Characterizing the Habitat of Slender-horned Spineflower (*Dodecahema leptoceras*)

Ecological Analysis*

Edith B. Allen
Department of Botany and Plant Sciences
University of California
Riverside, CA 92521-0124
tel. (909) 787-2123

Research participants: Nancy Ferguson, Sheila Kee, Lucia Vasquez

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SUMMARY

The slender-horned spineflower (*Dodecahema leptoceras*) is a federally-listed endangered species threatened by extinction due to rapid development in southern California. It is an annual plant that grows in alluvial fan sage scrub between 390 and 730 m in the Peninsular and Transverse Ranges. We undertook an ecological analysis to characterize the habitat of spineflower in eight of the nine known locations. The typical soil for spineflower is a silt soil with pH of 6.4, low salinity and electrical conductivity (E.C. of 164 mS). It has only 0.04 % total nitrogen, only 4 ppm available phosphorus, less than 1% organic matter, and a low cation exchange capacity. Furthermore, the variance of these edaphic values was small. However, the plant co-occurs with a variety of other alluvial fan plant species across the eight sites, so that sites look substantially different in their dominant vegetation, including sites with juniper, cottonwood, or no trees, and sites with 75% ground cover of cryptogamic crust, or virtually no crusts. None of the native species associated with spineflower was found at all eight sites, so no indicator species can be identified to detect spineflower habitat. Up to 11% cover of exotic grasses was found in plots occupied with spineflower. Thus while we have characterized the habitat based on edaphic factors, the associated plant species are variable.

We compared plots that were occupied and unoccupied by spineflower. Unoccupied adjacent plots that appeared visually suitable typically had edaphic factors and species composition that were not statistically different from occupied plots. Absence of spineflower from these adjacent plots may be due to lack of dispersal, or to some unmeasured edaphic or biotic factor. Distant, visually suitable plots were higher in N, P, CEC, and organic matter and are therefore likely unsuitable. Restoration of spineflower should occur in adjacent suitable plots or known historic localities, but the success of restoration cannot be guaranteed with these unknown factors. Restoration can therefore be used as an experimental technique to understand the realized niche of spineflower. Other factors such as soil microorganisms, herbivory, and seed dispersal have not been studied for this species, and would be useful information to understand the ecology and restoration of this species. A geomorphic assessment is submitted under separate cover.

INTRODUCTION

The slender-horned spineflower (*Dodecahema leptoceras*) is a federal and state-listed endangered species found only in Southern California. It is threatened by extinction due to rapid development in this region. The slender-horned spineflower occurs in alluvial fan sediments between 390 m and 730 m (Table 1), in drainage systems of the Peninsular (San Bernardino and San Jacinto) and Transverse (San Gabriel) Ranges of California. It grows in regions that range from 36-44 cm annual precipitation, and about 18°C mean annual temperature. It is a small-statured annual plant with remaining populations that are spatially disjunct from one another (Fig. 1). Our objectives were to characterize the habitat of this species to better understand why it selects these particular locations. Species select habitat based both on the physical characteristics of the environment and the associated biota. The constraints of the physical environment are considered the fundamental niche of the species, while the associated species that compete with or consume the organism in question define the realized niche (Malanson et al. 1992). Our efforts here were designed to define the physical setting, including soils and geomorphology, and to measure the associated plant species to begin to define the realized niche of this species. This information can be used to manage the species where it occurs currently, and to restore it to its former locations.

In theory, the fundamental niche is relatively simple to measure because it requires measurements of the physical environment, but it excludes the biotic interactions. The realized niche depends on complex interactions of biota and dispersal capabilities, and can be measured by examining the habitat the species occupies (Westman 1991). The inability to disperse to an area will also reduce the size of the realized niche. Inability to disperse can potentially be tested by transplanting the species to a suitable area. If the organism survives there, then dispersal, and not the environment, is the limiting factor. This could potentially be studied by restoring the plant to an area, and has been done for the rare species *Amsinckia grandiflora* in California (Pavlik 1993) and *Erigeron kachinensis* on the Colorado Plateau (Allphin and Harper 1994). Both of these species were successfully transplanted to former habitats or habitats that were predicted by measuring the environment. Demographic studies that measure yearly variation in plant populations also may shed light on the habitat requirements of organisms, and are the subject of a study by Nancy Ferguson and Dr. Richard Whitkus. Our objective here was to determine the realized niche of spineflower.

Another reason we did the vegetation assessment is to understand the species composition of plant communities that contain spineflower. We hypothesized that spineflower might be associated with one or more "indicator" species that, within some degree of statistical accuracy, would indicate that spineflower may be, or may once have been, present. The notion of indicator species has become popular in conservation studies (Kremen 1992, Weaver 1995). Spineflower occurs in alluvial fan scrub, and so may well be associated with certain other plant species. However, alluvial fan scrub has been broken down into several subassociations (Sawyer and Keeler-Wolfe 1995), and the habitat of spineflower is widely distributed from Bee Canyon Creek to Arroyo Seco (Fig. 1). Where potential indicator species are present but spineflower is absent, spineflower may once have been present and can be restored to the location.

We did both a geomorphic and an ecological habitat assessment. The ecological assessment is reported here, and the geomorphic assessment by Dr. Stephen Wells and Yvonne Wood is under separate cover. The ecological assessment included characterization of soil chemical and physical factors, and measurements of the surrounding plant community. The geomorphic assessment was done to understand the flood regimes and resultant terrace and bench morphologies of these drainage systems. Spineflower grows at various distances from stream channels in the drainages, but the ages of the terraces were previously unknown. This information is critical because it is likely that spineflower selects habitat of certain successional ages. Where damming or other alteration of river systems has occurred, new terrace deposits will no longer occur. Information about the terrace ages, edaphic factors, and plant community characteristics should enable better management of spineflower, both by conservation of existing habitat and potentially by future restoration in suitable, but currently unoccupied, sites.

METHODS

Vegetation Analyses. Eight sites were surveyed for the slender-horned spineflower study. These included two sites on the Santa Ana River, Orange Street and Cone Camp, and sites at Tujunga Wash, Lytle Creek, San Jacinto River, Dripping Springs (Arroyo Seco), Bee Canyon and Bautista Creek (Fig. 1). A ninth site, Temescal Canyon, was not evaluated because we could not obtain access. All sites were selected with the assistance and advice of the California Department of Fish and Game. Surveys were conducted between April 14 and May 19, 1995.

The vegetation survey was accomplished using two sampling techniques, plots and point-intercept transects. The approximate boundaries of occupied patches within each site were located using maps provided by CDFG. These patches were used as reference points for both survey techniques.

At each site, percent cover was assessed in four different categories of plots for a total of 25 plots. (1) Ten plots were occupied spineflower sites , (2) five plots were suitable unoccupied sites (i.e. sites that appeared visually similar to occupied sites but did not contain spineflower) that were adjacent (within 10 meters) to occupied sites, (3) five plots were located in grassy sites that were adjacent (within 10 meters) to occupied sites, but appeared otherwise suitable, and (4) five were suitable unoccupied sites that were distant from the occupied sites (approximately 100 meters). These plots were subjectively located according to plot category requirements, and following discussions with Mary Meyer of CDFG. The replicate plots were randomly placed at each location.

Percent cover of all vegetation was measured on each of the 25 plots, using a small (25 cm x 50 cm = 0.125 m^2) plot frame. To fulfill the "occupied" status, the plots were required to contain a minimum of 5 individual spineflower plants each. This requirement was easily met except at the Tujunga Wash site where it was necessary to drop to four plants per plot in order to meet the need for 10 occupied plots. The total number of spineflower were counted for each plot in addition to percent cover. All plant species that fell within the plot frame were listed and included within the percent cover estimate. In addition, % cover of bare ground, litter, and cryptogamic crust were noted.

Vegetation was also sampled using the point-intercept transect method, the Field Sampling Protocol developed by the California Native Plant Society (Appendix 1). A 50 meter transect was located within the area of occupied spineflower populations and another was located on a distant unoccupied site. Both transects were located in the same sites as the occupied and unoccupied distant plots described above. Vegetation measurements were taken at 0.5 meter intervals along the 50 meter transect. At each 0.5 meter interval, all vegetation and ground cover that intercepted the transect was recorded as a "hit" by layer -- ground, herb, shrub or tree. Also, all additional species found within 2.5 meters on either side of the tape were recorded separately and listed by layer.

All plant species not readily identified in the field were collected and pressed. They were later keyed out by Lucia Vazquez, technical assistant in Dr. Allen's laboratory, and confirmed by Andrew Sanders, curator of the UCR herbarium.

Raw vegetation data (and soils data, below) were entered onto Excel spreadsheets for analysis. The raw data were sent to Mary Meyer, CDFG, in September 1995.

Vegetation data were statistically analyzed using univariate and multivariate statistics. Analysis of variance was used to compare among plant species groups that occurred in the different plot categories, and to compare among soil factors. The least significant difference ($L.S.D._{0.05}$) was used as a *post hoc* test to determine which categories were significantly different (Steele and Torrie 1968). $L.S.D._{0.05}$ bars are shown in graphs, and $L.S.D._{0.05}$ values are listed in tables as appropriate. t-tests were used to compare species abundances along the transects in locations occupied or unoccupied by spineflower. Two types of multivariate analyses were used, detrended correspondence analysis and discriminant function analysis. More detailed information about the uses of the statistical tests is described for each specific analysis in the results section.

Soil sampling and chemical analyses. Three (3) soil cores of 2 cm dia x 10 cm deep each were taken from each of the 25 plots at each site. These were sieved and sent to the University of California, Division of Agriculture and Natural Resources Analytical Laboratory in Davis for the following analyses: total Kjeldahl nitrogen, bicarbonate extractable phosphorus, organic matter by combustion, and cation exchange capacity (C.E.C.). Analysis of pH, electrical conductivity (E.C.), and texture were done in Dr. Allen's laboratory. The former two were done using a soil paste and measured with a pH/EC meter, and texture was done by sieving followed by the Buoyucos hydrometer method. All soil analyses were done using standard procedures (Carter 1993). The samples analyzed in the Allen lab were combined by category, so four combined samples corresponding to the four plot categories were analyzed at each site. This was done because pH, EC and texture are less likely to vary across small plots in a small sample area, and because textural analyses are quite costly. Soil chemistry was analyzed by the Division of Agriculture and Natural Resources Analytical Laboratory of the University of California. We prepared individual samples from each plot, so there were a total of 25 samples per site. The samples analyzed by the Allen lab represent a mean of the plot categories, and were statistically compared among the eight sites. For the analyses sent to the DANR Lab, both within site and between site variances could be calculated.

RESULTS

Vegetation--Plot Data. The density of spineflower varied considerably in the occupied plots at each site, from a mean value of about 100 per m^2 to about 500 per m^2 at the eight sites, while percent cover varied from 3.5 to 12.5% (Fig. 2). Bee Canyon had the highest density and cover of spineflower, while Tujunga Wash had the lowest density and second lowest % cover. The L.S.D. bars in Fig. 2 show the significant differences among mean values, where the mean is significant at $P = 0.05$ if the difference between two means exceeds the value of the bar. The measured plots had the highest densities and cover of spineflower that could be found, because at each site the occupied plots were chosen to represent patches of spineflower with high density. At some sites, no more than ten 0.125 m^2 plots could be located with our minimum density definition for occupied plots. At all sites the locations of spineflower were restricted to a few isolated areas that were 10-20 m^2, and patches of spineflower were discontinuous within these areas. The data in Fig. 2 only represent local density and cover of spineflower, and do not reflect the extent of spineflower patches throughout each of the eight sample sites. For instance, Lytle Creek has a very small aerial extent of spineflower (Mary Meyer, personal communication), but has a very high density of spineflower where it does occur.

The percent cover of the different species varied with site and plot category. Species were grouped by life form and native/exotic origin for the univariate analyses (Appendix 2 and 3). The native forbs had up to 58% cover at the Bee Canyon suitable, unoccupied adjacent plots, and as low as 1 percent at several sites (Fig. 3). Typically the plot category with lowest native forb cover was the unoccupied grassy adjacent, but at Dripping Springs the suitable distant plots had the lowest native forb cover (although not significantly so). The occupied plots had either the highest or second highest percent cover of native forbs at each site, and some of this was due to the presence of spineflower, but also due to other native forbs. In each graph of Fig. 3 the L.S.D. bar shows which categories are significantly different from the others. For instance, at Bautista Creek, there are no significant differences, while at Cone Camp the suitable distant plots have significantly higher native forb cover than the other three categories. In addition, the occupied and the suitable adjacent plots have higher forb cover than the unoccupied grassy adjacent plots.

Native grasses were not abundant at any of the eight sites, and were dominated by *Vulpia octoflora* (Fig. 4, Appendix 2). No perennial grasses were observed. The highest native grass cover occurred at Tujunga Wash with about 11% cover on the suitable distant sites, but some categories at some sites had no native grasses. Occupied sites had relatively high, moderate, low, or no native grasses, so there seems to be no relationship of native grasses with spineflower.

Exotic forbs, which were dominated by *Erodium cicutarium*, occurred at all of the sites, but were especially low at the Orange St. site and relatively low at nearby Cone Camp (Fig. 5). Exotic forbs occurred in occupied plots at all of the sites, but had the lowest, highest, or intermediate cover on the occupied compared to the other plots. Therefore, there is no relationship of spineflower with exotic forbs. However, Lytle Creek had the highest exotic forb cover, and is the site that CDFG considers in the poorest condition with the overall smallest remaining population of spineflower.

As expected, exotic grasses had highest cover on the unoccupied grassy plots, as these plots were specifically chosen for grass cover (Fig. 6). Exotic grasses occurred in all plot categories, including up to 11% in occupied plots with spineflower.

Ground cover of cryptogamic crusts was also assessed in each of the sites (Fig. 7). These varied from virtually no presence of crusts in Tujunga Wash to 90% at Orange St. Again, occupied plots range from 70% to no cover of cryptogamic crusts, so there appears to be no relationship of spineflower with the crusts. There appears to be an inverse relationship between cover of crusts and exotic grasses just from examining Figs. 5 and 6, but a regression of exotic grasses vs. cryptogamic crusts only had a r^2 value of 0.032, and $P = 0.11$. The low r^2 can be explained by the high variability, which was caused by the large number of plots that had no crust formation at all, even at sites like Cone Camp and Orange Street where crust cover was high in general. The plots with no crust at these sites did not have high grass cover, and in addition many individual plots with high crust cover also had high grass cover. The apparent inverse relationship that one can view from the means in Figs. 5 and 6 does not hold statistically.

The data from Figs. 2-6 are summarized in Table 2, which shows the means of the four plot types averaged across the eight sites. Overall, the exotic grasses are most abundant in the unoccupied, grassy adjacent plots, not surprisingly so since these plots were chosen for high grass cover. The exotic forbs were also significantly higher in the grassy plots, while the native forbs were significantly lower in the grassy plots.

Cryptogamic crust was lowest in the grassy plots. Exotic grasses likely invaded patches where cryptogamic crusts were absent or destroyed. Exotic grasses invaded in the past 100-200 years, whereas cryptogamic crusts take centuries to form. In other words, it is not likely that the opposite invasion took place, cryptogamic crusts invading into stands of exotic grasses.

Vegetation--Transect Data. The plots were chosen to measure only herbaceous vegetation that occurred between the shrubs and trees at each site. The transects were run to include the larger-statured species, and to obtain a random sample of vegetation across the sites. A list of shrub and tree species from the transects is presented in Appendix 4a and 4b, and species groups in Appendix 5. The transects were placed over occupied and distant unoccupied plots, and all species were counted within a 50 m X 5 m area (a belt transect). The sites with highest species richness was Dripping Springs with 53 in the occupied, 32 in the unoccupied belt transect (Table 3). The high number of species was largely due to the high number of native forbs, up to 35 at Dripping Springs. Six of the sites had higher richness of species in occupied than unoccupied transects, although two of these (San Jacinto and Tujunga) had only one more species in the occupied transect (accounting for the presence of spineflower). One of the sites had equal richness (Cone Camp), and one had lower richness (Orange St.) in the occupied than unoccupied transects. The latter two were the two sites on the Santa Ana River. The two sites with the largest increase in species in occupied transects (Dripping Springs and Bautista) were also the narrowest washes where a distant site that looked visually similar was difficult to locate. Thus there is no strong evidence that occupied transects have more plant species. The lack of difference in richness between occupied and unoccupied transects is perhaps not surprising, after considering the 50 m length of the transect compared to the size of spineflower patches, 5 - 20 m. Thus the occupied transects also sampled large unoccupied areas.

The point cover values of the transects were statistically analyzed using a t-test to compare occupied with unoccupied transects (Table 4). These showed no significant differences in percent cover of any of the species groups, e.g., native grasses, shrubs, etc. The exotic grasses had $P = 0.09$, which, if a less rigorous significance level is accepted, would imply higher exotic grass cover in occupied transects (62.5%) than unoccupied transects (43.4%). Table 4 shows mean values, but the separate values for each site are shown in Appendix 4. What is not apparent from this analysis, but can readily be seen in Appendix 4, is that the shrub and tree layer consisted of different species at most of the sites. Bautista Creek had cottonwood trees, the two Santa Ana Wash sites and Bee Canyon had California juniper, and Drippings Springs had coast live oak. The other sites had no trees in the vicinity of the spineflower populations, but had varying shrub species. For instance, five sites had *Lepidospartum squamatum*, and only three sites had *Bebbia juncea* (Appendix 4a and 4b). As above for the small plot analyses where there is no evidence of association of any herbaceous species group with spineflower, it also appears that spineflower does not associate with any shrub or tree species of alluvial fan scrub in particular.

Soil Analyses. The measured soil factors were remarkably similar among the eight sites, but the suitable unoccupied distant plot category typically had higher values of N, P, CEC and organic matter (Table 5). Even in those sites where there was not a significant difference of a particular soil factor, such as Cone Camp, that factor most often had the highest mean value in the suitable unoccupied distant plots. An overall analysis of all the sites showed that all four of these factors were higher in the unoccupied suitable distant plots (bottom of Table 5). The results suggest that, while the unoccupied suitable distant plots looked similar visually, they were in fact different in several important soil factors, and were perhaps actually unsuitable for spineflower for this reason. The only other factor that stood out among the plot categories was significantly higher organic matter in some of the grassy sites. The higher organic matter in some of the grassy sites may be a result of grass invasion, as the grass plots had high cover and higher plant production than plots dominated by native forbs.

Comparing among sites, the concentration of nitrogen was lowest at the Bautista site with values of 0.016%, and highest at Dripping Springs with 0.055% in the occupied plots (Table 5). However, both of these values are extremely low, and Dripping Springs does not by any means have a high level of soil N. For instance, coastal sage scrub soils in the area tend to have 0.20% total N (Nelson and Allen 1993, Marquez and Allen 1995). The Bee Canyon site was also unusual in that it had the highest cation exchange capacity (Table 5).

