CORRELATION BETWEEN HABITAT CHARACTERISTICS AND NATIVE PERENNIAL GRASS SPECIES: IMPLICATIONS FOR RESTORATION

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ABSTRACT

This study took place in spring 1999, in Tehama County, California at The Nature Conservancy's Dye Creek Ranch, a 37,540 acre working cattle ranch. The vegetation at the site is predominately Blue Oak woodland with an understory of annual grassland. Relict stands of native perennial grasses can be found throughout the Ranch. The study surveyed a portion of the Ranch (8,000 acres) to determine a correlation between habitat characteristics and relict native stands. The purpose was to locate suitable sites for restoration of native grass species. Data were gathered for *Nassella pulchra* and *Nassella cernua* (and pooled as *Nassella*, Needlegrass), *Elymus glaucus* (Blue wild rye), *Melica californica* (Melic grass), and *Muhlenbergia rigens* (Deer grass). Results of the analysis determined that each species has specific habitat requirements. *Nassella* is the genus most general in its habitat requirements. It was found in two soil phases, four topographic positions, in full sun and partial shade, and with tough competitors such as *Avena* spp. (wild oats) and *Centaurea solstitialis* (yellow star thistle). The presence of *Elymus glaucus* is highly correlated with creek bottoms (78%) and full shade (67%). *Melica californica* is highly correlated with one soil phase (85%), seasonal creek banks (60%) and partial shade (56%). It held opposing positions in the community with *Nassella*, indicating it is not a competitor but it does have similar habitat requirements

(i.e. *Melica*'s requirement for partial shade opposes *Nassella*'s requirement for full sun while all other habitat characteristics may be the same). *Muhlenbergia rigens* was found in mesic, alluvial sites with 0 to 3% slope (62%) and in full sun (69%).

INTRODUCTION

Currently less than 5% of California's original native grassland ecosystem remains intact (Barbour & Billings, 1988). Restoration of native grassland has a number of ecological and economical advantages. Native perennial grasses can increase soil-water infiltration by providing larger diameter root channels to deeper subsoil (Stromberg & Kephart, 1996). With proper management, perennial grasses can effectively displace even the most obnoxious annual weeds, such as *Centaurea solstitialis*, yellow star thistle (YST) (Bugg et al., 1991). Replacing exotic annuals with native perennial grasses results in a longer grazing season (Menke, 1992). Additional benefits include reduced flammability of vegetation, increased stability in surface and sub-soils, the ability to hold and recycle nutrients more efficiently and an increase in soil organic matter, fertility and productivity (Stromberg & Kephart, 1996). Wildlife habitat also increases with a properly functioning native grassland because of greater plant diversity (Strait, 1999). Additionally, the Ranch cattle would have higher quality feed (Wrysinski et al., 1997) which, added to the longer grazing season, will allow for more management options.

Field testing of different seeding methods at the Ranch has produced a successful method of seeding *Nassella pulchra* (Needlegrass), which is commonly thought to have been the dominant native perennial grass of the area. Previous studies in restoration of native grasses in California have emphasized fields that have been disturbed by plowing

(Stromberg & Kephart, 1996). No previously published studies have addressed the question of where seeding perennial grasses should take place in wildland situations to achieve successful stand establishment. The objective of this study is to determine a correlation between habitat characteristics and the presence of relict stands of native perennial grass species.

STUDY AREA

The study was conducted at the Gray Davis Dye Creek Preserve (the Ranch) in Tehama County, California. The Ranch is located approximately 33 miles north of Chico, California near Los Molinos (SW corner, Section 13, T26N, R2W, Los Molinos, California, 7.5' quadrangle map). The Ranch is a 37,540 acre working cattle ranch and hunting preserve. The land is managed by both the Denny Land and Cattle Company and The Nature Conservancy (TNC) and currently supports 2,600 head of cattle.

The Ranch is located on an ecological subregion of California known as the Tuscan Flows Subsection (USDA, 1997). Vegetation of the area is predominantly Blue Oak woodland and annual grassland with occasional vernal pools at 300 ft elevation and scattered chaparral shrubs at about 500 ft elevation. Hot, dry summers and mild winters characterize the subsection. The mean annual precipitation ranges from 20 to 40 inches (51-102 cm), and is practically all rain. Mean annual temperature ranges from 56° to 64° F (13°-18° C). The mean freeze-free period is 250 to 300 days. Elevation of the study area ranges from 300 to 500 feet (91-152 m). The topography gradually increases in elevation to 2,350 ft (716 m). A steep rise from the alluvial plains to about 1,000 ft (305 m) elevation reveals uplands dissected by many gullies, seasonal creeks, and washes forming a striking array of southwest and northeast oriented canyons. These fantastic topographic features were formed by pyroclastic mudflows of late Pliocene origin known as the Tuscan Formation.

