

Forest Site Classification for Cultural Plant Harvest by Tribal Weavers Can Inform Management

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Do qualitative classifications of ecological conditions for harvesting culturally important forest plants correspond to quantitative differences among sites? To address this question, we blended scientific methods (SEK) and traditional ecological knowledge (TEK) to identify conditions on sites considered good, marginal, or poor for harvesting the leaves of a plant (beargrass; *Xerophyllum tenax*) used in tribal basket weaving. We relied on voluntary participation of six expert weavers, a stratified, randomized field sample, discriminant analysis (DA), a standardized color system, and paired *t*-tests. We accepted each weaver's classification (good, marginal, or poor) of forested sites for beargrass harvest and then measured forest and plant attributes on two plots at each harvest area in each class ($n = 72$). The DA yielded descriptive but not predictive results. Coarse woody debris (CWD) levels and the number of trees (trees per acre [TPA]) differed significantly between good and poor sites across California, Oregon, and Washington, whereas basal area did not. Good sites had less CWD ($P = 0.0360$) and fewer TPA ($P = 0.001$) than poor sites. Variations in leaf color decreased as the site class for plant harvest improved. Results reveal a crosswalk between ecological knowledge derived via SEK and TEK for culturally important plants.

Keywords: forest structure, cultural plants, silviculture, basketry, traditional ecological knowledge (TEK)

Some plants used by American Indians are scarce or declining in western North American forests, so information about how plant quantity and quality relate to site conditions is needed to change this trend. Our premise is that the best information for sustaining culturally important plants will come from studies that link

scientific and traditional ecological knowledge. Such an approach implies blending these types of knowledge to advance understanding of relations among forest site conditions, cultural practices, and land management. In this article, we focus on one understory plant but contend that a blended approach will apply to others. Moreover, a

blended approach could contribute to efficiencies in forestry practices, such as managing tree density or using prescribed fire, that are intended to support multiple objectives.

Traditional ecological knowledge (TEK), refers to a cumulative and evolving body of knowledge, beliefs, and practices that are transmitted culturally over generations (e.g., Berkes and Folke 1998, Berkes et al. 2000, Turner 2001, Menzies and Butler 2006). Other terms are used for such intergenerational, cultural knowledge, including indigenous knowledge and traditional ecological knowledge and wisdom (Turner et al. 2000, Corsiglia 2006). We adopt the term TEK for this article, with the understanding that it implies knowing a plant within a broader context of its landscape, history of place, site conditions, harvesting practices, and a multitude of cultural uses.

Culturally important plants, with a suitable condition for a specific need can be difficult to locate, access, and harvest (Anderson and Rowney 1999, Deur and Turner

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2005). Difficulties are compounded when the tribal members seeking cultural plants are elderly or otherwise have reduced mobility because plants suitable for a planned use may not be at sites they consider good for harvesting. At the same time, their knowledge is vital. Who better than experienced tribal elders and practitioners to teach novice harvesters and youth how to locate potential sites, use appropriate harvesting strategies, and match plant properties with intended cultural uses? It requires knowing what plants to harvest, in which locations, under what environmental conditions, and with what timing, intensity, and methods. Moreover, there may be traditional or customary restrictions on who can be involved or how. Such tribal knowledge and practices require familiarity with a place and its ecological processes, plus knowledge of plant properties and the ability to transform raw natural materials into an intricate item like a basket.

TEK is not easily shared beyond the context of a specific tribal harvesting practice because much of it is tacit, meaning that it is implied or indicated but not necessarily directly expressed (Turner 2001). Nonetheless, if it has relevance for land management, it needs to be generalized when possible and communicated accordingly. A role exists for scientific methods, therefore, that can support inferences made about the scope of knowledge obtained from traditional sources without requiring tribal practitioners to divulge specific practices. Hence, we used quantitative and qualitative research methods together with TEK to classify and describe site conditions for harvesting the leaves of one culturally important plant. The issue is not solely maintaining plant populations, but sustaining them with needed quality in places accessible for cultural harvests. We use the term “quality” for plant and site properties that are suitable for the specific purposes of harvesting and weaving.

Objectives

The main literature on TEK emphasizes using it to inform educational programs (e.g., Huntington 2000, Snively and Corsiglia 2001, Kimmerer 2002) and ecological restoration activities (e.g., Anderson and Rowney 1999, Shebitz 2005, Senos et al. 2006) or to interpret ecological conditions (e.g., Turner et al. 2000). A subset of this literature aims to combine TEK and sci-

entific ecological knowledge (SEK). We contribute to this small subset by expanding its application in forestry (e.g., Mason et al. 2012, Emery et al. 2014).

Our specific objectives in this study were 2-fold, namely, to develop and apply research methods that combine ecological knowledge gained via SEK and TEK and to document the biophysical characteristics of sites that tribal weavers identified as good, marginal, or poor for harvesting beargrass (*Xerophyllum tenax*) for tribal basketry. Across our multistate study area, numerous tribes are known to use beargrass in weaving both twined and coiled baskets (Table 1; Figure 1). It is plausible that classification of site conditions for plant harvest could vary with tribal affiliation or weaving style, given the variation in how beargrass is used with design weaves by different tribes (Table 1). However, some tribes historically wove baskets with beargrass obtained in trade (Zobel 2002), which means there may be desirable leaf properties that transcend a specific weaving tradition and instead relate directly to site conditions. Our expectation was that measurable differences exist among forest sites rated by tribal weavers as favorable or not for harvesting beargrass, independent of tribe and weaving style. To test this hypothesis, we relied on the voluntary participation of tribal weavers, a stratified and randomized field sample, and a standardized color system for plant tissue.

Methods

We used both quantitative and qualitative methods to combine SEK and TEK for our first objective and then we applied this

blended methodology to learn about beargrass. For our second objective, we documented the characteristics of sites that tribal weavers classified as good, marginal, or poor for harvesting beargrass by evaluating and describing their significant differences. Using beargrass as an example, the following series of numbered steps serve as a methodological framework for blending TEK and SEK for other culturally important species.