The textural analyses revealed the eight sites were also remarkably similar in soil texture, all being silt or silt loams (using a standard soil texture triangle) with a mean 85% silt, 3% clay, and 12% sand (Tables 6 and 7). Bee Canyon had higher clay content than the other sites, which may be the cause of higher cation exchange capacity and higher electrical conductivity. Bee Canyon also had higher pH. The mean overall pH was slightly acidic at about 6.5, and E.C. was low (a moderately saline E.C. value would be 2000 mS (milliSiemen), and these all had values of about 300 mS or lower). There were no significant differences among pH, E.C., or texture for any of the plot categories (Table 6). No statistical analyses were done in Table 6 because the values shown are all from composited soil samples as explained in the methods. However, statistical comparisons could be made among sites, and there were no significant differences between plot types among the sites (Table 6).

Multivariate Statistical Analyses. The multivariate analyses were used to show other relationships that the univariate analyses of variance could not show, and to relate plant and soil factors. An unanswered question about spineflower concerns the cause of its patchy distribution in a landscape mosaic, containing many patches that appear identical to visual inspection. If spineflower distribution was limited by association with other species due to competition in a resource-poor environment, we hypothesized that certain species would be good indicators for finding spineflower, or of potential spineflower habitat.

First we performed an ordination to determine the relative differences among the four plot categories and among the eight sites as determined by their species percent cover values. The ordination arranged the plot categories in relation to several coordinate axes, such that their relative positions to the axes and to each other gives information about their ecological similarity (See Figs. 9a-9f). Each axis corresponds to an eigenvalue calculated from the species matrix. The matrix in this case was created by the percent cover values of species in each plot category at each of the eight sites. We performed a detrended correspondence analysis (DCA) because this overcomes the distortion of the axes inherent in other ordination techniques (Gaugh 1982, Ludwig and Reynolds 1988).

Species percent cover data from the eight sites were analyzed using the DECORANA statistical software (Hill 1979). The DCA was done for 31 plant species located in 200 plots (25 plots/site). Though 144 species were identified over all sites, only those species occurring at mean abundance > 1 % on the sites were included in the analysis, leaving a total of 31 species. Species occurring with < 1% cover were judged too rare to be significant indicators of habitat type or environmental parameters, and would unduly influence the analysis if included. In addition, most of the rare species occurred in only one or two sites, leaving many 0 values in the data set. Deleting inabundant species at some set value is the typical procedure when many rare species are present.

Even after deleting rare species, a logarithmic transformation was needed to correct for the skewed distribution of the 31 species percent cover data. There were still many small values for inabundant species, and a few large values for abundant species. A (ln (y+1)) transformation was used on each of the remaining 31 species.

In addition to the transformation, inabundant species were 'downweighted' to minimize the influence of species occurring in only a few sites. DCA is sensitive to species occurring in a few sites, and these inabundant species, though maybe of high frequency, were considered reflective of between-site heterogeneity and not necessarily indicative of microsite differences that might distinguish between plots occupied and unoccupied by spineflower.

The DCA ordination was performed on log-transformed species data with downweighting of rare species. This produced three axes with higher eigenvalues than an ordination run on non-transformed data without downweighting. Large eigenvalues are more likely to differentiate among the objects in DCA (in this study, the eight sites, four plot categories, and species) than small eigenvalues. The results of the species DCA with transformations and downweighting are shown in Figs. 8 and 9. The respective eigenvalues of the first three eigenvectors are 0.6578, 0.5449, and 0.4016, respectively (Appendix 6). These values reflect the dispersion of species scores on the corresponding axis and are a measure of the relative importance of the axis. Values greater than 0.5 indicate good separation of species along axes. Certain species occurred at the extremes of all axes indicating that they occupy the environmental extremes within sites (Fig. 8). The exotic grasses *Bromus tectorum, Bromus rubens, Vulpia myuros, Avena barbatus* and *Bromus diandrus* were at one end of the axes, while *Schismus barbatus* and the native *Calyptridium monandrum* were at the other end of axes 1 and 2 (Fig. 8). The exotic grasses were present at all of the sites, but abundant only in the grassy plots. *Schismus* was present mainly at the more inland sites. *Yucca whipplei* is also at an extreme on all axes but most likely because it is rare within spineflower microsites (though abundant in some washes). This indicates that species associations do not reveal underlying environmental gradients influencing the distribution of spineflower. The species DCA also suggests there were no indicator species that co-occurred consistently with spineflower. To interpret Fig. 8, it should be overlayed on Fig. 9. The occupied spineflower plots did not cluster together (Fig. 9), and no species clusters are apparent in Fig. 8. This analysis only included the herbaceous species from the plot analyses, and did not include the woody species that were encountered in the line transects. However, the shrubs and trees also did not characteristically co-occur with spineflower, with different shrub or tree species at different sites (Appendix 4a, 4b).

Plot category distributions plotted on axes showed no discernible pattern (Fig. 9a and 9b). Sample plots from the eight sites as well as the four plot categories were intermixed and dispersed without any discernible aggregation across all three axes (comparing axis 1 with axis 2, and axis 1 with axis 3). Because there are 200 points (from 200 plots) in each of Figs. 9a and 9b, we divided the figures by sites (Figs. 9c-9f). These show that the occupied plots (labelled 1) are always intermixed with the three categories of unoccupied plots (labelled 2, 3, 4). The DCA did not differentiate the plot categories within each site based on species differences among the plot categories. In other words, the plot categories all had a similar species composition, and there were no indicator species that specifically occurred only in spineflower plots.

There was also a large degree of overlap among the sites (Figs. 9b-9f). [Two sites were graphed together per graph in Figs. 9b-9f. There is no particular order to the choice of which sites were graphed together]. However, some sites can be differentiated from other sites by examining these figures. For instance in Fig. 9c most Bee Canyon plots appear largely on the right side of the graph, and Bautista Creek plots appear on the left. The univariate analyses have already established that there was not species overlap among all the sites. The DCA analyses reflect the differences among dominant species at the different sites. None of the sites stands out as a discrete scatter of points because many sites do have some species in common.

A stepwise discriminant function analysis (DFA) was performed to relate the nine edaphic factors to the four plot categories. DFA is used when *a priori* groups have been identified, and the edaphic factors were used to determine whether these groups were "correctly" identified. In this case, the groups were the four plot categories, and the edaphic factors could be used to determine whether there were differences among the plot categories based on differences in soils.

A stepwise DFA was performed using BMDP (1993) software for the nine edaphic variables as follows: percent sand, silt, clay, nitrogen, organic matter, phosphorus pH, EC and CEC. Samples for each *a priori* selected category were pooled resulting in 31 samples over the eight geographic locations. The grassy unoccupied adjacent category was excluded for the Bautista Creek site due to missing data (otherwise, there would be 4 categories X 9 factors = 32).

Percent organic matter was the sole discriminating factor ($p=0.0102$) with the remaining eight measured variables providing no basis for separation of categories. Based upon the percent organic matter in the soil, the overall correct classification of the four groups was a modest 32.2%. After bias correction (jackknife), percent correct classification was reduced to 29.0%. Occupied and suitable unoccupied distant categories showed 50% and 62.5% correct classification after the jackknife correction, while suitable unoccupied adjacent and grassy categories showed no correct classification either before or after the bias correction.

These results indicate that few significant differences exist among the *a priori* category plot means for measured edaphic variables. Even organic matter, which was the sole discriminating factor, was not significantly higher in the suitable unoccupied distant plots for all sites (Table 5). Since some sites had significant differences in edaphic factors among categories while others did not, they were not significant in a multivariate analysis. However, examination of the coefficients of variation (the ratio of the variance to the mean) suggests that while category means may not differ significantly, the variances might. We did an ANOVA of the variances [not the means, the variances] of the edaphic values of each of the plot categories. The F-value for differences between category variances in occupied and suitable unoccupied distant groups was significant for nitrogen and phosphorus. This suggests that spineflower has a smaller range of tolerance for the concentrations of nitrogen and phosphorus in soils. The mean is not as important as the range of values in determining where this plant can live, and it has a low range of tolerance within occupied sites.

DISCUSSION

Although spineflower appears to have very narrow edaphic requirements, it seems to have a broad array of associated plant species. The typical soil for spineflower would be silt soil rather than a silt loam with a slightly acidic pH of 6.4, and low electrical conductivity (E.C. of 164 mS). It would have 0.04 % total nitrogen, 4 ppm available phosphorus, less than 1% organic matter, and a fairly low cation exchange capacity (<10 meq/100g). Furthermore, the variance of these values was tight. Unlike many plant species which can be found in quite a range of environmental values around some mean value, all of the spineflower populations were in locations with values very similar to the mean values. The higher clay content at Bee Canyon is an exception, and this soil is classified as a silt loam. The other soil properties at Bee Canyon are quite similar, although it has and therefore has similar water holding properties and as well as other chemical properties.

Comparing these soils to others in the region, they are typical for alluvium in the high percentage of silt they contain (U.S.D.A. 1971). The non-alluvial soils of the region that support coastal sage scrub (CSS) vegetation are sandy loams, loamy sands, loams, and clay loams. We did not find sandy soils in any of our plots, as was reported for Tujunga Wash (Chadwick 1993, unpublished observation cited in Prigge et al. 1993). The silty alluvium is very low in N, P and organic matter compared to the loams of local CSS soils, which may have up to 0.2 % total N, 40 ppm bicarbonate extractable P, and 5% organic matter (Nelson and Allen 1993, Cannon et al. 1995, Marquez and Allen 1996, Schultz 1996). The loams compared to the silty soils of our plots have similar pH and low E.C., but the C.E.C. of loam soils is higher.

Of the four plot categories sampled, only the suitable, unoccupied distant plots had mean values of edaphic factors that were consistently significantly higher than the other plot categories in most of the eight sites. Although the distant plot locations appeared similar to the eye prior to any measurements and statistical analyses, they were in fact different in soil properties. In locating the distant plot we looked for sites that were on the same terrace and presumably were the same age, but may have actually sampled a different terrace of different age in some of the smaller drainages, such as Bautista Creek. The occupied plots and the adjacent unoccupied plots appeared to have similar microtopography, with scattered, river-rounded cobble-sized rocks that in some cases formed rings around silt-filled depressions containing spineflowers and/or other annual herbs. These depressions were 1-10 m in diameter. Several of the distant sites did not conform to this microtopography as well, as cobbles were often more frequent and had smaller silt-filled basins in between. A more detailed microtopographic analysis would be useful to determine the range of sizes of silt basins that spineflowers choose for habitat. In addition, we do not know the depth of the basins nor the depth of the rooting zone of spineflower. Soil samples were taken to only 10 cm depth, and additional root profiles were not dug because this is a protected species. Soil profiles were done at two of the sites as part of the geomorphic analyses (see report by Wells), but these could also not be done in occupied plots. However, it is likely that roots of this species are shallow since it is a slight-statured annual.

Although spineflower selects a very restricted edaphic habitat, it associates with a range of plant species. The detrended correspondence analysis showed no species was characteristically associated with spineflower. The univariate analyses and the belt transects showed no species was found associated with spineflower across all the sites (Appendix 4a, 4b). Different tree, shrub and herb species were present on the different sites. The fact that cryptogamic crusts dominate in some sites but are nearly absent from other sites may be related to the range of ages of the surfaces, as is detailed in the geomorphology report. This suggests spineflower is associated with particular soils that may themselves have a range of ages but in any case have the needed set of edaphic requirements for spineflower.

While the abiotic factors that define the fundamental niche of a species can readily be measured, understanding the factors that determine the realized niche are still problematic. The realized niche is determined in part by the edaphic factors and climate, and also by the associated species, demography and dispersal. One group of species that could limit the realized niche of spineflower are the exotic annual grasses. We assumed that there would be an inverse relationship between exotic annual grasses and spineflower, but there was no significant relationship. The grassy plots had exotic grass cover that varied from 40 to 80% (Fig. 6) but were unoccupied by spineflower. The occupied spineflower plots had low exotic grass cover, never higher than 11%. Some of the adjacent unoccupied plots had up to 30% exotic grass cover, but some of them had less than 10% grass cover. Thus to determine a threshold of grass cover for survival of spineflower, we would need to measure a continuum of plots from occupied to unoccupied areas that contain exotic grasses. Our plots were set up to maximize differences in categories, to determine whether there were different edaphic factors that might control the different plant assemblages with occupied, unoccupied, and grass stands. However, at this point it seems reasonable to conclude that spineflower can withstand some low level of exotic grass competition within the occupied plots.

Little is understood about spineflower reproduction or method of dispersal, but demographic studies are being carried out by Nancy Ferguson and Dr. Richard Whitkus, University of California, Riverside. Populations fluctuate yearly depending upon precipitation and temperature during. Some patches appear to be stable over several years, varying in their density with annual precipitation, while others virtually disappear in dry years (Nancy Ferguson, personal communication), and still others are relatively new such as colonists in tire tracks at the San Jacinto site (Mary Meyer, personal communication). Because spineflower has such a narrow range of edaphic requirements for establishment, dispersing seeds must randomly find specific locations with these characteristics to establish a viable population. Similarly, researchers looking for suitable sites for restoration would also have to find the silty soils that have these exact values of nutrients.

If restoration of spineflower is a goal for the future, then the first step would be to locate sites with the needed soil factors and with relatively low exotic grass cover. The unoccupied adjacent suitable and the occupied sites were so similar in their edaphic factors, that locating suitable adjacent sites for restoration purposes will entail some degree of risk. Absence of spineflower from unoccupied sites may be due to lack of dispersal, or it may be due to a difference in some unmeasured edaphic or biotic factor.

The lack of an indicator species to define spineflower habitat is disappointing, but not surprising. Species turnover is expected across any large gradient, in this case the range of spineflower across longitude, latitude, and elevational changes. The one native species that all of these sites have in common is spineflower. The scale of locating indicator species is very important (Kremen 1992). We believe examining co-occuring species within plots and belt transects is the aprropriate scale here, as these represent the microsites in which spineflower grows.

The optimal strategy is to find historic evidence of spineflower existence, and then relocate the plants there. In many cases the sites have been destroyed by development, especially gravel mining. Establishing a rare species into a site where it does not occur now, and where there is no historic evidence of occurrence, is a risky undertaking. Lack of a plant in a certain area may be due to one of two reasons, either the environment is unsuitable, or the plant has not dispersed to that area. In the case of microsites for spineflower, additional adjacent sites could likely be found that have appropriate soil conditions. If the Department of Fish and Game decides to use restoration as a management tool, we recommend initial small scale restoration experiments that transplant seeds to nearby microsites with known edaphic factors. Observations of the success of these transplants will increase our understanding of the realized niche of this plant. Such transplants of rare species have been done successfully in a few cases, and are heartening examples of what can be done if the habitat and prior locations of a plant are well studied (Pavlik 1993, Allphin and Harper 1994).

One other area of research that was not touched upon here is soil and root microbiology of spineflower. Spineflower is a member of the Polygonaceae family, of which many annual members do not form mycorrhizae. However, we did not examine the roots of spineflower, as we do not have a permit to destructively sample the plant. Many other annual colonizing species do not form mycorrhizae, and in fact they may be inhibited in their growth by large quantities of mycorrhizal inoculum in the soil. All of the exotic grasses do form mycorrhizae, and they may have high inoculum density in their rhizospheres. Thus competition from annual grasses may be compounded by the high inoculum density. Before restoration is attempted, we recommend an assessment of mycorrhizae of spineflower and of inoculum density in different microsites.

Conclusions

• The microhabitats of spineflower appear to be basins filled with silty soil and surrounded by rounded cobbles.

• Within these microhabitats, spineflower grows in a very restricted range of soil factors in riverbed alluvium that is high in silt and low in nutrients and organic matter.

• Spineflower is associated with a wide range of plant species of alluvial fan scrub, including different dominant species of trees, shrubs and herbs on the eight different sites. No consistent indicator species co-occur with spineflower.

• Spineflower co-occurs with exotic grass species, but where percent cover of exotic grasses is very high, few spineflower plants are found.

• Experiments on restoration of plants into apparently suitable sites could be used to understand the interactions of biotic and abiotic factors on the distribution of this plant.

• No information is available on the soil microbiology or mycorrhizal status of this species, that might help in managing or restoring it.

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Fig. 1. Map showing historic and extant localities of slender-horned spineflower, and the eight locations where it was studied. Map provided by California Department of Fish and Game.

1) Bautista Creek
2) Bee Canyon Creek
3) Cone Camp on the Santa Ana River
4) Dripping Springs on Arroyo Seco Creek
5) Lytle Creek
6) Orange St. site on the Santa Ana River
7) San Jacinto Wash
8) Big Tujunga Wash

