Interface Between Ecology and Land Development in California
Edited by J.E. Keeley. 1993. Southern California Academy of Sciences, Los Angeles.

Native Grassland Restoration: The Initial Stage — Assessing Suitable Sites

Jon E. Keeley

Department of Biology, Occidental College, Los Angeles, CA 90041
Tel. (213) 259-2898; Fax (213) 341-4974

Abstract. Many annual grasslands present today in California persist on sites formerly dominated by coastal sage and chaparral and were never part of the original pristine prairie. Attempts to "restore" such sites to the native perennial grassland would be a mistake, since such sites are likely to be unsuitable for long-term persistence of native grasses. Establishing native grasses on such sites would represent "type conversion" rather than "community restoration." A comparison of grassland sites in southeastern Ventura County, California, presently dominated by native perennials, with sites lacking native perennial grasses, leads to the following generalizations. Relict stands of native perennial bunchgrass persist on sites with deep soils (50-100 cm), with high clay content and no rocks, mostly on north- and east-facing exposures. They are largely restricted to a few soil types. Grasslands devoid of native perennial grasses occur most often on rocky, shallow soils (10-30 cm), with little or no clay content, largely on south- and west-facing exposures. These annual-dominated grasslands occur on the same soil types where remnants of coastal sage and chaparral persist. It appears that many annual-dominated grasslands in this quadrangle were formerly coastal sage scrub vegetation that has been removed by repeated burning.

Keywords: Annual grassland; bunchgrass; disturbance; Valley Needlegrass Grassland.

Introduction

The Valley Needlegrass Grassland Community once dominated large portions of the California landscape, yet today it is ranked by the California Department of Fish and Game as having the highest ranking of rarity for plant communities in the state. This community is recognized by significant coverage with purple needlegrass (*Stipa pulchra*) often associated with other native perennial bunchgrasses such as the very similar *S. cernua*, and with *Poa scabrella* and *Koeleria cristata*, as well as forbs, both perennials and annuals.

Although much of the native grassland vegetation has been destroyed by agriculture and other development, a vast amount of it has been converted to annual grassland (Keeley 1990). Today, most of the grasslands in California are dominated by non-native annual species of European origin. These include grasses such as species of *Avena*, *Bromus*, *Hordeum*, and *Lolium* and forbs such as species of *Erodium*, *Brassica*, and *Centaurea*.

The precise distribution and composition of California native grasslands, prior to the invasion of exotic annual grasses, is still a matter of some debate. However, one thing is clear: not all annual grasslands present today are degraded native prairie. Due to the vigorous colonizing ability of the weedy annuals, it is certain that many annual grasslands occupy sites formerly dominated by coastal sage and chaparral (Cooper 1922; Hobbs 1983; Freudenberger et al. 1987; Keeley 1990) and were never part of the original pristine prairie.

This latter point is of fundamental importance in planning restoration programs designed to restore native grasslands. There is a mistaken notion in some land managers' minds that any annual grassland is a suitable site for restoration with native grasses. However, if that site represents a degraded coastal sage community, now dominated by annual grassland, it would be a mistake to attempt restoration on such a site. There are two reasons for this. The site factors are likely to be unsuitable for long-term persistence of native grasses and establishing native grasslands on such sites represents "type conversion" not "restoration."

Here I report on a study that compares site characteristics of grasslands that have significant stands of the perennial purple needlegrass with grassland sites in the same region that lack any native grass cover and are dominated solely by weedy annual grasses. Those sites with purple needlegrass are interpreted as remnants of the original Valley Needlegrass Grassland. I hypothesize that grassland sites lacking purple needlegrass were formerly either native grasslands or shrublands. It is predicted that if these sites were formerly native grasslands,

then the site characteristics should be statistically similar to those of sites with relic stands of native grasses. Alternatively, if these sites were formerly shrublands, then they should be significantly different from sites with relic stands of native grasses and be more similar to sites now dominated by shrublands.

Grasslands of the Calabasas Quadrangle, Southern California

The Calabasas Quadrangle, in southeastern Ventura County, is dominated by a mosaic of vegetation types, including non-native annual grassland, native bunchgrass grassland, oak savanna, coastal sage scrub, and chaparral (Freudenberger et al. 1987). This quadrangle has nearly 1000 hectares (2471 acres) of grassland distributed in a mosaic with other vegetation types (Freudenberger 1980 and unpublished data).

An intensive study of grasslands in the southeastern quarter of the quadrangle has demonstrated the presence of relatively extensive tracts of native Valley Needlegrass Grassland (Keeley 1991). This portion of the quadrangle has over 800 ha of grassland, largely dominated by non-native annual grasses, although *Stipa pulchra* is present on over 270 ha (Fig. 1) of which 175 ha had ≥ 10% cover (Keeley 1991). The California Department of Fish and Game considers native grasslands with this level of cover "significant" and worthy of conservation (Keeler-Wolf personal communication 1992).

