Historic Anthropogenically Maintained Bear Grass Savannas of the Southeastern Olympic Peninsula

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Abstract

This paper documents the existence and character of a little known fire-maintained anthropogenic ecosystem in the southeastern Olympic Peninsula of Washington State, U.S.A. Due to cessation of anthropogenic burning, there is no longer an intact example of this ecosystem. We present evidence from Skokomish oral tradition, historical documents, floral composition, tree-ring analysis, stand structure, and site potential to describe former savanna structure and function. We believe this system was a mosaic of prairies, savannas, and woodlands in a forest matrix maintained through repeated burning to provide culturally important plants and animals. The overstory was dominated by Douglas-fir (*Pseudotsuga menziesii*). Bear grass (*Xerophyllum tenax*) likely was a dominant understory component of the savannas, woodlands, and prairie edges. These lands grew forests in the absence of anthropogenic burning. Wide spacing of older trees or stumps in former stands and rapid invasion by younger trees in the late 1800s and early 1900s suggest a sudden change in stand structure. Shade-intolerant prairie species are still present where openings have been maintained but not in surrounding forests. Bark charcoal, fire scars, tree establishment patterns, and oral traditions point to use of fire to maintain this system. A common successional trajectory for all these lands leads to forested vegetation. These findings suggest that frequent application of prescribed burning would be necessary to restore this ecosystem.

Key words: **anthropogenically maintained, bear grass, ecosystem, fire, Olympic Peninsula, plant association, prairie, savanna, Skokomish Tribe, Twana, Washington, woodland, *Xerophyllum tenax*.**

Introduction

Some anthropogenically maintained ecosystems owe their character to cultural burning and are inherently unstable when management practices change. Fire-dependent habitats that were maintained through burning by Native Americans include the prairies and savannas of western Washington State, U.S.A. Although these habitats were common in the region prior to European settlement (Jones 1936; Norton 1979; Leopold & Boyd 1999), their former extent in the southeastern Olympic Peninsula is not well known.

In many cases, it is difficult to determine the past vegetation of an area undergoing succession following cessation of cultural practices that had maintained it in a different state. The historic structure and function of ecosystems may first be approximated by examining reference conditions and gathering ecological, archival, and ethnographic information pertaining to the systems. As an initial step, an understanding of the successional trajectory from the culturally maintained vegetation to the current later stage of succession is needed. This paper documents succession and links historical information and fire history to approximate the extent, composition, and function of a savanna–woodland–prairie complex supporting extensive patches of Bear grass (*Xerophyllum tenax* (Pursh) Nutt.) embedded in a forest matrix. This study serves as a model for recognizing and characterizing other former anthropogenic landscapes by using current site and vegetation characteristics as indicators of the previous ecosystem.

Prior to European settlement, anthropogenic burning in many areas was regular, constant, and long term, causing cumulative effects reflected in current plant communities and species distributions (Pyne 1982; Anderson 1996, 2005; Boyd 1999). Prairie and savanna flora and fauna were integral components of diets, medicines, baskets, and rituals of local tribes (Norton 1979). The most significant sources of complex carbohydrates in the diets of Olympic Peninsula tribes came from bulbs and rhizomes found in prairies and savannas. Bracken fern (*Pteridium aquilinum* (L.) Kuhn) and Common camas (*Cammasia quamash* (Pursh) Greene) were commonly used by the Skokomish and other native peoples in wetter Washington coastal environments (Gunther 1974; Norton 1979; Deur 2000). Berries growing in prairie forest ecotones were important sources of sugars and vitamins. Bear grass, used in Skokomish basketry and burial ceremonies (Gunther 1974; Shebitz 2005), also grew historically on the periphery of prairies (B. Miller, Skokomish Tribe, 2004, personal

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communication). According to Skokomish oral tradition, fire intervals were determined, in part, to maximize production of Trailing blackberry (*Rubus ursinus* Cham. and Schlecht) (B. Miller, Skokomish Tribe, 1996, personal communication). Prairies and savannas provided important Blacktail deer (*Odocoileus hemionus*) and Elk (*Cervus canadensis*) winter range, and were convenient places to hunt (Kruckeberg 1991; B. Miller, Skokomish Tribe, 2004, personal communication).

Contemporary fire regimes often deviate from pre-European regimes in intensity, extent, and frequency (Quintana-Ascencio et al. 2003). Over the past century, fire suppression has led to fuel increases and shifts in species distributions (Lepofsky et al. 2003; Ruppert 2003; Wrobleski & Kauffman 2003). Reconstructing historic fire regimes is essential in determining the frequency and intensity with which to reintroduce prescribed burning for restoration. Several studies suggest reference fire regimes should be based on traditional burning practices (Swetnam et al. 1999; Brockway et al. 2002; Keeley 2002).

Our objective is to provide evidence for the historic existence and character of an anthropogenically managed savanna ecosystem on the southeastern Olympic Peninsula of Washington as mixed prairie forest areas supporting extensive patches of bear grass. We compare data from two vegetation types identified on 1929 aerial photographs as savanna and matrix forests and describe forest invasion of savannas in the late 1800s. We interpret current vegetation in light of tree-ring analysis, fire history, and native oral traditions to reconstruct former savanna vegetation. We discuss our results in terms of site potential, cultural influence, and fire history. This information is assisting current efforts of the Olympic National Forest (ONF) in restoring savannas to the area.