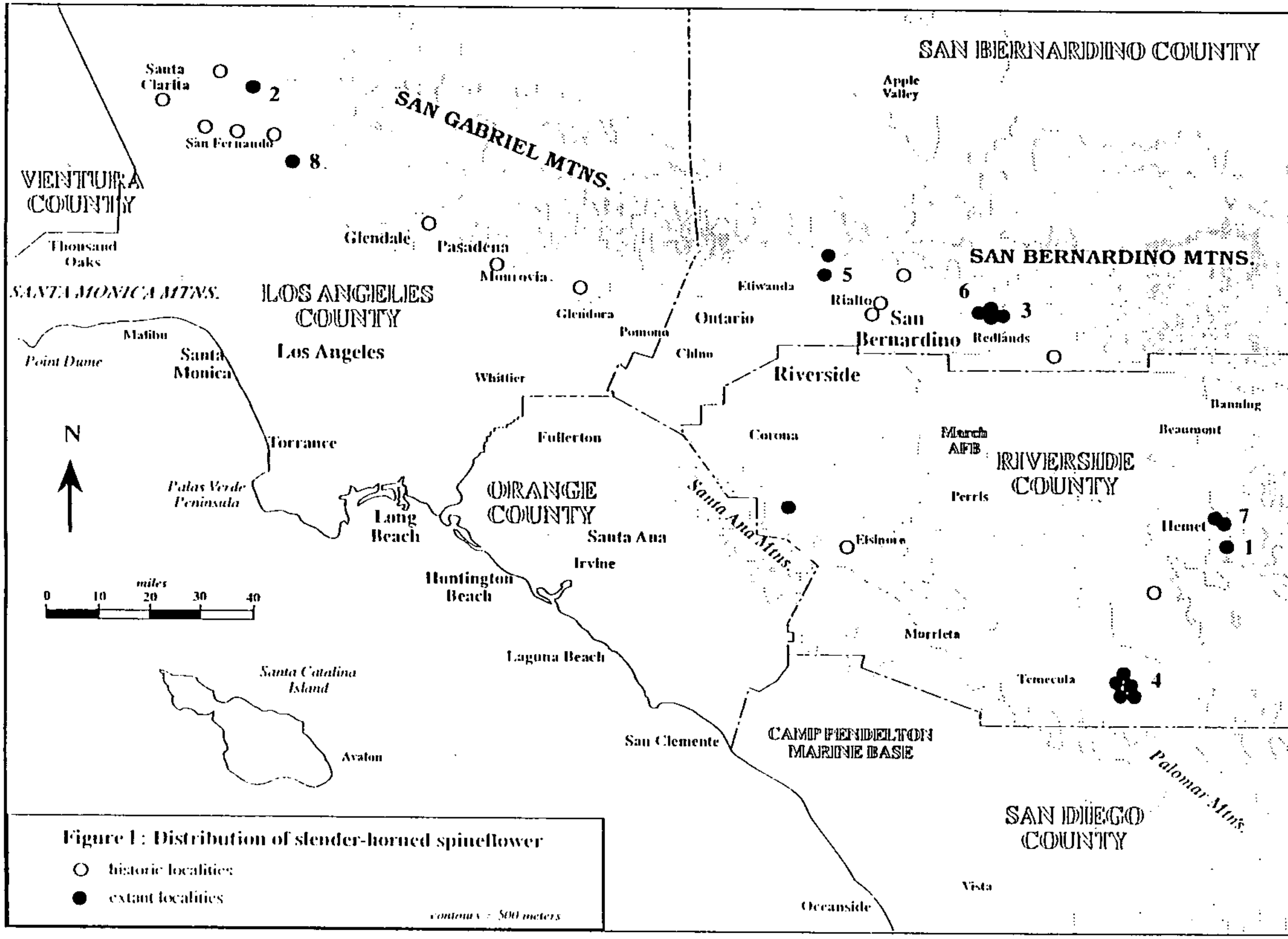


Figure 1: Distribution of slender-horned spineflower

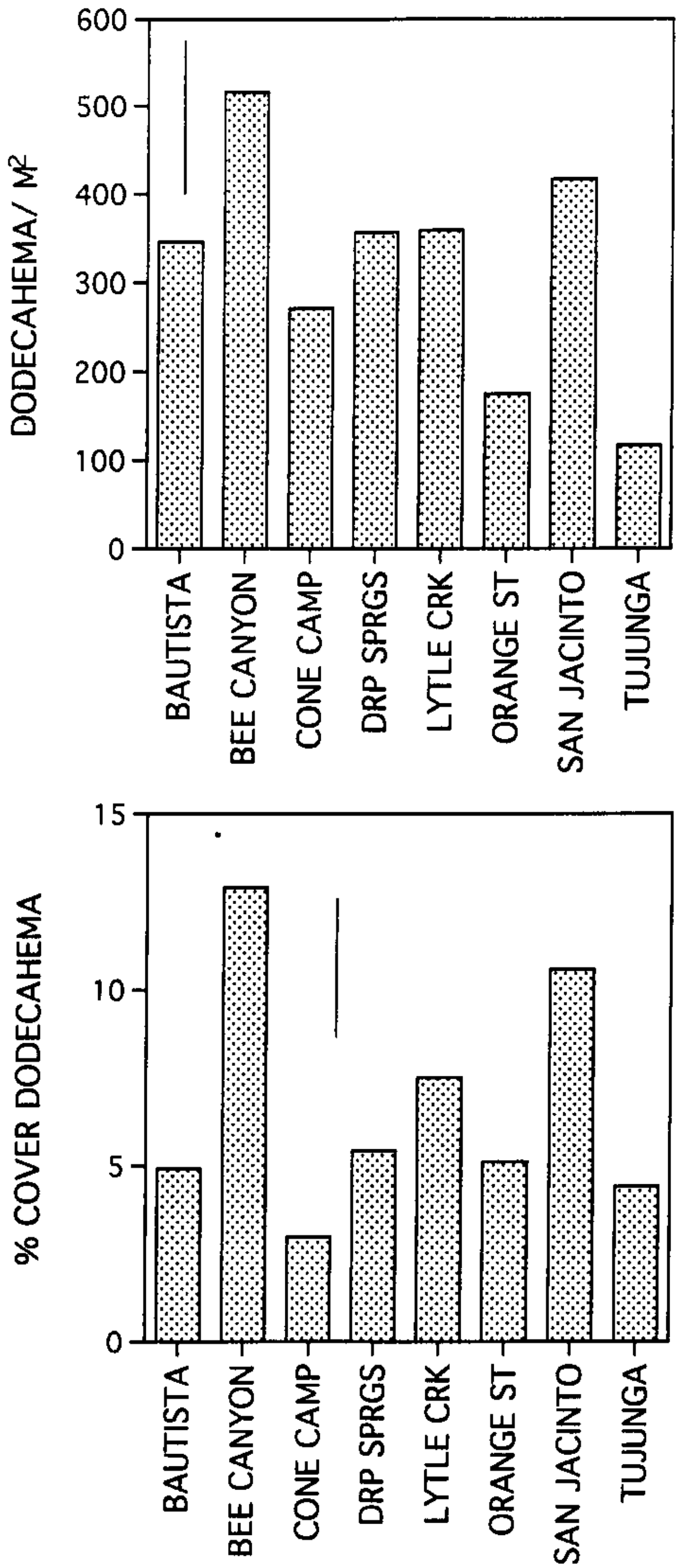


Fig 2. Density per m^2 and percent cover of slender-horned spineflower at eight sites. Error bars are L.S.D. 0.05. The L.S.D. shows significant difference at P = 0.05 between any two column means if the difference between those two means exceeds the value of the bar.

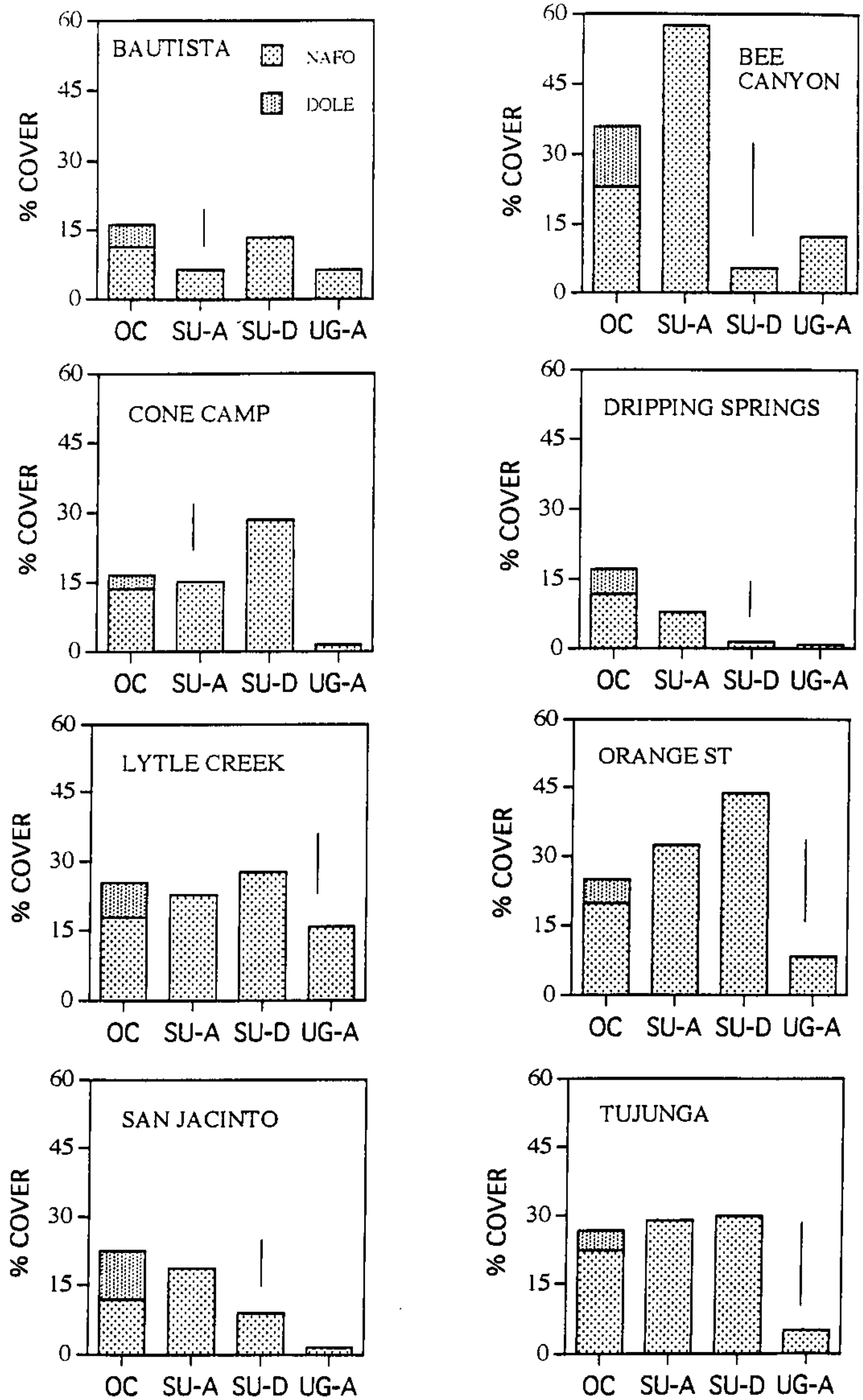


Fig. 3. Percent cover of native forbs, including spineflower, in four plot categories at eight sites. OC = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG-A = unoccupied grassy adjacent, NAFO = native forbs except spineflower, DOLE = *Dodecahema leptoceras*. Error bars are L.S.D.$_{0.05}$. The L.S.D. shows significance difference at P = 0.05 between any two column means if the difference between those two means exceeds the value of the bar.

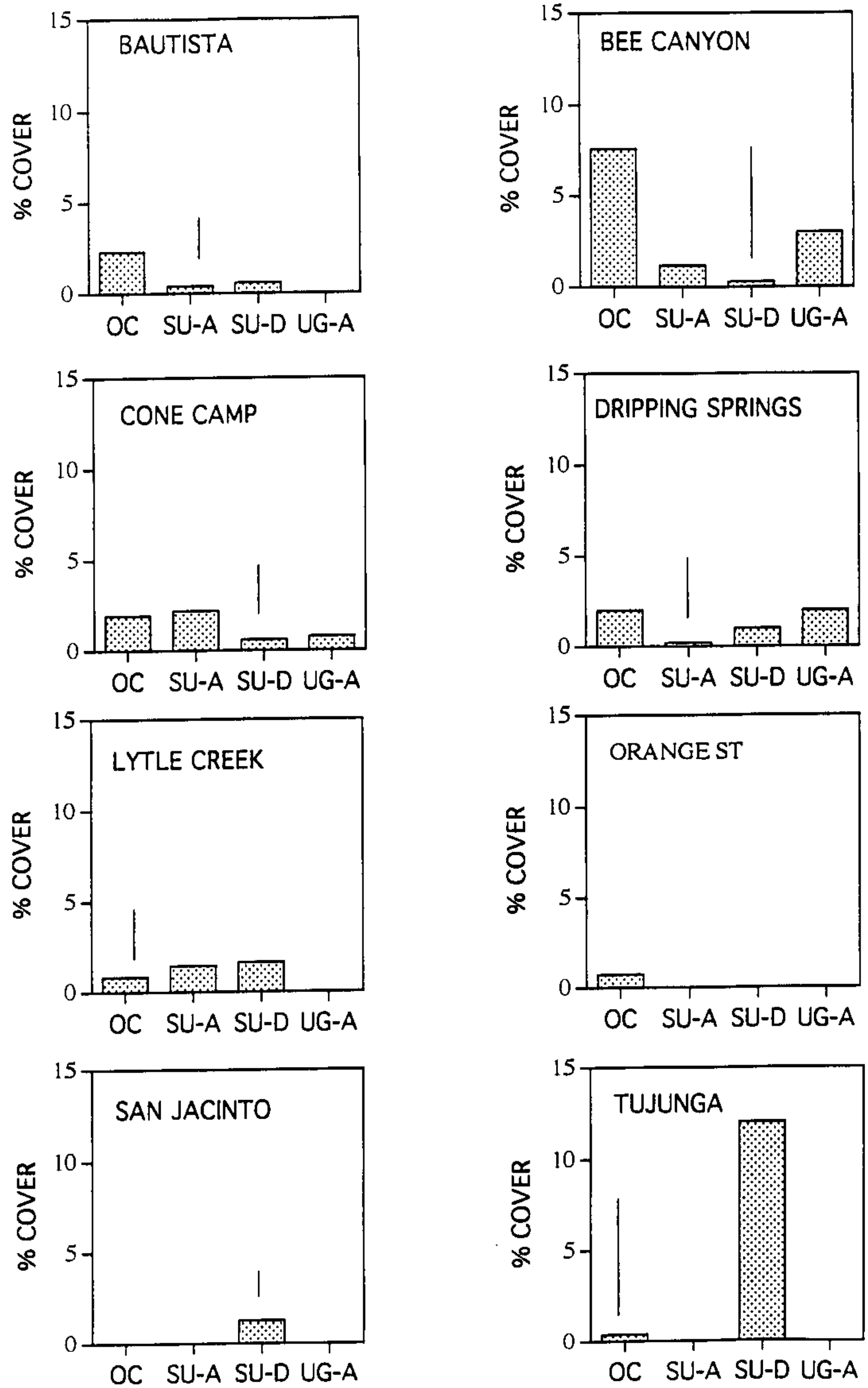


Fig. 4. Percent cover of native grasses in four plot categories at eight sites. OC = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG = unoccupied grassy adjacent. Error bars are $L.S.D._{0.05}$.

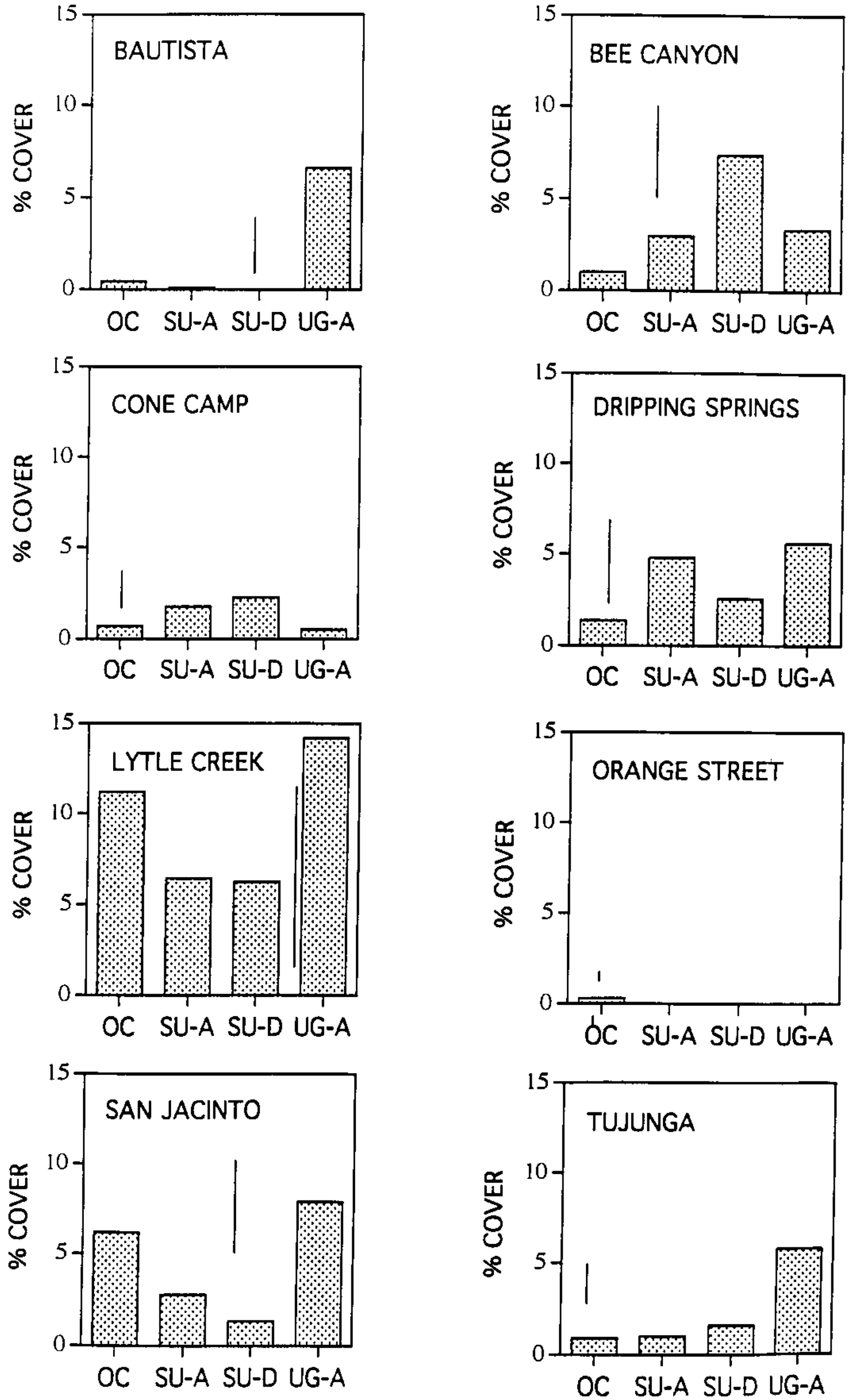


Fig. 5. Percent cover of exotic forbs in four plot categories at eight sites. OC = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG = unoccupied grassy adjacent. Error bars are L.S.D.$_{0.05}$.

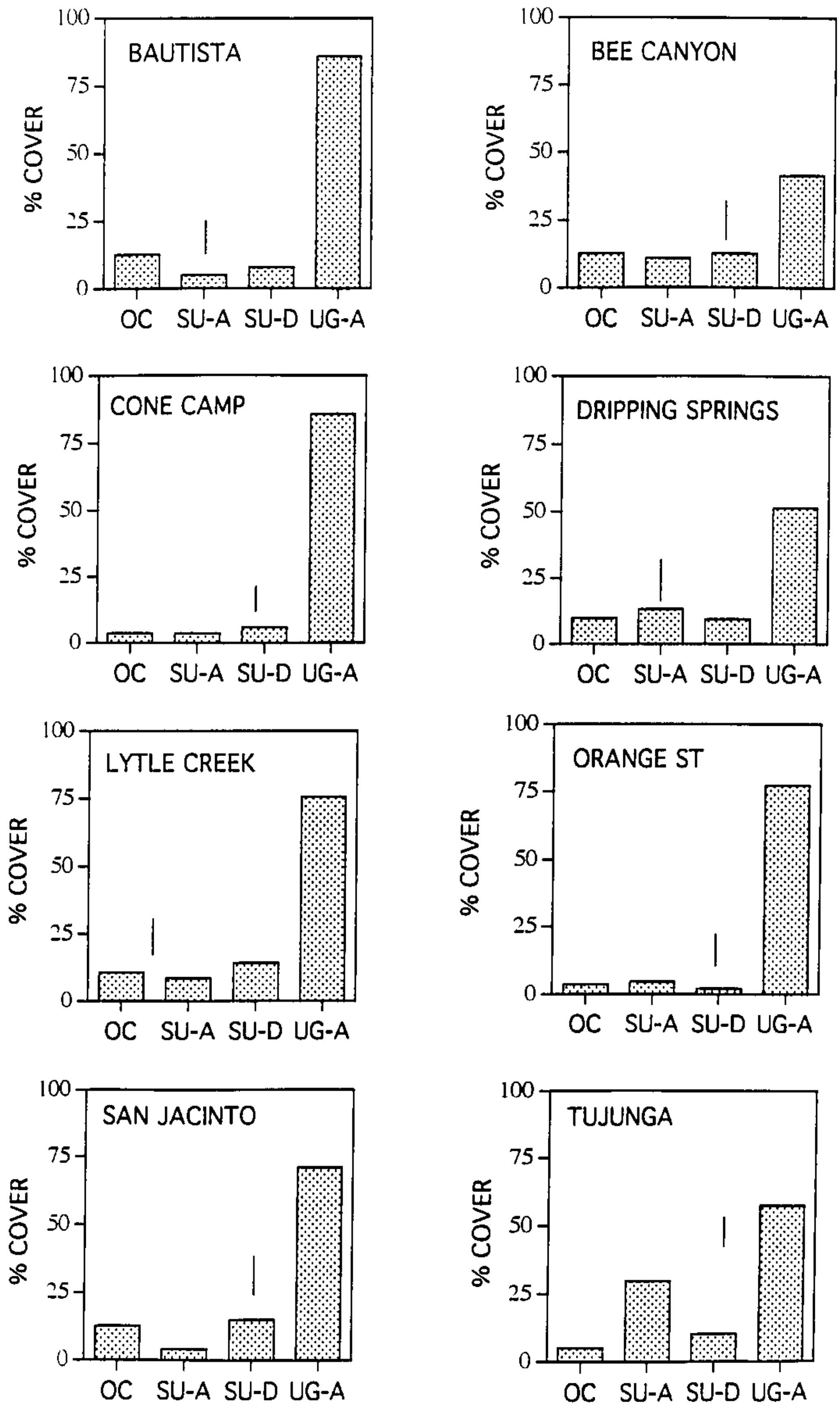


Fig. 6. Percent cover of exotic grasses in four plot categories at eight sites. OC = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG = unoccupied grassy adjacent. Error bars are L.S.D.$_{0.05}$.

