EXOTIC AND NATIVE PLANT MONITORING AT JEPSON PRAIRIE PRESERVE, 2001

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EXECUTIVE SUMMARY

This report describes the development of a monitoring system to assess populations of selected exotic and native plants at the Jepson Prairie Preserve. The monitoring system is primarily based on the use of permanent belt transects (20 m wide) that traverse all of the pastures at the preserve. Transects are divided into 50 m long segments for purposes of data collection and analysis. Percent cover for each monitored species within each transect is estimated visually and assigned to one of three cover categories. Specific point/polygon mapping is used in conjunction with the transect system to monitor rarely occurring target weeds. Initial monitoring along the transects was conducted during a one week period in mid-April 2001. Two transects were resurveyed in June 2001 for comparison with spring monitoring. This report discusses the sampling method in detail and presents results of the baseline monitoring. Preliminary statistical analyses show significant associations between plant cover and soil type, burning, and grazing intensity. Among the target weeds surveyed, perennial pepperweed (*Lepidium latifolium*) appears to have spread significantly since 1995.

INTRODUCTION

Jepson Prairie Preserve is managed to maintain a Central Valley vernal pool and native grassland ecosystem. The Preserve currently supports a wide diversity of native plants as well as a number of exotic plants. Some of these exotic plants have the potential to displace native plants and seriously degrade the integrity of the ecosystem. The purpose of this project is to develop a system to monitor exotic and native plants so that changes in vegetation can be detected and hopefully corrected before they lead to serious degradation of the ecosystem.

Several factors needed to be taken into consideration in the design of the monitoring system. First, soil conditions at Jepson Prairie are diverse, both in terms of soil chemistry and microtopographical relief. These soil factors strongly influence plant distribution. Hence, in order to make valid comparisons between different years, variation due to differences in soil type or microtopography should be eliminated. This is most readily accomplished by ensuring that the same specific areas are resurveyed in successive years. Otherwise, changes observed may be due to positional change of the observer rather than to actual change in species composition.

Second, the monitoring method needs to be as independent of observer bias as possible. Monitoring will be conducted over a period of many years, so it is likely that different personnel will be collecting data in different years. Subjective cover ratings, such as those used in the 1995 survey (The Nature Conservancy 1996) may be interpreted differently by different evaluators. If the cover of a given species is assigned different cover ratings by different observers, variation is added to the data set which obscures actual cover changes. To the degree possible, vegetation assessments need to be objective and quantifiable to reduce this source of error. However, given the constraints of time and resources available for monitoring, assessment methods must also be relatively simple and fast, while still maintaining a high level of reproducibility.

Changes in weather conditions, such as the timing and amount of winter rainfall, can favor some species and disfavor others. Hence, some of the year to year variation in vegetation composition will be associated with weather conditions alone. By minimizing error associated with other controllable factors, such as location and observer bias, our ability to model the variation associated with weather will be improved.

One of the major questions for preserve managers is whether management practices such as burning and grazing are having their desired effects and whether changes in the timing, frequency, and/or intensity of these practices can be used to provide more effective control of target weeds. The data from the annual native and exotic plant monitoring may be used to assess the impacts of various management inputs, but only certain comparisons may be valid if multiple factors that affect plant cover are confounded. Planned studies are needed to investigate the effects of various management regimes, but the design and execution of such studies is beyond the scope of the monitoring effort. Nonetheless, the monitoring data can be used to address certain management questions and may also provide information that can be used to form hypotheses that can be tested through controlled experiments.

METHODS

Plant species monitored

Targeted exotic plants to include in weed monitoring were chosen based on conversations with Foundation staff, and review of the earlier weed monitoring program results by The Nature Conservancy (1996). The targeted weeds have the potential to displace native species at the preserve. With the exception of *Taeniatherum caput-medusae*, most target weeds (Table 1) currently have relatively limited distributions and/or populations. Controlling the spread and/or density of the targeted exotics may be possible through available management practices. A number of common weedy species, including *Bromus diandrus* (ripgut brome) and *Lolium multiflorum* (annual ryegrass), have not been included on the list because they are widespread, occur in relatively high densities, and are not currently thought to be manageable. The targeted weed species include perennial forbs, late season annual forbs, and grasses. *Erodium* spp. were included in the monitoring of exotics to represent the early season exotic forb plant guild (Pollak and Kan 1998) even though they are not considered to be targeted exotics.

The list of plants to include in native plant monitoring (Table 2) was chosen after consulting with Kevin Rice (UC Davis) and Carol Witham (Vernalpools.org). Species were selected as common representatives of native plant guilds (native graminoids, native early forbs, and native late forbs) described in Pollak and Kan (1998).

Transect based monitoring

We established a system of parallel belt transects which form the backbone of the monitoring effort (Figures 1 and 2). We placed at least 1 transect in each pasture. We used the mapped soil types (Bates 1977) to guide placement of transects to ensure that most or all of the soil types present within each pasture were represented within that pasture's transect(s). In a few instances, transects were divided into offset segments or legs to avoid areas that could not be sampled (e.g., pond in Norris pasture, transect 18).

We used a handheld Garmin® 12XL GPS receiver operating without differential correction to establish the starting point of each transect and to navigate along transects in the field. The GPS display was set to UTM coordinates which display position as X and Y coordinates in meters. Each transect was divided into segments 50 m long. Segment length was determined using GPS readings. For each transect segment, an area extending out approximately 10 m on either side of the centerline of the transect was evaluated. Hence, each transect segment covered an area of about 1000 m^2 (50 by 20 m = 0.1 ha). A measuring tape was used to help the evaluators determine the 10 m distance from the centerline initially and was used for spot checking visual distance estimates during the evaluation. Because the length of most transects was not an exact multiple of 50, the final segment in most transects was either slightly longer or shorter than the 50 m target length. The total area surveyed in the transect system amounts to about 5% of the total area of the pastures at the Jepson Prairie Preserve, excluding Olcott Lake (Table 3). The distribution of transect segments by pasture is shown in Table 4.

We placed a cylindrical galvanized steel post (about 1.2 m tall) with an attached perforated galvanized plate (8 by 18 cm) at the start and end of each transect. The 6 posts that are not located adjacent to fence lines (transects 4, 15 and 18) are also painted with red heat-resistant paint to increase their visibility.

Table 1. Monitored exotic plant species arranged by plant family.

Common name	**Scientific name**	**Category**	**Abbreviation used occasionally in report**
Apiaceae			
Fennel	*Foeniculum vulgare*	late perennial forb	
Asteraceae			
Italian thistle	*Carduus pycnocephalus*	late annual forb	*ItalT*
Yellow star-thistle	*Centaurea solstitialis*	late annual forb	*YST*
Purple star-thistle	*Centaurea calcitrapa*	late annual forb	*PST*
Bull thistle	*Cirsium vulgare*	late annual forb	
Wild lettuce	*Lactuca serriola*	late annual forb	*Lact*
Milk thistle	*Silybum marianum*	late annual forb	
Cocklebur	*Xanthium strumarium*	late annual forb	
Brassicaceae			
Perennial pepperweed	*Lepidium latifolium*	late perennial forb	*Pep*
Geraniaceae			
Filaree[1]	*Erodium* spp.	early annual forb	
Poaceae			
Goat grass	*Aegilops cylindrica*	annual grass	
Medusahead grass	*Taeniatherum caput-medusae*	annual grass	*Med*

[1]*Erodium* spp. are not considered to be target weeds.

Table 2. Monitored native plants arranged by plant family.

Common name	**Scientific name**	**Category**	**Abbreviation used occasionally in report**
Asteraceae			
Goldfields	*Lasthenia* spp. (species with conspicuous ray flowers, including *L. californica* and *L. fremontii*)	early annual forb	*Goldfields*
Yarrow	*Achillea millefolium*	late perennial forb	*Achillea*
Poaceae			
Annual hairgrass	*Deschampsia danthonioides*	annual grass	*Desch*
Semaphore grass	*Pleuropogon californicus*	annual grass	*Pleuro*
Purple needle grass	*Nassella pulchra*	perennial grass	*Nassella*
Scrophulariaceae			
Butter and eggs	*Triphysaria eriantha* ssp. *eriantha*	early annual forb	*Triphys*
Violaceae			
Johnny-jump-up	*Viola pedunculata*	early perennial forb	*Viola*

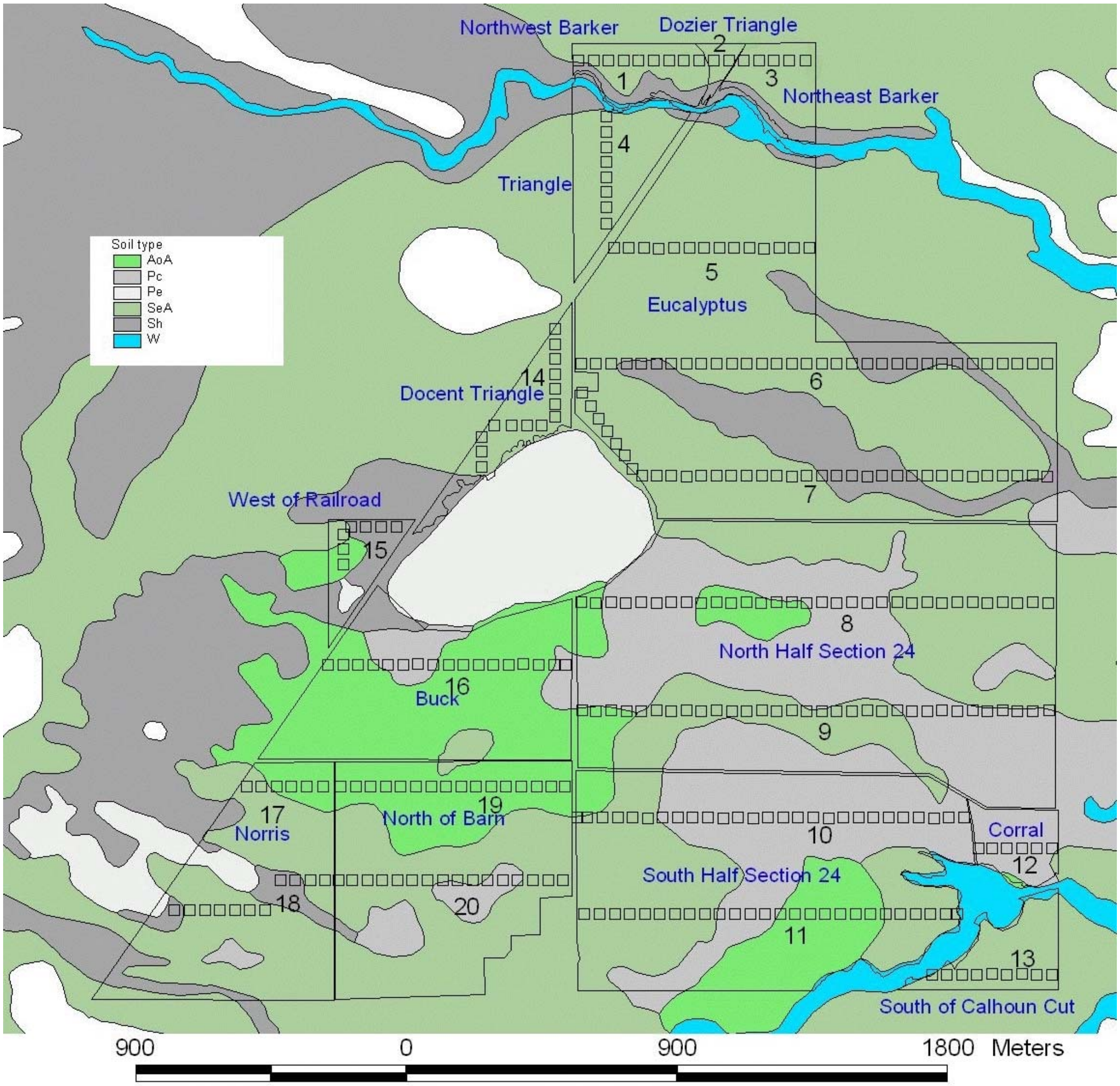


Figure 1. Transect segment locations superimposed on pasture map and soil types. Pasture names are in blue. Numbers assigned to each transect (1 to 20) are shown in black. Black squares which mark transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