By researching and reintroducing anthropogenic systems while encouraging community engagement and local culture, our project is an example of "focal restoration" (Higgs 2003:4). This practice recognizes restoration as a practice that "builds value through participation, and in so doing strengthens human communities" (Higgs 2003:226). Knowledge of former habitat structure and function facilitates incorporating traditional indigenous management into restoring native biodiversity and strengthening cultural traditions dependent on the land (Shebitz & Kimmerer 2005).

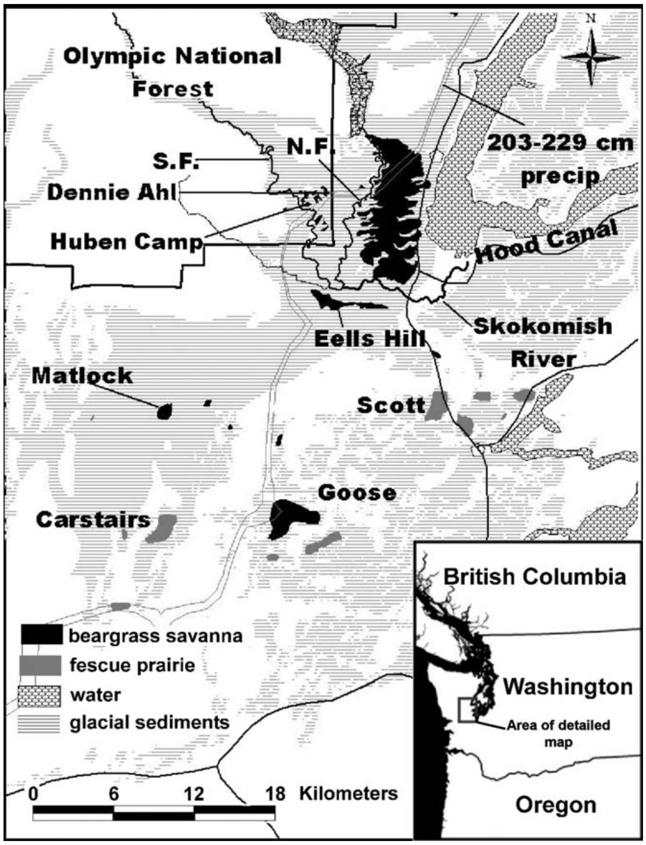

Figure 1. Distribution of former prairies and savannas in the study area. This paper focuses on bear grass savannas. Precipitation increases from south and east to north and west in this area.

Methods

Our study area is the lower Skokomish River Basin in the southeastern Olympic Peninsula (Fig. 1), a landscape currently dominated by forest and agricultural sites. The Skokomish River is formed by the confluence of its North Fork (NF) and South Fork (SF). This paper focuses on plateaus north and south of the river (elevation 180–213 m). Precipitation ranges from 175 cm on Hood Canal to 226 cm near Dennie Ahl Seed Orchard (Dennie Ahl) (USDA NRCS 1999). The natural fire regime of forests north and west of the Skokomish savannas is characterized by large stand-replacing fires that likely affected the study area in 1308, 1508, 1668, and 1701 (Henderson et al. 1989). Smaller, patchy fires at 70- to 100-year intervals characterized the fire regime of the dry Douglas-fir forests of the Puget Trough (Agee 1990).

We refer to areas dominated by bear grass as "bear grass savannas" and areas dominated by Roemers fescue (*Festuca roemeri* (Pavlick) Alexeev) and Common camas as "fescue prairies" (Chappell & Crawford 1997). Bear grass savannas have higher precipitation than most fescue prairies (Fig. 1) but lower than forests to the north and west.

"Savanna" is herbaceous vegetation with scattered or widely spaced woody plants, usually including some low trees (Bailey 1998). "Woodland" is dense savanna or widely spaced forest, and "parkland" is a mosaic of small prairies in woodland or forest matrixes. "Prairie" is an herb-dominated area without mature trees. We collectively refer to the prairies, savannas, parklands, and woodlands in the study area as savanna. Matrix forest and savanna are two types of vegetation identified from the 1929 aerial photographs used to stratify our data for analysis. Matrix forest had a continuous tree canopy and surrounded the savanna. The savanna had openings ranging from about 0.1 ha to many hectares. Our use of "plant association" follows Henderson et al. (1989) and is similar to that proposed by Daubenmire (1968). Plant association names reflect the presumed climax community described from the oldest available stands and are used for any part of the sere. The term "climax" denotes theoretical potential natural vegetation under the current climate in the absence of major disturbance.

Bear grass is an evergreen, perennial herb of the Melanthiaceae family (Rudall et al. 2000). It has tough, dry leaves up to 60 cm long, 5–10 mm wide at the base, and narrow and stiff at the tip (Maule 1959). It has a tuber-like woody rootstock from which large, dense tussocks of leaves arise. Vegetative reproduction occurs through rhizomes between spring and summer. Bear grass flower stalks grow to 150 cm tall and are topped with a club-shaped inflorescence of white flowers (Munger 2003). Flowering occurs in 5- to 7-year intervals (Munger 2003), and maximum flowering may be somewhat dependent on fire (Kruckeberg 2003).