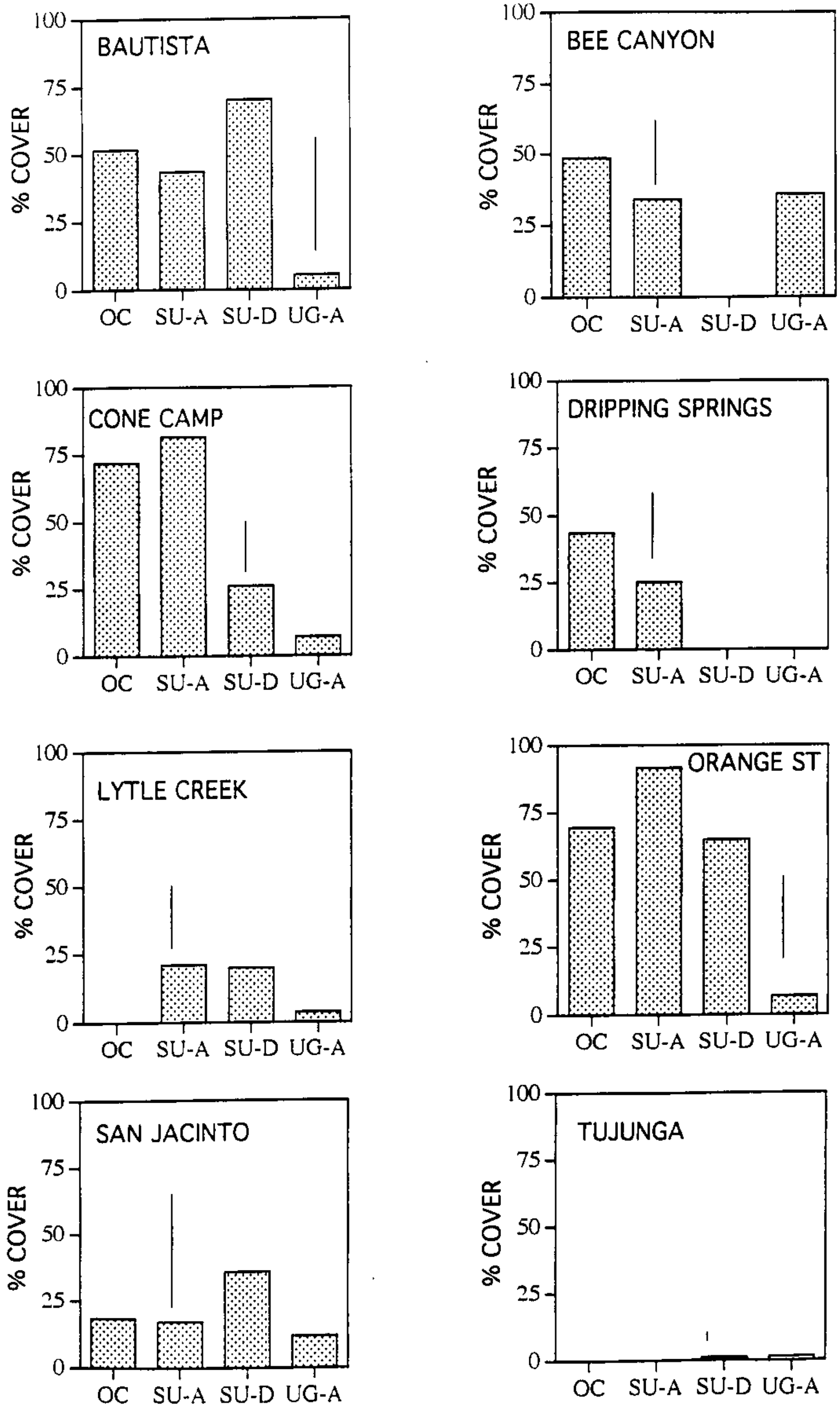
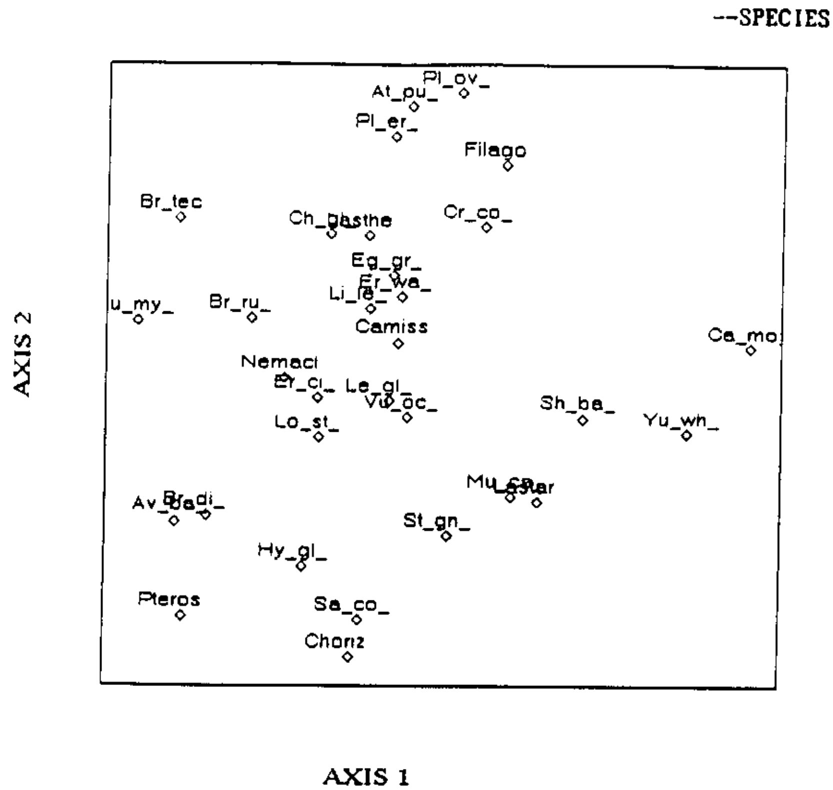


Fig. 7. Percent cover of cryptogamic crusts in four plot categories at eight sites. OC = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG = unoccupied grassy adjacent. Error bars are L.S.D.$_{0.05}$.



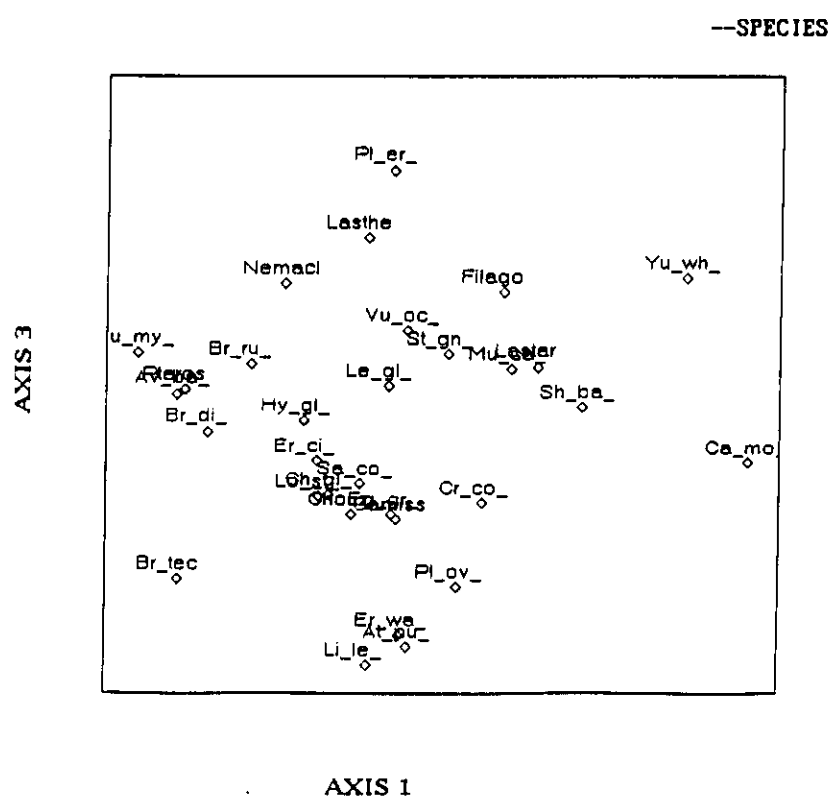


Fig. 8. Results of Detrended Correspondence Analysis on species, showing comparisons of axes 1 and 2, and 1 and 3.

Codes for Fig. 9.

1 = occupied; plot nos. 1-10 (10, 11...19, 110)
2 = suitable unoccupied adjacent; plot nos. 1-5 (21, 22...25)
3 = suitable unoccupied distant; plot nos. 1-5 (31...35)
4 = unsuitable grassy adjacent; plot nos. 1-5 (41...45)

BA = Bautista Creek
BC = Bee Canyon
CC = Cone Camp
DS = Dripping Springs
LC = Lytle Creek
OS = Orange St.
SJ = San Jacinto
TU = Tujunga Wash

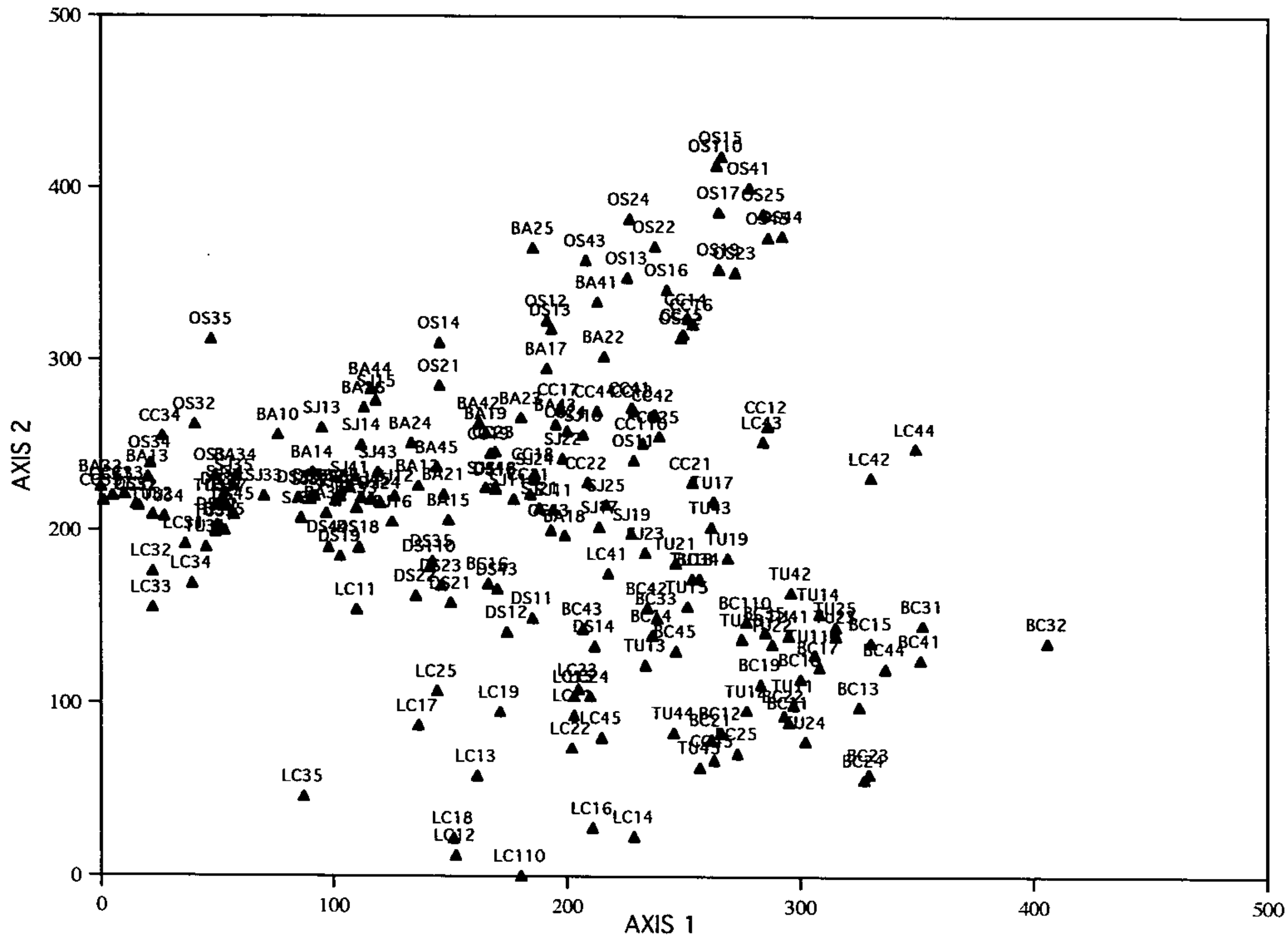


Fig. 9a. Results of Detrended Correspondence Analysis on samples (plots), showing comparisons of axes 1 and 2.

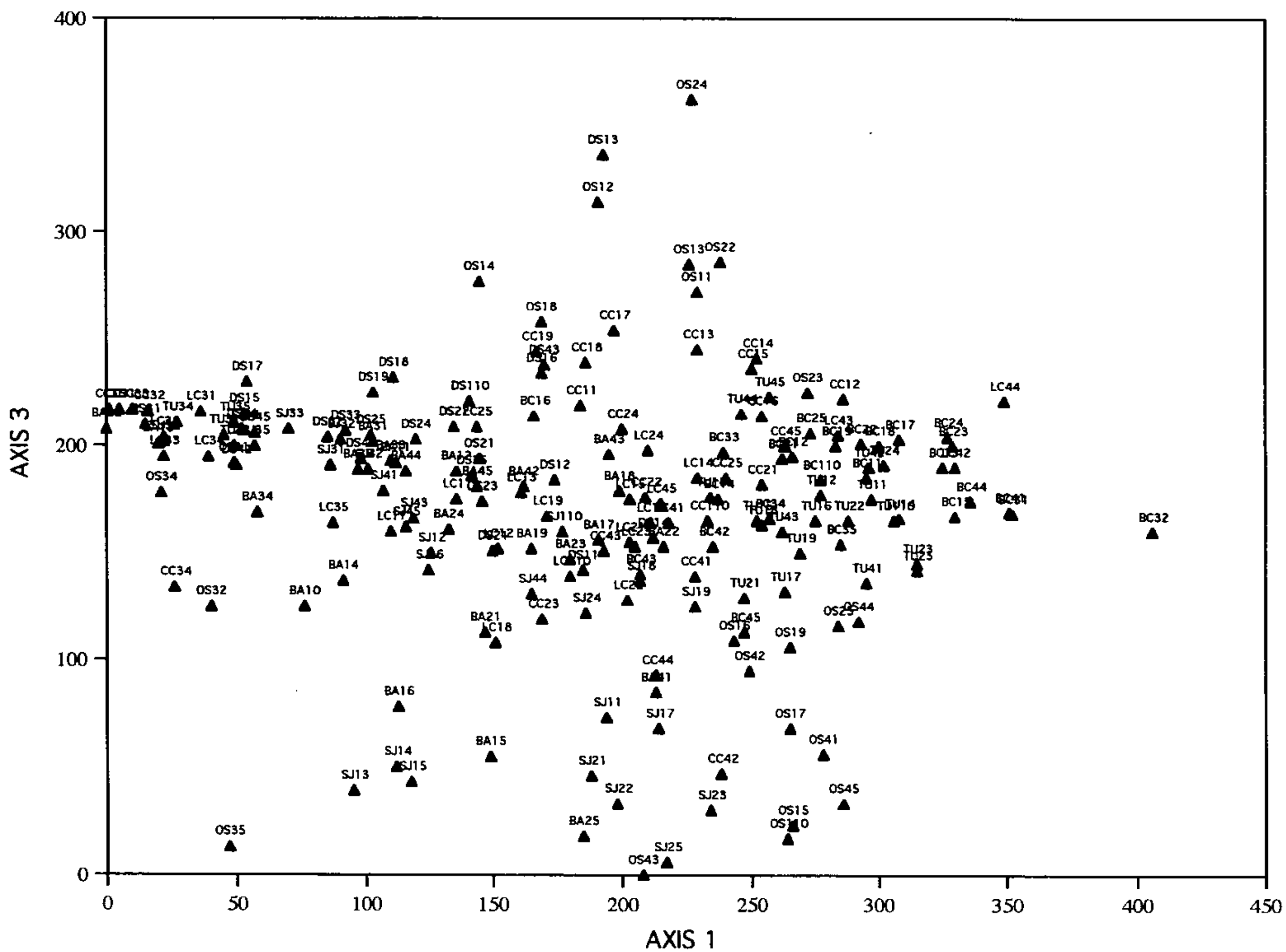


Fig 9b. Results of Detrended Correspondence Anaylsis on samples (plots), showing comparisons of axes 1 and 3.