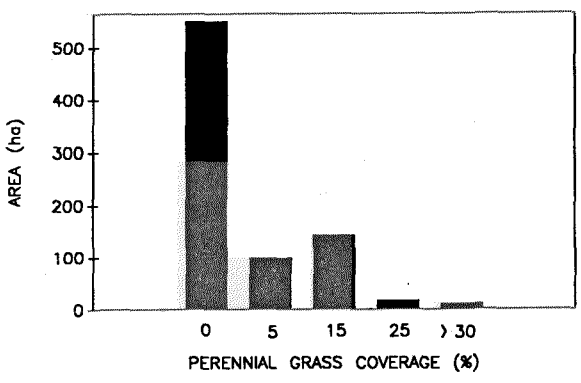

Figure 1. Perennial grass coverage on grasslands in the Calabasas Quadrangle, Ventura Co., CA. Sampling was done by dividing grasslands into 108 "landscape units" (based on natural topographic features and homogeneity of vegetation) and counting the density of different-size perennial bunchgrasses in plots of 50 m² (N = 6 to 157, depending upon size of the landscape unit and homogeneity of vegetation). (See Keeley 1991).

Table 1. Distribution by slope aspect of 36 randomly selected grassland sites (landscape units) dominated by native perennial grasses (≥ 10% cover) and annual-dominated sites that lack perennial grasses. There is a highly significant slope aspect difference ($P < 0.001$) between perennials and annuals.

Site	Slope aspect	
	North and East	South and West
Perennial grasses	17	2
Annual grasses	4	13

Site characteristics associated with native and non-native grasslands

In an earlier study (Keeley 1991) the grasslands in the southeastern quarter of the quadrangle were subdivided into approximately 100 landscape units and the percentage of native grass cover was determined.

Subsequent studies on these same sites have shown that landscape units with more than 10% cover by *Stipa pulchra* tended to be most commonly distributed on the more mesic north and east slope aspects whereas sites (landscape units) largely lacking this native grass, and dominated almost entirely by non-native annuals, were significantly more common on the more arid south- and west-facing exposures (Table 1).

Soil characteristics are often key factors in the distribution of different vegetation types. Evidence, however, suggests that these annual grasslands and perennial grasslands are quite similar in inorganic soil constituents. A subsample of soil from 40 sites (landscape units), half with significant native grass cover (perennial sites) and half lacking any native grasses (annual sites), revealed that soil nutrients N, K, and P, were not significantly different between annual and perennial sites (Table 2). Organic matter was likewise not significantly different,

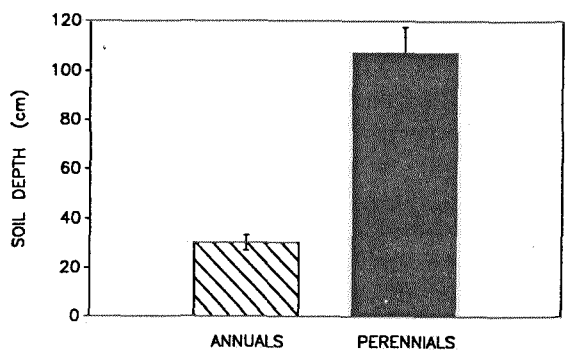

Figure 2. Soil depth for randomly selected points within landscape units that had significant native grass coverage (≥ 10%) and sites dominated by annual grasses (and lacking perennial grasses) in the Calabasas Quadrangle ($N = 20$, + 1 *S.E.*).

Table 2. Soil nutrient characteristics for a subsample of 20 sites (landscape units) dominated by native perennial grasses (≥ 10% cover) and 20 annual-dominated sites (which lacked perennial grasses). Soil analyses by the Soil Laboratory, University of Alaska, Fairbanks, AL.

	Soil Nutrients (ppm)				
	Nitrogen	Potassium	Phosphorus	Organic Matter (%)	pH
	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$	$\bar{X} \pm S.D.$
Perennial	13 ± 3	185 ± 69	87 ± 47	2.6 ± 1.1	6.3 ± 0.3
Annual	23 ± 13	318 ± 223	124 ± 71	2.3 ± 0.8	6.9 ± 0.6
P	< 0.10	< 0.20	< 0.40	< 0.50	< 0.05

although soil pH on annual sites tended to be more basic than on perennial sites (Table 2).

Soil depth was a significant factor in the distribution of native grasses. The native bunch grasses were best represented on the deeper soils (Fig. 2), and across the entire area there was a highly significant relationship between perennial grass cover (nearly all *Stipa pulchra*) and soil depth (Fig. 3).