Pacific Northwest Native Americans value bear grass as a basketry material (Rentz 2003), yet are concerned that its quality and quantity are declining in part due to commercial harvesting by the floral industry (Shebitz 2005). We believe that another potential cause of its reported decline may be increases in canopy cover resulting from the suppression of natural and anthropogenic fires in former savannas.

The study area is in the current and historic homeland of the Twana (Skokomish Tribe). Skokomish villages were located at the mouth of the Skokomish River, along the river's main stem, at the confluence of the NF and SF and along the NF (Elmendorf & Kroeber 1992). Movement to the Skokomish Reservation in the mid-1800s resulted in cultural change and discontinuance of traditional land management.

Aerial photographs (1:7,500) covering the southeastern ONF and adjacent lands were taken in 1929 prior to timber harvest and used with modern maps and aerial photographs to interpret vegetation and to map former savannas. General Land Office survey (GLO) maps, completed in 1895, and accompanying notes were used to locate savannas and other landscape features. Washington State Examiners Reports on Land and Timber (Wade & Dodwell 1910) and the 1930s Survey of Forest Resources in Washington and Oregon (Harrington 2003) summarized survey information (Andrews & Cowlin 1934, 1940) and documented timber harvest, fires, timber, and shrub conditions. Although GLO surveys can miss detail smaller than sections (1 square mile or 259 ha) that did not cross section lines, the 1910 surveys record timber volumes by 1/16 section. Resolution in the 1930s survey was variable but generally matched or exceeded that of previous surveys.

Prairies and savannas were mapped from field observations, 1929 aerial photographs, and GLO maps (Fig. 1). There are four former bear grass savanna sites of interest in our study area: (1) Dennie Ahl, an annually mowed tree seed orchard maintained by the ONF since 1957, was open woodland in 1929; (2) Hubin Camp, which is currently forested, has the only remaining uncut savanna overstory (Fig. 2) and in 1929 was a 12-ha woodland surrounding a 3-ha prairie; (3) the NF plateau, which became forested, was a 3,000-ha parkland of mixed savanna and woodland in 1929; and (4) Eells Hill, which was an open savanna in 1929 where forest succession has been prevented by Christmas tree farming (Fig. 3). Eells Hill savanna extended south, but only portions visible on 1929 aerial photographs were mapped.

Percent canopy cover and tree age data were available from 27 circular 0.04- or 0.08-ha U.S. Forest Service Area Ecology Program plots near Dennie Ahl and Hubin Camp. Nineteen forested plots were in 50+ year old harvested or unharvested matrix stands. Eight plots were in former savanna including three at Hubin Camp. Each plot was classified to plant association (Henderson et al. 1989). Site index values were calculated from plot tree ages and heights (McArdle & Meyer 1930) and averaged by vegetation type. Site index is the height a tree will grow under forest conditions in 100 years (Daniel et al. 1979) and is used here to index Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franko) productive potential. Overstory and key understory percent canopy coverages were averaged by species and vegetation type. Statistical comparisons of plot site index, elevation, slope, and species covers between vegetation types were made using analysis of variance (ANOVA) for normally distributed data and Kruskal–Wallis tests for non-normally distributed data ($\alpha = 0.05$).

Species lists and general observations were compiled for Dennie Ahl, Eells Hill, Hubin Camp, and the NF

Figure 2. The Hubin Camp site. Former bear grass savanna with dominant Douglas-fir now in a matrix of young Douglas-fir and Lodgepole pine (*Pinus contorta*). The small trees are 60–120 years old. The large tree is similar sized to others that date to the 1700s. Note the bear grass in the foreground.

Figure 3. Bear grass and Kinnikinnick (*Arctostaphylos uva-ursi*) dominated Christmas tree farm on Eells Hill.

Plateau and other sites. Plant taxonomy follows USDA NRCS the PLANTS Database (USDA NRCS 2004). Observations on presence or absence of large stumps, snags, live trees, or mound-pit topography (as occurs when trees are uprooted by wind) that would indicate previous forest conditions were noted.

To provide a basis to interpret aerial photographs and historical information, Douglas-fir tree age data were collected from several sites. Forty tree ages from 26 increment cores and 14 basal stump slabs came from 19 former savanna sites between the SF and Hood Canal. Twenty-four ages from increment cores came from eight matrix forest sites near the SF. Trees for increment coring were selected from dominant or codominant trees. Thirteen basal stump slabs from Hubin Camp Douglas-fir and Lodgepole pine (*Pinus contorta* Dougl. ex Loud) represent smaller to middle-size classes, whereas increment cores represent the larger size classes. One basal stump slab came from a large, recently dead Douglas-fir tree with fire scars near Dennie Ahl. In addition to tree ages, five fire scars, four tree-ring releases, and four radial growth suppression sequences were identified on slabs or cores. Growth releases (sudden increases in ring widths) were noted because they may indicate postfire release from competition. Radial growth suppressions (sudden decreases in ring widths) may indicate crown injury associated with fire.

We estimate that increment cores with less than 200 rings came within 0–10 years of the pith and increment cores of 200–300 rings came within 0–20 years of the pith. When the pith was absent, we estimated missing rings from the interior ring curvature and ring widths. We assumed a 7- to 10-year add-on for breast height. Pre-1600 ages are less accurate extrapolations from increment cores based on interior ring widths, core length, and tree diameter.