Step 1. Plant Natural and Cultural History Identification

We used existing, written documentation about beargrass to guide the selection of variables for field sampling. Particular focus was given to plant life history and leaf properties desired for weaving baskets. Beargrass is a lily-like plant; it grows in a wide variety of habitat types and conditions, but in just two geographic areas. One area is maritime, from the mountains of northwestern Washington south into western-central California, whereas the other is continental, from Canada south into Wyoming along the Rocky Mountains. Its only congeneric relative, eastern turkeybeard (*Xerophyllum asphodeloides*), is restricted to the southeastern United States where it is classified as threatened in portions of its range. Beargrass reproduces both by seed and by sprouting and is adapted to survive disturbances, such as fire and landslides, if the rhizome is unaffected. It is found at its highest densities under canopy openings in a variety of forest types, but evidence is scarce about the effects of competition or light on its reproduction and growth. Within the maritime region

Management and Policy Implications

Different types of ecological knowledge can contribute to identifying forest management objectives for culturally important plants. Study results imply that managing tree density can provide understory conditions to promote the growth of beargrass leaves preferred by tribal weavers. Results also imply that managing down wood levels is important so that coarse woody debris (CWD) (>3 in.) is not a physical barrier for tribal harvesters. Across sites in California, Oregon, and Washington, average tree BA per acre did not differ significantly, ranging between 175 and 197 ft²/acre. On sites considered good for beargrass harvest, however, the BA was distributed on fewer trees (average 127) than it was on sites the tribal weavers identified as marginal (average 177) or poor for harvest (average 172). A similar trend existed for deadwood. Namely, the average amount of total surface wood and litter increased as the site classification declined in quality, with good = 14 tons/acre, marginal = 19 tons/acre, and poor = 22 tons/acre. Taken together, the forest conditions identified by tribal weavers as good for harvesting beargrass had, on average, significantly fewer, larger diameter trees and less surface wood, litter, and CWD than did poor sites. The structural elements preferred by tribal weavers for beargrass harvest, therefore, relate directly to those associated with managing fire behavior in similar forest types.

Table 1. Examples of tribes (California, Oregon, and Washington) using beargrass in the design weave of twined and coiled basketry.

Design weave (beargrass)			Twined		Coiled	
	Full-twist overlay	Half-twist overlay	Overlay	Wrapped twine	False embroidery	Imbricated
California	Hat Creek Modoc Pit River Shasta Wintun	Hupa Karuk Pit River Tolowa Wiyot Yurok	Yana			
Oregon	Kalapuya Umatilla	Siletz Takelma Tututni Umatilla	Siletz	Clatsop Umatilla	Tillamook Umatilla	
Washington	Klickitat	Chehalis Quinault Skokomish	Chinook Nisqually Puyallup Quileute Skokomish	Chinook Makah Quileute		Chehalis Klickitat Nisqually Puyallup Yakama
Example of basket (and date) of each design weave (beargrass)	CAS 0090-0015* (early 1900s)†	CAS 0473-0023* (ca. 1977)†	2013.10.44* (ca. 1840)‡	NA 26* (ca. 1830-1840)	Turnbaugh and Turnbaugh, 1986§	2005.001* (ca. 2004)

* Museum accession number.

† California Academy of Sciences, San Francisco, CA: Anthropology collection database. Available online at research.calacademy.org/anthro/collections; last accessed May 15, 2014.

‡ Portland Art Museum, Portland OR. 2014. Native American art collection. Available online at www.portlandartmuseum.us/mwebcgi/mweb.exe?request=home; last accessed May 15, 2014.

§ Peabody-Turnbaugh, S., and W.A. Turnbaugh. 1986. *Indian baskets*. Schiffer Publishing, Atglen, PA. 264 p.

|| Hallie Ford Museum of Art, Salem, OR: Native American collection. Available online at willamette.edu/arts/hfma/collections/native_american/index.html; last accessed May 15, 2014.



Figure 1. Examples of ancestral and contemporary baskets (see Table 1). Top row: Coiled baskets. Primary traditional weaving materials shown: western red cedar (*Thuja plicata*) and beargrass (*Xerophyllum tenax*). Left: unknown Klickitat artist, *Basket*, ca. 1870/1880. Courtesy of Portland Art Museum, Portland, OR. Museum Purchase: Helen Thurston Ayer Fund. Accession number 40.35.21. Middle: Tribal weaver harvesting beargrass, 2012. Courtesy of Frank Lake. Right: Nettie Jackson (Klickitat), *Large Cedar Root Berry Basket*, 1983. Courtesy of Maryhill Museum of Art, Goldendale, WA. Gift of Mary Dodds Schlick, in memory of William T. (Bud) Schlick, 1925-1992. Accession number 2010.03.001. Bottom row: Twined baskets. Primary traditional weaving materials shown: hazel (*Corylus cornuta*), bear-grass (*Xerophyllum tenax*), alder bark-dyed woodwardia fern (*Woodwardia fimbriata*) and maidenhair fern (*Adiantum pedatum*). Left: unknown Karuk artist, *Woman's Hat*, ca. 1900. Courtesy of Portland Art Museum, Portland, OR. Gift of Miss Mary Forbush Failing. Accession number 18.2.8. Middle: Twined basket, 2012. Courtesy of Frank Lake. Right: unknown Klamath artist, *Tobacco Basket*, ca. 1950. Courtesy of Portland Art Museum, Portland, OR. The Elizabeth Cole Butler Collection. Accession number 2012.25.22.

in particular, many American Indian tribes harvest beargrass for cultural purposes, the primary use being basketry with a twined or coiled foundation (Table 1). Beargrass leaves are durable yet flexible, so they can be woven, braided, or wrapped tightly. Evidence suggests that tribal basket weavers favor longer, thinner, more pliable leaves with less pigmentation and a snowy white color at the base. Leaves with these properties are often associated with postfire conditions (Hummel et al. 2012).

Step 2. Preliminary Site Identification

Some areas of interest to land managers and tribal harvesters where beargrass grew were identified before field reconnaissance. The biophysical characteristics of the sites were described from existing soil maps, elevation, fire or forest management history, and general location near roads or other features. Road accessibility to sites with high densities of beargrass was desired by many tribal gatherers. We used a rule set that included distance from a road, forest vegetation community type, public ownership, fire history, and personal knowledge of the area to identify potential sites. We aimed to include a geographic range on the Pacific Coast from northwestern California to central Washington.