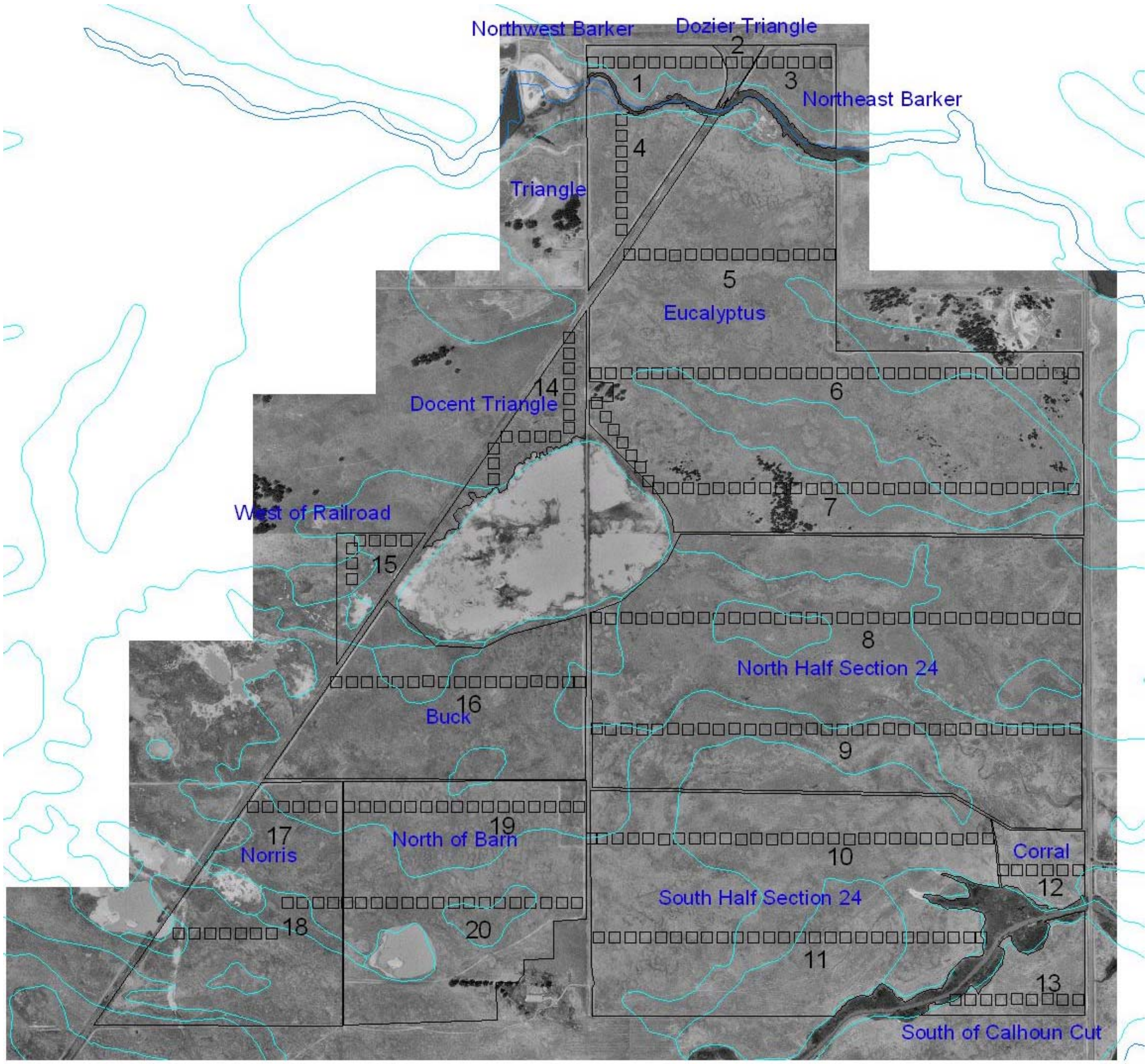


Figure 2. Transect segments, pasture outlines, and soil type outlines superimposed on digital ortho imagery of the preserve (June 1993). Soil type outlines are in light blue. Pasture names are in dark blue. Numbers assigned to each transect (1 to 20) are shown in black. Black squares which mark transect segments are centered over the midpoint of the segment and are not to scale.

Table 3. Transect dimensions relative to Jepson Prairie Preserve acreage.

Total transect length	16,115 m (10 miles)
Transect width	20 m
Total area covered by transects	32.23 ha
Total Preserve pasture area	602.8 ha (1,490 acres)
Percent sampled in transects	5.35%

Table 4. List of pastures monitored, including approximate pasture areas (based on grazing records), transect segments, and approximate sample percentage. Please note that pasture areas calculated from ArcView differ from those used in grazing records. To maintain consistency with other documents, we have used areas reported in the grazing records. Areas of the nongrazed Docents, Dozier, and West of Railroad pastures are based on ArcView calculations because their areas are not reported in grazing records.

Pasture	Approximate area (acres)	Approximate area (ha)	Transect number(s)	Number of transect segments	Approximate sample percentage
Buck	100	40	16	17	4
Corral	20	8	12	6	7
Docents	23	9	14	14	15
Dozier	3.5	1.4	2	2	14
Eucalyptus	370	150	5, 6, 7	81	5
Norris	120	49	17, 18	17	4
North Half Section 24	340	138	8, 9	64	5
North of Barn	150	61	19, 20	32	5
Northeast Barker	15	6	3	5	8
Northwest Barker	15	6	1	9	15
South Half Section 24	248	100	10, 11	53	5
South of Calhoun Cut	35	14	13	9	6
Triangle	35	14	4	8	6
West of Railroad	15	6	15	7	12

Plant cover estimates

We visually estimated the amount of cover of each of the monitored plant species within each transect segment using the cover classes shown in Table 5 below. We developed visual depictions of the cover classes to aid evaluators in assigning cover classes.

Table 5. Cover classes used for estimating exotic and native plant cover.

Cover class rank	Plant cover	Equivalent area within 0.1 ha transect segment
0	Not observed	Not observed
1	>0 to <1% cover	<10 square meters
2	1% to 10% cover	10 to 100 square meters
3	>10% cover	>100 square meters

Initial weed and native plant cover ratings were made between 12 and 18 April 2001 by the authors of this report. On 23 June 2001, we reassessed weed cover in transects 6 and 8 (Figure 1) to determine how weed ratings are affected by the assessment date.

Polygon monitoring

We also tested the use of GPS receivers to map polygons (large patches) and/or points (small patches) that represent populations of certain weed species observed beyond the transects. For mapped weeds we recorded species and the number of weeds present by approximate count classes (1-10, 11-50, 51-100, 101-500, >500). We also characterized the predominant microtopography at the site of weed occurrence using the following categories: depressed area (e.g. swale or pool), flat (average elevation), or elevated area (e.g., mound). Individual weeds or small patches (<10 m along one axis) were recorded as points. Larger patches were mapped by recording the coordinates of two or more points along the outer border of the patch.

Additional site variables

GIS layers of the mapped soil type were downloaded from the USDA National SSURGO database. Grazing records for the interval July 1993 through June 2000 were obtained from the grazer through SCFOSF and were entered into a spreadsheet for summarization and calculation of derived variables. Grazing data were expressed as average AUM (animal unit months) per acre for each pasture. We also obtained fire records for the period 1995 through 2000 from Ken Poerner of SCFOSF. No burning occurred in 1996, 1997, or 1998.

Data analysis

We used JMP statistical software (SAS Inc., Cary NC) for data analysis. Unless otherwise indicated, effects or differences are referred to as significant if $P \leq 0.05$. The individual cover class ranks were treated as ordinal variables. We used ordinal logistic regression to test for effects of selected predictors on the cover rank outcome. We also used analysis of variance and analysis of covariance to compare sums of cover class ranks. For these analyses, sums of cover class ranks within transect segments were transformed to the square root of (rank sum + 0.5) prior to analysis to stabilize the variance (Steele and Torrie 1960). We used a paired t-test to compare April and June monitoring results.

RESULTS AND DISCUSSION

Comparison of spring and summer ratings

Native species

At the time of the April survey, *Lasthenia* spp. were at peak bloom to slightly past, most *T. eriantha* and *V. pedunculata* were past peak bloom, and *A. millefolium* was just starting to bloom. Most *D. danthonioides* and *P. californicus* plants were fully headed out whereas most *N. pulchra* were vegetative or just beginning to head. Overall, these plants were at nearly optimal stages for cover estimation at the time of the April survey. In areas where sheep had recently grazed, the tops of *D. danthonioides* and *P. californicus* were eaten off, making assessments of these species more difficult. In general, few areas had been affected by recent sheep grazing at the time of the April monitoring.

We did not attempt to reassess native cover in the June survey. None of the monitored native annual species could be reliably assessed in June because they were entirely dry, often largely destroyed by grazing and trampling, and in some areas, overtopped by later maturing vegetation. Only *N. pulchra* and *A. millefolium* could have been rated at that time. Based on our observations during the June rating, ratings for these species would not have differed between April and June.

Exotic species

In April, *Erodium* spp. ranged from full bloom to past bloom. In areas where it was past bloom the distinctive fruits generally made this species quite obvious. *Erodium* spp. were relatively easy to detect, but because they occurred at relatively high densities, cover ratings for *Erodium* spp. tended to require a high level of mental effort on the part of the evaluator. Cover for these species could not be reliably rated in June.

In general, the targeted exotics were less obvious in April than June because many of these are summer annuals. *L. serriola* and most of the thistles had not yet started to bolt in April, and so were somewhat less obvious then than they were in June. *L. latifolium* was beginning to bolt in April and was readily observed in both April and June surveys. *T. caput-medusae* had not headed out in all areas by the April survey, so observations of the previous year's thatch was often necessary to confirm the presence of vegetative plants. It was also difficult to rate *T. caput-medusae* cover in June. *A. cylindrica* was not observed in transects monitored in April or June.

We used paired t-tests to compare results of April and June ratings on the same transect segments. These test showed that only *L. serriola* cover was rated significantly lower in April than in June ($P>|t|=0.0066$). Of the 64 transect segments scored in April and June, *L. serriola* was detected in 12 segments in April but was found in 24 transect segments in June (Figure 20). In April, the small green *L. serriola* rosettes were often hidden by taller grasses and from a distance resembled rosettes of other native composites. In June, the green inflorescences of *L. serriola* were quite evident against the brown background of lodged dried grasses and forbs, even though some inflorescences had been partly removed by sheep. None of the *L. serriola* June cover rank estimates were greater than 1% cover.

Although the mean difference in April and June ratings for *T. caput-medusae* was essentially zero, April and June cover ratings for this species were different in 39% (25/64) of the transects segments. Most of these differences (16/25=64%) were shifts of a single cover rating class; the remainder were differences of 2 classes. However, because 13 of the June ratings were higher and 12 lower than April ratings on the same segments, there was no directional shift in the overall mean ratings for these pastures. Changes in cover ratings could reflect real differences in cover between April and June due to the stage of plant development and/or shifts in transect position related to GPS navigation errors. Some of the differences, especially single class shifts could be related to visual estimation differences, especially when the rated cover is close to the class edge (e.g., near 1% or 10% cover). Only one segment scored as lacking *T. caput-medusae* in April was found to have this species in June (cover rating 1). However, 9 segments scored as positive for *T. caput-medusae* in April were scored as negative in June. Subsequent grazing and site conditions in June may have made *T. caput-medusae* more difficult to detect at that time.

For the *C. pycnocephalus* and *C. solstitialis*, very few transect segments had different ratings in April and June (5 and 1, respectively). For *L. latifolium*, April and June ratings did not differ in any segment.