Study area soils are very gravelly, moderately well- to excessively well-drained, medial sandy loams, medial loams, or loamy sands. They are forest soils of low fertility with ochric epipedons and strongly to moderately acid reaction near the surface (U.S. Department of Agriculture, Soil Conservation Service 1960). Soils were derived from Vashon recessional continental glacial drift (Porter 1976; Barnosky 1983). Total nitrogen and organic matter from three mineral soil samples taken at 20-cm depth from matrix forest plots was determined by the Oregon State University Soils Lab.

Information concerning cultural practices came from historic documents, transcribed oral accounts, and interviews with current Skokomish Tribal Members. Open-ended, semistructured interviews were conducted in November 2004 by D.S. The consultants were Bruce Miller, a Skokomish elder, master basketmaker, and community leader, and Michael Pavel, a Traditional Bearer of Southern Puget Salish Culture. Miller, a respected authority on the past landscape structure of the study area, was taught about the importance of prairies from a young age. Pavel, a prominent teacher of Twana tradition and history, was interviewed in a former savanna near Dennie Ahl and refers to it in his response.

Results

The 1929 aerial photographs show numerous open areas without evidence of timber extraction (Figs. 4 & 5) that we refer to as the savanna ecosystem. There are few snags or down logs in most openings. Areas of continuous forest canopy surrounding and intermingling with the savannas are the matrix forests. Ground surveys found that former savannas are devoid of mound-pit topography and have large widely spaced Douglas-fir stumps or trees showing the former savanna tree spacing.

Productivity

Matrix forests have low productivity relative to other area forests not on flat glacial outwash landforms that frequently have overstory hardwoods and Western swordfern (*Polystichum munitum*) in the understory indicating moister and more fertile soils (Henderson et al. 1989). The mean site index for 19 matrix plots was 36 m (Table 1). Eleven nearby plots not on the outwash plain, but on glacial drift, averaged a site index of 49 m. Eight savanna plots were significantly lower in site index. Three 20-cm-depth soil samples from matrix forest plots averaged 3.7% (SD = 0.79) organic matter and 0.06% (SD = 0.02) total nitrogen.

Plots were not intentionally selected randomly, so tests of significance are questionable. However, site index values given by Henderson et al. (1989) for the associations in matrix or savanna are significantly different whether weighted by number of plots ($p > 0.0001$) or not ($p = 0.02$) (Table 2).

Current Forest Vegetation

Former savanna and matrix forest overstories are dominated by Douglas-fir (Table 3). Lodgepole pine occurs in

Figure 4. Lower SF of the Skokomish River in 1929, near Hubin Camp and what is today the Dennie Ahl. (North is at top.)

former savannas, and hardwoods including Red alder (*Alnus rubra* Bong.) are in some matrix plots. Pacific madrone (*Arbutus menziesii* Pursh) is in former savannas but not on plots. Former savanna plots currently have significantly more bear grass, Lodgepole pine, and Douglas-fir, but less Western swordfern and Western hemlock (*Tsuga heterophylla* (Raf.) Sarge) than matrix plots (Table 3). Understories are dominated by Salal (*Gaultheria shallon* Pursh) in both matrix and savanna. Other forest indicator species and their occurrence by site are given in Table 4.

Currently Open Areas

The two sites that have been recently maintained in an open condition (Eells Hill and Dennie Ahl) have the most prairie indicator species and the least forest indicator species (Table 4). Sites that were once open, but are now forested, have few prairie indicator species, but retain some edge species. At Eells Hill, salal dominates shaded skirts at the base of abandoned Christmas trees, but at Hubin Camp and Goose Prairie, it dominates under closed canopies.

Fire History

In the vicinity of Hubin Camp, some large Douglas-fir trees have traces of bark charcoal near the ground and large, dead limbs starting at 4 or 5 m above ground. Douglas-fir 50- to 150-cm diameter at breast height (dbh) and >200 years old are scattered in a dense matrix of Douglas-fir and Lodgepole pine 10- to 20-cm dbh and about 100 years old (Fig. 2). Prior to 1877, savanna tree establishment was intermittent over a longer period of time than in matrix forests. Most trees in former savanna appear to have established after 1877, but most matrix trees established between 1668 and the early 1800s (Fig. 6). An age class predating 1668 was not found on the ONF in the vicinity of our matrix forests by Henderson et al. (1989) or in our data.

Figure 5. Lower NF of the Skokomish River in 1929. The open area north of the hairpin river bend is a recent burn. Other open areas are savanna remnants. (North is at top.)

A woodland tree near Dennie Ahl that established a few years after the 1701 fire had a fire scar from 1776 followed by radial growth suppression. None of our savanna trees established from 1808 to 1877, but one fire scar, two radial growth suppressions, and one release suggest fires occurred during that period. Three tree-ring scars in the late 1800s and early 1900s from the NF Plateau may have been associated with settlement activities.

Historical and Cultural Findings

GLO notes and maps from near Dennie Ahl do not mention savannas but refer to an “old Indian trail” passing

Table 1. Mean site index, elevation, and slope for plots in the vicinity of Dennie Ahl and Hubin Camp by fire regime.

Fire Regime (n)	*Site Index*[a]	*Elevation (m)*	*Slope (%)*
Matrix forest (19)	36	203	8
Savanna (8)	30	213	5
ANOVA, p^b	0.01	0.17	0.80

[a] 100-year site index for Douglas-fir in m/100 year (McArdle & Meyer, 1930). The height that dominant and codominant trees will grow to in 100 years on the average. These site index values were calculated from tree measurements and ages from trees on the plots.
[b] Parametric ANOVA for site index; Kruskal–Wallis for elevation and slope.