Step 3. Participant Recruitment and Final Site Selection

Expert weavers were identified by referral, with our main sources being contemporary weavers, basketweaver associations, schools, and community organizations. Six weavers from three states and four tribes agreed to participate in the study. They are not identified more specifically to uphold confidentiality. We consulted with tribal cultural resource specialists and federal policies to confirm that knowledge being shared by tribal members was not subject to regulation. Moreover, we agreed that research sites would remain confidential if requested by tribal participants (USC Title 25 § 3056¹). It is important that scientists learn in advance about existing policies, laws, and regulations that affect any cultural plants to be studied, including protection of tribal TEK and confidentiality of sites.

We selected our final study sites in California, Oregon, and Washington (Figure 2) based on information from the tribal participants and associated land use history, including, for example, ancestral or ceded territories, past or present forest or fire management history or related activities in cooperation with tribes, land use designation, site

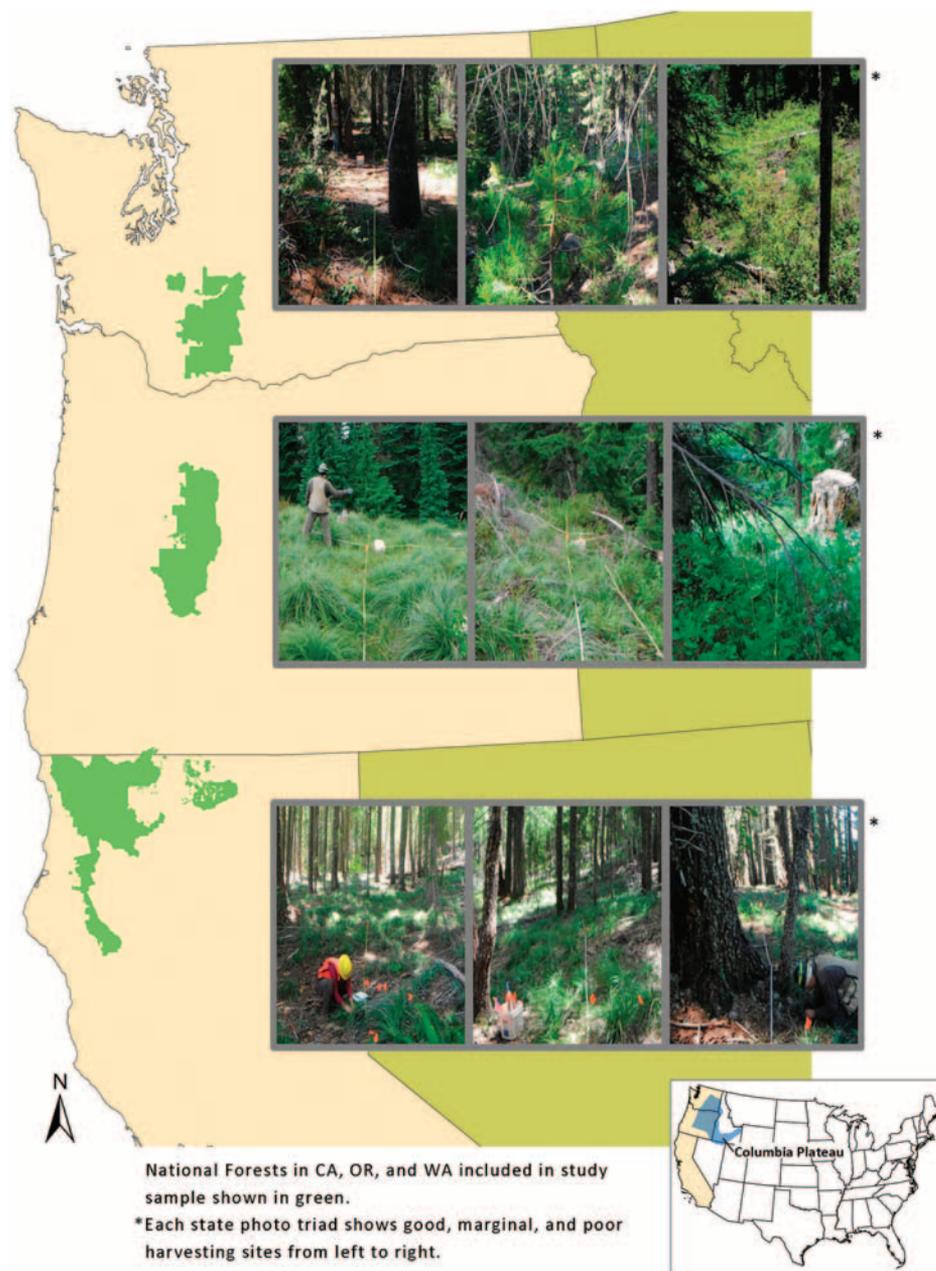


Figure 2. Study area (California, Oregon, and Washington) for field sampling good, marginal, and poor sites for harvesting beargrass for basketry.

accessibility, and physical stamina or mobility of participants. Trees species were predominantly coniferous, including Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), subalpine fir (*Abies lasiocarpa*), ponderosa pine (*Pinus ponderosa*), and western larch (*Larix occidentalis*).

Step 4. Field Sampling

Input from both written and oral sources helped us identify variables of potential importance for classifying sites by har-

vest quality. For our blended research approach, we elected to accept each weaver's qualitative classification of a site as good, marginal, or poor for harvesting beargrass and then used field methods adapted from ecology and forestry to sample the site and plant variables. Our conceptual model in this study can, therefore, be described as TEK = SEK + latent variables ± error. This approach acknowledges the existence of traditional knowledge that may not be measurable but, nonetheless, quantifies some site attributes that may be important in the

identification of forest management objectives and planning management activities.