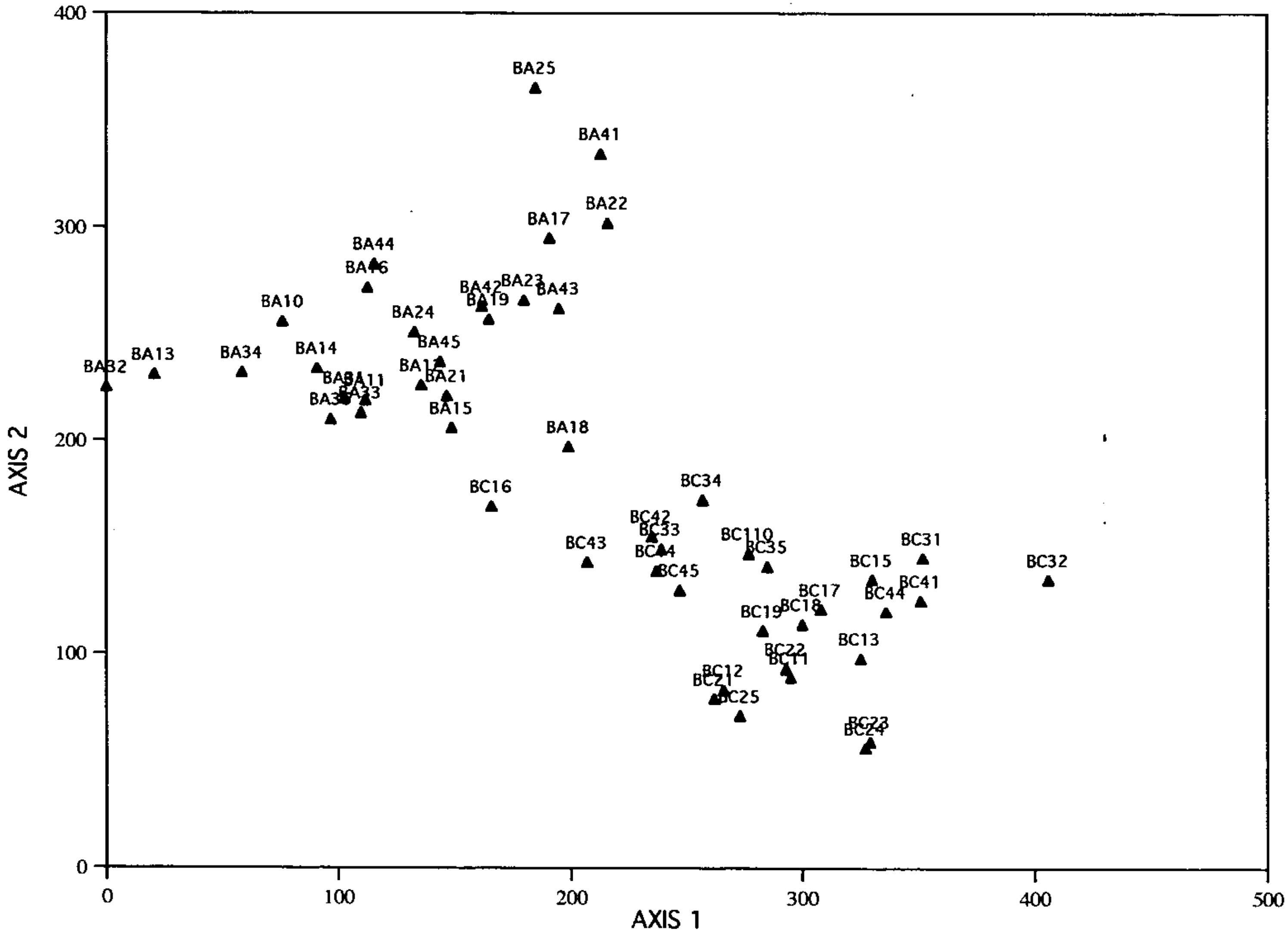


Fig. 9c. Results of Detrended Correspondence Analysis on samples (plots), showing comparisons of axes 1 and 2 for Bautista and Bee Canyon sites.

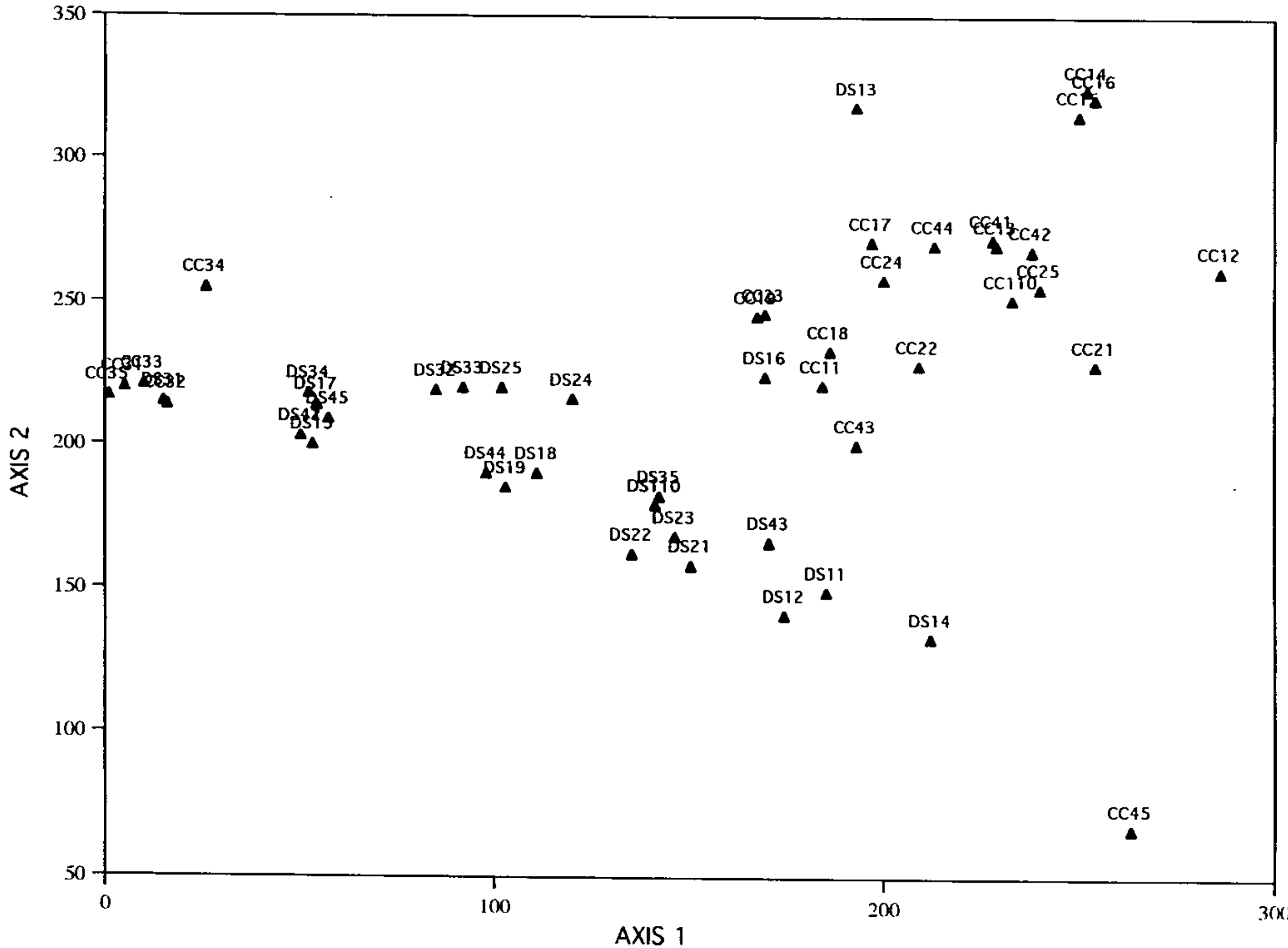


Fig. 9d. Results of Detrended Correspondence Analysis on samples (plots), showing comparisons of axes 1 and 2 for Cone Camp and Dripping Springs sites.

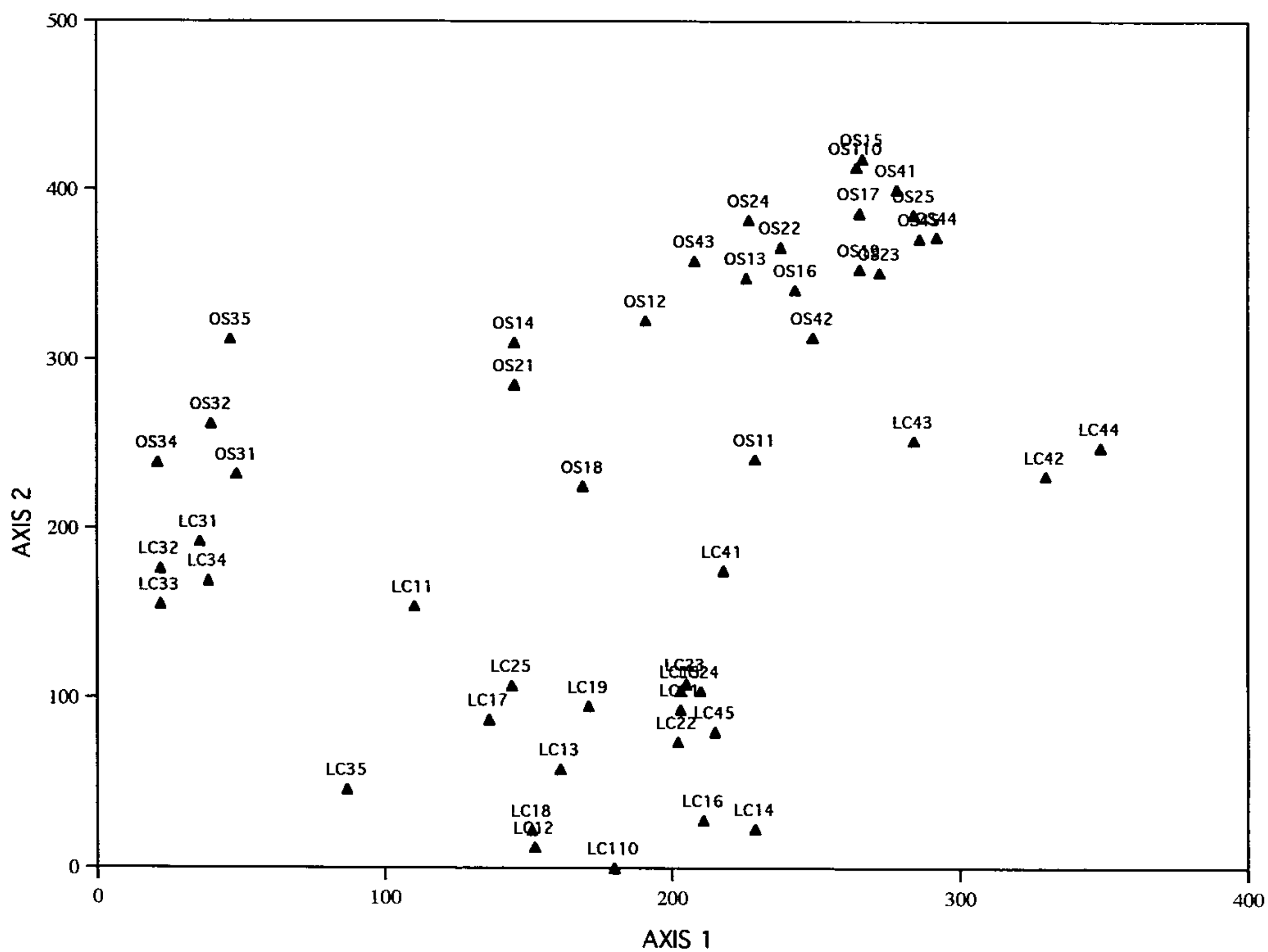


Fig. 9e. Results of Detrended Correspondence Analysis on samples (plots), showing comparisons of axes 1 and 2 for Lytle Creek and Orange Street sites.

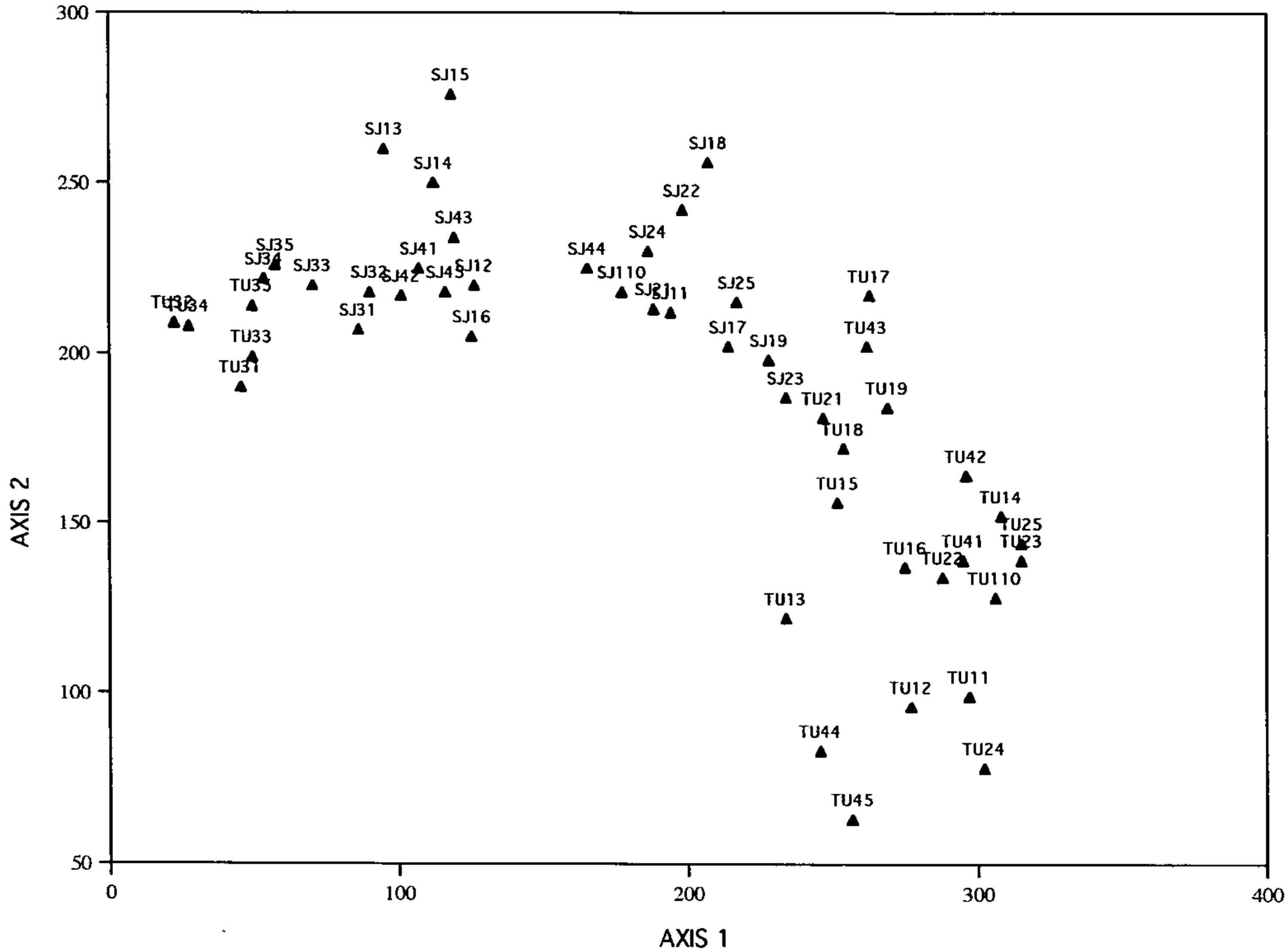


Fig. 9f. Results of Detrended Correspondence Anaylsis on samples (plots), showing comparisons of axes 1 and 2 for San Jacinto and Tujunga Wash sites.

Table 1. Annual precipitation and temperature and elevations of eight sites that are habitat for slender-horned spineflower. The nearest weather station was chosen for each site. Temperature data are not collected at two weather stations. Values are ten year means from 1986-1995.

SITE	SITE ELEVATION		WEATHER STATION	WEATHER STA. ELEVATION		Mean Yearly Precipitation		Mean Yearly Temperature	
	feet	meters		feet	meters	inches	centimeters	°F	°C
Bautista	2400	732	San Jacinto	1560	476	14.77	37.5	64	18
Bee Canyon	1750	534	Piru	730	223	17.49	44.4	no data	
Cone Camp	1660	506	San Berdo Hosp.	1125	343	15.10	38.4	65	18
Drpg. Sprgs.	1700	518	Lake Skinner	1492	455	14.34	36.4	no data	
Lytle Creek	2000	610	San Berdo Hosp.	1125	343	15.10	38.4	65	18
Orange St.	1280	390	San Berdo Hosp.	1125	343	15.10	38.4	65	18
San Jacinto	1500	457	San Jacinto	1560	476	14.77	37.5	64	18
Tujunga	1250	381	Burbank Valley	655	200	16.17	41.1	65	18

Table 2. Mean of all sites from plot data. SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG-A = unoccupied grassy adjacent. LSD = least significant difference.

SPECIES	OCCUPIED	SU-A	SU-D	UG-A	LSD
Exotic Grasses	8.8 a	10.0 a	9.6 a	68.3 b	5.2
Exotic Forbs	2.8 a	2.5 a	2.7 a	5.5 b	2.2
Native Grasses	2.0 a	0.7 a	2.2 a	0.7 a	1.6
Native Forbs	23.2 a	23.7 a	19.8 a	6.4 b	6.2
Crust	37.9 a	39.2 a	27.3 a	9.0 b	14.4
Bareground	35.2 a	33.0 a	43.5 a	8.6 b	12.5
Litter (Leaf)	6.0 a	4.0 a	4.4 ab	11.1 c	3.7

Table 3. Richness (number of species per 50 m x 5 m belt transects) of species groups in transects occupied and unoccupied by spineflower. Unoccupied distant sites were used.

SPECIES	Bautista		Bee Canyon		Cone Camp		Dripg Sprgs		Lytle Creek		Orange St		San Jacinto		Tujunga	
	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC
Exotic grasses	4	7	3	3	5	5	3	4	6	5	6	6	5	6	3	3
Exotic forbs	2	4	2	1	3	2	3	2	2	2	2	2	2	3	2	1
Native grasses	1	0	3	3	1	1	2	2	1	1	0	1	0	1	0	0
Native forbs	30	17	26	24	18	20	35	18	19	10	16	17	20	17	8	5
Native shrubs	8	3	6	5	11	11	9	6	6	8	6	5	6	5	5	8
Native trees	1	0	1	1	1	0	1	0			0	1				
Fern					1	0										
Total	46	31	41	37	39	39	53	32	34	26	30	31	33	32	18	17

Table 4. Mean percent of points intercepted for each species group on 50 m line transects occupied or unoccupied by spineflower. t-value = value of t-test; P = probability of significance.

SPECIES	% OF POINTS OCCUPIED	% OF POINTS UNOCCUPIED	t-value	P
Exotic Grasses	62.5	43.4	1.812	0.091
Exotic Forbs	13.3	12.8	0.102	0.921
Native Grass	3.3	1.8	0.830	0.421
Native Forbs	30.8	24.0	1.168	0.262
Native Shrubs	17.9	18.6	-0.088	0.931
Native Trees	1.1	0.0	1.000	0.334
Bareground	25.9	33.6	-0.612	0.550
Crust	18.4	18.9	-0.051	0.960
Litter	32.6	38.1	-0.843	0.413
Rock	10.8	7.9	0.393	0.700

Table 5. Mean values of soil factors from four plot categories at eight sites. The overall grand mean of all sites is shown at the bottom of the table. The soil factors are nitrogen (%), phosphorus (ppm), cation exchange capacity (milliequivalents per 100 g soil), and organic matter (%). O = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG-A = unoccupied grassy adjacent. Significant differences are shown by letters a,b,c where mean values with different letters are significantly different, based on the $L.S.D._{0.05}$.