1.3 km north. Another trail passed through or skirted at least five former prairies visible in the 1929 aerial photographs and was headed toward the confluence of the Skokomish Forks—an important Skokomish village (Elmendorf & Kroeber 1992) 8 km south of Hubin Camp. Shortly after crossing this trail, the surveyor noted Hubin Camp 171 m to the southwest, suggesting a long, open line of sight. Neither the 1910 nor 1930s surveys indicate savanna or timber harvest in the Hubin Camp/Dennie Ahl area (Wade & Dodwell 1910; Harrington 2003).

GLO notes and maps indicate most of Eells Hill was woodland with young trees but mentions a small grassy prairie. Salal is the most often mentioned understory species in GLO notes throughout the Skokomish area. The 1910 survey for Eells Hill mentions features such as old and new fire damage, open understory, short-bodied trees, meadows, jack pine (Lodgepole pine), "no brush to speak of," "no down timber," and "good for stock to roam" (Wade & Dodwell 1910). Eells Hill is mostly classified by the 1930s survey as "old growth," although cutover lands are shown nearby (Harrington 2003).

Table 2. Plant associations and numbers of plots for each vegetation type.

n	*SI**	*Plant Association*
Matrix forest		
2	25	*Pseudotsuga menziesii/Gaultheria shallon*
9	35	*Tsuga heterophylla/Gaultheria shallon*
2	29	*Tsuga heterophylla/Gaultheria shallon/Xerophyllum tenax*
3	45	*Tsuga heterophylla/Gaultheria shallon/Polystichum munitum*
3	40	*Tsuga heterophylla/Gaultheria shallon/Berberis nervosa*
Savanna ecosystem		
3	25	*Pseudotsuga menziesii/Gaultheria shallon*
4	29	*Tsuga heterophylla/Gaultheria shallon/Xerophyllum tenax*
1	24	*Tsuga heterophylla/Rhododendron macrophyllum/Xerophyllum tenax*

All three savanna plant associations, but only two of the matrix forest plant associations, include *Xerophyllum tenax* (the *Pseudotsuga menziesii/Gaultheria shallon* association also has *Xerophyllum tenax* in it). Site index units (SI) in meters.
* Mean plant association site index values and classification of plant associations from Henderson et al. (1989). McArdle & Meyer (1930) 100-year Douglas-fir site index in meters.

GLO notes do not mention savanna or timber harvest on the NF Plateau. The 1910 survey shows timber harvest only for the northern fringe and the sloping edges of the plateau to the east and south. Notes for the area we mapped as savanna include "fire has swept the whole section, but at different times," "clean surface," "limby and scattering fir," "quite free from logs and brush," and "the only drawback [to timber harvest] is there is not enough to make it a good paying proposition." Maps for the 1930s survey of the NF Plateau indicate no further timber harvest had occurred since 1910 (Harrington 2003).

In reference to the vicinity of the NF and SF Skokomish rivers, Michael Pavel stated: "This prairie area was extremely important to the well-being of what we consider to be several families of the Twana … I've been told by elders who have already passed away … the practice of caring for this land was something that we maintained for several thousand years … it was manicured like a park. And it was that way until the late 1800s. People stopped doing that around that time when they were forcibly moved to the reservation to transition to another, static kind of life style. We were very nomadic, so it was important for us, when we returned to this land … to come back to a place that wasn't overgrown, wasn't crowded out … [I]t was a joyous place to be able to gather … and it was also a domain that would encourage the introduction and maintenance of the animal species that would feed us; the deer, the elk, the bear [*Ursus americanus*] … along with the gathering of plants such as the blueberries [*Vaccinium ovalifolium* Sm.] and the huckleberries [*Vaccinium parvifolium* Sm.] and tiger lilies [*Lilium columbianum* hort. ex Baker]. This would become our grocery store, but it was also our bedroom and our living room. It was a place that we could worship" (M. Pavel, Skokomish Tribe and Washington State University, 2004, personal communication).

Bruce Miller stated that prairies were burned on 2- to 3-year cycles, depending on weather conditions and brush growth. Burning was conducted after the first frost of the autumn: "… [o]ne of the primary purposes of the prairies was to perpetuate the root gathering sites… And the prairies were part of our commitment to our ancestors to maintain grazing grounds for elk and deer …[a]s the burning of the prairie ceased, the forest gradually choked up the areas that were prairie land and greatly reduced the foraging land that we aborigine provided for the grazing animals" (B. Miller, Skokomish Tribe, 2004, personal communication).

In 1933, the United States Court of Claims awarded the Skokomish over $3 million in part because settlers took tribal land that was used for growing food and textile plants. The court recognized "[t]hat the lands of claimants were kept free from underbrush by the Indians making fires …" (United States Court of Claims No. F-275 1933). Tribal members were asked about their land management practices:

> Question: Do you know whether or not the Indians in olden days used to burn the underbrush …?

Table 3. Canopy coverage (%) of several species from matrix and savanna vegetation plots in the vicinity of Dennie Ahl and Hubin Camp.