For each variable, we evaluated different sampling methods by considering their suitability and availability to land managers. This was an important step, because a variety of methods exist and all choices involved tradeoffs. For example, percent canopy cover can potentially affect beargrass growth and resultant leaf quality, but this variable can be estimated ocularly (with high bias, greater error, and lower price) or measured by using a spherical densitometer (moderate bias, minor error, and moderate price) or light spectrum instrument (low bias, high precision, and high price). Another variable, deadwood, can affect site access and it too, can be sampled with different methods that involve tradeoffs in repeatability, bias, precision, unit of measure, time, and cost to document. We selected particular instruments or methods that matched limitations imposed by time and budget to standardize methods across the range of conditions we expected to encounter.

Each of the six weavers was driven to different locations and asked to offer a preliminary assessment of sites as good, marginal, or poor for harvesting beargrass. After a range of sampling sites was seen, each participant was asked to personally check the quality of leaves on some individual plants at a site to make their final determination. Across each of the three site types selected (~6–25 acres), we marked out six patches (100–500 ft²) that represented conditions in which the weaver would harvest beargrass. We then threw a die to select two of the six patches at random and established two sample plots per patch. This resulted in a total number of 12 sample plots per weaver (3 site types × 2 patches × 2 plots). Thus, for the six weavers we sampled 72 plots.

The sample plots were circular, with a radius of 45 ft. On each plot, the following site attributes were measured or estimated: diameter of each tree, height of tallest tree, deadwood in tons per acre by size class (using the Maxwell and Ward 1980 visual photo series), trees per acre (TPA), percent slope at plot center (clinometer), and percent canopy cover at four cardinal directions (spherical concave densitometer). In addition, several plant attributes were measured. To do so, we first divided each plot into four quadrats by extending two measuring tapes in cardinal directions. By beginning at due north and walking toward plot center, we sampled the first five beargrass plants en-

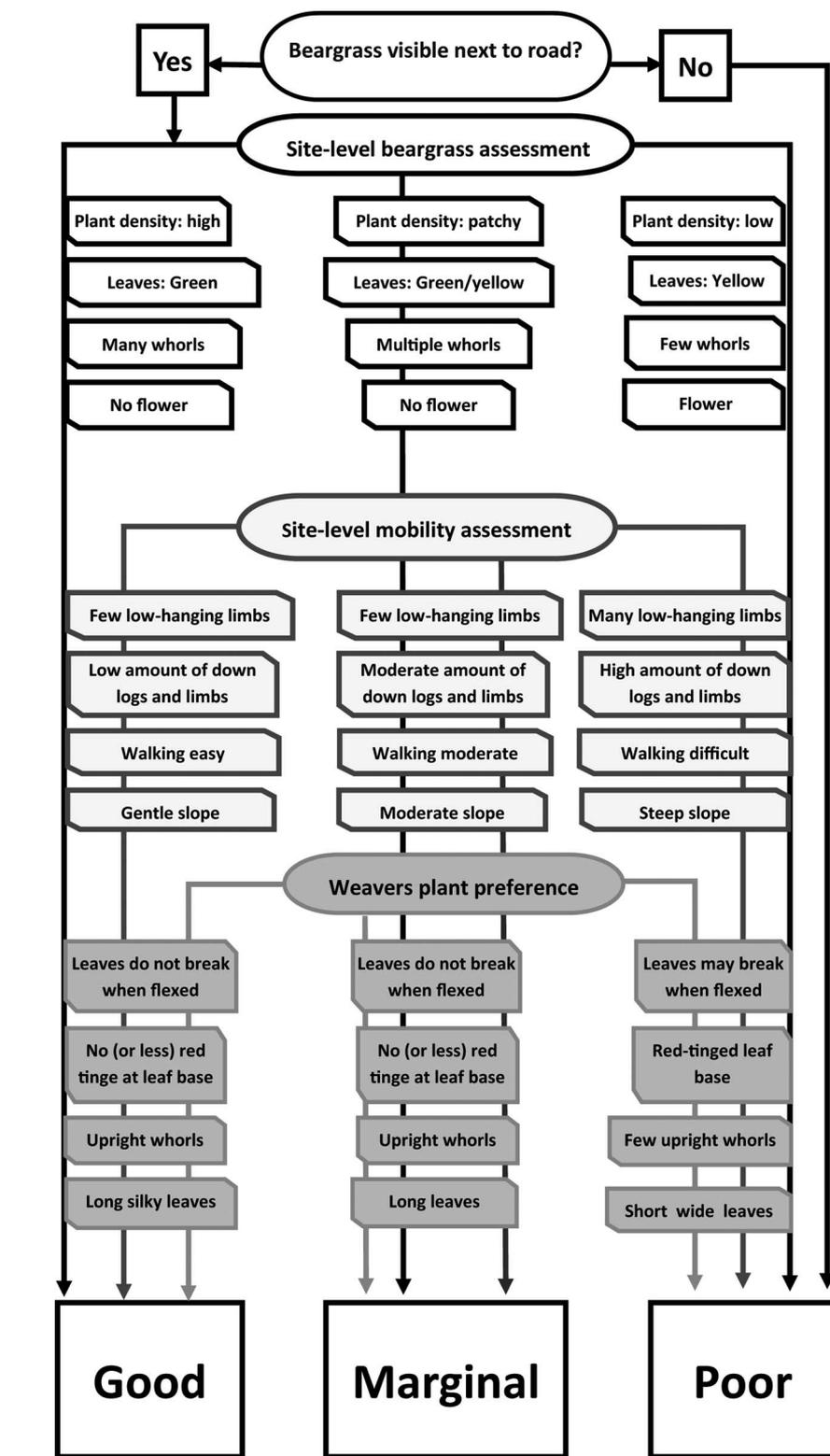


Figure 3. Decision key created from field visits with tribal weavers to study sites (California, Oregon, and Washington).

countered along the tape and extending 18 in. on either side. If five beargrass plants were not encountered on the first transect, we continued by beginning at due east and walking toward plot center until five plants were sampled. On each sampled

plant, the code that most closely corresponded to the color at the midpoint of longer leaves of a central whorl was assigned using the Munsell plant tissue color guide (Munsell 2011). We tallied the number of emergent whorls of new leaf growth because

they contain the best basketry material and thus are targeted for harvest by tribal weavers.