The soils in the study area consist of three associations with eight phases represented (USDA, 1967). The Tuscan-Inks association includes the Tuscan, Inks, and Keefer soil phases. The association is characterized by nearly level to steep, cobbly soils that are shallow to moderately deep to hardpan. The soil was formed in stratified deposits of alluvium derived from volcanic rocks of andesite, basalt and rhyolite. The Toomes-Guenoc association includes the Toomes soil phase. This association is characterized by shallow or moderately deep, rocky, gently sloping to steep soils underlain by volcanic rock. The underlying rock in the Toomes-Guenoc association is predominantly andesite with inclusions of basalt. The Columbia-Vina association includes the Berendos soil phase. The association is characterized by very deep, nearly level, moderately fine textured to moderately coarse textured soils on flood plains of the Sacramento River. The soil formed in alluvium derived from sedimentary, volcanic, and granitic rocks. Two other soil phases within the study area are Riverwash and Millrace, which are soils of high gravel and cobblestone content. They have been cut by stream channels or are part of active or intermittent stream channels.

The agricultural history of the study area is long and varied (Stechman, 1996). The area was part of a land grant received by Job Dye in 1845. Cattle were grazed on the land from 1845 to 1868. From 1868 to 1884, new owner Joseph Cone grazed sheep and dryland farmed wheat on the acreage. In 1906, Cone switched to raising cattle. Ownership changed hands many times until in 1940, Stover and Conrad bought the property and it was given the name Dye Creek Ranch. Recent historical records show that for 35 years 2,350 cattle per year have been grazing the Ranch property. Presently cattle are grazed in the study area in the month of November and the month of May. This year 1720 acres in the study area were not grazed at all due to a prescribed burn scheduled for June.

METHODS

During the spring and early summer, 1999, a survey was taken on 8,000 acres of the Ranch to determine the areas that contained remnant populations of native perennial grasses. Before each pasture was surveyed, a review of the Tehama County Soil Survey was done to determine what soils were in the pasture and where changes in soil phase occurred. Once in the field and a relict stand was found, a photograph was taken of the stand including the site in which it was found. All data regarding site characteristics were noted in a field journal. Data were recorded on the following characteristics: species, soil phase (taken from Tehama County Soil Survey), topography, elevation, amount of shade (full sun, partial shade, full shade, canyon shadow), percent slope, aspect, associated species, number of plants, and size of stand. Species found on the preserve in numbers large enough for which data analysis was possible are *Nassella cernua* and *Nassella pulchra* (Needlegrass), *Melica californica* (Melic grass), *Muhlenbergia rigens* (Deer grass) and *Elymus glaucus* (Blue Wild Rye). There were not enough sightings of two other species (*Poa secunda* and *Aristida hamulosa*) to perform data analysis. Data for *Nassella cernua* and *Nassella pulchra* were pooled as *Nassella*.

Indirect gradient analysis, or vegetation ordination, is the technique commonly employed to order vegetation data (Kent & Coker, 1992). This technique is employed independently of environmental data. Once the vegetation data have been described and summarized the environmental data are compared and summarized. Thus the environmental interpretation is indirect. The three environmental variables compared and summarized in this analysis were elevation, shade, and slope. The results of the indirect gradient analysis were used to run a principal component analysis to calculate a correlation matrix between all species and variables. The correlation matrix was collapsed into two major trends or components. Pearson correlations were calculated between each of the three environmental variables and the two principal components. Proportional distributions were constructed for each native grass species across levels of each of the three classificatory variables (nominal or, without numerical value or rank) (soil phase, topographic position, and associated species) and the ordinal variable (shade). A plot was prepared of each species' aspect distribution and the median for the species' distribution was calculated (Holmes, 1999).

RESULTS

Figure 1 shows the results of the principal component analysis. This is a biplot of the data on the first two principal components, each component being a weighted combination of variables.

Results of the species ordination analysis were not especially strong as the first two components only account for 63% of the total variation in the data. *Elymus* and *Nassella* are separated by the first component and *Muhlenbergia* and *Melica* are separated by the second component. This suggests that species distributions are dissimilar for each of these two pairs (Holmes, 1999).