Fire Regime (n)	*Pseudotsuga menziesii*	*Tsuga heterophylla*	*Pinus contorta*	*Hard Woods**	*Polystichum munitum*	*Xerophyllum tenax*	*Gaultheria shallon*
Matrix Forest (19)	70	12	0	5	6	1	85
Savanna (8)	88	11	10	0	0	14	87
ANOVA *p*	0.01	0.02	<0.0001	0.24	0.04	0.0002	0.41

* Includes *Alnus rubra*, *Acer macrophyllum*, and *Populus trichocarpa*.

Answer: They used to burn, yes; they had a big burn for their berries …

Question: What time of the year did they do the burning so as to prevent the big fires?

Answer: The fall of the year generally … (p. 617).

Question: Was there any prairie land in the Skokomish country?

Answer: …Yes; we own a little … we owned half of that territory this side of Shelton, a little prairie (testimony of Frank Allen, 23 March 1927; United States Court of Claims No. F-275 1930 p. 617; 1933).

Discussion

The modern moist maritime climate of western Washington developed about 4,500 years ago (Barnosky 1983) and does not support the frequency of natural fire required to maintain savannas. Rapid forest succession on former savannas after 1877 demonstrates forest potential in the absence of anthropogenic fire. In most of western Washington, fire-return intervals ranged from 90 to 300 years, with forests, not savannas, developing between fires (Henderson et al. 1989; Agee 1990).

The past existence of bear grass savanna is supported by open areas in the 1929 aerial photographs with few snags or logs; remnant prairie species; large, old, widely spaced Douglas-firs with low limbs; bark charcoal and fire scars; and lack of mound-pit topography. Skokomish oral traditions, court testimony, and high fire frequency required for open conditions suggest anthropogenic management. Complex stand structure visible in the 1929 aerial photographs indicates a dynamic, open ecosystem. However, because forest colonization began in the late 1800s, the 1929 aerial photographs may not accurately portray the full extent of openness. Jones (1936) noted succession in the early 1900s and stated that older residents of the Olympic Peninsula reported that prairies were more extensive and caused by annual burning by Indians.

People have likely inhabited western Washington for the past 10,000 years (Ames & Maschner 1999). Although we have little knowledge of their cultures, it has been suggested that anthropogenic burning to maintain open areas on the Olympic Peninsula began over 3,500 years ago (Wray & Anderson 2003). Olympic Peninsula tribes used controlled burns to favor specific plants even after the establishment of reservations in the mid-1800s (James & Chubby 2002).

Savanna maintenance might have been facilitated by comparatively low tree productivity. Slower growing trees would have required less frequent burning. This factor was likely important in western Washington where high precipitation encourages tree and shrub growth while limiting the burning season. Throughout the Northwest, bear grass is associated with infertile soils and low productivity (Henderson et al. 1989; Atzet et al. 1996; Diaz et al. 1997). Poverty grass (*Danthonia spicata* (L.) Beauv. ex Roemer & J.A.) and Lodgepole pine are also associated with low nitrogen and fire (Stewart 1933; Daubenmire 1978). We propose that where fertility or water-holding capacity was low, forests grew slowly, thus remaining open between fires. Or, perhaps burning over a long time retarded the accumulation of fertility in savannas relative to surrounding forests by volatilizing or converting organic nitrogen to soluble forms.

Jones (1936) described bear grass in "open park-like forests" transitioning to closed forest. The successional trajectory of abandoned bear grass savanna under current climate is toward forest of the Western hemlock/salal/bear grass or similar plant associations (Henderson et al. 1989). Jones' species list is similar to the current Eells Hill flora, but development at Eells Hill of salal skirts in the shade of abandoned Christmas trees suggests a successional trajectory toward current conditions at Hubin Camp and Goose Prairie.

The current Dennie Ahl savanna flora is depauperate compared with Eells Hill. The difference in species composition might be because in 1929 Dennie Ahl was a shady woodland and Eells Hill a sunny savanna. We suggest Dennie Ahl was an anthropogenic woodland that experienced tree encroachment due to cessation of burning. Overstory removal for the seed orchard in 1957 permitted a few prairie species to survive, but the prairie flora was probably never as diverse as that of Eells Hill.

Matrix forest apparently established in the late 1600s and 1700s after stand-replacing fires. Our tree ages are consistent with savanna tree establishment before, during, and after forest regrowth from 1668 and 1701 fires and indicate that the dense cohort currently covering much of the former savanna is 100–120 years old. Our tree sample is not extensive and must be interpreted with caution, but our age estimate of the current dense cohort is consistent

Table 4. The authors' interpretation of indicator value for native species found at Eells Hill (EH), Dennie Ahl (DA), North Fork Skokomish plateau (NF), and Hubin Camp (HC).