In addition to plot measurements, a decision key was created from information shared by the weavers during field visits (Figure 3). The key illustrates the considerations these women and men gave to certain site and plant conditions.

Step 5. Preliminary Data Summaries

We summarized preliminary results from the field study, which we then presented during an informal panel at the 2012 Northwest Native American Basketweavers Association (NNABA) meeting in Auburn, Washington. The panel included every tribal study participant and USDA Forest Service research staff. The lead agency scientist, who described the purpose and objectives of the study, was the only nontribally affiliated panel member. Panel observers included interested weavers attending the NNABA meeting. Our research goals for the panel were to determine whether the weavers felt we had measured the right variables and had not omitted something important. In qualitative research, this step is referred to as “member checking” (Janesick 2000). Our outreach goal was to honor the contribution of study participants by sharing some preliminary results. We learned several things from the weaver panel, namely, (1) there was interest and discussion about down wood (e.g., amount, size, and distribution) as a site descriptor, (2) no key variables were identified as having been omitted from the field study, (3) it was easier for weavers to describe and identify “good” and “poor” site characteristics than “marginal,” and (4) participants appreciated that we brought information to them.

The NNABA weaver panel reinforced the value of the blended approach we used in the study because traditional and scientific knowledge each made a contribution. Researchers learned that the weavers who participated in the study had classified sites based on personal integration of many factors, including what they saw in the field and what they had previously observed, been told, or experienced. They did not distill site and plant qualities into individual variables. Plant qualities, when considered good enough to harvest, were evaluated in relation to the site conditions and proximity to better plants. Nonetheless, tribal participants were interested in how the researchers identified and measured variables because

Table 2. Variables from discriminant analysis of good, marginal, and poor sites (California, Oregon, and Washington) for harvesting beargrass for basketry.

Variable	Good	Marginal	Poor
Site			
Elevation (ft)	4,152 (340)	4,097 (426)	4,123 (410)
Tree			
BA (ft ² /acre)	197 (175)	181 (148)	175 (144)
Total trees (TPA)	127 (57)	177 (105)	172 (67)
Deadwood			
Residue (in.)	0.20 (0.10)	0.30 (0.20)	0.20 (0.10)
Duff/litter (in.)	1.14 (0.90)	1.08 (0.70)	1.20 (0.70)
Size class 1 (<1 in. tons/ac)	0.95 (0.66)	1.30 (0.67)	1.40 (1.04)
Size class 3 (1–3 in. tons/ac)	1.40 (0.55)	2.10 (1.09)	1.90 (0.96)
Size class 9 (3–9 in. tons/ac)	5.30 (2.00)	9.80 (6.40)	10.70 (06.5)
Leaf color			
Hue	5.08 (0.22)	5.18 (0.51)	5.48 (0.94)
Chroma	4.95 (0.52)	5.03 (0.70)	4.91 (0.74)
Value	4.14 (0.27)	4.04 (0.32)	4.10 (0.38)

Data represent means (SD).

they felt it could help them describe to novice weavers what they were seeing when identifying the characteristics of a good site. In turn, the researchers learned from the weavers why some seemingly important variables might indeed affect their harvest criteria. For example, the amount and size of down wood could affect ease of physical site access, harvester mobility, and speed of leaf collection. Hence, down wood may be both a direct factor affecting potential fire behavior and an indirect factor affecting cultural use harvesting efficiency. Importantly, it is a variable that can be quantified and managed. We chose to investigate both the total amount of down wood and the subset of down wood ≥ 3 in., which we distinguish as coarse woody debris (CWD) in this article. Without the interaction of researchers and weavers, less would have been learned about the potential importance of down wood by size class and arrangement on site classification for cultural harvest than we learned in combination. The NNABA panel also confirmed the merits of multivariate analysis to evaluate the qualitative classes because the weavers themselves relied on a multivariate assessment of each site.

Data Analysis

We used the measured variables in discriminant function analysis (DA) (SAS Institute, Inc. 2000), either directly (e.g., down wood by size class) or calculated (e.g., basal area [BA]), to predict class membership by using continuous or binary independent variables. In ecology, DA is also used descriptively (Williams 1983). A multivariate analysis of variance, such as Wilks' λ that we selected, tests the statistical significance

of mean differences of the groups. We confirmed that our data were not highly correlated (<0.7) and assumed multivariate normality. Our original interest in the potential role of leaf color in site classification was increased by weaver comments during member checking at the NNABA panel. In the system of color theory we used, hue is a combination alphanumeric scale, whereas chroma and value are numeric (Munsell 2011). The Munsell system is qualitative, in that it uses perceptible color space instead of a quantitative measure of visible light (Viscarra Rossel et al. 2005). All of our recorded hues were in the same alphabetic class of “green-yellow” (GY), so we used only the numeric component of the hue scale in the DA.

We identified the combination of site, tree, size classes of deadwood, and leaf variables that maximized the number of correctly classified good sites by using the resubstitution method in DA; the list of final variables is shown in Table 2. The site features of longitude and latitude were not in the final model, although elevation was included. From the final complete set, we excluded the color “triplet” of hue, chroma, and value to evaluate the effect on classification error and on distance between classes. Resubstitution uses the fitted discriminant function to reclassify the sample data that were used to fit the discriminant function in the first place. The effect is that the model is “validated” with in-sample observations only.