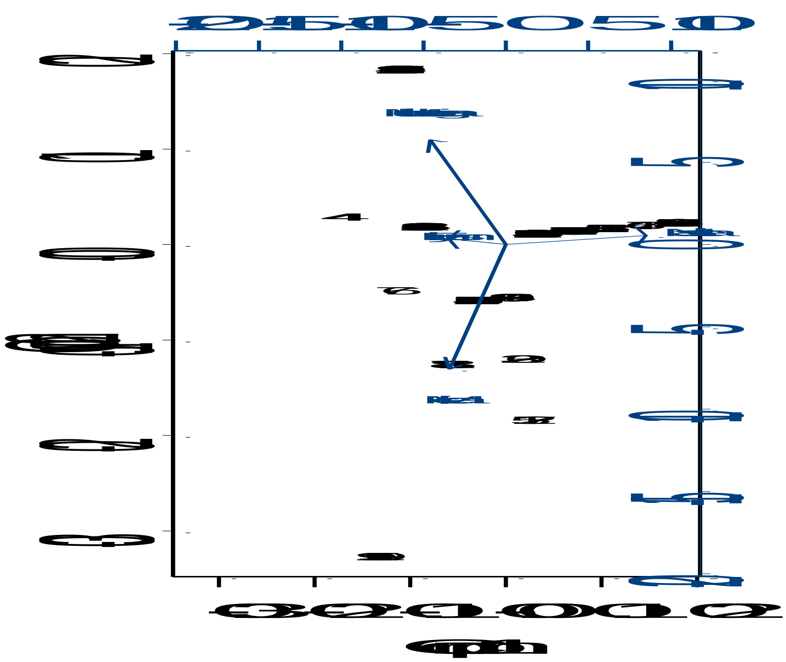

Figure 1. Biplot from principal component analysis of Dye Creek data. Species are represented by arrow, numbers represent observations (Holmes, 1999).

Table 1 provides Pearson correlations between each environmental variable and each principal component. None of these correlations is large, although it does appear that a weak negative correlation exists between slope and the second principal component that separates *Muhlenbergia* and *Melica*. *Melica* occurred on steeper slopes than *Muhlenbergia*.

Table 1. Pearson correlations between each environmental variable and each principal component (Holmes, 1999).

	Elevation	Shade	Slope
1st Component	-0.19	0.21	-0.07
2nd Component	-0.15	0.19	-0.41

Figure 2 provides aspect distribution of relict sites by species. *Nassella* and *Melica* occur on all aspects, while *Elymus* and *Muhlenbergia* are sites with southwest aspects. Median aspects are 236° for *Nassella*, 195° for *Melica*, 210° for *Elymus*, and 210° for *Muhlenbergia*. Thus, the centers of their aspect distributions all tend to face southwest.

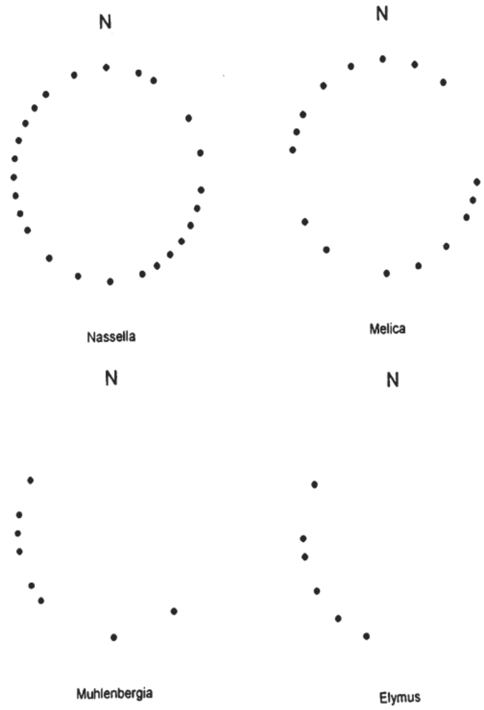

Figure 2. Aspect distribution of relict sites for each species. North is indicated by an "N". Dots indicate the location of one or more relict sites (Holmes, 1999).

Table 2 shows the species distribution for each of the three classificatory variables, plus shade. Marked deviations from the median distribution are highlighted. Review of the results of the analysis shows that all species preferred the Toomes very rocky loam, 10 to 30% slope soil phase (TgD) except for *Muhlenbergia*, which prefers Keefers complex, channeled, 0 to 3 & slope soil phase (Kn). Of the four species, all had distinct preference for topographic position except *Nassella*, which is equally distributed on four topographic positions. *Nassella* and *Muhlenbergia* prefer full sun whereas *Melica* prefers partial oak shade and *Elymus* prefers full shade. *Nassella* is commonly found with wild oats & YST. *Melica* is most frequently found with short annuals, *Elymus* with no associated species, and *Muhlenbergia* is associated with *Cynodon dactylon* (Bermuda grass) and *Lolium multiflorum* (annual rye grass).