Location	Plot Type	N %	Sign. Diff.	P ppm	Sign. Diff.	C.E.C. meg/100g	Sign. Diff.	O.M. %	Sign. Diff.
Bautista	O	0.016	a	2.67	a	4.95	a	0.276	a
Bautista	SU-A	0.016	a	1.92	ac	5.40	a	0.240	a
Bautista	SU-D	0.035	b	4.30	b	7.50	b	0.790	b
Bautista	UG-A	0.018	a	1.08	c	5.20	a	0.268	a
	LSD	0.009		1.46		1.72		0.284	
Bee Canyon	O	0.031	a	4.17	a	18.35	a	0.528	a
Bee Canyon	SU-A	0.041	ab	6.06	ab	18.80	a	0.734	ab
Bee Canyon	SU-D	0.050	b	7.52	b	19.10	a	0.870	b
Bee Canyon	UG-A	0.039	ab	7.54	b	18.30	a	0.652	ab
	LSD	0.012		3.24		2.98		0.259	
Cone Camp	O	0.027	a	4.02	a	5.20	a	0.604	a
Cone Camp	SU-A	0.021	a	1.70	a	4.50	a	0.482	a
Cone Camp	SU-D	0.031	a	2.86	a	5.90	a	0.646	a
Cone Camp	UG-A	0.025	a	2.92	a	5.25	a	0.530	a
	LSD	0.011		3.36		1.22		0.214	
Dripping Springs	O	0.055	a	5.86	a	7.95	a	0.882	a
Dripping Springs	SU-A	0.036	a	6.74	ac	5.80	b	0.792	a
Dripping Springs	SU-D	0.067	a	14.36	b	10.70	c	1.542	b
Dripping Springs	UG-A	0.048	a	7.76	c	8.20	a	1.238	c
	LSD	0.089		1.89		1.24		0.301	
Lytle Creek	O	0.045	a	5.78	ab	6.00	a	0.741	a
Lytle Creek	SU-A	0.044	ab	5.76	ab	5.40	a	0.760	a
Lytle Creek	SU-D	0.198	b	6.74	b	7.80	b	1.240	b
Lytle Creek	UG-A	0.042	ab	4.60	a	8.30	b	0.612	c
	LSD	0.161		1.57		1.40		0.145	
Orange St.	O	0.039	a	3.43	a	6.85	a	0.569	a
Orange St.	SU-A	0.054	b	3.84	ab	8.10	b	0.800	b
Orange St.	SU-D	0.052	ab	5.14	b	6.50	a	0.978	bc
Orange St.	UG-A	0.066	b	6.26	bc	6.20	a	1.194	c
	LSD	0.016		1.40		1.04		0.265	
San Jacinto	O	0.029	a	4.48	a	6.15	a	0.468	a
San Jacinto	SU-A	0.034	a	3.82	a	5.60	a	0.484	a
San Jacinto	SU-D	0.090	b	20.02	b	15.60	b	1.316	b
San Jacinto	UG-A	0.039	a	3.30	a	5.60	a	0.474	a
	LSD	0.014		4.49		3.11		0.237	

Table 5. Cont.

Location	Plot Type	N %	Sign. Diff.	P ppm	Sign. Diff.	C.E.C. meg/100g	Sign. Diff.	O.M. %	Sign. Diff.
Tujunga	O	0.037	a	1.53	a	6.10	a	0.643	a
Tujunga	SU-A	0.042	ab	3.06	b	6.00	a	0.722	ab
Tujunga	SU-D	0.051	b	2.94	b	7.00	a	0.908	b
Tujunga	UG-A	0.035	a	2.26	ab	5.90	a	0.590	c
	LSD	0.012		1.48		1.35		0.263	
ALL SITES	O	0.040	a	3.99	a	7.69	a	0.590	a
ALL SITES	SU-A	0.036	a	4.11	a	7.45	a	0.630	a
ALL SITES	SU-D	0.070	b	7.99	b	10.01	b	1.040	b
ALL SITES	UG-A	0.040	a	4.47	a	7.87	a	0.690	a
	LSD	0.022		1.56		2.01		0.131	

Table 6. Mean values of % sand, clay, and silt, and pH and electrical conductivity (milliSiemen) from four plot categories at eight sites. The values represent one reading from a composited sample of five subsamples taken for each category. O = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG = unoccupied grassy adjacent.

Location	Plot Type	% Sand	% Clay	% Silt	pH	EC
Bautista	O	7.51	0.00	92.49	6.67	130.00
Bautista	SU-A	7.52	1.25	91.23	6.84	131.00
Bautista	SU-D	7.52	1.25	91.23	6.50	139.00
Bautista	UG-A	12.56	2.51	84.93	6.81	248.00
Bee Canyon	O	20.35	10.17	69.48	7.27	324.00
Bee Canyon	SU-A	24.17	8.90	66.93	7.23	362.00
Bee Canyon	SU-D	25.50	7.65	66.85	6.83	319.00
Bee Canyon	UG-A	17.89	5.11	77.00	7.09	366.00
Cone Camp	O	10.02	3.76	86.22	6.01	134.00
Cone Camp	SU-A	1.25	1.25	97.50	6.00	125.00
Cone Camp	SU-D	7.51	2.50	89.98	5.92	127.00
Cone Camp	UG-A	10.02	2.51	87.47	6.02	154.00
Dripping Springs	O	10.04	2.51	87.45	6.53	150.00
Dripping Springs	SU-A	10.04	2.51	87.45	6.58	168.00
Dripping Springs	SU-D	7.53	2.51	89.96	5.87	168.00
Dripping Springs	UG-A	10.06	1.26	88.68	6.64	263.00
Lytle Creek	O	12.53	2.51	84.96	5.83	122.00
Lytle Creek	SU-A	12.53	2.51	84.96	5.89	131.00
Lytle Creek	SU-D	7.52	2.51	89.97	5.94	153.00
Lytle Creek	UG-A	7.53	1.26	91.21	5.78	168.00
Orange St.	O	2.51	0.00	100.00	6.74	168.00
Orange St.	SU-A	7.52	1.25	91.23	6.81	194.00
Orange St.	SU-D	17.56	2.51	79.93	6.79	200.00
Orange St.	UG-A	10.03	2.51	87.46	6.96	268.00
San Jacinto	O	10.04	3.77	86.19	6.78	147.00
San Jacinto	SU-A	10.06	5.03	84.90	6.93	188.00
San Jacinto	SU-D	10.04	5.02	84.93	6.79	214.00
San Jacinto	UG-A	35.17	7.54	57.29	7.10	n.d.
Tujunga	O	10.04	2.51	87.45	5.50	140.00
Tujunga	SU-A	7.54	2.51	89.95	6.51	153.00
Tujunga	SU-D	10.04	7.53	82.43	6.64	132.00
Tujunga	UG-A	15.07	2.51	82.42	6.51	152.00

Table 7. Mean values of clay, and silt, and pH and electrical conductivity (milliSiemen) from four plot categories at eight sites (data from Table 6). The values represent one reading from a composited sample of five subsamples taken for each category. O = occupied, SU-A = suitable unoccupied adjacent, SU-D = suitable unoccupied distant, UG-A = unoccupied grassy adjacent. The letter a shows that there were no significant differences among any of the plot categories for these factors, based on the L.S.D. $_{0.05}$.

Location	Plot Type	% Sand	% Clay	% Silt	pH	EC
ALL SITES	O	10.38	3.15	86.78	6.42	164
ALL SITES	SU-A	10.08	3.15	86.77	6.60	182
ALL SITES	SU-D	11.65	3.94	84.41	6.41	182
ALL SITES	UG-A	14.79	3.15	82.06	6.61	202
LSD		7.05	2.7	9.45	0.51	76

Appendix 1.

FIELD SAMPLING PROTOCOL
California Native Plant Society
Rare Plant Communities of California
Σεχ. 95/3/20

INTRODUCTION

This document describes the procedures used for vegetation sampling by CNPS. The samples will provide information for the classification and description of selected plant communities in California. The sampling method is based on a 50 m long point-transect centered in a 50 m x 5 m *plot*. At each 0.5 m interval along the transect (beginning at the 50 cm mark and ending at 50.0 m), a point is projected vertically into the vegetation. Each species intercepted by a point is recorded, providing a tally of hits for each species in the herb, shrub, and tree canopies. In so far as it is possible, it is important to take care to stretch the tape taut, in order to maintain a consistent sampling area. Percent cover for each species according to vegetation layer (herb, shrub, and tree) can be calculated from these data. Finally, a list of all additional species within the 250 m^2 plot is made.

Often, the composition and abundance of the species within a type will vary with seasonality or in response to disturbance, such as fire. The optimal time to sample vegetation is determined by flowering dates such that as many species as possible can be identified. This becomes of greater concern in herbaceous vegetation types as opposed to those dominated by woody species.

PLOT LOCATION

Plots are located within subjectively chosen patches of homogeneous vegetation. Once such an area has been chosen and approximate boundaries defined, the transect is objectively located. The observer may walk to the center of the patch and then determine the center of the transect in an arbitrary manner (e.g. by tossing an object over the shoulder). The direction of the transect line from this center point is chosen randomly, using a wrist watch: the position of the second hand can refer to a compass direction, with noon equivalent to north.

For unusual cases such as narrow bands or small patches of vegetation which do not lend themselves to the placement of a straight 50 m long transect, the transect may be bent or curved. However, this should be avoided whenever possible in order to maintain consistency among the plots and to avoid observer bias in establishing the transects. In a narrow riparian corridor, for instance, locate the center of the patch which is long enough to accommodate a transect and flip a coin to determine the direction of the transect parallel to the axis of the patch.

REPLICATION

Determining how many plots to establish in a given patch of vegetation involves an assessment of the size and floristic variability of the patch, the time available to the field team, and the proximity of additional patches of the same vegetation type. Here the volunteers must make a decision, which will be based on these considerations after spending enough time in the field to gain a familiarity with the type. In some patches, one plot will adequately capture the composition and structure of the vegetation type; in others, additional plots will be necessary. For example, if a team establishes a plot in a patch of forest vegetation, and it is evident to the members of the team that the floristic composition and structure of the plot does not adequately represent that of the patch, additional plots should be established. If there are a number of individual patches of the same type in an area, it may be preferable to spread the sampling among them, thus capturing the variability among adjacent stands. Before embarking on a sampling campaign, contact the Department of Fish and Game/CNPS plant ecologist (916-324-6857) for assistance with developing a strategy for sampling a given vegetation type.

GENERAL PLOT INFORMATION

The following items are included on each datasheet. As a rule, please avoid the use of abbreviations.

Temporary field plot number: Assigned in the field, using a unique number for each patch and for each replicate plot within a patch. Permanent plot numbers will be assigned by CNPS.

Date: Date of sampling.

Contact Person: Name, address and phone number of individual responsible for data collection on the plot.

Observers: Names of individuals assisting on the plot.

County: County plot is located in.

USGS Map: The name of the USGS map the plot is located on; note series (15' or 7½').

CNPS Chapter: CNPS chapter, or other organization or agency if source of data is other than CNPS chapter.

Elevation: Recorded in feet or meters; please indicate units.

Slope: Degrees, read from clinometer or compass or estimated; averaged over plot.

Aspect: Degrees from true north, read from a compass or estimated; averaged over plot.

UTMN and UTME: Northing and easting coordinates using the Universal Transverse Mercator (UTM) grid as delineated on the USGS topographic map; to the nearest 0.01 of a km. See sample map for an example of determining coordinates.

UTM zone: Universal Transverse Mercator zone. Zone 10 for western part of California (west of the 120th latitude); zone 11 for eastern part of California (east of the 120th latitude).

Township/Range/Section/Quarter section/Quarter-Quarter section/Meridian name: Legal map location of site; this is useful for land ownership determination. Meridian designations for California: Humboldt; Mt. Diablo; San Bernardino.

Landowner: Name of landowner or agency acronym if known; else list as 'private'.

Photographs: (optional). Describe view direction of color slides taken of the site.

Transect length: Length of transect sampled in meters; standard length is 50 m.

Transect direction: Direction of the transect in degrees.

Site Location: A careful description which makes revisiting the vegetation patch and plots possible; give landmarks and directions. Indicate location on a photocopy of a USGS topographic map (preferably 7.5') and attach to field survey form; if possible, draw a boundary around the patch on the map.

SITE AND VEGETATION DESCRIPTION

CNPS Series: Name of series, stand or habitat according to the CNPS classification (Sawyer and Keeler-Wolf 1995); if the type is not known, or is not defined by the CNPS classification, leave the space blank.

Association: Name of association according to the CNPS classification.

Upland/Wetland: Indicate if the sample is in a wetland or an upland; note that a site need not be officially delineated as a wetland to qualify as such in this context.

Patch size: Estimated size (in acres or hectares; indicate units) of patch being sampled.

Community size: Estimated area (in acres or hectares; indicate units) covered by the vegetation being sampled; include all areas within 1 km of the sample site.

Adjacent series: Adjacent vegetation series, stands or habitats according to CNPS classification; list in order of most extensive to least extensive.

Adjacent land uses: List adjacent land uses (e.g. grazing, mining, timberland, residential, wilderness, recreational, etc.)

Threats: Enter codes for threats to the stability of the plant community. Characterize each as either light, moderate or heavy.

Code	Threat description	Code	Threat description
01	Development	16	Biocides
02	ORV activity	17	Pollution
03	Agriculture	18	Unknown
04	Grazing	19	Vandalism/dumping
05	Competition from exotics	20	Foot traffic/trampling
06	Logging	21	Improper burning regime
07	Insuff. pop/stand size	22	Over-collecting/poaching
08	Altered flood/tidal regime	23	Erosion or runoff
09	Mining	24	Altered thermal regime
10	Hybridization	25	Landfill
11	Groundwater pumping	26	Degraded water quality
12	Dam/inundation	27	Wood cutting
13	Other (describe)	28	Military operations
14	Surface water diversion	29	Recreational use (non-ORV)
15	Road/trail construct/maint.	30	Rip-rap, bank protection

Vegetation trend: Characterize the community as either increasing (expanding), stable, decreasing, fluctuating or unknown.

Vegetation structure: Circle the appropriate term which characterizes the structure of each layer. If more than three layers are evident, e.g. sublayers are present, describe these as well.

Continuous = continuously interlocking or touching crowns
Intermittent = interlocking or touching crowns interrupted by openings
Open = infrequently interlocking or touching crowns

Phenology: Characterize the phenology as either early, peak or late.

Macrotopography: Characterize the large-scale topographic position of the site. This is the general position of the sample along major topographic features of the area.

Microtopography: Characterize the local relief of the site. This is the general shape or lay of the ground along minor topographic features of the area.

Site History: Describe the history of the site, e.g. evidence of disturbance or past use. Please be as specific as possible: e.g. if flooded, indicate year of flood; if plowed, indicate how often.

Additional comments: Feel free to note any additional observations of the site, or deviations from the standard sampling protocol. If additional data were recorded, e.g. if tree diameters were measured, please indicate so here.

WETLAND COMMUNITY TYPES

Cowardin class: If the plot is located in a wetland, record the proper Cowardin system name. Systems are described in detail in: Cowardin et al. 1979. Classification of wetlands and deepwater habitats of the United States. US Dept. of Interior, Fish and Wildlife Service, Office of Biological Services, Washington D.C.

Marine: habitats exposed to the waves and currents of the open ocean (subtidal and intertidal habitats).

Estuarine: includes deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (i.e. estuaries and lagoons).

Riverine: includes all wetlands and deepwater habitats contained within a channel, excluding any wetland dominated by trees, shrubs, persistent emergent plants, emergent mosses, or lichens, and any channels that contain oceanic-derived salts greater than 0.5%.

Lacustrine: includes wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and 3) total area exceeds 8 ha (20 acres). Similar areas less than 8 ha are included in the lacustrine system if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 m (6.6 feet) at low tide. Oceanic derived salinity is always less than 0.5%.

Palustrine: includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity derived from oceanic salts is less than 0.5%. Also included are areas lacking vegetation, but with all of the following four characteristics: 1) areas less than 8 ha (20 acres); 2) active wave-formed or bedrock shoreline features lacking; 3) water depth in the deepest part of the basin less than 2 m (6.6 feet) at low water; and 4) salinity due to ocean-derived salts less than 0.5%.

Vertical distance from high water mark of active stream channel: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated vertical distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

Horizontal distance from high water mark of active stream channel: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated horizontal distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

Stream channel form: If the plot is located in or near a community along a stream, river, or dry wash, record the channel form of the waterway. The channel form is considered S (single channeled) if it consists of predominantly a single primary channel and M (multiple) if it consists of multiple channels interwoven or braided.

SOIL AND GROUND SURFACE DESCRIPTION (optional; contact CNPS plant ecologists for community types for which this information is critical).

Coarse fragments, bedrock: Estimate the percent coverage of each size class at or near the ground surface averaged over the 250 m^2 plot.

Gravel: rounded and angular fragments < 3 inches in diameter

Cobble: rounded and angular fragments 3 - 10 inches in diameter

Stone: rounded and angular coarse fragments > 10 inches in diameter

Bedrock: extent of exposed bedrock at surface of plot

Soil series: Soil series based on the USDA system of soil classification recorded from local soil map.

Parent material: Geologic parent material of site.

VEGETATION DATA

Point-intercept transect: A 50 m long tape is laid along the center of the plot and secured at both ends. The observer uses a 1 meter length of steel roundbar to sight along a vertical line at every 0.5 m interval from the 0.5 to the 100 meter mark.. Each species intercepted by the vertical line is tallied by vegetation layer. A total of 100 points along the transect are thus sampled.

Assessment of Layers. Estimates of the maximum height of the herb and shrub layers, and the minimum height of the tree layer, are recorded. These estimates are made after a quick assessment of the vegetation and its structure; these need not be overly precise, and will vary among vegetation types. A caveat: if a number of plots are being established within the same community type, it is important to be consistent when assigning layers. This is not difficult after 2 or 3 transects have been established. Some types will have more than three layers (e.g. two tree layers of different maximum height); this should be indicated in the plot description. However, data are recorded for only three layers (herb, shrub and tree) whenever possible. The manner in which a species is recorded on the data sheet depends on the layer it occupies. The layer a species occupies will usually be determined by growth form, but exceptions will occur. For instance, a plot may contain a shrubby, multi-stemmed form of a tree species which occupies the shrub layer.

Because the species occupies the shrub layer, even though nominally a tree, it is treated as a shrub and recorded in the shrub layer on the data sheet. Similarly, a shrub occupying space in the tree canopy is recorded in the tree layer. Seedlings of woody plants, shorter than the maximum height of the herb layer, are recorded in the herb layer. An individual plant is recorded within only one layer, depending on the height of the tallest part of the individual. A species may, however, be represented in more than one layer on a plot depending on the height of each individual. For example, a single transect may contain seedlings of a tree species in the "herb", or lowest layer; saplings in the "shrub", or second layer; and mature trees in a third layer.

Determining Hits. It is important not to bias the location of the point to include a plant; this will result in overestimation of plant cover. This bias is most likely to be a problem with the herbaceous species. Take care to record hits along the same side of the tape within a plot; which side is unimportant, as long as one is consistent. The roundbar provides a line which can be projected into the vegetation layer. Only hits which fall within the canopy outline (delineated by visually rounding out the canopy edges) of a tree, shrub, or herb, or which directly hit an annual grass or other linear growth form, are valid (see Figure 1a). If two species within a single layer are intercepted by a point, both are recorded for that layer (see Figure 1b). If no vascular plant is hit by a point, a non-plant category (bare, rock, or litter in the herb layer; sky in the shrub or tree layers) is recorded as a hit for that layer. If the tree and shrub layers are both bare, *and* the herb layer is either bare or occupied by a non-vascular plant (rock, moss, lichen, litter) then the category BARE at the top of the page also receives a tally. Although this may seem redundant, recording non-hits in this manner allows for the calculation of absolute plant cover for the entire plot as well as for each separate layer. Plant names are recorded as Latin binomials (not common names) and should be consistent with the Jepson Manual (Hickman 1993).