The results of the DA were not statistically significant, yet identified categories of important structural and ecological vari-

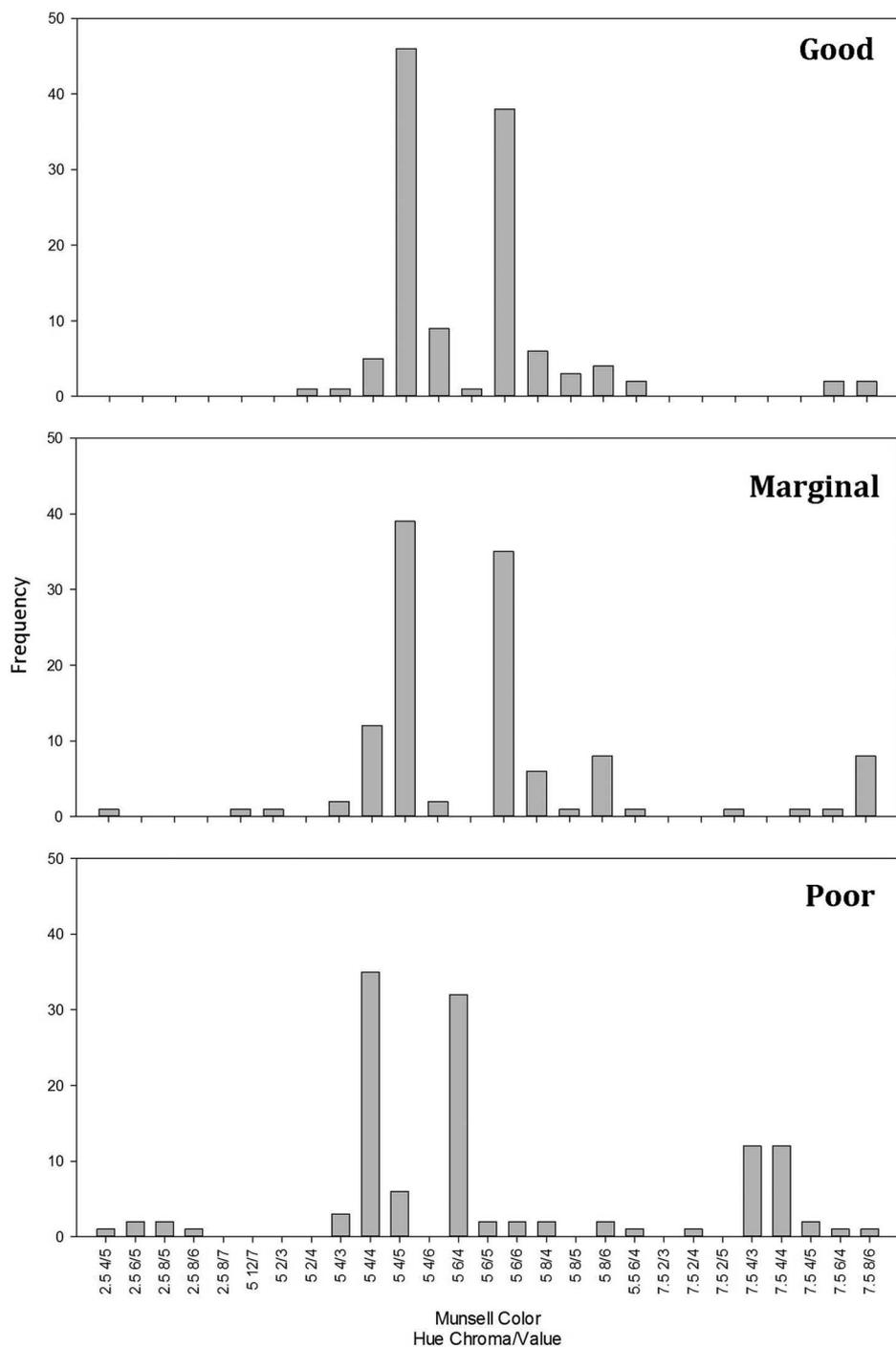


Figure 4. Distribution of beargrass leaf color on sites (California, Oregon, and Washington) classified by tribal weavers as good, marginal, or poor for harvesting beargrass for basketry.

ables, including tree (BA and TPA), down wood (total surface), and leaf color. We used paired *t*-tests to evaluate differences in means between the individual tree and down wood variables and harvest site classification (Husch et al. 2003). We also added a test of means for CWD because of the discussion about it at the NNABA panel.

Results

Across all weaving styles and forest types represented in the study, there was consistency in the leaf color that tribal participants associated with good harvesting sites for beargrass. When leaf color was mainly within the middle hue (5GY) and had few instances of different hues, the site

was generally judged to be good (Figure 4). In contrast, several instances outside of the middle hue downgraded weaver judgment of the site. This color consistency held true even though leaves were harvested from different whorl layers on individual plants according to different tribal weaving styles.

The average BA (ft²/acre) was similar across all site classifications, but it was distributed on fewer average TPA on the good sites (Figure 5). That is, sites classified by weavers as marginal or poor had, on average, more TPA than sites classified as good. A similar trend existed for deadwood. Good sites had fewer TPA ($P = 0.001$) and less CWD ($P = 0.036$) than poor sites. The average amount of total dead surface wood in tons per acre increased as the site classification declined in quality (good = 14, SD 5; marginal = 19, SD 10; and poor = 22, SD 11). The average CWD (≥ 3 in.) amounts were good (12 tons/acre), marginal (17 tons/acre), and poor (20 tons/acre). The 3–9 in. size class of deadwood included in the model (Table 2) and important to weavers (Figure 6) followed the same trend.

Evidence was lacking for statistically significant mean differences in our three classes (Wilks' $\lambda = 0.475$, $P < 0.55$). The classification summary from the full model returned the highest number of correctly grouped sites. The highest classification rate was for good (83.3%), followed by marginal and poor (66.7%) (Table 3). The distance from good to marginal was equal to the distance from marginal to poor (2.2). The color triplet changed these distances and altered the relationship among sites. Without color, marginal sites were judged to be closer to poor sites than they were to good sites. Color was the least variable on good sites, becoming more variable as quality was judged to decline (Figure 4). Despite this trend, every class had instances in which it was misclassified as either of the other two (Table 3).