Table 2. Species distribution on the three classificatory variables, plus shade. Numbers indicate the percent that each species was found with a particular variable. Marked deviations from the median distribution are highlighted (Holmes, 1999).
Soil phases are: TgD, Toomes very rocky loam, 10 to 30% slope; IcD, Inks cobbly loam, 3 to 30% slope; TxC, Tuscan very stony loam, 3 to 15% slope; Mr, Millrace complex, channeled, 0 to 3% slope; Bg, Berrendos clay loam, 0 to 3% slope; Rr, Riverwash; Kn, Keefers complex, channeled, 0 to 3% slope; and TuB, Tuscan cobbly loam, 1 to 5% slope.
Associated species: 1&3, Short Annuals in addition to Oats & YST.

	Soil Phase										
	TgD	**IcD**	**TxC**	**Mr**	**Bg**	**Rr**	**Kn**	**TuB**			
Nassella	0.70	0.20	0.02	0.01	0.02	0.00	0.01	0.02			
Melica	0.85	0.10	0.00	0.05	0.00	0.00	0.00	0.00			
Elymus	0.78	0.11	0.00	0.11	0.00	0.00	0.00	0.00			
Muhlenbergia	**0.31**	0.00	0.00	0.08	0.00	0.08	**0.54**	0.00			
Median	**0.74**	**0.11**	**0.00**	**0.06**	**0.00**	**0.00**	**0.01**	**0.00**			
	Topographic Position										
	SeasCrkBank	Roadside	CrkBot	RockOut	Draw	Seep	RiparBank	RockLawn	Alluvium	OakSavan	
Nassella	0.28	0.02	0.01	0.21	0.06	0.01	0.00	0.20	0.21	0.01	
Melica	**0.60**	0.00	0.07	0.19	0.02	0.00	0.02	0.02	0.07	0.00	
Elymus	0.00	0.00	**0.78**	0.00	0.00	0.00	0.11	0.00	0.11	0.00	
Muhlenbergia	0.00	0.00	0.23	0.00	0.00	0.00	0.15	0.00	**0.62**	0.00	
Median	**0.14**	**0.00**	**0.15**	**0.10**	**0.01**	**0.00**	**0.07**	**0.01**	**0.16**	**0.00**	
	Shade										
	Oak-Full	Oak-Part	Full Sun	CanyonShadow							
Nassella	0.08	0.36	0.58	0.00							
Melica	0.08	**0.56**	0.36	0.00							
Elymus	**0.67**	0.33	0.00	0.00							
Muhlenbergia	0.08	0.08	0.69	0.15							
Median	**0.08**	**0.35**	**0.46**	**0.00**							
	Associated Species										
	Shrt Ann	BrushAnn	OatsYST	None	Buckwheat	1 & 3	SedgeRush	Clover	Medusa	Bermuda	Lolium
Nassella	0.25	0.00	0.33	0.02	0.05	0.14	0.00	0.05	0.14	0.00	0.03
Melica	**0.45**	0.02	0.25	0.02	0.05	0.16	0.00	0.05	0.00	0.00	0.00
Elymus	0.00	0.00	0.00	**0.67**	0.00	0.11	0.00	0.00	0.00	**0.22**	0.00
Muhlenbergia	0.00	0.00	0.26	0.15	0.00	0.04	0.04	0.00	0.00	**0.26**	**0.26**
Median	**0.12**	**0.00**	**0.26**	**0.09**	**0.02**	**0.12**	**0.00**	**0.02**	**0.00**	**0.11**	**0.02**

DISCUSSION

The data analysis of the four most commonly found relict populations of native perennial grasses in the surveyed area of the Ranch shows *Nassella* to be a generalist. It grows in two soil phases (TgD, IcD), four topographic positions (seasonal creek bank, rock outcrop, rocky lawn, and alluvium), in full sun and partial sun, in deeper soils with other deep rooted, tall species such as wild oats & YST, or in shallower soils with a combination of non-native short statured annuals (Table 2). This conclusion is supported by the principal component analysis (Figure 1). A review of Figure 1 shows that the analysis of the first principal component (which accounts for the most variance and describes the dominant pattern among the species) is weighted positively by *Nassella* and negatively by the other species. This indicates that the distribution of *Nassella* across sites contrasts with the distribution of the other species. Figure 2 shows that Nassella can be found over a wide range of aspects, but the median aspect is 236°, facing southwest.