Two other soil characteristics were important. The percentage of clay in the soil was significantly greater ($P < 0.01$) on sites dominated by perennials (Fig. 4), and percentage of rock was significantly greater ($P < 0.01$) on sites lacking perennials and dominated entirely by annuals (Fig. 5). The correlation between percentage of rock and perennial grass cover was significant ($r = 0.41$, $P < 0.01$, $N = 40$) but there was a tremendous range of cover values at the lowest rock levels. This is illustrated by examining the residual of the regression at the different percentages of rock in the soil (Fig. 6). Nearly all of the deviation from the regression of perennial cover vs. rock is for sites with no rock. I interpret this to mean that sites with rocky substrates are not suitable for perennial grasses and are uniform in their lack of them. Substrates lacking a significant rock component are suitable sites for perennial grasses. The wide deviation in perennial grass cover for these non-rocky sites (Fig. 6) reflects the fact that on many such sites significant native grass cover has persisted, but on many other such suitable sites, native perennial grasses have been eliminated by other factors such as disturbance.

A feature of this region is that it is a mosaic of different soil types (Fig. 7). All sites were categorized with respect to soil type (Table 3) and it is clear that sites with significant perennial grass cover are almost exclusively on one of three soil types: Diablo, Santa Lucia, or

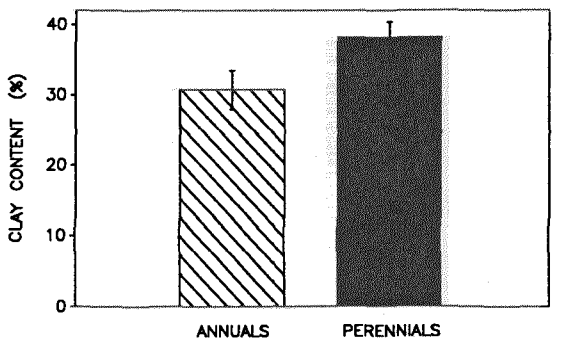

Figure 4. Percentage of clay in soils of landscape units with significant native grass coverage (≥10%) and sites dominated by annual grasses (and lacking perennial grasses) in the Calabasas Quadrangle ($N = 20, + 1\ S.E.$) (methods according to Cox 1985).

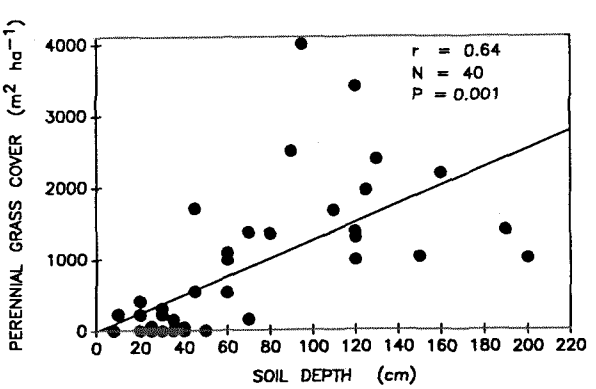

Figure 3. Regression of perennial grass cover and soil depth for 40 landscape units in the Calabasas Quadrangle.

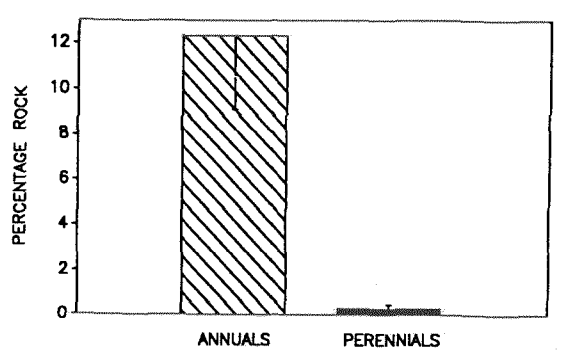

Figure 5. Percentage of rock in soils of landscape units with significant native grass coverage (≥10%) and sites dominated by annual grasses and lacking perennial grasses in the Calabasas Quadrangle ($N + 20, + 1\ S.E.$) (methods according to Cox 1985).

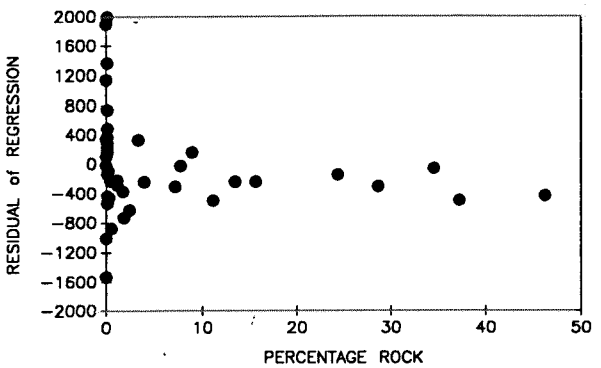

Figure 6. Distribution of regression residuals for regression of percentage of rock and perennial cover in the Calabasas Quadrangle.