For several reasons, we believe that the timing of the April survey was optimal for a one-time survey of the native and exotic plants. Most of the monitored natives can only be assessed readily in spring near peak bloom. Furthermore, with the exception of *L. serriola*, target weed species were no more likely to be detected in June than in April, and mean cover ratings did not differ between these two dates. Because *L. serriola* is not a high priority weed species and any errors of omission are likely to occur in areas where the density of this species is low, a reduced detection efficiency for this species is unlikely to adversely affect weed monitoring objectives. Also, differences in *T. caput-medusae* ratings in April and June were not sufficient to change overall averages or to alter inferences drawn from the data. Finally, field conditions were much more pleasant in April than in June. This is a significant factor because it is anticipated that trained volunteers will be used for the annual monitoring. We believe that it would be far easier to recruit and retain volunteers for spring monitoring than summer monitoring, and that evaluators would become fatigued (and presumably less efficient) less quickly in the spring than in the summer.

Overall species distribution

April cover ratings by transect segment for each monitored species are graphically depicted at the end of this report. Native species are shown in Figures 9-15, *Erodium* is shown in Figure 16, and the target weed species are depicted in Figures 17-25. These figures are ArcView presentations of the transect data and various base map information. The GIS and database files used to produce these figures have been transmitted to SCFOSF with this report.

Three of the monitored natives (*Lasthenia* spp., *T. eriantha*, *N. pulchra*) and two monitored exotics (*Erodium* spp., *T. caput-medusae*) occurred in well over 50% of the transect segments in April (Figures 3, 4). As noted above, because *L. serriola* was not efficiently detected in April, it is possible that this species also occurred in close to 50% of the transect segments. The remaining native species occurred in less than 40% of the transect segments, whereas the remaining weed species were present in less than 20% of the segments. *Erodium* spp. and *Lasthenia* spp. were not only the most commonly encountered species overall, but had the greatest overall cover of all monitored species (Figures 3, 4).

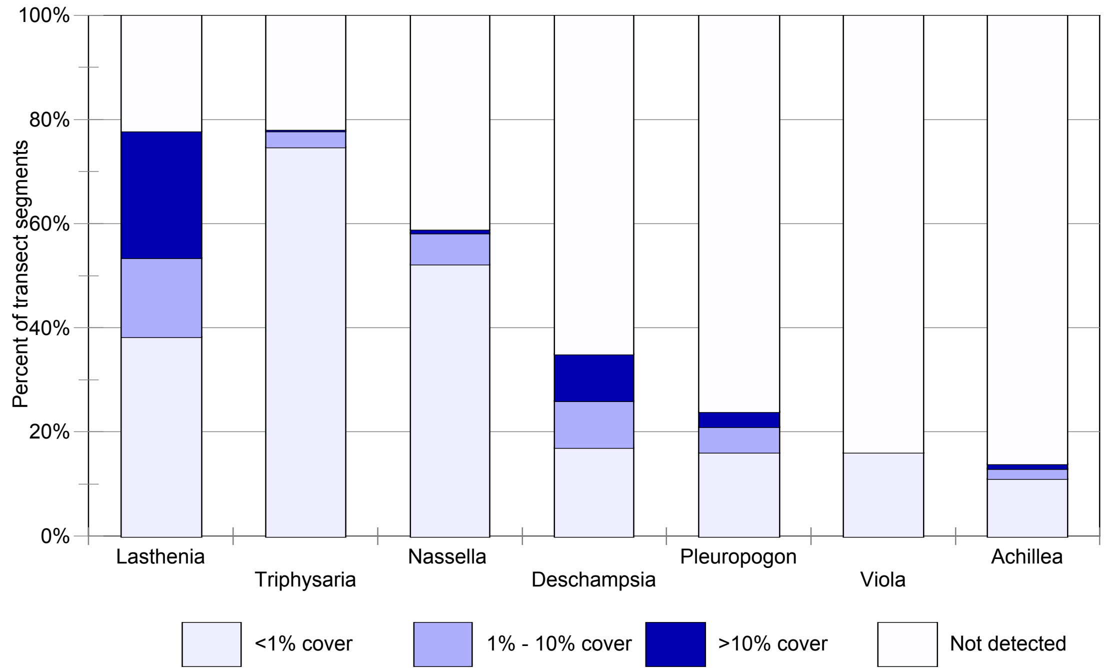


Figure 3. Percent of transect segments containing each cover class for monitored native plants, April 2001.

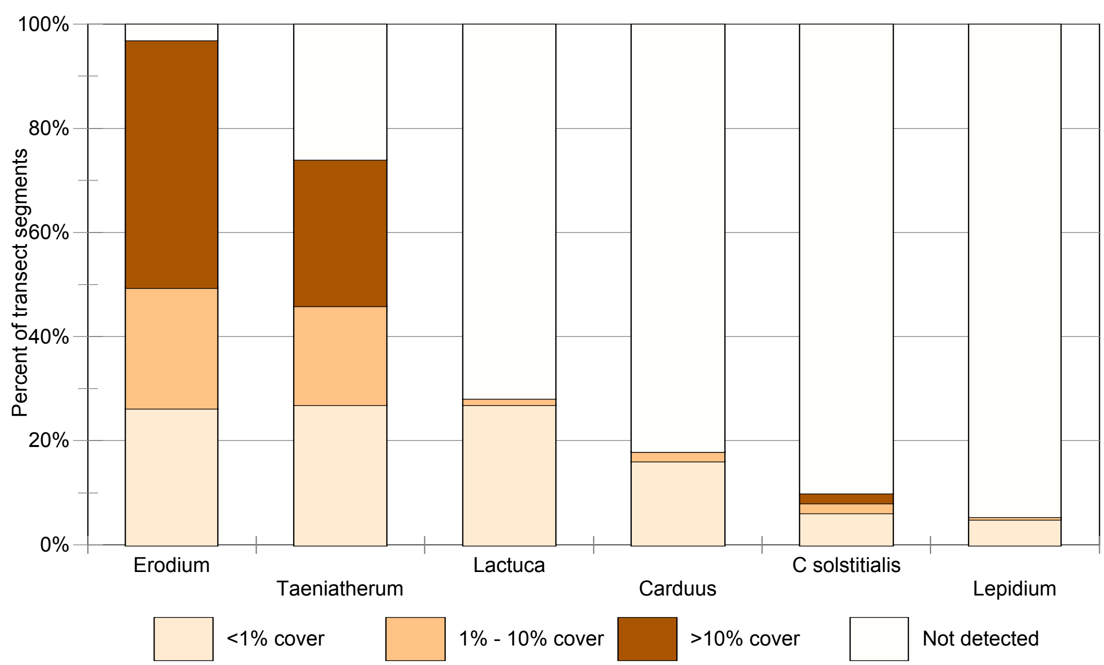


Figure 4. Percent of transect segments containing each cover class for monitored exotic plants, April 2001.

Most transect segments contained more than 1 target native plant species (Table 6). Only 3% of the transect segments contained no monitored native species, although undoubtedly these transects contained other native species that we did not monitor. No target weed species were seen in 17% of the transect segments (Table 6). It is also apparent from Table 6 that the count of native species per segment is distributed in a roughly symmetrical fashion about the midpoint. In contrast, the distribution of weed species counts is markedly left skew, as would be expected if most weed species monitored were relatively rare.

Among the monitored exotics, *F. vulgare, C. calcitrapa, S. marianum, X. strumarium* and *A. cylindrica* did not occur within the transects. We marked the coordinates of these species and *C. vulgare* using the GPS when we observed them in areas outside of the transects (see polygon monitoring below). In general, these outlying weed populations were more obvious in June than in April, with the exception of *A. cylindrica,* which was not observed.

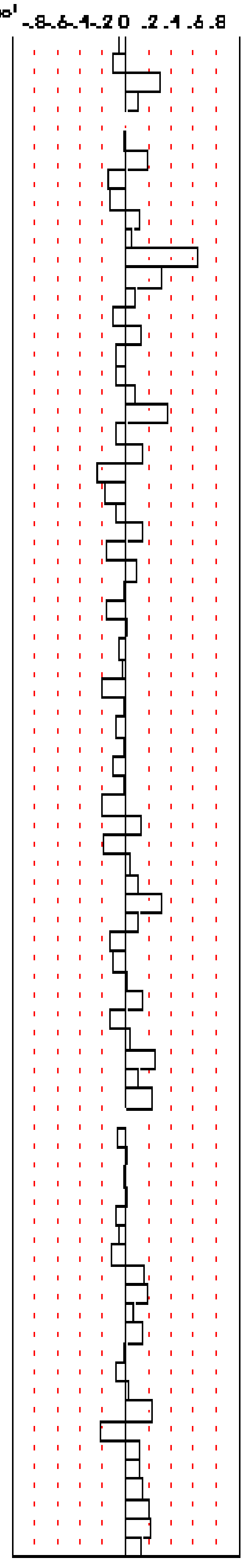
Table 6. Percent of transect segments having various number of target species. *Erodium* spp. are excluded from the counts of exotics.

Target species per transect segment	Percent of segments	
	Native species	Targeted exotic species
0	3	17
1	10	47
2	20	24
3	29	9
4	24	3
5	11	0.3
6	2	

To assess associations between different plant species statistically we used the nonparametric Spearman's Rho correlation coefficient (Figure 5). This correlation coefficient is computed on the ranks of the data values instead of on the values themselves. As expected, cover ranks for certain species are correlated, in large part because they are correlated with soils and moisture regimes within transect segments. For example, cover of *Lasthenia* spp., *D. danthonioides*, and *P. californicus* are positively correlated. All three of these species are most common in and near swales, pools, and playas. Likewise, *V. pedunculata* and *A. millefolium*, which are found almost exclusively on mounds and uplands, are positively correlated. An interesting negative correlation is that observed between *Erodium* spp. and *Lasthenia* spp. Based on our observations, we believe that this negative correlation may reflect differences in salinity tolerance between these species groups. However, the positive correlation between the weeds *C. solstitialis* and *L. latifolium*, which tend to occupy different microhabitats, is more likely related to the fact that both were common in the rather weedy pastures in the northern portion of the preserve. It is important to remember that correlations may exist between species for a variety of reasons, including chance, and that correlation does not imply a cause and effect relationship.

Figure 5 overleaf. Spearman's Rho correlation coefficients between target species evaluated in April 2001 at Jepson Prairie Preserve. The significance of each correlation coefficient is shown in the column to the left of the bar chart. Species codes used in this figure are listed in Tables 1 and 2.