Discussion

This study suggests how land managers could combine management objectives for forest overstory and understory plants when determining target levels for key stand structural elements, namely, by identifying the forest conditions associated with desired understory plant properties and then incorporating this information into silvicultural, fuels, and fire management activities. In the mixed-conifer forest types included in this study, for example, a body of literature exists about relations among size class distribu-

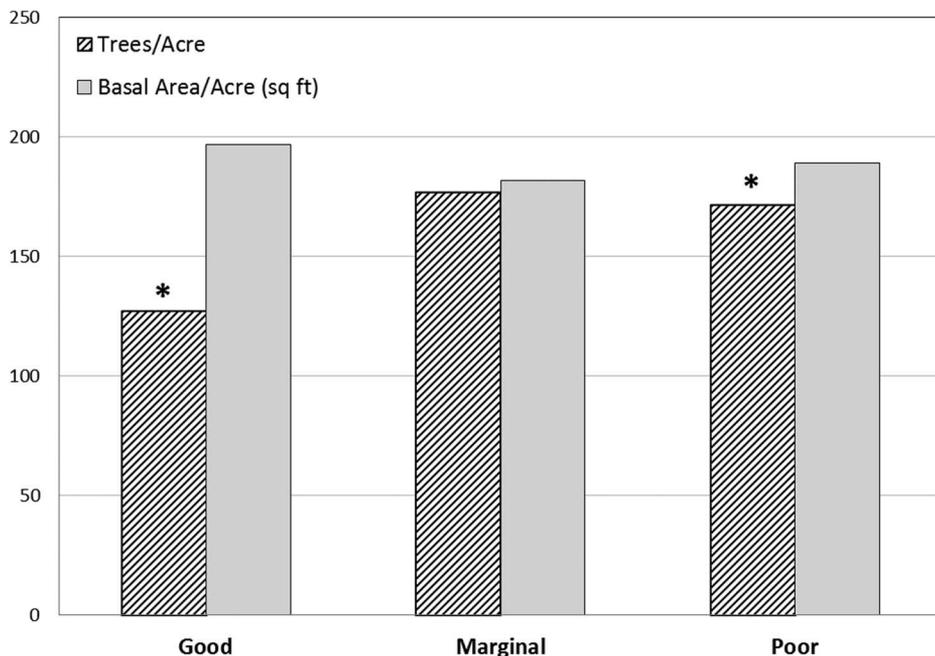


Figure 5. Average BA and TPA on sites (California, Oregon, and Washington) classified by tribal weavers as good, marginal, or poor for harvesting beargrass for basketry. *Significant difference ($\alpha = 0.05$) between good and poor sites.

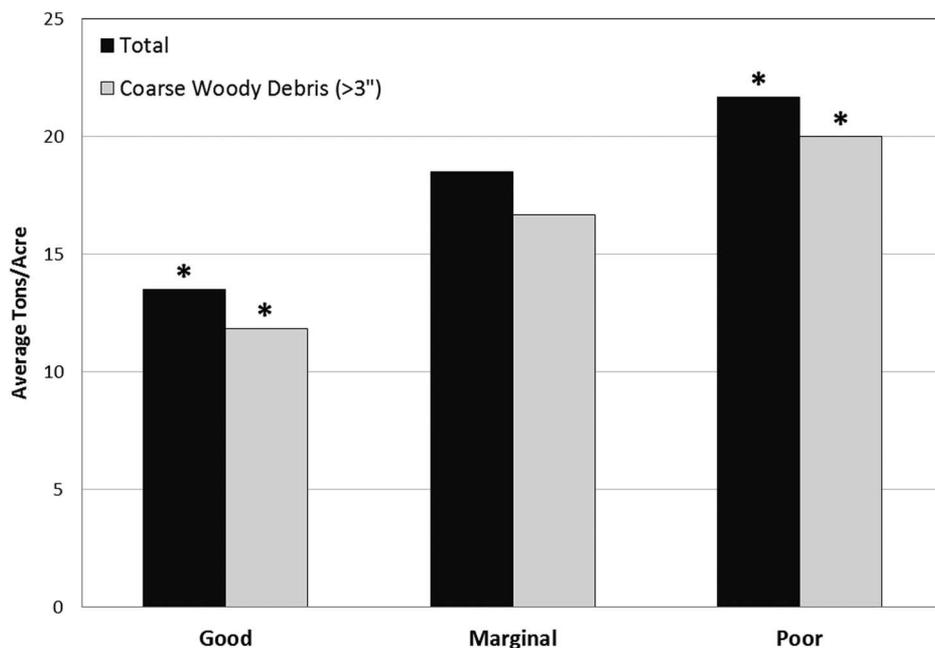


Figure 6. Dead surface wood (tons/acre) on sites (California, Oregon, and Washington) classified by tribal weavers as good, marginal, or poor for harvesting beargrass for basketry. *Significant difference ($\alpha = 0.05$) between good and poor sites.

tions of trees and down wood and fire behavior and severity (e.g., Hummel and Agee 2003). In particular, fire modifies forest structure along a gradient, thinning smaller to larger trees and thin- to thicker-barked species as intensity increases. This finding implies that managing beargrass sites for fewer, larger trees and lower levels of down

wood in all size classes could moderate future fire severity and contribute to good conditions for tribal harvesting of leaves for weaving.

We used the example of beargrass, but other culturally important plants lend themselves to a similar approach. Our study demonstrates a crosswalk between ecological

Table 3. Classification rates from discriminant analysis of good, marginal, and poor sites (California, Oregon, and Washington) for harvesting beargrass for basketry.

	Good	Marginal	Poor	Total
Good	10 (83.3%)	1 (8.3%)	1 (8.3%)	12
Marginal	2 (16.7%)	8 (66.7%)	2 (16.7%)	12
Poor	2 (16.7%)	2 (16.7%)	8 (66.7%)	12
Total	14	11	11	36
Error rate	0.17	0.33	0.33	0.28

knowledge derived empirically via scientific methods and via TEK because clear differences between good and poor harvesting sites were identified by both. This result implies that general guidelines can be developed to aid in managing specific sites for culturally important plants as required by federal law. The blended approach we developed and applied demonstrates that SEK can be advanced by combining qualitative and quantitative methods and that TEK can be generalized using scientific methods. This involves paying attention to the units and methods of measure for different variables of interest used by tribal practitioners and how they are similar to or different from what is understood, described, and used by scientists or land managers.