Nassella prefers Toomes very rocky loam, 10 to 30% slope (TgD)(70%); and Inks cobbly loam, 3 to 30% slope (IcD)(20%). Both soils are well drained with low available water holding capacity and low fertility. Permeability is moderate and runoff is slow to medium. The difference between the soils is mainly soil depth. The Toomes is 8-15 inches deep while the Inks is 10-24 inches deep. *Nassella* prefers full sun (58%) but will tolerate partial shade (36%).

Melica is almost exclusively found on the Toomes very rocky loam, 10 to 30% slope (TgD) (85%). It prefers seasonal creek banks (60%), but may be found as often as *Nassella* on rock outcrops (19%). It prefers partial shade (56%), but tolerates full sun

(36%), the opposite of *Nassella*. *Melica* is most commonly associated with short non-native annuals (45%), but tolerates the presence of wild oats & YST (25%).

The second principal component (Figure 1) shows that *Melica* and *Muhlenbergia* have different distributions in terms of slope. The Pearson correlation (Table 1) provides correlation between each environmental variable and each principal component. The negative correlation between slope and the second principal component suggests that sites that have lower slopes contained more *Muhlenbergia*, conversely, *Melica* occurs on steeper slopes. This information concurs with *Melica*'s 60% preference for seasonal creek banks. The median aspect for *Melica* was 195°, tending towards the southwest.

Data analysis indicates that *Melica* has similar habitat requirements to *Nassella*. Both are highly correlated with the Toomes very rocky loam, 10 to 30% slope, (*Nassella*, 70%, *Melica*, 85%). Both are correlated with seasonal creek banks (*Nassella*, 28%, *Melica*, 60%) and rocky outcrops (*Nassella*, 21%, *Melica* 19%). Preference for sunlight is the opposite, with *Nassella* preferring full sun and tolerating partial shade (58% and 36%) while Melica prefers partial shade and tolerates full sun (56% and 36%). They are both associated with the same non-native annuals and forbs. *Nassella* is found with short annuals (25%), wild oats & YST (33%), a combination of the two (14%), and with Medusa head (14%) while *Melica* is found with short annuals (45%), wild oats % YST (25%), and a combination of the two (16%). *Melica* was not found with Medusa head.

Elymus glaucus is highly correlated with the Toomes very rocky loam, 10 to 30% slope (TgD) (78%), creek bottoms (78%), full shade (67%) to partial shade (33%). It occurs primarily without associates (67%), or with Bermuda grass (22**%**). Elymus prefers a southwest facing aspect, the median being 210°.

Muhlenbergia is correlated with Keefers complex, channeled, 0 to 3% slope (Kn) (54%) and Toomes very rocky loam, 10 to 30% slope (TgD) (31%). *Muhlenbergia* is found on alluvium deposited in the channels (62%) and creek bottoms (23%). It is highly correlated with full sun (69%) but also occurs in canyon shadow (15%). *Muhlenbergia* occurs with wild oats & YST (26%), Bermuda grass (26%), and *Lolium multiflorum* (26%) reflecting a more mesic habitat. The median aspect for *Muhlenbergia* is 210°.

Data analyses indicate that *Nassella* is correlated with more habitat variables than the three other species. The ability to grow in various habitats coupled with the development of a successful seeding method and high nutritive value (Wrysinski et al., 1997) makes this an appropriate native perennial grass for restoration.

No seeding method has been developed for *Melica californica*. Since this species parallels many of *Nassella*'s habitat requirements, *Melica* may be a species of consideration for restoration work in the future. It is known to be nutritious and highly palatable (Wrysinski et al., 1997; Stebbins, 1999).

Developing a seeding method for the highly specialized sites that *Elymus glaucus* prefers in the studied portion of the Ranch may be of consideration as well. Nutritive value for *Elymus glaucus* has been tested with positive results and its value to wild life is documented (Wrysinski et al., 1997; Strait, 1999).

Muhlenbergia rigens is important to wild life and for stabilizing creek banks but grazers do not utilize it. Therefore it would not be an economically important species for restoration.

This study examined the correlation between habitat characteristics and the distribution of native perennial grasses. Any possibility that relict stands may be environmentally distinct from the rest of the landscape was not addressed by this study. Furthermore, this study reflects data taken from only a portion of the Ranch. When additional acreage is surveyed information regarding species/habitat correlations should be further refined.

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