Variable	by Variable	Spearman Rho	Prob>|Rho|
Desch	Nasella	-0.0559	0.3159
Pleuro	Nasella	-0.1120	0.0439
Pleuro	Desch	0.2976	<.0001
Triphys	Nasella	0.1079	0.0524
Triphys	Desch	0.0040	0.9435
Triphys	Pleuro	-0.0060	0.9144
Viola	Nasella	0.1915	0.0005
Viola	Desch	-0.1509	0.0065
Viola	Pleuro	-0.1389	0.0124
Viola	Triphys	0.1175	0.0346
Goldfield	Nasella	0.0565	0.3107
Goldfield	Desch	0.6342	<.0001
Goldfield	Pleuro	0.3241	<.0001
Goldfield	Triphys	0.0933	0.0937
Goldfield	Viola	-0.1078	0.0526
Achillea	Nasella	0.1286	0.0206
Achillea	Desch	-0.0803	0.1494
Achillea	Pleuro	-0.0798	0.1516
Achillea	Triphys	0.0866	0.1196
Achillea	Viola	0.3741	<.0001
Achillea	Goldfield	-0.0735	0.1871
Med	Nasella	0.1583	0.0043
Med	Desch	-0.2409	<.0001
Med	Pleuro	-0.1783	0.0013
Med	Triphys	-0.0759	0.1727
Med	Viola	0.1457	0.0086
Med	Goldfield	-0.1711	0.0020
Med	Achillea	0.1005	0.0709
YST	Nasella	-0.0135	0.8090
YST	Desch	-0.1730	0.0018
YST	Pleuro	0.0105	0.8501
YST	Triphys	-0.0522	0.3488
YST	Viola	-0.0346	0.5349
YST	Goldfield	-0.2128	0.0001
YST	Achillea	-0.0239	0.6677
YST	Med	-0.0815	0.1431
ItalT	Nasella	-0.0179	0.7482
ItalT	Desch	-0.1147	0.0390
ItalT	Pleuro	-0.0137	0.8063
ItalT	Triphys	-0.2072	0.0002
ItalT	Viola	0.1342	0.0156
ItalT	Goldfield	-0.1850	0.0008
ItalT	Achillea	0.0349	0.5312
ItalT	Med	0.1080	0.0520
ItalT	YST	0.3198	<.0001
lact	Nasella	0.1142	0.0399
lact	Desch	-0.1457	0.0086
lact	Pleuro	-0.1171	0.0351
lact	Triphys	0.0147	0.7916
lact	Viola	0.1441	0.0094
lact	Goldfield	-0.1399	0.0117
lact	Achillea	0.0440	0.4301
lact	Med	0.2735	<.0001
lact	YST	0.1064	0.0557
lact	ItalT	0.2373	<.0001
Pep	Nasella	0.0053	0.9243
Pep	Desch	-0.0622	0.2644
Pep	Pleuro	0.0076	0.8911
Pep	Triphys	-0.0229	0.6814
Pep	Viola	0.0120	0.8301
Pep	Goldfield	-0.0881	0.1133
Pep	Achillea	-0.0574	0.3030
Pep	Med	-0.1265	0.0228
Pep	YST	0.1652	0.0029
Pep	ItalT	0.1865	0.0007
Pep	lact	0.0676	0.2249
Erodium	Nasella	0.1459	0.0085
Erodium	Desch	-0.0074	0.8951
Erodium	Pleuro	-0.0928	0.0953
Erodium	Triphys	0.0175	0.7541
Erodium	Viola	0.2332	<.0001
Erodium	Goldfield	-0.2218	<.0001
Erodium	Achillea	0.1199	0.0309
Erodium	Med	0.1274	0.0218
Erodium	YST	0.1426	0.0101
Erodium	ItalT	0.2127	0.0001
Erodium	lact	0.2202	<.0001
Erodium	Pep	0.1326	0.0170



Overall correlations between targeted weeds and natives

As an initial attempt to produce a general index of weed and native plant cover, we summed the cover ranks for each of the targeted weeds and natives for each segment. A high rank sum for a species group (native or exotic) generally indicates that a high cover and/or diversity of the monitored species for that group. Thus, a desirable vegetation outcome is a high rank sum for native species and a low rank sum for target weeds. *Erodium* spp. ratings were omitted from these calculations because current management is not directed either for or against these exotic species.

Across all transect segments, rank sums for weed cover tend to be inversely correlated with rank sums for native plant cover (Spearman's Rho=-0.245, $P<0.0001$, $n=324$). While this is generally consistent with the hypothesis that target weeds tend to displace native species, other alternative explanations cannot be ruled out. For example, areas with certain soil conditions may be both favorable to native species and unfavorable for most target weed species or disturbance regimes in certain areas may have both favored weed populations and disfavored establishment of native species. The latter situation clearly exists in the Eucalyptus pasture in areas around the old eucalyptus stumps.

Unweighted versus weighted cover rank sums

One potential problem with using straight rank sums as an index for overall weed and native cover is that cover classes are unweighted and therefore do not correspond directly to the percent cover range represented by each rating (Table 5) . However, assigning appropriate weighting factors to the ranks is difficult because the frequency distributions of plant cover are generally left skewed rather than normally distributed. Because of this distribution, weighting each rating by the midpoint of its respective interval would overweight the higher ranks. Furthermore, the maximum cover represented in cover class 3 (>10% cover) is unknown, although it is far less 100%. Hence, the appropriate central value for cover class 3 is not obvious.

We empirically tested a range of possible weightings for the ranks and examined the resultant frequency distributions. The best weighting we tested was a progressive 3-fold weighting of the ranks (i.e., 1,3,9). While this weighting tends to accentuate differences, such as those between pastures (discussed below), the overall pattern of differences is the same using weighted or unweighted ranks. Although the use of a weighted rank sum may be worth investigating further when additional data are gathered, we have used the unweighted rank sums as a somewhat conservative index of plant cover and diversity for this report.

Overall target weed and native cover by pasture

Rank sums of native and weed cover averaged by pasture are shown in Figure 6. Rank sum averages generally reflect our overall impressions of the pastures. In general, the northernmost fields (Dozier, NE and NW Barker, and portions of Eucalyptus), as well as the Corral and S of Calhoun Cut pastures had higher populations of target weeds and lower cover of monitored native species than other fields. In contrast, the southwestern pastures (Buck, North of Barn, Norris) had below average weed populations and relatively high cover of monitored native species, especially *Lasthenia* spp. and *D. danthonioides*. The South half of Section 24 pasture stands out as a pasture with relatively high levels of both natives and weeds. Overall, significant differences exist between pastures in the rank sums for both natives and target weeds ($P<0.0001$ one way ANOVA for square root transformed rank sums). However, cover rank sums for both natives and weeds varied widely within pastures (Figure 6).

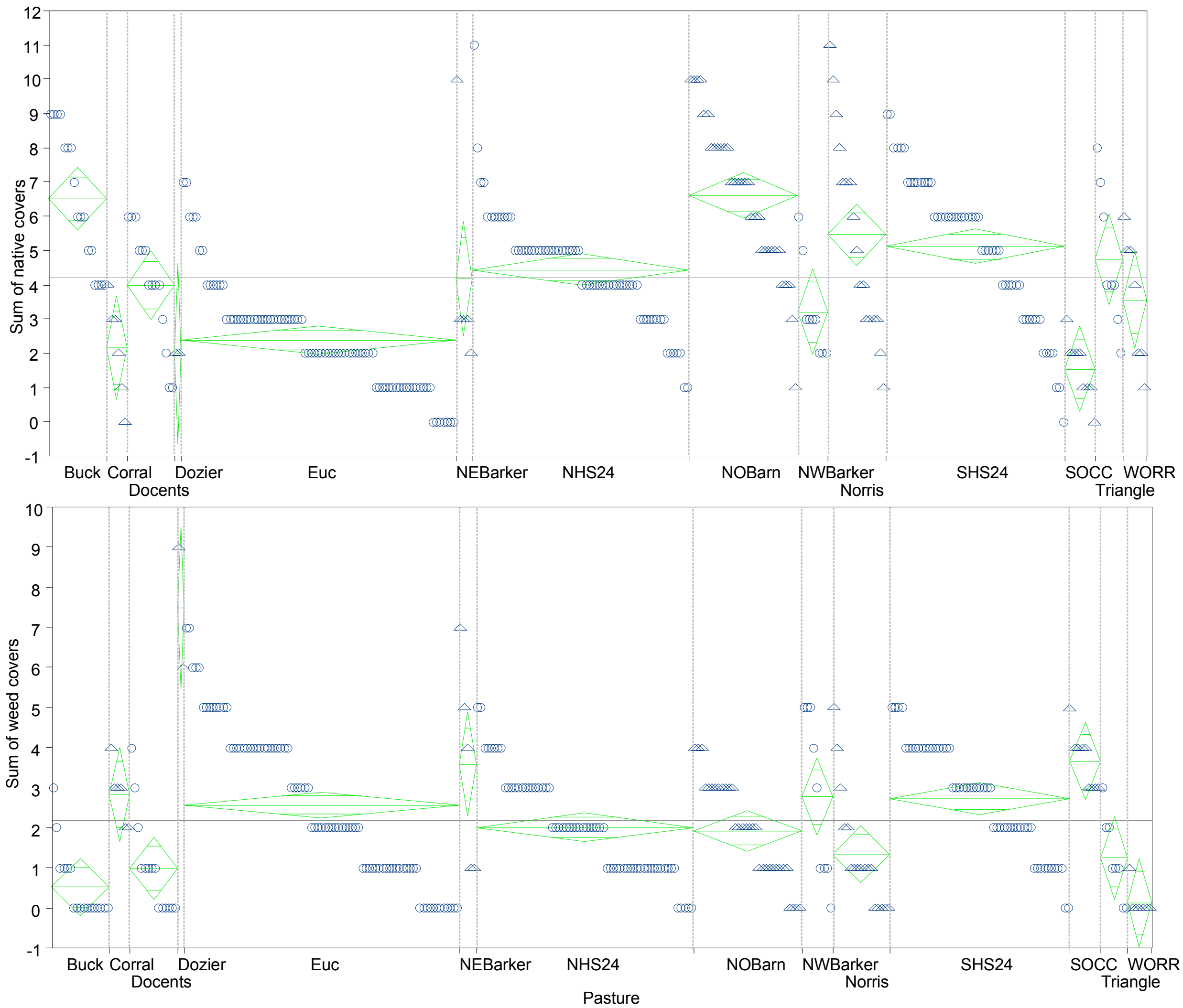


Figure 6. Plot of rank sums for native species (top) and target weed species (bottom) by pasture at Jepson Preserve. Individual segment rank sums are shown alternately as circles or triangles for clarity. The horizontal line in each graph represents the overall average. The center line of each diamond represents the mean for the pasture; the vertical extent of each diamond represents the 95% confidence interval based on a pooled variance for all segments. The horizontal spread of each diamond is proportional to the number of transect segments in each pasture. *Erodium* cover is not included with either the native or target weed covers.

Soil type and the distribution of target exotic and native species

Soil type is one of the factors that influence the distribution of monitored natives and target weeds among pastures. As shown in Figure 1 and Table 7, different soil types are represented to varying degrees in the different pastures, and the transects sample a subset of the soil variation found within each pasture. Pescadero clay, one of the five soil types mapped at Jepson Prairie, (Bates 1977) did not occur within the transects because it occurs only beneath large vernal pools including Olcott Lake. The remaining four soil types were represented to varying degrees in the transects (Table 7).

According to Bates (1977), two of these soils, Pescadero clay loam (Pc) and Solano loam (Sh) may be slightly to highly saline (ECe=4-8 and 2-10 dS/m, respectively). Pescadero clay loam has an alkaline soil reaction (pH 7.9-9.0+) whereas Solano loam's reaction is somewhat acidic (pH 5.1-6.5) in the surface soil. San Ysidro sandy loam (SeA) and Antioch - San Ysidro complex (AoA) are nonsaline soils with slightly acidic (pH 5.6-6.5) surface horizons. Areas mapped to Solano loam and Antioch-San Ysidro complex can contain small amounts of the other soil types (Bates 1977).

Soil salinity is likely to play a large role in the distribution of plant species at Jepson Prairie for several reasons. First, because plant species vary in their ability to grow in saline soils, only salt-tolerant species are able to colonize areas with highly elevated salinity levels. Salt tolerant plants may also have a competitive advantage over salt sensitive species in areas where soil salinity is elevated, but below critical thresholds. Furthermore, in soils where salinity is correlated with high levels of exchangeable sodium (saline-sodic soils), resulting soil deflocculation leads to slow drainage and hence longer periods of ponding in the winter and spring.

In the absence of actual soil salinity data, we used the dominance of saltgrass (*Distichlis spicata*), the presence of efflorescence on the soil surface, and overall plant growth to identify areas likely to be affected by excess salinity. Of the species monitored, our observations led us to believe that that *Erodium* spp. are among the most salt sensitive species, whereas *Lasthenia* spp. is among the most salt tolerant. Among the two native annual grasses, *D. danthonioides* appeared to be much more tolerant of salinity than *P. californicus*. We believe that a better understanding of the variation in soil salinity across the preserve and the relative salt sensitivity of various native and exotic species present would aid in the interpretation of vegetation dynamics at the preserve.