The importance of beargrass leaf color for both tribal and commercial harvesters has been reported elsewhere (Hummel et al. 2012). Evidence suggests that overstory conditions are related to leaf color, with a dense canopy casting more shade and thus creating conditions for darker leaf pigmentation (Schlosser and Blatner 1997). To our knowledge, this study is the first to investigate leaf color by using a standardized system and, in so doing, document its consistency across several forest types and tribal weaving techniques. In this respect, our results are informative beyond identifying the leaf color desired for weaving: they can be related to the levels of CWD, BA, and TPA on sites considered good for harvesting beargrass. The implication is that some optimal range of BA/TPA exists that is suitable for beargrass to develop leaves of the desired color for weaving. Although our results provide information about conditions in this range, we cannot yet identify the entire range itself, which would require data from more years, sites, and tribal weavers.

Despite a consistency in color preference across all sites and weavers, we were

unable to identify any combination of variables that explained statistically significant mean differences among good, marginal, and poor sites as classified by the weavers. Although it was possible to correctly identify class membership more than 66% of the time for our sample, it was not possible to predict it. The main reasons for this outcome probably relate to the size, timing, and scale of our sample. It is possible, but less likely, that we excluded important variables, given our blended approach and the member checking that we undertook with tribal participants. We consider each of these aspects in turn in the following paragraphs.

Size of Sample

Our original intent was to have a larger number of expert weavers from more tribes and thus the ability to sample more sites and plots within each harvest suitability class. We found it difficult to enroll participants, however, due to negative views of or experience with the USDA Forest Service, concerns about disclosing proprietary cultural resource information, and agency restrictions on travel. Our final set of participants may not have represented all relevant groups within the population of tribal weavers. Given the variability we encountered, the final sample size limited our ability to use DA to identify significant differences among classes or to create predictive models. We were, however, able to identify statistically significant differences in TPA and CWD between good and poor sites because we included SEK methods with TEK. The study, therefore, demonstrates how to advance communication and knowledge among different ways of describing the forest structural conditions desired for different management objectives. Any future research like this that blends qualitative and quantitative methods to study culturally important plants will benefit by ensuring that the sample of tribal participants covers all relevant social variables and that the number of sites and plots sampled covers the expected variation in key sites and plant attributes.

Timing of Sample

Our sampling occurred during just one summer, which meant that plant growth and leaf properties did not cover the entire amplitude of available conditions. For example, although it has been documented that leaf properties associated with burned sites are desirable for weaving, we did not explicitly address the role of fire history in

our analysis of site condition. We observed that weavers' identification of a good site changed more than did that of a poor site, based on what was available in our sampling year. The weavers wanted to see all the potential sites before deciding which belonged in which class. Among the weavers from northwestern California there was a marked preference to harvest beargrass from sites burned within the past 2 years, whereas this was less of a factor for tribal weavers farther north. Areas or sites considered "good" or "marginal" one year could be better or worse in other years, depending on intervening fire, management, or other factors such as drought and summer temperature that affect the population of beargrass.

Scale of Sample

In the process of conducting the study, it became apparent that tribal gatherers used two scales of assessing the site before actual harvesting. The first condition was physical, meaning ease of access to the forest site where beargrass grew. The second was the condition or quality of beargrass at the site. Our attempt to cross-walk SEK sampling methods with TEK logic and practices involved uniting different assessment techniques. Sometimes in field conversations with study participants, TEK information was obtained that SEK sampling alone would not have revealed. For example, weavers coming from geographically distinct basketry traditions (e.g., from Northwestern California twined to Columbia Plateau coiled) (Table 1) expressed different preferences for the leaf size (e.g., leaf blade base width) and for which leaves (e.g., internal compared to external) were harvested and used from the whorls. In addition, we observed that leaves with higher moisture content were valued by weavers during harvesting as determined by the "squeaky" sound accompanying extraction. Although not quantified in this study, moisture content can influence color.

It was also true that our SEK approach provided a new way for the weavers to think about how they assessed a site. Sometimes it was evident that they went to sites because they were shown those sites by someone else and so had never thought about what made it good other than that recommendation and/or they had never tried to deconstruct what they observed at a site; they just knew it was good enough (or not). The importance of down wood in different size classes was a factor not explicitly considered yet clearly influential, particularly with respect to how

much time was spent harvesting compared with how much usable material was obtained. Some of the classification error might relate to differences in microsites between sampled plots and the site in which the beargrass was located.

In addition to the aforementioned sampling issues, there are ongoing social and environmental issues related to the growth and harvest of cultural resources that provide context for this and any subsequent field studies that blend SEK and TEK. The best research on specific, culturally important plants will be a product of cooperation between scientists and tribal practitioners. In this study we learned that compensating the participants for their time and travel required different types of agreements or contracts. For example, suitable cultural plants are not always located on tribal lands so there is a need for tribal members to access and harvest botanical resources elsewhere. Going somewhere to harvest is not strictly an issue of rights and access, however, but is also negotiated through complex interpersonal and intertribal relationships. For example, if personnel on a national forest conduct a project to improve or enhance basketry materials, many tribal weavers will still seek "permission" or make "payment" to the recognized tribal elder or senior basket weaver on whose traditional territory the project has taken place. Further, weavers may be of mixed tribal and ethnic ancestry, with enrollment affiliation with one tribe but cultural and family ties with other tribal areas. Respect and reciprocity to follow traditional customs may or may not be compatible with modern forest management and jurisdiction. One direct impact is that weavers may have to travel from their home or reservation to their ancestral lands or to an area where access and suitable basketry plant materials occur. This means that those living at greater distance from their ancestral territory will incur greater expenses and need to take more time to participate in forest management planning, consultations, coordination, and collaboration and to harvest valued plant resources. In addition to these and other social issues, a key environmental issue is the presence of other culturally important plants at the same site. Importantly, TEK is rarely single species focused but is biophysically and metaphysically related. Even though beargrass was our target species for research and harvesting, tribal participants often evaluated, harvested, or tended to other plants in the vicinity. The totality of

the gathering experience includes the desired plants and the surrounding landscape, which underscores the appropriateness of using multivariate methods. Evidence from this study supports our premise that the best information for sustaining culturally important plants will come from studies that link scientific and traditional ecological knowledge. Scientists working with tribal practitioners and land managers working to increase access to suitable plant materials need to be mindful of factors that perpetuate traditional practices, including those involved in harvesting.

Endnote

1. US Code (USC), Title 25, Chapter 32A, Section 3056: Prohibition on disclosure.

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