems were present and likely being managed with fire more than 3,000 years ago. Ethnographically, large quantities of camas were harvested, processed in pit or earth ovens, and stored for winter (Hajda 1990:507). Surplus camas was traded from western Washington to groups east of the mountains (Gibbs 1877:170). Native elder testimony confirms the diverse and abundant prairie resources were managed and maintained by frequent, low intensity fires:

> *"In this tribe here, the chiefs in month of August compell [sic] the Indians to burn the prairies, to make the grass grow well, the strawberries plentiful, and black berries." —Jonas Secena, Chehalis (Adamson 1926-1927:348)*

The results of our experiment indicate that time since burn (between 1, 2, 3 years) had a significant effect ($p < 0.001$) on the overall abundance of camas (Table 3). Areas that were burned annually or biannually had significantly more aboveground mature camas plants, than did areas burned every three years (Tukey test). The results also indicate a significant difference ($p < 0.001$) between burn treatment areas in terms of the average MI of plants (Table 4). The combination of these test results supports the hypothesis that frequent burning increases camas productivity by increasing 1) the overall number of mature camas plants available for harvest and 2) the season of harvest by extending the effective flowering-fruiting period. These results lend credibility to the historically and ethnographically reported one- to two-year fire return interval for prairie burning. Results are generally consistent with expectations except that the area burned every other year showed greater camas abundance but lower average maturity. This result may be explained by other variables, such as greater moisture at that particular burn site or it may indicate that two years are required for full recovery from burning. Longer-term burn treatments should be performed to ascertain whether camas would continue to be productive with repeat burning at this return interval within the same patch (Dunwiddie 2002).

Figure 5. Left, common blue camas (*Camassia quamash*) and right, giant camas (*Camassia leichtlinii*). Upper Chehalis names for these plants are *qá·wm'* and *ʔukwíla*, respectively.

Findings and Recommendations

Implications of Reconstructing Indigenous Fire Regimes for Pacific Northwest Ecological Restorationists

"If land managers, ecologists, and archaeologists understand the intricacies and mechanics of how and why native people shaped ecosystems, this will enrich their inventory of management methods, and they will be in a better position to make informed, historically based decisions." (Anderson and Barbour 2003:276)

A question that ecological restorationists must contemplate is whether to consider

Table 3. Post-hoc Tukey test results at the 95-percent confidence interval showing average camas per sample for each burn treatment (time since burn = 1 year, 2 years, 3 years) and control (burn = 0 year). Significantly different averages are placed in separate columns (subsets). Mean camas abundance was significantly greater in plots in the 2-years since burn area (subset 3 with an average of 26 camas/sample) than in the 1-year since burn area (subset 2 with average 14 plants/sample), the 3-years since burn area (average 7 plants/sample), or the control (average 6 plants/sample). The average number of camas was not different in the control and 3-year burn areas.

Years since burn	Sample size	Subset 1	Subset 2	Subset 3
0	139	6		
3	106	7		
1	137		14	
2	118			26

Table 4. Post-hoc Tukey test results at the 95-percent confidence interval showing average Maturity Index (MI) per sample for each burn treatment (time since burn = 1 year, 2 years, 3 years). Significantly different averages are placed in separate columns (subsets). The results of this test show a significant difference between each burn treatment site and camas MI. Mean MI was significantly greater in plots in the 1-year since burn area (subset 3 with an average MI of 2.52/sample) than in the 3-years since burn area (subset 2 with average MI of 2.37/sample) or the 2-years since burn area (average MI of 1.52/sample).

Years since burn	Sample size	Subset 1	Subset 2	Subset 3
2	116	1.52		
3	97		2.37	
1	124			2.52

indigenous fire frequency as "natural" or seek to mimic historic fire regimes by understanding and incorporating indigenous TEM practices. Anderson (2005:335) argues that restoring landscapes and ecosystems to a condition that is self-sustaining may be impossible if that "natural" condition has not existed in the last ten to twelve thousand years. Therefore, understanding the practices, patterns and effects of indigenous fire management is critical to restoring historic fire regimes. To do so requires an interdisciplinary and integrative approach that addresses issues of scale (in time and space) and acknowledges the important role of indigenous peoples' TEM (Anderson and Barbour 2003, Anderson 2005).

In this paper, we compiled multiple lines of evidence (Table 1) that were used to gain an understanding for the former timing, purposes, extent, and effects of indigenous burning practices of southwestern Washington prairies. We found that: 1) the distribution and locations of historic prairies were extensive, including prairies with both wet and dry soils and different plant assemblages, 2) each prairie place is named in the Upper Chehalis language and many are mentioned in oral history and traditions (embedding indigenous histories into the landscapes they managed and maintained for thousands of years), 3) the prairies were predominantly burned in the fall and were burned for a variety of reasons, including the production of roots, berries, nuts, and as habitats for hunted mammals, 4) fire frequencies at the prairie landscape scale likely occurred on one to two year return-intervals, 5) camas productivity increases with burning on one and two year return-intervals, 6) the camas flowering-fruiting season is extended in prairies with Mima mounds, which would have extended the camas harvest season, and 7) camas processing (and likely prairie TEM) dates back 3,800 years ago in the Upper Chehalis River basin.