		Indicator Value			*Location*			
Species	*Common Name*	*Prairie*	*Edge*	*Forest*	*EH*	*DA*	*NF*	*HC*
Trees								
Arbutus menziesii Pursh	Pacific madrone		×	×	×		×	×
Pinus contorta Dougl. ex Loud.	Lodgepole pine		×	×	×	×	×	×
Pseudotsuga menziesii (Mirbel) Franco var. *menziesii*	Douglas-fir		×	×	×	×	×	×
Salix scouleriana Barratt ex. Hook.	Scoulers willow		×		×		×	×
Shrubs								
Arctostaphylos uva-ursi (L.) Spreng	Kinnikinnick	×	×		×	×	×	×
Arctostaphylos × *media* Greene	[Columbiana × Uva-ursi]	×	×		×			
Mahonia aquifolium (Pursh) Nutt.	Hollyleaved barberry	×	×		×	×		
Eriophyllum lanatum var. *lanatum* (Pursh) Forbes	Wooly sunflower	×			×			
Gaultheria shallon Pursh	Salal		×	×	×		×	×
Goodyera oblongifolia Raf.	Western rattlesnake plantain			×				×
Holodiscus discolor (Pursh) Maxim.	Oceanspray		×	×	×		×	×
Lonicera ciliosa (Pursh) Poir. ex DC.	Orange honeysuckle		×	×	×			
Paxistima myrsinites (Pursh) Raf.	Oregon boxleaf		×	×	×			
Rhododendron macrophyllum D. Don ex G. Don	Pacific rhododendron			×			×	×
Rosa gymnocarpa Nutt.	Dwarf rose			×	×		×	×
Symphoricarpos hesperius G.N. Jones	Trailing snowberry	×	×		×			
Vaccinium caespitosum Michx.	Dwarf bilberry	×	×		×			
Vaccinium ovatum Pursh	California huckleberry		×	×	×		×	×
Herbs								
Achillea millefolium L. *var. occidentalis* DC.	Western yarrow	×	×		×	×	×	
Agrostis pallens Trin.	Seashore bentgrass	×			×			
Allotropa virgata Torr. & Gray ex Gray	Sugarstick			×				×
Anemone lyallii Britt.	Little mountain thimbleweed	×	×		×			
Antennaria howellii Greene spp. *neodioica* (Greene) Bayer	Howells pussytoes	×	×		×	×	×	
Apocynum androsaemifolium L.	Spreading dogbane	×	×		×			
Boschniakia hookeri Walp.	Vancouver groundcone			×				×
Campanula scouleri Hook. ex A. DC.	Pale bellflower	×			×			
Castilleja hispida Benth.	Harsh Indian paintbrush	×	×		×		×	
Danthonia spicata Beauv. ex Roemer & J.A. Schultes var. *pinetorum Piper*	Poverty oatgrass	×	×		×	×	×	×
Erythronium oregonum Applegate	Giant white fawnlily	×	×		×			
Festuca roemeri (Pavlick) Alexeev	Roemers fescue	×				×		
Fragaria virginiana Duchesne ssp. *platypetala* (Rydb.) Hall	Virginia strawberry	×			×			
Fritillaria affinis (Schultes) Sealy	Checker lily	×	×		×			
Iris tenax Dougl. ex Lindl.	Toughleaf iris	×	×			×		
Lilium columbianum hort. ex Baker	Columbian lily	×	×		×	×	×	×
Lupinus albicaulis Dougl. ex Hook.	Sicklekeel lupine	×	×		×	×	×	
Lupinus latifolius Lindl. ex J.G. Agardh	Broadleaf lupine	×	×		×			
Luzula multiflora (Ehrh.) Lej.	Common woodrush	×	×		×	×	×	
Packera macounii (Greene) W.A. Weber & A. Löve	Siskiyou mountain ragwort	×	×		×			
Polystichum munitum (Kaulfus) K. Presl	Western swordfern			×	×		×	×
Pteridium aquilinum (L.) Kuhn	Western brackenfern	×	×	×	×	×	×	×
Ruppertia physodes (Dougl. ex Hook.) J. Grimes	Forest scurfpea	×	×		×			
Ranunculus occidentalis Nutt. var. *occidentalis*	Western butercup	×			×			
Rubus ursinus Cham. and Schlecht.	California blackberry	×	×	×	×	×	×	×
Solidago simplex Kunth ssp. *simplex* var. *simplex*	Mt. Albert goldenrod	×			×			
Trillium ovatum Pursh	Pacific trillium			×				×
Viola adunca Sm. var. *adunca*	Hookedspur violet	×			×			
Xerophyllum tenax (Pursh) Nutt.	Common bear grass	×	×	×	×	×	×	×

Edge species may also be found in woodlands or dry, open forests.

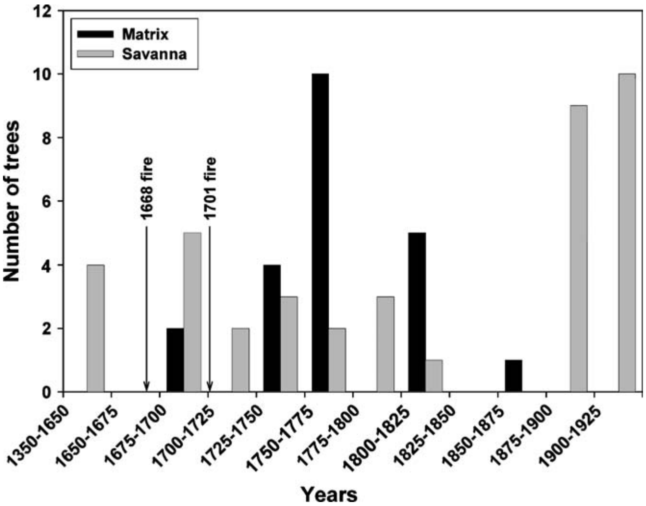

Figure 6. The number of tree ages by 25-year age classes in savanna and matrix forest. Most establishment after 1900 occurred before 1920. No matrix forest trees established between 1815 and 1859. Note that the first bar is for 300 years.

with observations of open areas and tree establishment indicated by the 1910 survey (Wade & Dodwell 1910). We suggest that parts of the savanna were too sparsely forested to carry a crown fire, so some savanna trees survived ground fires, explaining trees predating the matrix forests. We suggest anthropogenic savanna fires in the 1700s and early 1800s occasionally burned into establishing matrix forests, accounting for their more than 100-year establishment period.