It may be helpful to consider the above as a series of decision rules. In the herb layer: IF the point intercepts a grass, or the canopy outline of an herbaceous or woody species, record a hit for that plant. If more than one species is intercepted, record a hit for each within that layer. IF AND ONLY IF no vascular plant is intercepted in the herb layer, one and only one non-vascular plant category receives a hit: the options are bare, litter, rock or moss/lichen.

In the shrub and tree layers: IF the point intercepts the sphere of influence of an individual, that species receives a hit for the layer which the highest point of the individual occurs within.

<u>Data Sheets</u>: In order to accommodate different styles of recording, two types of datasheet have been prepared. Some observers may find it more convenient to use the long form, which provides a prompt for which point is being recorded. This form must then be summarized on the short form by summing the hits for each species and recording them by layer. Alternatively, the short form may be used directly; please take the time to sum the tallies as indicated on the sample data sheet.

<u>Additional Species</u>: All vascular plants not recorded for the transect are listed by layer after searching the entire 250 m^2 plot (2.5 m on each side of the 50 m transect). A careful and exhaustive search is required to be sure that no species are missed.

<u>Unknown specimens</u>: Plant specimens which cannot be determined to species in the field, or which need further verification, are collected and pressed according to standard procedure. Each specimen is assigned a field unknown number made up of the plot number and a sequential number unique to each unknown plant on the plot. For example, unknown number CNPS4-2-6 is the sixth unknown specimen collected on the second plot established in patch number 4. This number is recorded on the datasheet in lieu of a species name. When in doubt, it is preferable to record a species as unknown rather than guessing.

EQUIPMENT

50 m tape	clipboard/data sheets	*Optional:*
steel roundbar	topographic map	clinometer
compass	surveyor stakes (for marking corners)	watch with second hand

Appendix 2. Dominant species in occupied plots.

	A	B	C	D
1	LOCATION	SPECIES	MEAN % COVER	FREQUENCY
2				(total = 10)
3				
4	Lytle Creek	Avena barbata	1.85	9
5	Cone Camp	Bromus rubens	1.17	10
6	Dripping Spgs	Bromus rubens	2.8	8
7	Lytle Creek	Bromus rubens	2.4	8
8	Orange St.	Bromus rubens	1.15	7
9	San Jacinto	Bromus rubens	6.35	10
10	Tujunga	Bromus rubens	2.16	10
11	Bautista	Bromus tectorum	3.55	8
12	San Jacinto	Bromus tectorum	5.1	5
13	Dripping Spgs	Camissonia sp.	1.5	5
14	Bautista	Camissonia strigulosa	1.72	10
15	San Jacinto	Camissonia strigulosa	2.85	7
16	San Jacinto	Chaenactis glabriuscula	2.15	9
17	Cone Camp	Crassula connata	1.66	10
18	Tujunga	Crassula connata	4.9	10
19	Bautista	Dodecahema leptoceras	4.9	10
20	Bee Canyon	Dodecahema leptoceras	12.9	10
21	Cone Camp	Dodecahema leptoceras	3	10
22	Dripping Spgs	Dodecahema leptoceras	5.4	10
23	Orange St.	Dodecahema leptoceras	5.1	10
24	San Jacinto	Dodecahema leptoceras	10.6	10
25	Tujunga	Dodecahema leptoceras	4.35	10
26	Lytle Creek	Dodecahema leptoceras	7.5	10
27	San Jacinto	Erodium cicutarium	6	10
28	Cone Camp	Filago californica	5.31	9
29	Orange St.	Filago californica	3.3	9
30	Lytle Creek	Hypochaeris glabra	10.2	10
31	Bee Canyon	Lastarriaea coriacea	7.7	8
32	Lytle Creek	Lastarriaea coriacea	3.15	8
33	Tujunga	Lastarriaea coriacea	5.65	10
34	Cone Camp	Lasthenia coronaria	2.72	9
35	Bee Canyon	Lessingia glandulifera	3.1	8
36	San Jacinto	Linanthus lemmonii	2.4	7
37	Tujunga	Mucronea californica	4.38	7
38	Tujunga	Pectocarya linearis	1.52	8
39	Dripping Spgs	Plantago erecta	2.45	4
40	Orange St.	Plantago erecta	4.1	4
41	Bautista	Plantago ovata	3.45	5
42	Orange St.	Plantago ovata	8	5
43	Lytle Creek	Salvia columbare	2.3	7

Appendix 2. Dominant species in occupied plots.

	A	B	C	D
1	LOCATION	SPECIES	MEAN % COVER	FREQUENCY
2				(total = 10)
44				
45	Bee Canyon	Shismus barbatus	9.6	9
46	Tujunga	Shismus barbatus	2.35	7
47	Bee Canyon	Stylocline gnaphaloides	5.1	8
48	Lytle Creek	Stylocline gnaphaloides	5	9
49	Orange St.	Stylocline gnaphaloides	1.35	4
50	Tujunga	Stylocline gnaphaloides	3.9	10
51	Bautista	Vulpia myuros	8.15	10
52	Dripping Spgs	Vulpia myuros	7.1	9
53	Orange St.	Vulpia myuros	2.35	7
54	Cone Camp	Vulpia myuros	2.25	10
55	Lytle Creek	Vulpia myuros	3.6	9
56	Bautista	Vulpia octoflora	2.3	6
57	Bee Canyon	Vulpia octoflora	7.2	10
58	Cone Camp	Vulpia octoflora	1.95	6
59	Dripping Spgs	Vulpia octoflora	2	4

Appendix 3. Species list from small plots and transects at eight sites.

Achnatherum coronatum	NATIVE
Acourtia microcephala	NATIVE
Adenostema fasciculatum	NATIVE
Ambrosia acanthicarpa	NATIVE
Amsinkia menziesii var. intermedia	NATIVE
Antirrhinum coulterianum	NATIVE
Artemisia californica	NATIVE
Artemisia douglasiana	NATIVE
Artemisia tridentata	NATIVE
Artostaphylos sp.	NATIVE
Athysanus pusillus	NATIVE
Avena barbata	EXOTIC
Avena fatua	EXOTIC
Baccharis salicifolia	NATIVE
Bebbia juncea	NATIVE
Bromus arenarius	EXOTIC
Bromus diandrus	EXOTIC
Bromus hordeaceus	EXOTIC
Bromus madritensis ssp. rubens	EXOTIC
Bromus tectorum	EXOTIC
Bromus trinii	NATIVE
Calandrinia ciliata	NATIVE
Calochortus venustus	NATIVE
Calyptridium monandrum	NATIVE
Calystegia macrostegia ssp. intermedia	NATIVE
Camissonia bistorta	NATIVE
Camissonia californica	NATIVE
Camissonia confusa	NATIVE
Camissonia hirtella	NATIVE
Camissonia stigulosa	NATIVE
Caulanthus heterophyllus var. pseudosimulans	NATIVE
Ceanothus crassifolius	NATIVE
Centaurea melitensis	EXOTIC
Chaenactis glabriuscula	NATIVE
Chamaesyce albomarginata	NATIVE
Chorizanthe parryi var. parryi	NATIVE
Chorizanthe staticoides	NATIVE
Cirsium occidentale ssp. californicum	NATIVE
Claytonia perfoliata	NATIVE
Collinsia heterophylla	NATIVE
Conyza canadensis	NATIVE
Coreopsis californica	NATIVE
Crassula connata	NATIVE
Croton californicus	NATIVE

Appendix 3. Species list from small plots and transects at eight sites.

Cryptantha intermedia	NATIVE
Cryptantha micrantha var. lepida	NATIVE
Daucus pusillus	NATIVE
Dichelostemma capitatum	NATIVE
Dodecahema leptoceras	NATIVE
Dudleya sp.	NATIVE
Emmenanthe penduliflora var. penduliflora	NATIVE
Encelia actoni	NATIVE
Encelia californica	NATIVE
Encelia farinosa	NATIVE
Ephedra aspera	NATIVE
Eriastrum densifolium	NATIVE
Eriastrum sapphirinum	NATIVE
Ericameria linearifolia	NATIVE
Ericameria pinifolia	NATIVE
Erigeron foliosus	NATIVE
Eriodictyon crassifolium	NATIVE
Eriodictyon trichocalyx	NATIVE
Eriogonum fasciculatum	NATIVE
Eriogonum gracile	NATIVE
Eriogonum thurberi	NATIVE
Eriophyllum confertiflorum var. tanacetiflorum	NATIVE
Eriophyllum multicaule	NATIVE
Eriophyllum wallacei	NATIVE
Erodium cicutarium	EXOTIC
Eucrypta chrysanthemifolia	NATIVE
Filago californica	NATIVE
Filago gallica	EXOTIC
Galium angustifolium	NATIVE
Gilia angelensis	NATIVE
Gilia capitata ssp. abrotanifolia	NATIVE
Gilia ochroleuca ssp. bizonata	NATIVE
Gilia splendens	NATIVE
Gutierrezia californica	NATIVE
Heterotheca sessiliflora ssp. fastigiata	NATIVE
Hirshfeldia incana	EXOTIC
Hypochaeris glabra	EXOTIC
Juniperus californica	NATIVE
Keckiella antirrhinoides	NATIVE
Keckiella cordifolia	NATIVE
Lamarckia aurea	EXOTIC
Lastarriaea coriacea	NATIVE
Lasthenia chrysantha	NATIVE
Lasthenia coronaria	NATIVE

Appendix 3. Species list from small plots and transects at eight sites.

Layia platyglossa	NATIVE
Lepidium virginicum	NATIVE
Lepidospartum squamatum	NATIVE
Lessingia filaginifolia	NATIVE
Lessingia glandulifera	NATIVE
Linanthus lemmonii	NATIVE
Linaria canadensis	NATIVE
Lotus hamatus	NATIVE
Lotus scoparius	NATIVE
Lotus strigosus	NATIVE
Lupinus bicolor	NATIVE
Lupinus concinnus	NATIVE
Lupinus excubitus	NATIVE
Lupinus truncatus	NATIVE
Malacothamnus fasciculatus	NATIVE
Malacothrix clevelandii	NATIVE
Malosma laurina	NATIVE
Marah fabaceus	NATIVE
Marrubium vulgare	EXOTIC
Melilotus indica	EXOTIC
Mimulus brevipes	NATIVE
Minuartia douglasii	NATIVE
Mirabilis californica	NATIVE
Mucronea californica	NATIVE
Muilla maritima	NATIVE
Nemacladus ramosissimus	NATIVE
Nemophila menziesii	NATIVE
Oenothera californica	NATIVE
Opuntia basilaris	NATIVE
Opuntia littoralis	NATIVE
Opuntia parryi	NATIVE
Orthocarpus	NATIVE
Pectocarya linearis	NATIVE
Pectocarya penicillata	NATIVE
Pellaea mucronata	NATIVE
Phacelia distans	NATIVE
Phacelia minor	NATIVE
Plagiobothrys nothofulvus	NATIVE
Plantago erecta	NATIVE
Plantago ovata	NATIVE
Plantago patagonica	NATIVE
Poa secunda	NATIVE
Populus fremontii	NATIVE
Pterostegia drymarioides	NATIVE

Appendix 3. Species list from small plots and transects at eight sites.

Rafinesquia californica	NATIVE
Rhamnus ilicifolia	NATIVE
Salvia apiana	NATIVE
Salvia columbare	NATIVE
Sarcostemma cynanchoides ssp. hartwegii	NATIVE
Schismus barbatus	EXOTIC
Selaginella bigelovii	NATIVE
Senecio flaccidus douglasii	NATIVE
Silene antirrhina	NATIVE
Sisymbrium altissimum	EXOTIC
Solanum xanti	NATIVE
Sonchus oleraceus	EXOTIC
Stephanomeria pauciflora	NATIVE
Stephanomeria virgata	NATIVE
Stillingia linearifolia	NATIVE
Stylocline gnaphaloides	NATIVE
Thysanocarpus curvipes	NATIVE
Toxicodendron diversilobum	NATIVE
Tropidocarpum gracile	NATIVE
Uropappus lindleyi	NATIVE
Vicia ludoviciana	NATIVE
Vulpia microstachys	NATIVE
Vulpia myuros	EXOTIC
Vulpia octoflora	NATIVE
Yucca whipplei	NATIVE

Appendix 4a. Percent of shrub and tree species from 100 points per 50 m <u>LINE TRANSECTS</u> occupied and unoccupied by spineflower at eight sites. Unoccupied distant sites were used.

SHRUBS:	B	B	BC	BC	CC	CC	DS	DS	LC	LC	OS	OS	SJ	SJ	T	T
	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC
Bebbia juncea					1						3					
Encelia actonii (dead)													1			
Encelia californica	3												2			
Encelia californica (dead)													5			
Eriodictyon crassifolius								2			1					14
Eriodictyon trichocalyx										1						
Eriodictyon trichocalyx x crassifolius																5
Eriogonum fasciculatum	2				5	2	12	6	10	8					6	19
Eriogonum fasciculatum (dead)					4	1			2							
Gutierrezia californica										2					5	
Lepidospartum squamatum	5					1				4	3				9	2
Lepidospartum squamatum (dead)	4					2										
Lotus scoparius		10				2	37	38						1		
Lotus scoparius (dead)	1				1	1										
Opuntia parryi					2	2			3							
Opuntia sp. (prickly pear)					5	3										
Salvia apiana	2															
Senecio flaccidus douglasii		2														
UNK shrub dead						2										
Yucca whipplei										1					7	5
Total Points Intercepted	17	12			18	16	49	46	15	16	7		8	1	27	45
TREES:																
Populus fremontii		4														
Juniper californica			1		1							11				
Quercus agrifolia							9									

B = Bautista, BC = Bee Canyon, CC = Cone Camp, DS = Dripping Springs, LC = Lytle Creek, OS = Orange Street, SJ = San Jacinto and T = Tujunga

Appendix 4b. Presence of shrub and tree species from 5 m <u>BELT TRANSECTS</u> occupied and unoccupied by spineflower at eight sites. Unoccupied distant sites were used.

	B	B	BC	BC	CC	CC	DS	DS	LC	LC	OS	OS	SJ	SJ	T	T
SHRUBS:	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC	OC	UNOC
Adenostema fasciculatum							x									
Arctostaphylos sp.	x															
Artemisia californica					x					x						
Artemisia tridentata		x														
Baccharis glutinosa		x														
Bebbia juncea	x															
Ceanothus crassifolius							x									
Encelia californica					x	x										
Encelia farinosa						x									x	
Eriastrum densifolium							x	x								
Ericameria linearifolia						x										
Ericameria pinifolia							x									x
Eriophyllum confertifolium														x	x	
Eriogonum fasciculatum		x		x							x	x	x			
Gutierrezia californica									x							
Lepidospartum squamatum		x	x		x		x					x				
Lotus scoparius	x								x					x		
Mirabilis californica					x											
Opuntia parryi	x											x		x		
Opuntia sp. (prickly pear)					x	x				x	x	x				
Rhamnus ilicifolia				x			x	x								
Salvia apiana											x					
Senecio flaccidus douglasii		x														
Toxicodendron diversilobum				x												
Yucca whipplei			x						x			x				
Yucca whipplei (dead)												x				
TREES:																
Juniperus californica			x	x												

B = Bautista, BC = Bee Canyon, CC = Cone Camp, DS = Dripping Springs, LC = Lytle Creek, OS = Orange Street, SJ = San Jacinto, T = Tujunga.

Appendix 5. Mean percent of points intercepted for all species groups on 50 m LINE TRANSECTS occupied and unoccupied by spineflower, by location.

LOCATION		EXOTIC GRASSES	EXOTIC FORBS	NATIVE GRASSES	NATIVE FORBS	NATIVE SHRUBS
BAUTISTA	occ	70	0	0	18	17
BEE CANYON	occ	45	12	7	23	1
CONE CAMP	occ	59	5	4	32	19
DRIPPING SPRINGS	occ	89	15	13	30	49
LYTLE CREEK	occ	46	26	2	44	15
ORANGE ST.	occ	61	17	0	29	7
SAN JACINTO	occ	68	19	0	22	8
TUJUNGA	occ	62	12	0	48	27
mean	occ	62.50	13.25	3.25	30.75	17.88

LOCATION		EXOTIC GRASSES	EXOTIC FORBS	NATIVE GRASSES	NATIVE FORBS	NATIVE SHRUBS
BAUTISTA	unocc	40	1	0	17	10
BEE CANYON	unocc	47	34	2	33	0
CONE CAMP	unocc	56	10	1	31	16
DRIPPING SPRINGS	unocc	98	7	3	14	50
LYTLE CREEK	unocc	12	6	0	4	16
ORANGE ST.	unocc	38	19	2	40	11
SAN JACINTO	unocc	38	22	6	35	1
TUJUNGA	unocc	18	3	0	18	45
mean	unocc	43.38	12.75	1.75	24.00	18.63

Appendix 5. Mean percent of points intercepted for all species groups on 50 m LINE TRANSECTS occupied and unoccupied by spineflower, by location.