For both target weeds and natives, the effect of soil type on the cover rank sums was highly significant in a one-way analysis of variance ($P < 0.0001$, square root transformed data). Transect segments assigned to San Ysidro sandy loam had the highest levels of target weeds overall (Figure 7, lower graph), whereas segments assigned to the Antioch-San Ysidro complex and Pescadero clay loam had the highest levels of monitored native species (Figure 7, upper graph). The fit of the ANOVA model for soil type was better for native cover than for weed cover (adjusted $R^2 = 0.1333$ for natives and 0.0681 for weeds, square root transformed data).

Table 7. Number of transect segments per pasture mapped to each soil type. The soil type assigned to each segment is based on an overlay of the transect segment center point on a digital version of the Solano County Soil Survey (USDA SSURGO database).

	Soil type				
Pasture	Antioch - San Ysidro complex (AoA): nonsaline, acid	Pescadero clay loam (Pc): saline, alkaline	San Ysidro sandy loam (SeA): nonsaline, acid	Solano loam (Sh): saline, acid	Totals
Buck	12	5	-	-	17
Corral	-	6	-	-	6
Docents	-	-	14	-	14
Dozier	-	-	2	-	2
Eucalyptus	-	-	63	18	81
NE Barker	-	-	5	-	5
N Half S24	13	22	29	-	64
N of Barn	16	3	13	-	32
NW Barker	-	-	9	-	9
Norris	4	-	10	3	17
S Half S24	7	25	21	-	53
S of Calhoun Cut	-	-	9	-	9
Triangle	-	-	8	-	8
W of Railroad	2	-	1	4	7
Totals for all transects	54	61	184	25	324

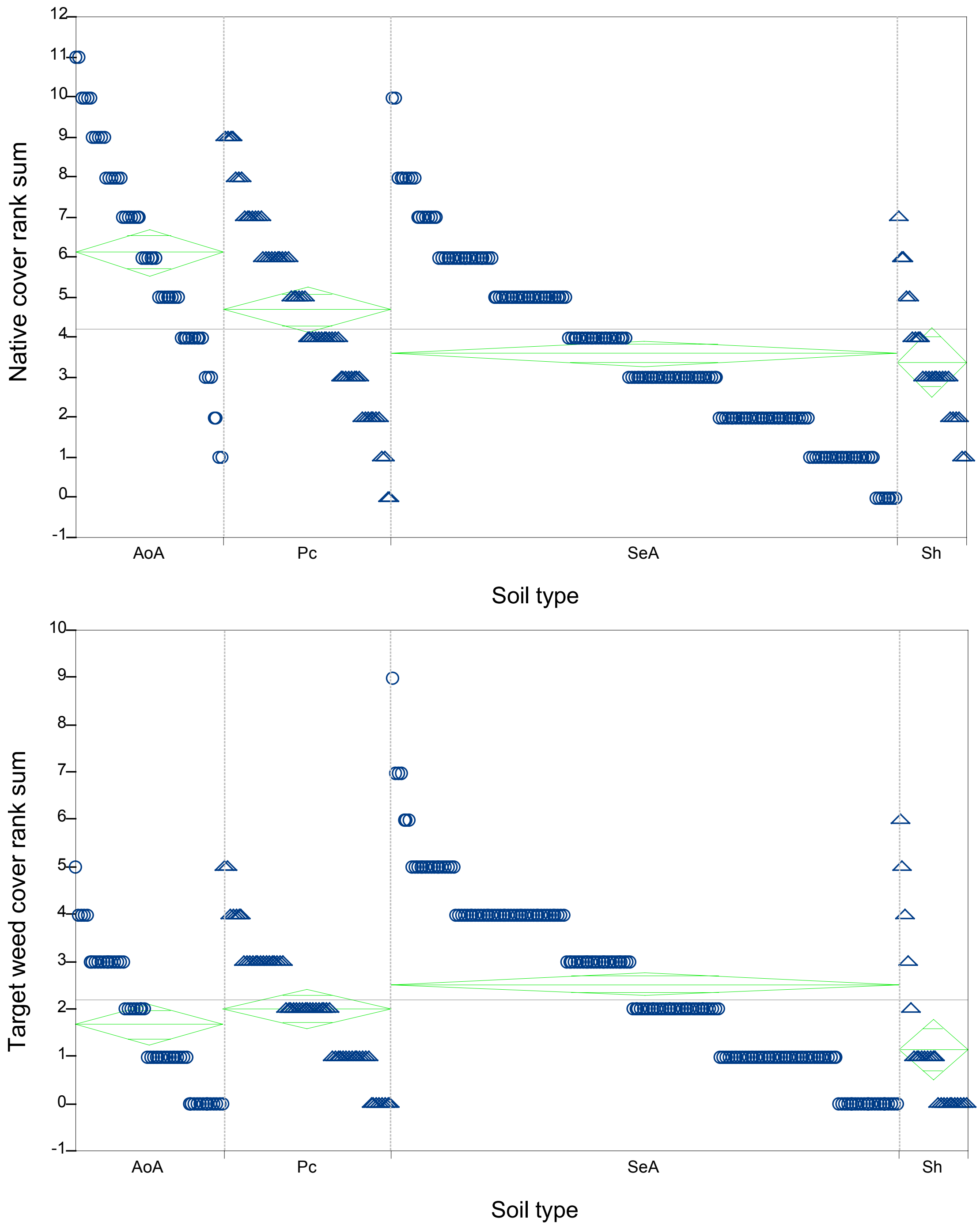


Figure 7. Plot of rank sums for native species (top) and target weed species (bottom) by soil type at Jepson Preserve. The horizontal line in each graph represents the overall average. Individual segment rank sums are shown alternately as circles or triangles for clarity. The center line of each diamond represents the mean for the soil type; the vertical extent of each diamond represents the 95% confidence interval based on a pooled variance for all segments. The horizontal spread of each diamond is proportional to the number of transect segments on each soil type. *Erodium* cover is not included with either the native or target weed covers. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, SeA=San Ysidro sandy loam, Sh=Solano loam.

Correlation of management practices with soil type and exotic and native species distribution

Pastures differ not only with respect to soil type, but also with respect to past management history. Management practices also contribute to differences in plant cover seen among the various pastures. However, our ability to identify relationships between management factors and the abundance of monitored exotic and native weeds is limited because grazing and burning treatment are partly confounded with soil type. For example, among the five pastures that were burned in June 2000, all transect segments in four pastures (NE and NW Barker, Triangle, Docents) are found on San Ysidro sandy loam. In the Corral pasture, which was also burned in 2000, the transect segments are all on Pescadero clay loam, but specific grazing data for this field are lacking (grazer's records indicate the corral was pastured with the north half of section 24 or the south half of section 24). One pasture (W of Railroad), with 7 transect segments has been grazed by cattle instead of sheep. This pasture also lacks specific grazing intensity data and cannot be included in analyses that include a grazing variable. The only nongrazed fields are the Dozier and Docents units, with a combined total of 16 transect segments on a single soil type (San Ysidro sandy loam). In addition to these singularities, overall grazing intensity since at least 1993 varies by soil type (Figure 8).

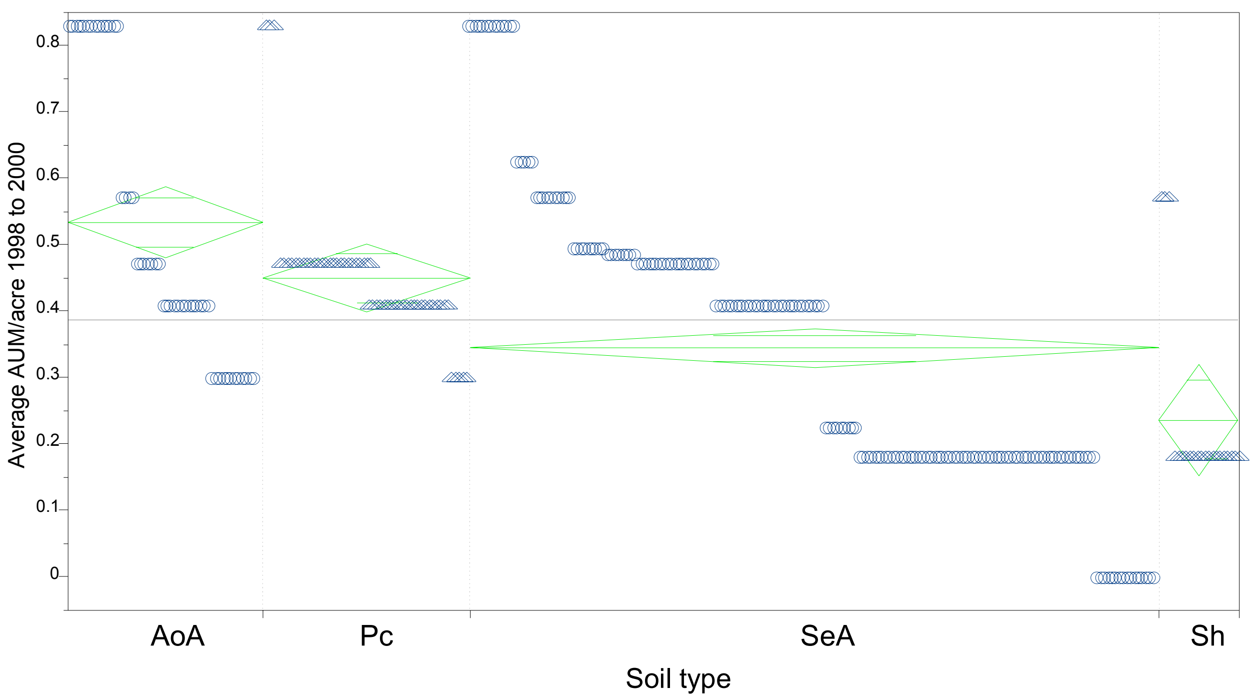


Figure 8. Average AUM/acre for each transect segment by soil type at Jepson Prairie for the period July 1998 to June 2000. Circles or triangles represent the values present for each transect segment, and alternate for clarity. The horizontal line in each graph represents the overall average. The center line of each diamond represents the mean for the soil type; the vertical extent of each diamond represents the 95% confidence interval based on a pooled variance for all segments. The horizontal spread of each diamond is proportional to the number of transect segments on each soil type. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, SeA=San Ysidro sandy loam, Sh=Solano loam.

Effects of grazing intensity

We excluded data from transect segments that had burned within the two previous years and constructed ordinal logistic regression models using grazing variables and soil type as predictors (Table 8). These models showed significant positive associations between the two previous years stocking rate (1998 - 2000 average AUM/acre) and cover of *N. pulchra*, *D. danthonioides, Lasthenia* spp., and *Erodium* spp . Significant negative associations between 1998 - 2000 stocking rate and cover were seen for the target weeds *C. pycnocephalus* and *C. solstitialis*. Soil type was highly significant in models for *Lasthenia* spp., *V. pedunculata*, *N. pulchra*, *A. millefolium, C. pycnocephalus, Erodium* spp, and *T. caput-medusae*. This high correspondence between cover and soil type is interesting, given the relative coarseness of the soil map and the fact that microtopographic relief (e.g., swale, upland, flat) is not directly addressed by soil type. Neither variable was significant for *P. californicus* or *T. eriantha*. *L. latifolium* was not analyzed because so few points remained in the data set when the recently burned pastures were excluded.

Table 8. Model and parameter significance levels (effect likelihood ratio χ^2 test) for ordinal logistic regression models for native and exotic species cover class ranks for transect segments which were not burned in either 1999 or 2000 (n=265).