Table 3. Number of hectares with 0%, 1-9%, and >10% perennial grass cover on each grassland soil type in Calabasas Quadrangle (see Fig. 7). (Soil type was determined for each of the landscape units from USDA maps and area was quantified by computer program Sigma-Scan).

Type	Area by Perennial Grass Cover Class (Ha)		
	0%	1-9%	≥ 10%
Major soil types:			
Diablo	2	35	25
Santa Lucia	50	155	123
San Andreas	3	42	11
Zamora	11	47	0
Calleguas	110	0	0
Linne	24	0	0
Millsholm	112	46	0
Minor Soil Types:			
Salinas	0	14	0
San Benito	0	2	6
Gaviota	0	1	0
Castaic-Balcom	0	0	8
Total hectares:	312	342	173

Figure 7. Soil map for southeastern corner of Calabasas Quadrangle (from USDA Soil Survey, Ventura Co.). Db = Diablo; Se = Santa Lucia; Sb = San Andreas; Zm = Zamora; Ca = Calleguas; Le = Linne; Mh = Millsholm.

Table 4. Soil characteristics of main grassland soil types in the Calabasas Quadrangle (see Fig. 7).

Soil Type	Texture	pH	Sites (*N*)
		X ± *S.D.*	
Soils supporting significant perennial grass cover:			
Diablo	Dark clay	6.7 ± 0.4	10
Santa Lucia	Shaly, clay loam	6.2 ± 0.3	18
Zamora	Dark clay loam	6.1 ± 0.1	2
Soils supporting annual grass cover (lacking perennial grasses):			
Calleguas	Calcareous shaly loams	7.5 ± 0.1	6
Linne	Silty clay loams	7.6	1
Millsholm	Loam	6.3 ± 0.2	3

San Andreas. Certain soil types are noteworthy in the lack of any native perennial grass cover; e.g., Calleguas and Linne. Characteristics of these soil types are shown in Table 4. In general, native perennials are best developed on slightly acidic soils with a significant clay content whereas annual dominated sites, devoid of native perennials, are more basic soils that are calcareous or silty loams. These latter soil types are typical of sites dominated by coastal sage scrub and chaparral and these shrub communities were seldom found on clay substrates.

Conclusions

A fundamental problem of ecology is to correlate patterns and processes (Watt 1947). Processes accounting for the distributional pattern of non-native annual grasslands and native perennial grasslands in the Calabasas Quadrangle include soil type, aspect, and disturbance regime. The data presented above are consistent with the hypothesis that the total extent of grasslands today is likely much greater than under pristine conditions. Sites with significant native perennial grass cover are likely relicts of the original prairie. Sites dominated almost entirely by non-native annuals have two origins. Some represent degraded native grassland; these sites have soil characteristics indistinguishable from perennial grass sites. In a restoration program these would be the sites selected for native grassland restoration. Other annual grasslands represent degraded coastal sage or chaparral.These sites have soil characteristics quite dissimilar to perennial grass sites and more similar to sites now dominated by shrublands. Restoration programs should avoid such sites for establishing native grassland.

Literature Cited

Cooper, W.S. 1922. The broad-sclerophyll vegetation of California. Carnegie Institution of Washington Publication No. 319. 124 p.

Cox, G.W. 1985. Laboratory manual of general ecology. Wm.C. Brown Publishers, Dubuque, IO. 248 p.

Freudenberger, D.O. 1980.Grassland distribution dynamics of the Los Angeles Basin. Honors thesis, Occidental College, Los Angeles, CA. 62 p.

Freudenberger, D.O., B.E. Fish, and J.E. Keeley. 1987. Distribution and stability of grasslands in the Los Angeles Basin. Bulletin of the Southern California Academy of Sciences 86:13-26.

Hobbs, E.R. 1983. Factors controlling the form and location of the boundary between coastal sage scrub and grassland in southern California. Ph.D. dissertation, University of California, Los Angeles, CA. 307 p.

Keeley, J.E. 1990. The California valley grassland Pp.1-23 *in* A.A. Schoenherr, ed. Endangered plant communities of southern California. Special Publication No. 3, Southern California Botanists, Claremont, CA.

Keeley, J.E. 1991. Final report: native grassland assessment on Ahmanson Ranch. Report on file with the Ventura County Planning Department, Ventura, CA.

Watt, A.S. 1947. Pattern and process in the plant community. Journal of Ecology 35:1-22.