LOCATION		NATIVE TREES	DODECAHEMA	BAREGROUND	CRUST	LITTER	ROCK
BAUTISTA	occ	0	1	34	23	38	2
BEE CANYON	occ	0	4	51	0	38	10
CONE CAMP	occ	0	2	3	41	34	12
DRIPPING SPRINGS	occ	9	2	67	2	26	4
LYTLE CREEK	occ	0	3	0	34	3	52
ORANGE ST.	occ	0	0	20	19	50	2
SAN JACINTO	occ	0	0	24	28	51	0
TUJUNGA	occ	0	0	8	0	21	4
mean	occ	1.13	1.50	25.88	18.38	32.63	10.75
LOCATION		NATIVE TREES	DODECAHEMA	BAREGROUND	CRUST	LITTER	ROCK
BAUTISTA	unocc	0	0	73	2	23	0
BEE CANYON	unocc	0	0	10	36	46	7
CONE CAMP	unocc	0	0	16	37	45	0
DRIPPING SPRINGS	unocc	0	0	66	0	34	18
LYTLE CREEK	unocc	0	0	3	15	50	32
ORANGE ST.	unocc	0	0	18	60	28	0
SAN JACINTO	unocc	0	0	53	1	43	0
TUJUNGA	unocc	0	0	30	0	36	6
mean	unocc	0.00	0.00	33.63	18.88	38.13	7.88

Appendix 6. Detrended Correspondence Analysis output, showing raw data of species scores and sample scores that were used to create Figs. 8 and 9.

```
****************** Detrended Correspondence Analysis (DCA) *****************
PC-ORD, Version 2.0
10 May 1996, 17:06

DCAVEG.OUT
Number of non-zero data items:     1336

Downweighting selected.  Weights applied to columns, in sequential order:
  .344  .494  .372 1.000 1.000  .472 1.000 1.000  .529 1.000
 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000  .840 1.000
  .519  .892  .854 1.000  .161  .655 1.000 1.000 1.000 1.000
  .100
Axes are rescaled
Number of segments: 30
Threshold:    .00


                  ---------- Axis 1 ----------

   .151215 = residual at iteration  0
   .013283 = residual at iteration  1
   .003062 = residual at iteration  2
   .000480 = residual at iteration  3
   .000127 = residual at iteration  4
   .000021 = residual at iteration  5
   .657824 = eigenvalue


Length of gradient:      3.505
Length of segments:    .20   .19   .19   .19   .18   .17   .17   .17   .17   .
Length of segments:    .17   .18   .18   .19   .21   .23   .26   .29
Length of gradient:      3.719

Length of gradient:      4.012
Length of segments:    .19   .19   .20   .20   .19   .19   .18   .18   .18   .
Length of segments:    .18   .18   .18   .18   .19   .19   .20   .21   .21   .
Length of segments:    .21
Length of gradient:      4.064

                  ---------- Axis 2 ----------

   .117423 = residual at iteration  0
   .058055 = residual at iteration  1
   .013510 = residual at iteration  2
   .001796 = residual at iteration  3
   .000331 = residual at iteration  4
   .000051 = residual at iteration  5
   .544907 = eigenvalue


Length of gradient:      3.592
Length of segments:    .29   .27   .27   .28   .29   .28   .25   .21   .17   .


Length of segments:    .14   .14   .14   .14   .14   .15   .14   .14
```

```
Length of gradient:     4.086


Length of gradient:     4.184
Length of segments:   .20   .19   .19   .18   .18   .19   .20   .22   .23   .:
Length of segments:   .24   .22   .20   .18   .18   .18   .18   .19   .20   .:
Length of segments:   .21
Length of gradient:     4.181


                 ---------- Axis 3 ----------

   .087811 = residual at iteration  0
   .047218 = residual at iteration  1
   .003118 = residual at iteration  2
   .000180 = residual at iteration  3
   .000014 = residual at iteration  4
   .401579 = eigenvalue


Length of gradient:     2.603
Length of segments:   .26   .28   .29   .29   .27   .25   .20   .16   .12   .1
Length of segments:   .10   .09   .09   .09
Length of gradient:     3.371


Length of gradient:     3.613
Length of segments:   .18   .18   .17   .17   .17   .18   .19   .21   .23   .2
Length of segments:   .24   .24   .22   .19   .17   .16   .16   .16   .16
Length of gradient:     3.627
```

DCAVEG.OUT

SPECIES SCORES

N	NAME	AX1	AX2	AX3	RANKED 1 EIG= .658			RANKED 2 EIG= .545		
1	At_pu_	234	422	-62	6	Ca_mo_	527	24	Pl_ov_	435
2	Av_ba_	34	32	180	31	Yu_wh_	473	1	At_pu_	422
3	Br_di_	61	37	144	27	Sh_ba_	383	23	Pl_er_	394
4	Br_ru_	98	223	207	16	Lastar	345	14	Filago	367
5	Br_tec	36	317	3	21	Mu_ca_	322	5	Br_tec	317
6	Ca_mo_	527	195	114	14	Filago	315	10	Cr_co_	309
7	Camiss	224	201	59	10	Cr_co_	298	8	Ch_gl_	303
8	Ch_gl_	165	303	82	24	Pl_ov_	277	17	Lasthe	302
9	Choriz	185	-94	64	28	St_gn_	268	11	Eg_gr_	264
10	Cr_co_	298	309	74	1	At_pu_	234	12	Er_wa_	244
11	Eg_gr_	219	264	64	30	Vu_oc_	232	19	Li_le_	233
12	Er_wa_	227	244	-51	12	Er_wa_	227	4	Br_ru_	223
13	Er_ci_	155	148	115	7	Camiss	224	29	Vu_my_	221
14	Filago	315	367	275	23	Pl_er_	220	7	Camiss	201
15	Hy_gl_	143	-9	154	11	Eg_gr_	219	6	Ca_mo_	195

16	Lastar	345	50	205	18	Le_gl_	216	22	Nemacl	167
17	Lasthe	198	302	325	19	Li_le_	200	13	Er_ci_	148
18	Le_gl_	216	145	187	17	Lasthe	198	18	Le_gl_	145
19	Li_le_	200	233	-79	26	Sa_co_	192	30	Vu_oc_	130
20	Lo_st_	156	111	80	9	Choriz	185	27	Sh_ba_	129
21	Mu_ca_	322	55	202	8	Ch_gl_	165	31	Yu_wh_	114
22	Nemacl	126	167	282	20	Lo_st_	156	20	Lo_st_	111
23	Pl_er_	220	394	388	13	Er_ci_	155	21	Mu_ca_	55
24	Pl_ov_	277	435	-5	15	Hy_gl_	143	16	Lastar	50
25	Pteros	41	-56	184	22	Nemacl	126	3	Br_di_	37
26	Sa_co_	192	-59	93	4	Br_ru_	98	2	Av_ba_	32
27	Sh_ba_	383	129	167	3	Br_di_	61	28	St_gn_	19
28	St_gn_	268	19	217	25	Pteros	41	15	Hy_gl_	-9
29	Vu_my_	-1	221	218	5	Br_tec	36	25	Pteros	-56
30	Vu_oc_	232	130	239	2	Av_ba_	34	26	Sa_co_	-59
31	Yu_wh_	473	114	287	29	Vu_my_	-1	9	Choriz	-94

SAMPLE SCORES - WHICH ARE WEIGHTED MEAN SPECIES SCORES

N	NAME	AX1	AX2	AX3	RANKED 1 EIG= .658			RANKED 2 EIG= .545		
1	BA11	112	219	192	42	BC32	406	130	OS15	418
2	BA12	136	226	188	41	BC31	352	135	OS110	413
3	BA13	20	231	201	46	BC41	351	146	OS41	400
4	BA14	91	234	137	124	LC44	349	132	OS17	386
5	BA15	149	206	55	49	BC44	336	140	OS25	385
6	BA16	113	272	78	30	BC15	330	139	OS24	382
7	BA17	191	295	156	122	LC42	330	149	OS44	372
8	BA18	199	197	179	38	BC23	329	150	OS45	371
9	BA19	165	257	152	39	BC24	327	137	OS22	366
10	BA10	76	256	125	28	BC13	325	15	BA25	365
11	BA21	147	221	113	188	TU23	315	148	OS43	358
12	BA22	216	302	153	190	TU25	315	134	OS19	353
13	BA23	180	266	147	32	BC17	308	138	OS23	351
14	BA24	133	251	161	179	TU14	308	128	OS13	348
15	BA25	185	365	18	185	TU110	306	131	OS16	341
16	BA31	103	220	202	189	TU24	302	21	BA41	334
17	BA32	0	225	208	33	BC18	300	54	CC14	324
18	BA33	110	213	193	176	TU11	297	127	OS12	323
19	BA34	58	232	169	197	TU42	296	56	CC16	321
20	BA35	97	210	189	26	BC11	295	78	DS13	318
21	BA41	213	334	85	196	TU41	295	55	CC15	315
22	BA42	162	263	181	37	BC22	293	147	OS42	313
23	BA43	195	262	196	149	OS44	292	145	OS35	312
24	BA44	116	283	188	187	TU22	288	129	OS14	310
25	BA45	144	237	181	52	CC12	286	12	BA22	302
26	BC11	295	89	185	150	OS45	286	7	BA17	295
27	BC12	266	83	195	45	BC35	285	143	OS33	287
28	BC13	325	98	190	123	LC43	284	136	OS21	285
29	BC14	237	139	175	140	OS25	284	24	BA44	283

30	BC15	330	135	167	34	BC19	283	155	SJ15	276
31	BC16	166	169	214	146	OS41	278	6	BA16	272
32	BC17	308	121	203	35	BC110	277	71	CC41	272
33	BC18	300	114	200	177	TU12	277	57	CC17	271
34	BC19	283	111	200	181	TU16	275	53	CC13	270
35	BC110	277	147	184	40	BC25	273	74	CC44	270
36	BC21	262	79	194	138	OS23	272	72	CC42	268
37	BC22	293	93	201	184	TU19	269	13	BA23	266
38	BC23	329	59	200	27	BC12	266	22	BA42	263
39	BC24	327	56	204	130	OS15	266	23	BA43	262
40	BC25	273	71	206	132	OS17	265	142	OS32	262
41	BC31	352	145	168	134	OS19	265	52	CC12	261
42	BC32	406	135	160	135	OS110	264	153	SJ13	260
43	BC33	239	149	197	75	CC45	263	64	CC24	258
44	BC34	257	172	166	182	TU17	263	9	BA19	257
45	BC35	285	141	154	36	BC21	262	10	BA10	256
46	BC41	351	125	169	198	TU43	262	158	SJ18	256
47	BC42	235	155	153	44	BC34	257	65	CC25	255
48	BC43	207	143	140	200	TU45	257	69	CC34	255
49	BC44	336	120	174	56	CC16	254	123	LC43	252
50	BC45	247	130	113	61	CC21	254	14	BA24	251
51	CC11	184	221	219	183	TU18	254	60	CC110	251
52	CC12	286	261	222	54	CC14	252	154	SJ14	250
53	CC13	229	270	245	180	TU15	252	124	LC44	248
54	CC14	252	324	241	55	CC15	250	63	CC23	246
55	CC15	250	315	236	147	OS42	249	59	CC19	245
56	CC16	254	321	214	50	BC45	247	162	SJ22	242
57	CC17	197	271	254	186	TU21	247	126	OS11	241
58	CC18	186	233	239	199	TU44	246	144	OS34	239
59	CC19	167	245	244	131	OS16	243	25	BA45	237
60	CC110	233	251	165	65	CC25	240	4	BA14	234
61	CC21	254	228	182	43	BC33	239	173	SJ43	234
62	CC22	209	228	176	72	CC42	238	58	CC18	233
63	CC23	169	246	119	137	OS22	238	19	BA34	232
64	CC24	200	258	208	29	BC14	237	141	OS31	232
65	CC25	240	255	185	47	BC42	235	3	BA13	231
66	CC31	5	220	217	163	SJ23	234	122	LC42	231
67	CC32	16	214	216	178	TU13	234	164	SJ24	230
68	CC33	10	221	217	60	CC110	233	61	CC21	228
69	CC34	26	255	134	53	CC13	229	62	CC22	228
70	CC35	1	217	217	104	LC14	229	2	BA12	226
71	CC41	228	272	139	126	OS11	229	170	SJ35	226
72	CC42	238	268	47	71	CC41	228	17	BA32	225
73	CC43	193	200	151	159	SJ19	228	133	OS18	225
74	CC44	213	270	93	139	OS24	227	171	SJ41	225
75	CC45	263	67	200	128	OS13	226	174	SJ44	225
76	DS11	185	149	142	121	LC41	218	81	DS16	224
77	DS12	174	141	184	165	SJ25	217	169	SJ34	222
78	DS13	193	318	336	12	BA22	216	11	BA21	221
79	DS14	212	133	157	125	LC45	215	51	CC11	221
80	DS15	53	200	215	157	SJ17	214	68	CC33	221
81	DS16	169	224	234	21	BA41	213	16	BA31	220
82	DS17	54	214	230	74	CC44	213	66	CC31	220
83	DS18	111	190	232	79	DS14	212	90	DS25	220
84	DS19	103	185	225	106	LC16	211	93	DS33	220
85	DS110	141	179	221	114	LC24	210	152	SJ12	220
86	DS21	150	158	151	62	CC22	209	168	SJ33	220

87	DS22	135	162	209	148	OS43	208	1	BA11	219
88	DS23	146	168	174	48	BC43	207	92	DS32	219
89	DS24	120	216	203	158	SJ18	207	94	DS34	218
90	DS25	102	220	205	113	LC23	205	160	SJ110	218
91	DS31	15	215	210	105	LC15	203	167	SJ32	218
92	DS32	85	219	204	111	LC21	203	175	SJ45	218
93	DS33	92	220	207	112	LC22	202	70	CC35	217
94	DS34	52	218	208	64	CC24	200	172	SJ42	217
95	DS35	142	182	186	8	BA18	199	182	TU17	217
96	DS41	50	203	191	162	SJ22	198	89	DS24	216
97	DS42	50	203	191	57	CC17	197	91	DS31	215
98	DS43	170	166	238	23	BA43	195	165	SJ25	215
99	DS44	98	190	194	151	SJ11	194	67	CC32	214
100	DS45	57	209	206	73	CC43	193	82	DS17	214
101	LC11	110	154	160	78	DS13	193	195	TU35	214
102	LC12	152	12	152	7	BA17	191	18	BA33	213
103	LC13	161	58	178	127	OS12	191	161	SJ21	213
104	LC14	229	23	185	161	SJ21	188	151	SJ11	212
105	LC15	203	104	175	58	CC18	186	20	BA35	210
106	LC16	211	28	164	164	SJ24	186	100	DS45	209
107	LC17	136	87	175	15	BA25	185	192	TU32	209
108	LC18	151	22	108	76	DS11	185	194	TU34	208
109	LC19	171	95	167	51	CC11	184	166	SJ31	207
110	LC110	180	0	139	13	BA23	180	5	BA15	206
111	LC21	203	93	155	110	LC110	180	156	SJ16	205
112	LC22	202	74	128	160	SJ110	177	96	DS41	203
113	LC23	205	108	153	77	DS12	174	97	DS42	203
114	LC24	210	104	198	109	LC19	171	157	SJ17	202
115	LC25	144	107	209	98	DS43	170	198	TU43	202
116	LC31	36	192	216	63	CC23	169	73	CC43	200
117	LC32	22	176	204	81	DS16	169	80	DS15	200
118	LC33	22	155	195	133	OS18	169	193	TU33	199
119	LC34	39	169	195	59	CC19	167	159	SJ19	198
120	LC35	87	46	164	31	BC16	166	8	BA18	197
121	LC41	218	175	164	9	BA19	165	116	LC31	192
122	LC42	330	231	190	174	SJ44	165	83	DS18	190
123	LC43	284	252	205	22	BA42	162	99	DS44	190
124	LC44	349	248	221	103	LC13	161	191	TU31	190
125	LC45	215	80	173	102	LC12	152	163	SJ23	187
126	OS11	229	241	272	108	LC18	151	84	DS19	185
127	OS12	191	323	314	86	DS21	150	184	TU19	184
128	OS13	226	348	285	5	BA15	149	95	DS35	182
129	OS14	145	310	277	11	BA21	147	186	TU21	181
130	OS15	266	418	23	88	DS23	146	85	DS110	179
131	OS16	243	341	109	129	OS14	145	117	LC32	176
132	OS17	265	386	68	136	OS21	145	121	LC41	175
133	OS18	169	225	258	25	BA45	144	44	BC34	172
134	OS19	265	353	106	115	LC25	144	183	TU18	172
135	OS110	264	413	17	95	DS35	142	31	BC16	169
136	OS21	145	285	194	85	DS110	141	119	LC34	169
137	OS22	238	366	286	2	BA12	136	88	DS23	168
138	OS23	272	351	225	107	LC16	136	98	DS43	166
139	OS24	227	382	362	87	DS22	135	197	TU42	164
140	OS25	284	385	116	14	BA24	133	87	DS22	162
141	OS31	49	232	192	152	SJ12	126	86	DS21	158
142	OS32	40	262	125	156	SJ16	125	180	TU15	156
143	OS33	72	287	78	89	DS24	120	47	BC42	155

144	OS34	21	239	178	173	SJ43	119	118	LC33	155
145	OS35	47	312	13	155	SJ15	118	101	LC11	154
146	OS41	278	400	56	24	BA44	116	179	TU14	152
147	OS42	249	313	95	175	SJ45	116	43	BC33	149
148	OS43	208	358	0	6	BA16	113	76	DS11	149
149	OS44	292	372	118	1	BA11	112	35	BC110	147
150	OS45	286	371	33	154	SJ14	112	41	BC31	145
151	SJ11	194	212	73	83	DS18	111	190	TU25	144
152	SJ12	126	220	150	18	BA33	110	48	BC43	143
153	SJ13	95	260	39	101	LC11	110	45	BC35	141
154	SJ14	112	250	50	171	SJ41	107	77	DS12	141
155	SJ15	118	276	43	16	BA31	103	29	BC14	139
156	SJ16	125	205	142	84	DS19	103	188	TU23	139
157	SJ17	214	202	68	90	DS25	102	196	TU41	139
158	SJ18	207	256	137	172	SJ42	101	181	TU16	137
159	SJ19	228	198	125	99	DS44	98	30	BC15	135
160	SJ110	177	218	160	20	BA35	97	42	BC32	135
161	SJ21	188	213	46	153	SJ13	95	187	TU22	134
162	SJ22	198	242	33	93	DS33	92	79	DS14	133
163	SJ23	234	187	30	4	BA14	91	50	BC45	130
164	SJ24	186	230	122	167	SJ32	90	185	TU110	128
165	SJ25	217	215	6	120	LC35	87	46	BC41	125
166	SJ31	86	207	191	166	SJ31	86	178	TU13	122
167	SJ32	90	218	203	92	DS32	85	32	BC17	121
168	SJ33	70	220	208	10	BA10	76	49	BC44	120
169	SJ34	53	222	207	143	OS33	72	33	BC18	114
170	SJ35	57	226	200	168	SJ33	70	34	BC19	111
171	SJ41	107	225	179	19	BA34	58	113	LC23	108
172	SJ42	101	217	189	100	DS45	57	115	LC25	107
173	SJ43	119	234	166	170	SJ35	57	105	LC15	104
174	SJ44	165	225	131	82	DS17	54	114	LC24	104
175	SJ45	116	218	162	80	DS15	53	176	TU11	99
176	TU11	297	99	175	169	SJ34	53	28	BC13	98
177	TU12	277	96	177	94	DS34	52	177	TU12	96
178	TU13	234	122	176	96	DS41	50	109	LC19	95
179	TU14	308	152	166	97	DS42	50	37	BC22	93
180	TU15	252	156	165	141	OS31	49	111	LC21	93
181	TU16	275	137	165	193	TU33	49	26	BC11	89
182	TU17	263	217	132	195	TU35	49	107	LC16	87
183	TU18	254	172	163	145	OS35	47	27	BC12	83
184	TU19	269	184	150	191	TU31	45	199	TU44	83
185	TU110	306	128	165	142	OS32	40	125	LC45	80
186	TU21	247	181	129	119	LC34	39	36	BC21	79
187	TU22	288	134	165	116	LC31	36	189	TU24	78
188	TU23	315	139	145	194	TU34	27	112	LC22	74
189	TU24	302	78	191	69	CC34	26	40	BC25	71
190	TU25	315	144	142	117	LC32	22	75	CC45	67
191	TU31	45	190	205	118	LC33	22	200	TU45	63
192	TU32	22	209	202	192	TU32	22	38	BC23	59
193	TU33	49	199	200	144	OS34	21	103	LC13	58
194	TU34	27	208	211	3	BA13	20	39	BC24	56
195	TU35	49	214	211	67	CC32	16	120	LC35	46
196	TU41	295	139	136	91	DS31	15	106	LC16	28
197	TU42	296	164	190	68	CC33	10	104	LC14	23
198	TU43	262	202	160	66	CC31	5	108	LC18	22
199	TU44	246	83	215	70	CC35	1	102	LC12	12
200	TU45	257	63	223	17	BA32	0	110	LC110	0