Species	**Overall model likelihood ratio P>χ^2**	**Predictor variables Likelihood Ratio P>χ^2 (effect direction)**	
		Soil type	**Average AUM/acre 1998-2000**
Natives			
Achillea millefolium	<0.0001	0.0001	0.1512
Deschampsia danthonioides	<0.0001	0.7074	<0.0001 (+)
Lasthenia spp.	<0.0001	0.0006	<0.0001 (+)
Nassella pulchra	<0.0001	0.0202	<0.0001 (+)
Viola pedunculata	<0.0002	0.0053	0.0912
Exotics			
Carduus pycnocephalus	<0.0001	<0.0001	0.0240 (-)
Centaurea solstitialis	<0.0001	0.1603	<0.0001 (-)
Erodium spp.	<0.0001	<0.0001	0.0004 (+)
Lactuca serriola	0.0066	0.0384	0.1173
Taeniatherum caput-medusae	0.0011	0.0004	0.3768

The native perennial soaproot (*Chlorogalum pomeridianum),* was observed only in transects 2 (Dozier) and 15 (W of Railroad). Neither of these transects has been grazed by sheep for an extended period, although the W of Railroad pasture has been grazed by cattle for many years. Sheep have grazed most of the pastures for many years, so most species that are poorly adapted to the traditional grazing regime have probably been eliminated from the grazed fields.

Effects of Fire

Only 42 transect segments were located in the five pastures that were burned in 2000. An additional 10 segments were located in an area on the east edge of the N Half Section 24 pasture that was burned in 1999. Although we do not have prefire plant cover ratings, some effects of the 2000 fire are reasonably obvious. In three pastures (Docents, NW Barker, Triangle), *T. caput-medusae* was nearly completely suppressed (Figure 24). *T. caput-medusae* cover was still substantial in the two remaining burned pastures (NE Barker, Corral; Figure 24). Clearly, either the timing or characteristics of the burns in the two latter pastures were suboptimal for effective *T.*

caput-medusae control. *Erodium* cover was also high in the pastures burned in 2000 (Figure 16), although similarly high levels of *Erodium* spp. occurred in large portions of other pastures that had not been burned recently.

Interaction between fire and grazing

Because the San Ysidro soil (SeA) shows variation in both recent fire and grazing history, the effects of these two factors can be examined for this soil type. Ordinal logistic regression models for four native and five exotic species were significant (Table 9). In general, cover of the native species was positively associated with higher previous year stocking levels and recent burning. Among exotic species, both positive and negative associations with grazing and recent burning were observed.

Table 9. Model and parameter significance levels (effect likelihood ratio χ^2 test) for ordinal logistic regression models for native and exotic species cover class ranks developed for transect segments on San Ysidro sandy loam soil (n=183).

Species	Overall model likelihood ratio P>χ^2	Predictor variables Likelihood Ratio P>χ^2 (effect direction)	
		Average AUM/acre 1999-2000	Burned 1999 or 2000
Natives			
Deschampsia danthonioides	<0.0001	<0.0001 (+)	0.0035 (+)
Lasthenia spp.	<0.0001	<0.0001 (+)	NS
Nassella pulchra	<0.0001	<0.0001 (+)	0.0003 (+)
Triphysaria eriantha	0.0005	0.0150 (+)	0.0003 (+)
Exotics			
Carduus pycnocephalus	0.0464	0.0134 (–)	NS
Centaurea solstitialis	<0.0001	0.0005 (–)	0.0486 (+)
Erodium spp.	<0.0001	NS	<0.0001 (+)
Lepidium latifolium	0.0040	NS	0.0183 (+)
Taeniatherum caput-medusae	<0.0001	0.0010 (+)	<0.0001 (–)

We looked at overall effects of fire and grazing on the San Ysidro soil through analysis of covariance on cover rank sums. For the monitored native species average stocking density 1998-2000 was the best grazing variable. The model (Table 10) indicates that native cover rank sum increases with grazing intensity (over the range of intensities represented) and is higher in plots that have been burned recently. The significant interaction between these factors results from the fact that the positive correlation between grazing and native cover rank sum is limited to nonburned transect segments. Burned segments show no association between grazing and native cover rank sum, presumably because the effects of recent fire largely mask those of grazing.

Table 10. Analysis of covariance model for the sum of native plant cover ranks (square root transformed) for transect segments on San Ysidro sandy loam.

Source	DF	F Ratio	Prob>F	Adjusted R^2	N
Overall model	3	27.0413	<0.0001	0.3003	183
Effect test	**DF**	**F Ratio**	**Prob>F**	**Parameter estimate**	
Average AUM/acre 1998-2000	1	22.1828	<0.0001	0.8317	
Burned 1999 or 2000	1	4.8818	0.0284	0.09138	
Interaction	1	27.7170	<0.0001	-0.8230	

The equivalent model for target weed cover rank sum is shown in Table 11. For target weeds, using long term stocking density (1993-2000) improved model fit slightly compared with the 1998-2000 stocking density. Model fit for target weeds was much poorer than for the native species.

Although recent burning shows a clear negative effect on weed cover rank sum, the overall effect of grazing intensity is nonsignificant. Investigation of the significant interaction term reveals that a significant negative correlation between grazing intensity and weed cover rank sum exists only for nonburned transect segments. However, the strength of this effect is insufficient to make the grazing variable significant in the overall model.

Table 11. Analysis of covariance model for the sum of target weed cover ranks (square root transformed) for transect segments on San Ysidro sandy loam. *Erodium* cover is not included in this analysis.

Source	DF	F Ratio	Prob>F	Adjusted R^2	N
Overall model	3	2.7893	0.0063	0.1073	183
Effect test	**DF**	**F Ratio**	**Prob>F**	**Parameter estimate**	
Average AUM/acre 1993-2000	1	0.1977	0.6571	-0.01555	
Burned 1999 or 2000	1	11.9540	0.0007	-0.1583	
Interaction	1	13.9422	0.0003	0.1306	

Polygon monitoring

While transects are effective for monitoring both native and exotic species that are relatively common on the preserve, they do not efficiently detect relatively rare plant populations that are spatially clustered. In order to document the presence of target weed infestations that are localized or new, we tested the mapping of weed populations outside of the transects as points or polygons. We found that the amount of effort and time required to map individual infestations can be substantial if the target weed is present in multiple spots. We eventually determined that mapping weed points and polygons was only efficient for weed species that are rarely encountered. Such points need only be mapped if they are found outside of transect segments.

Among the targeted exotics, *F. vulgare, C. calcitrapa, C. vulgare, S. marianum, X. strumarium*, and *A. cylindrica* are sufficiently uncommon in all pastures that their presence at the preserve can only be documented adequately by point/polygon mapping. In contrast, *C. pycnocephalus, L. serriola,* and *T. caput-medusae* are so common and widespread that point/polygon mapping is impractical. *L. latifolium* and possibly *C. solstitialis* represent an intermediate situation. In some fields, primarily from the Eucalyptus pasture north, these species are too common to map individual populations (Figures 21, 22, 23). However, in most other pastures, these species are confined to discrete infestations or isolated individuals that are more efficiently monitored via point/polygon mapping (compare Figures 22 and 23 for *L. latifolium*). Hence, a combination of monitoring techniques will be necessary for species such as these.

Rare target weeds located within sight beyond transects can be readily mapped during the annual survey. In addition, rarely occurring weeds could be mapped within the course of other preserve activities by personnel equipped with a GPS receiver and a standardized datasheet for recording point/polygon attribute data. These two methods would probably locate many, though not all, outlying target weed occurrences. A more systematic survey would be needed to ensure complete coverage of the inter-transect areas, though it is questionable whether the resources to conduct this additional survey are likely to become available. It would probably not be practical to survey the inter-transect spaces on the preserve by foot, although it might be feasible if vehicles (e.g., ATVs, mountain bicycles) were used. Since most of the uncommon target weeds are summer annuals, it would probably be most efficient to survey inter-transect areas in early summer after the spring annuals have dried up. While conducting the June monitoring of transects 6 and 8 we observed some populations of *L. latifolium*, *C. vulgare,* and *S. marianum* well beyond the transect area that had not been obvious in the April monitoring.

We found that it was a fairly complicated process to convert GPS coordinates taken around the perimeter of a weed population into a polygon using ArcView 3.2. We were eventually able to accomplish it using a third party extension. Given that ArcView themes can only include a single type of data (e.g. point or polygon), we found that it was more efficient to leave polygon perimeters coded as a series of points, each with the same weed population attribute data. We used a unique polygon number field to allow for identification of those points which constitute a given polygon boundary.

Comments on methodology

Based on 302 transect segments surveyed between 4/12/01 and 4/18/01 for which time records were available, the average time spent per transect segment was 3.22 minutes. This total, which applies to a well-trained two person team, includes time spent mapping point/polygon data near the transects, and some but not all of the time spent walking between successive transects. Based on this average time, a two person team would have required about 17.4 hours of field time to read the transects. Probably an additional hour of time could be added to this total to account for time spent walking between transect ends.

Hence, the total direct field time required was about 37 person-hours or about three 6-hour days for a single two-person team. Using two teams, it should take about 3 half days to collect the data. Three person teams are likely to be the optimal arrangement for monitoring transects: one person uses the GPS to navigate along the transect, one person specializes in rating native plant cover and the third person specializes in rating exotic cover. Monitoring position with the GPS is rather distracting, so having a person assigned primarily to that task is the optimal arrangement. If only two people are available for each transect, the GPS should be handled by the person with fewer plant species to rate, which will vary somewhat by transect.

Transects are most efficiently read in sets or loops that minimize the amount of walking between adjoining transects. Based on our experience, the following combinations of transects can be monitored as sets, none of which should require more than 3 to 4 hours of field time for a trained 2 or 3 person team:

Transect set	Transect numbers
1	1 - 5
2	6, 7
3	8, 9
4	10, 11
5	12, 13
6	17 - 20
7	14 - 16

The list of monitored plants currently is at the upper limit of what is possible for two evaluators to handle. It may be possible to increase detection of some of the target weeds such as *L. serriola* by decreasing the number of monitored exotics. For example, *Erodium* spp., which are present in almost every transect segment and require a good deal of mental energy to evaluate, could be dropped from the monitoring list without compromising weed monitoring goals. Alternatively *L. serriola* could be dropped from the monitoring list because it is not a high priority weed. For future monitoring it probably makes sense to assign the most botanically skilled volunteers to those areas which are likely to be the most difficult to rate. Although differences in observer ratings of plant cover could contribute to variability in the data, we believe that adequate evaluator training/calibration and the use of visual aids should help minimize this source of variation. The use of only 3 cover ranks also serves to help minimize variation related to different observers.

Some orientation on the microsite factors that influence plant distribution will help improve the efficiency with which volunteers detect species that may be difficult to spot. For instance, many species are either limited to or more likely to occur on upland or mound areas (e.g., *A. millefolium, N. pulchra, V. pedunculata, C. solstitialis, C. pycnocephalus, L. serriola*). When mounds occur near the outer edges of the transect, the evaluator generally needs to detour over to them to look closely for these species. Knowing the preference of *P. californicus* for wet, generally nonsaline swales and the co-occurrence of *D. danthonioides* with *Lasthenia* spp. on flats and lowlands aids in the detection of these species when they are at low densities. Evaluation aids developed for volunteers will include notes on the typical microsites where given species are found.

The nominal accuracy of the unaided GPS is 15 meters, but our typical accuracy was generally much better than that. Positional errors may have caused transect segments to vary in length or drift from the true directional bearing by several meters. However, such errors had little impact on cover ratings due to the large size of the transect segments (1000 m^2) and the relatively broad cover class categories (Table 5). At most, such positional errors could rarely result in a difference in cover ratings of one rank, or might cause an uncommon species to be shifted from one segment to the adjacent one. Such differences would not be sufficient to change the interpretation of monitoring results.

While navigation with the uncorrected GPS worked well, anticipated advances in GPS technology should lead to improved positional accuracy which will improve the sensitivity and reliability of the method. Although not on the market in time for our April survey, it is now possible to buy affordable handheld receivers that make use of the experimental WAAS system to provide positional accuracies of 3 m or less. Currently there is one WAAS satellite (number 47) positioned over the Pacific Ocean, which we were able to use to obtain differentially-corrected readings in our June survey.