The fire-return interval necessary for the savanna ecosystem cannot be determined with our data, and a single interval may not be appropriate. The fire regime of the woodlands and some matrix forests may have been similar to Agee's (2002) moderate/mixed-severity fire regime with 25- to 75-year fire-return intervals. Cooper (1859) observed prairie tree invasion within 20 years after burning stopped in the 1850s south of Puget Sound, suggesting frequent burning is required to maintain open areas. In our study area, low-intensity savanna fires might not have scarred many trees, so tree-ring records are not adequate to determine the fire-return interval. Kertis (1986) found an apparent anthropogenic fire frequency of 11–34 years from the mid-1700s to 1900 in oak woodlands about 30 km northeast of our study area, but this conservative estimate was based on few trees and only on fires hot enough to cause scars. Miller (B. Miller, Skokomish Tribe, 2004, personal communication) stated that the Skokomish Tribe burned about every 2–3 years. Because stand structure varied from parklands to open prairies, we suspect that more open core areas were burned at short intervals (2–3 years), whereas peripheral areas burned less frequently and possibly incidentally, depending on weather conditions during burning.

We suggest that savanna tree establishment was determined by the frequency, intensity, and completeness of anthropogenic burning as well as climatic and cultural events. An equilibrium may have been established that drifted with climate, population, and cultural changes affecting burning and establishment conditions. Lack of savanna and matrix tree establishment in the early to mid-1800s may represent the maximum savanna extent that local people needed. An abrupt increase in tree establishment on savannas from 1877 to 1920 signals the cultural shift ending anthropogenic burning or the first favorable postburning establishment period. Tree sizes noted by GLO surveyors suggest earlier establishment at Eells Hill, but it is not clear if those trees were invading burned matrix forest or savanna. In any case, some savanna was still present in 1929.

Conclusion

We conclude that an anthropogenic bear grass savanna ecosystem was an important part of the southeast Olympic Peninsula vegetation for at least the last several hundred years. Flora, fire history, 1929 aerial photographs, historical documents, and oral traditions all support its existence. Its anthropogenic nature is supported by Skokomish oral traditions, historical accounts, and a historical fire regime in surrounding forests that is too infrequent to account for savanna structure. It is not clear if these savannas were located in relatively infertile sites because they required less maintenance there, or if long-term fire management resulted in lower fertility. However, in the context of site selection for restoration, site fertility is an important consideration because fertility affects both maintenance and floral composition.

There is no single model for restoration, so understanding ecosystem function is essential. Although the processes that created the community may not operate the same today, if modern cultures see value in former ecosystems, an understanding of those processes may enable sufficient restoration of the structural and floral components to provide those values. By working with indigenous cultures, there is great potential to understand the pivotal role that traditional land management practices played in shaping the landscape. But beyond the mechanistic understanding of how things came to be, is the revitalization of the culture that gave purpose to this landscape in the beginning. In the end, it will be the success of this cultural revitalization and the degree to which it finds sustenance in the extended societal matrix that will determine the success and longevity of the landscape restoration. Thus, the goals of restoration must be culturally meaningful and socially attainable. Savannas would enable the Skokomish to once again gather and teach their children and others about their traditions. Therefore, not only is there the instrumental benefit of ecological restoration but as a focal restoration endeavor (Higgs 2003:237), reintroducing bear grass savannas to the southeastern Olympic Peninsula also has cultural benefits.

The ONF initiated savanna restoration in 1995 to establish as faithfully as possible the original savanna flora based on many of the findings presented here. Thirteen hectares of Douglas-fir forest north of Dennie Ahl was thinned in 2001 based on densities in the 1929 aerial photographs. In September 2003 the unit was treated with prescribed fire with more burns planned for 3- to 5-year intervals. In the words of Keith Dublanica, Director of Skokomish Natural Resources, "Such a project can span generations as well as cultures and it affords a unique opportunity to investigate, monitor and adaptively manage natural resource landscapes" (U.S. Department of Agriculture, Forest Service 2003).

Implications for Practice

- A no longer extant bear grass savanna ecosystem has been recognized and partially characterized, opening the door to its restoration. It is likely that many other unrecognized anthropogenic communities also exist.
- Plant community succession may make anthropogenic communities difficult to recognize. Traditional knowledge and historical documents may be necessary to interpret current, ground-based information to first recognize, then restore the community if that is deemed important.
- Site fertility is an important restoration consideration because it affects both floral composition and maintenance effort of the restored site. This is especially important when community succession has made it difficult to recognize the former extent of the system.
- Site potential vegetation provides the conceptual basis for understanding the inherent instability of anthropogenic systems and their tendency to "move" in certain successional directions.
- Restoration to the "original community" is probably an unattainable goal in most cases and in the case related in this paper. But with an adequate understanding of the community, past, and present, it may be possible to restore sufficient structural and functional elements to achieve predefined, focused goals. Success of restoration likely will hinge on local community involvement in setting and achieving these goals.

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