Because most western Washington prairie restoration is driven by habitat conservation and species recovery objectives (Pendergrass and others 1999, Dunwiddie and others 2001, Kaye and others 2001, Schultz 2001), very few restoration projects or recovery plans explicitly address cultural objectives or deliberately simulate indigenous management practices (but see Shebitz 2005). We recommend that restorationists seek to understand past cultural practices and incorporate them into restoration planning because of the effects that indigenous burning had on populations, community and landscape scales of ecological organization in the past (Beckwith 2004, Deur and Turner 2005, Anderson 2005).

We recommend a framework (Table 5) for developing restoration projects in landscapes that were formerly managed by indigenous burning. In this framework, reconstructing historic fire regimes that reflect indigenous peoples' management practices and their reasons to burn is an essential first step to restoring traditionally managed prairies to pre-European settlement conditions. Site selection and exploratory experiments to simulate indigenous management techniques are other key steps. Our framework builds upon recommendations for restoring endangered species habitats and for applying indigenous management practices to restoration projects (Schultz 2001, Anderson 2005). For both sets of objectives, it is important to understand what the distribution, geographical extent, and species composition of historic prairies and savannas were in the past. Understanding how indigenous management practices shaped the ecology of these habitats includes learning what the historic species assemblages were, the ways indigenous people used fire and other management techniques, including how ethnobotanical plants were harvested (Anderson 2005:339-340). Whether focal species are culturally significant or at risk of endangerment, returning frequent, low-intensity fires and implementing follow-up monitoring are essential restoration project elements.

We recognize that prairie restoration must also address current conditions and limitations, particularly the effects of large fuel accumulations, introduced species and their responses to fire, and other forms of disturbance (Dunwiddie 2002, Lesica and Martin 2003). We also

Table 5. Recommended framework for integrating indigenous TEM into prairie restoration projects and recovery strategies in the Pacific Northwest.

Task	Potential methods	Contribution to restoration
Reconstruct historical anthropogenic fire regimes by researching past ecological and cultural condition of the area (ranging in scale from regional landscape history to the site of interest)	Ethnographic interviews Evaluate ethnological and ethnobotanical data Tree establishment dates and fire scar data Current ecological conditions: e.g., distribution of shade-intolerant species, tree growth forms, fire scars Historic maps, surveys, documents, photographs Explorer journals and notes Published literature High resolution charcoal area recruitment (CHAR) analysis in association with pollen core data Review paleoecological and archaeological data	The regional past extent of anthropogenically managed systems enables you to see the former relationship between your system of interest and the landscape Past species presence and distribution as aims of restoration Past fire regimes can assist in developing management strategies. Research similar restoration projects involving fire in the ecosystem of interest
Research similar restoration projects involving fire in the ecosystem of interest	Review published literature Contact governmental, tribal and conservation agencies	Learn from others' successes and failures prior to initiating your own restoration
Learn about former TEM of cultural resources	Review published literature Conduct interviews with tribal members Review previously-conducted interviews	Past management can assist current restoration objectives by ensuring presence of desired species
Designate the area for restoration activity Select a reference ecosystem if available	Work with indigenous groups, governmental agencies, and conservation agencies to determine sites that were formerly managed through anthropogenic fire that are feasible for current and future study	A restoration project is only successful if the site is appropriately selected. The more interactions with local stakeholders you have, the more knowledge about the site will be learned
Conduct small-scale experiments to understand the initial and potential long-term effects of reintroducing burning	Record pre-disturbance (i.e. fire reintroduction) ecological conditions, focusing on species of interest Work with land management groups (fire crews) to introduce disturbance	Experiments provide unparalleled opportunities to understand the effects of fire, on both a species and ecosystem level
Prepare the site for larger burns if desired	Thin to reduce fuel loads Change the vegetation structure to represent an early seral community Introduce seeds of desired species	Initiating the restoration includes site preparation and plant installation of desired species
Adaptively manage the site based on monitoring and evaluation (ecological findings) from initial and subsequent burns	Reintroduce burning at former frequencies and intensities if feasible If frequent fire is not practical due to budgetary, environmental, or social constraints, experiment with effects of different management techniques (i.e. clearing woody vegetation manually, mechanically or with herbicides)	Restoring the site to its pre-European settlement condition will likely have the benefits of reintroducing landscape heterogeneity and ensuring the presence of species of ecological and cultural value associated with that successional stage

acknowledge that the TEM practices that influenced prairie ecology and camas productivity included much more than fire management—see Beckwith (2004) for details on traditional harvesting practices and their effects on camas bulb size and offset production and Anderson (2005) for details on the many different types of indigenous management practices that influenced plant communities.

We believe that culturally significant ethnobotanical plants and at-risk species can both be restored by reconstructing historical fire regimes that accurately reflect long-term, indigenous management practices. Beckwith (2004:224) says that a *sense of roots* (origins) is a necessary ingredient of ecological restoration, especially if restoration is to accurately reflect the historical ecology and ethnoecology of place. To do so requires understanding the deep past, including environmental and cultural processes that shaped the places that we seek to restore today.

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