Comparisons with other research

Spread of target weeds

In October 1995, a walking survey of Jepson Prairie was conducted by The Nature Conservancy staff and volunteers (The Nature Conservancy 1996). The general monitoring approach was similar to the approach described in this report, although the 1995 survey was much less intensive: approximately one 20 ft circle was rated per 10 acres. Judging from the distribution maps included in the 1996 report, the 1995 survey also omitted the pastures north of Barker Slough and south of Calhoun Cut, as well as the S Half of Section 24.

Among the target weeds documented in the 1995 study, only *L. latifolium* appears to have spread significantly. In 1995, only four small *L. latifolium* infestations were reported. In our current survey, we have documented extensive, dense patches of *L. latifolium* along Barker Slough and many smaller *L. latifolium* patches throughout NW Barker pasture. Populations of this target weed are also found throughout the Triangle pasture and isolated spot infestations are found in the Eucalyptus pasture, the small corrals north of the barn, and near Calhoun Cut (Figure 23).

L. latifolium is a rhizomatous perennial and is very difficult to eradicate. It has great potential for invading the flat and swale topographic positions throughout the preserve. We think much more attention needs to be paid to management of this species. Efforts should be directed at eradicating it from the Eucalyptus pasture where it is just getting established. In addition, if eradication efforts are not directed at the Triangle and Barker pastures, *L. latifolium* is likely to overrun large areas of these pastures.

It is difficult to tell how much *C. pycnocephalus* and *C. solstitialis* populations have changed since 1995. We documented populations of these species that are clearly more extensive than was shown in 1995 survey. However, it is difficult to determine how much of this difference is related to the higher sampling intensity used in our survey.

We noted that *C. pycnocephalus* and *C. solstitialis* are especially prevalent around old tree stumps in the Eucalyptus pasture. There may be several reasons for this, but the high level of disturbance and lack of competitive native species in these areas probably contributes to the high localized populations of these target weeds. Efforts should be made to prevent an expansion of this problem as the remaining eucalyptus is removed. One possible strategy would to make a concerted effort to establish appropriate native species (e.g. *N. pulchra, A. millefolium*) in these newly exposed, generally upland areas. Because it appears that sheep tend to congregate around stumps, complete removal of the stumps may also reduce the high level of disturbance in these areas that favors invasive exotics.

Factors associated with plant population levels

Most of the associations between burning, grazing and plant cover noted in this report have been previously reported (Pollack and Kan 1998). Pollack and Kan (1998) reported that June burning was completely effective for eliminating *T. caput-medusae*. As noted above, *T. caput-medusae* was apparently eliminated from some but not all of the transects that were burned in 2000, which suggests that the timing and/or intensity of the burn was suboptimal in some of the pastures. Our observations also concur with previous descriptions of the importance of mound, intermound, and pool microtopography on vegetation occurrence at Jepson Prairie (Pollack and Kan 1998). Correlations between species occurrence (Figure 5) and associations between vegetation and soil types (Figure 7) are at least in part related to microtopographical preferences of various species and the association of certain microtopographies with specific soil types. Within our relatively short

(50 m) transect segments variation in microtopography was sometimes considerable. We did not try to assign a predominant microtopography to each transect segment, though if this information is collected eventually, it could be used to help explain some of the variability in the data.

Although the analyses we presented based on transect data generally do not break any new ground, their concurrence with previous analyses and observations provides at least some validation for the methodology we used. The transect-based monitoring system was sensitive enough that differences in vegetation associated with past grazing and fire regimes could be detected. This increases our confidence that analyses of monitoring data collected in successive years should enable Preserve managers to detect and document significant changes in vegetation that may occur. One challenge in future analyses lies in the separating the effects of varying environmental conditions from those of management inputs.

CONCLUSIONS

We believe that changes in target weed populations and selected native species at Jepson Prairie Preserve can be monitored effectively through the use of the transect based and point/polygon monitoring methods presented in this report. We also believe that it is feasible to implement annual monitoring at the preserve with the help of trained volunteers using these methods. We believe that the techniques used represent a reasonable compromise between efficiency and sensitivity and are within the technical capabilities of trained volunteers assisted by SCFOSF staff. We believe that the monitoring methods will be most useful if they are consistently applied on an annual basis.

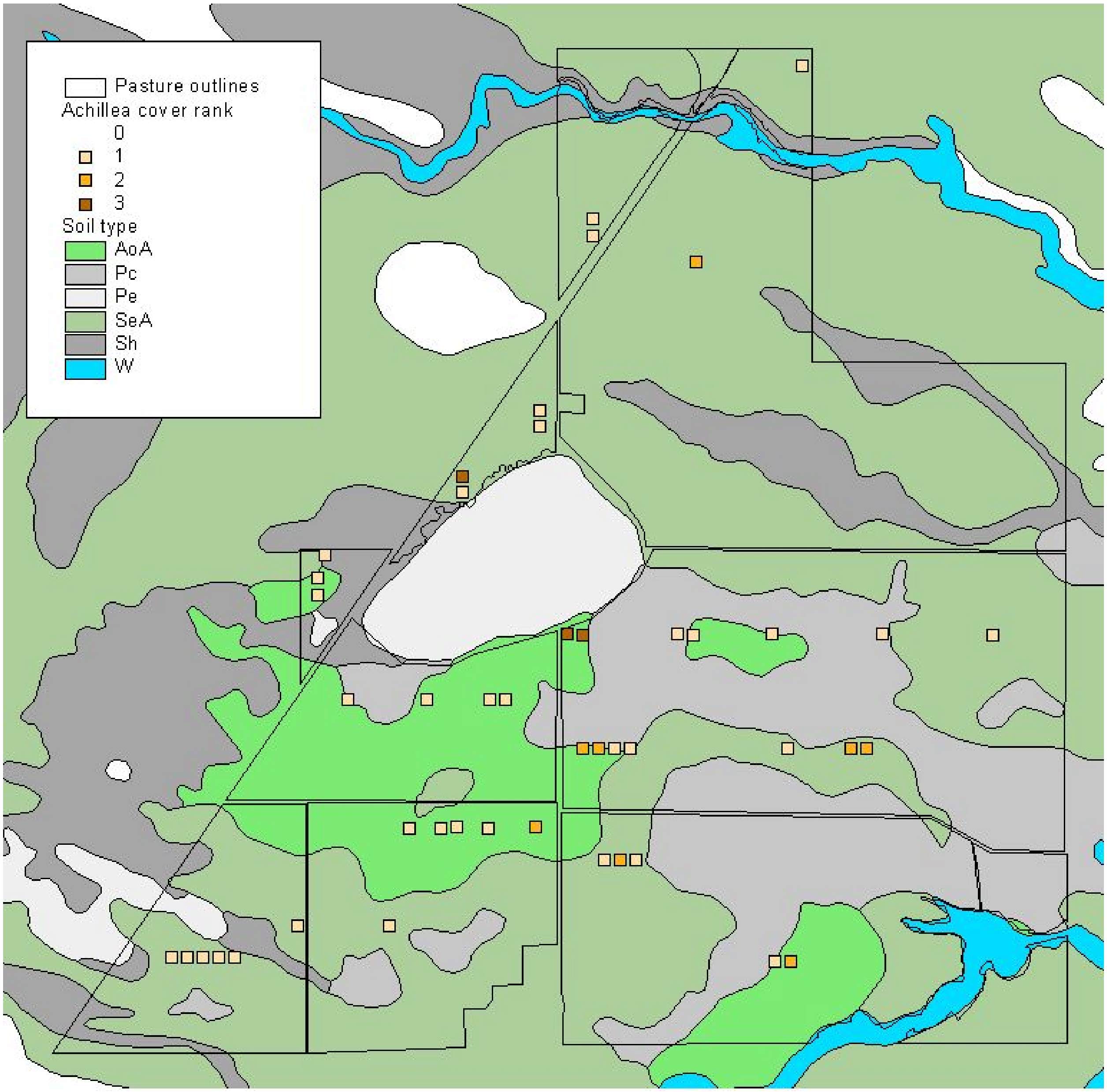


Figure 9. *Achillea millefolium* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

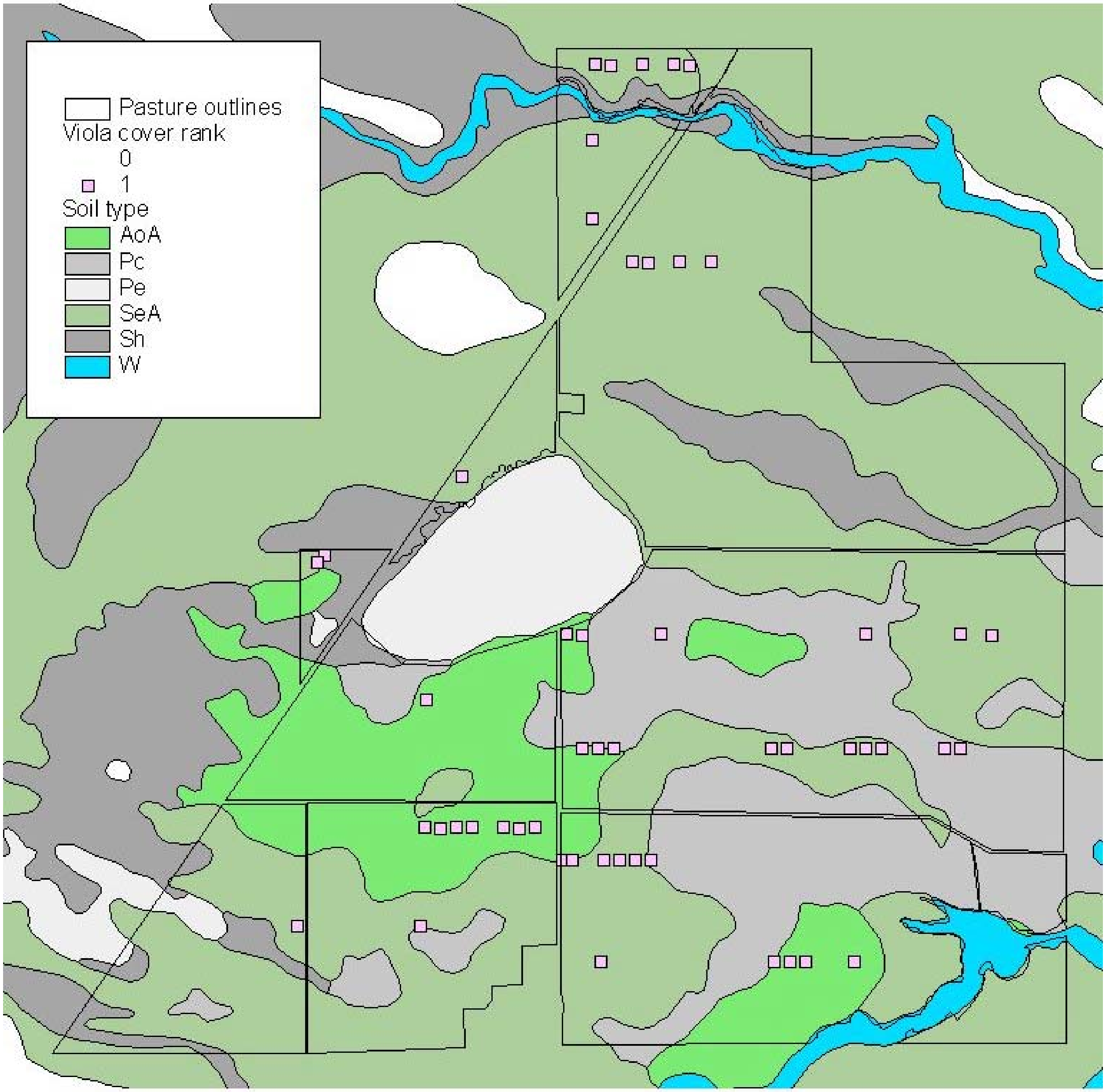


Figure10. *Viola pedunculata* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

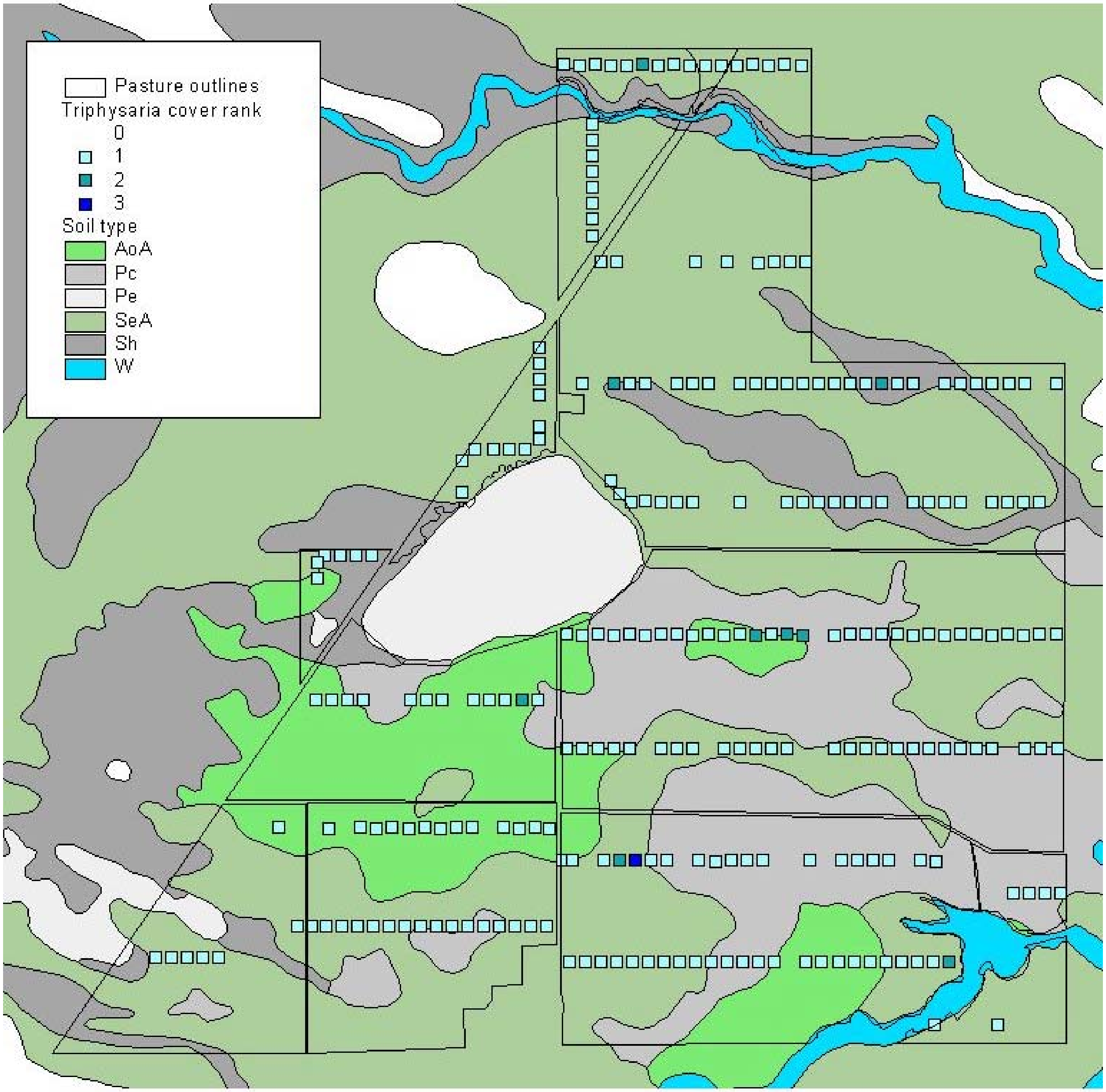


Figure 11. *Triphysaria eriantha* spp. *eriantha* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

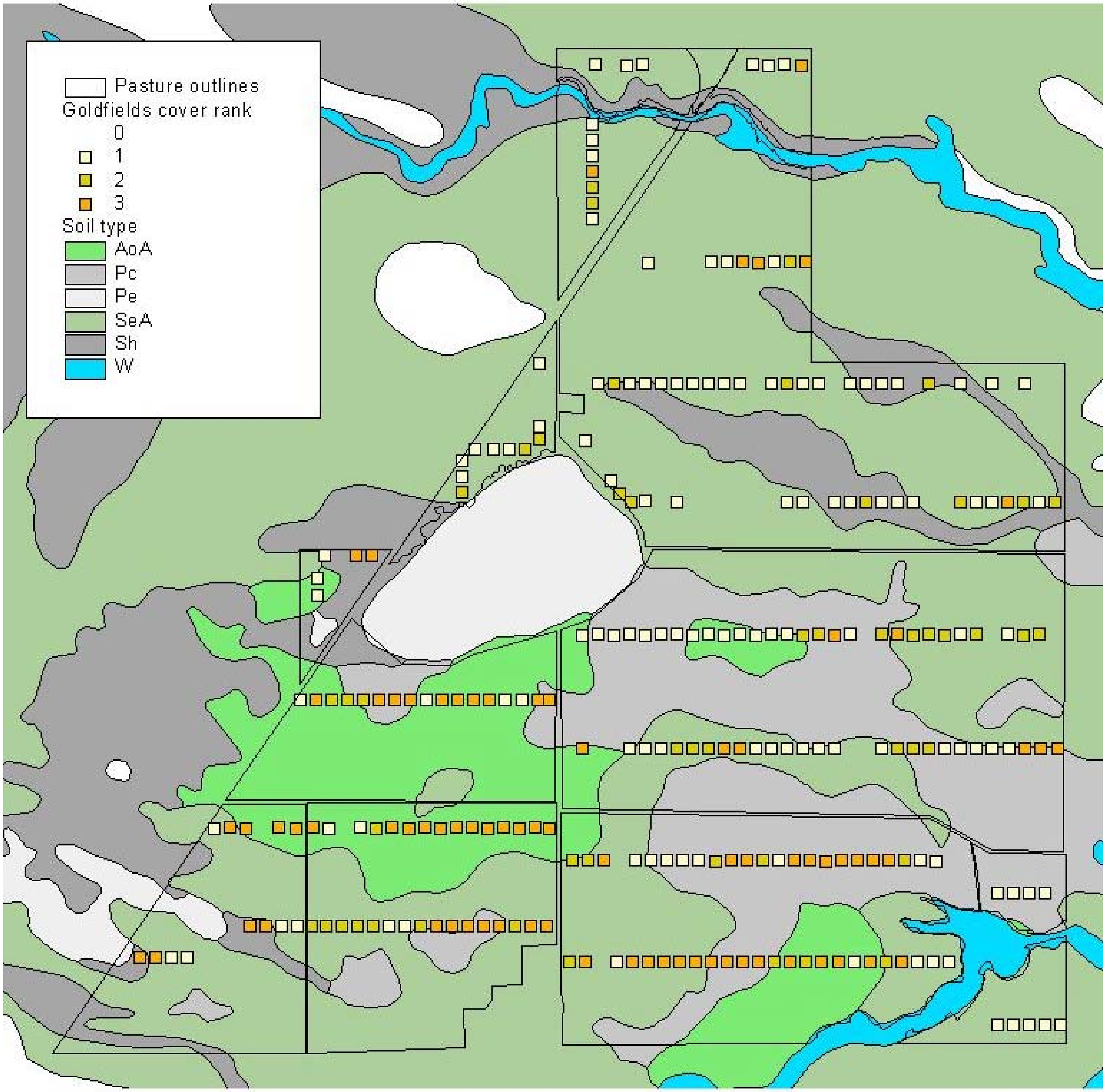


Figure 12. *Lasthenia* spp. (species with conspicuous ray flowers, including *L. californica* and *L. fremontii*) cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

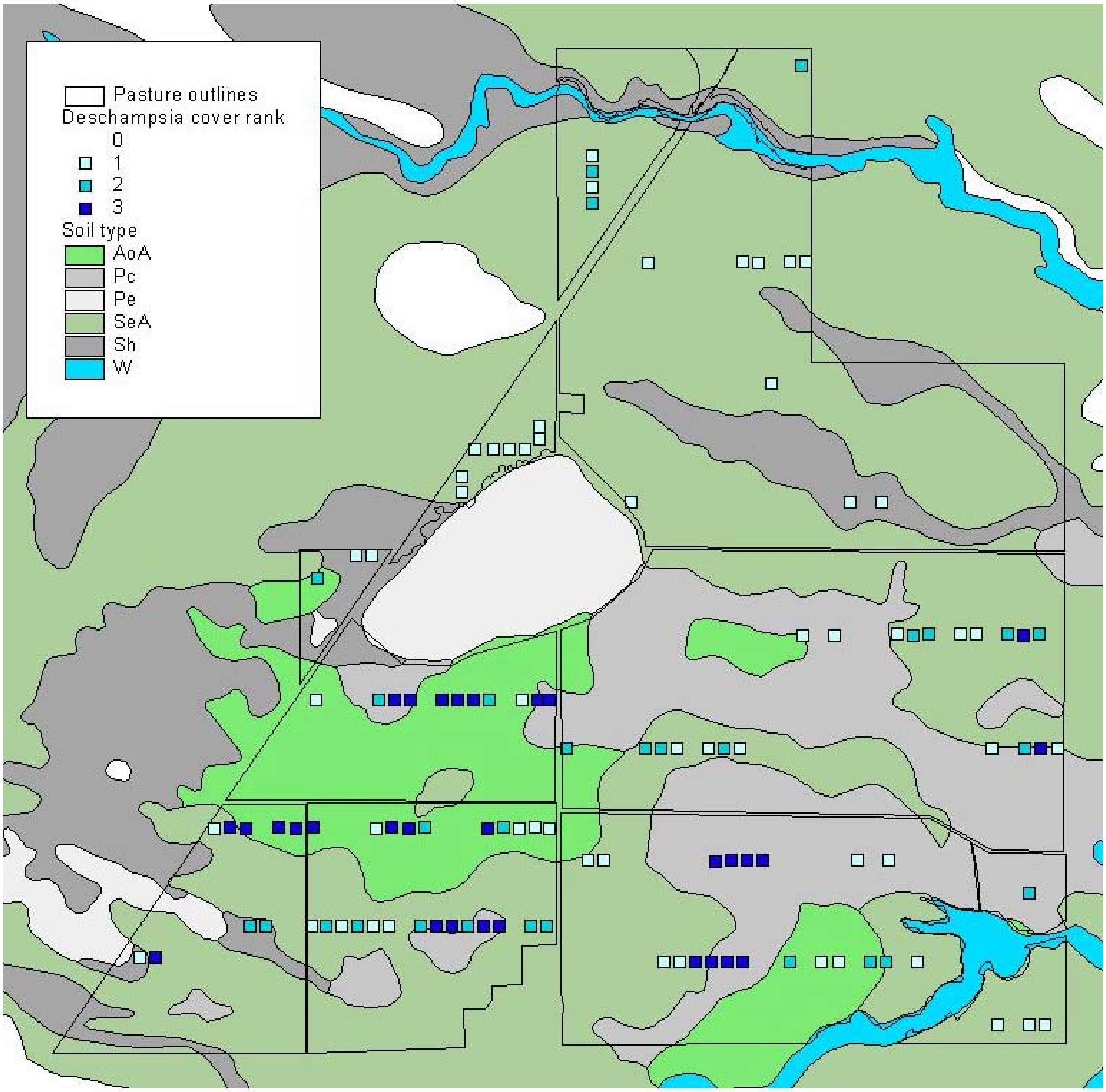


Figure13. *Deschampsia danthonioides* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

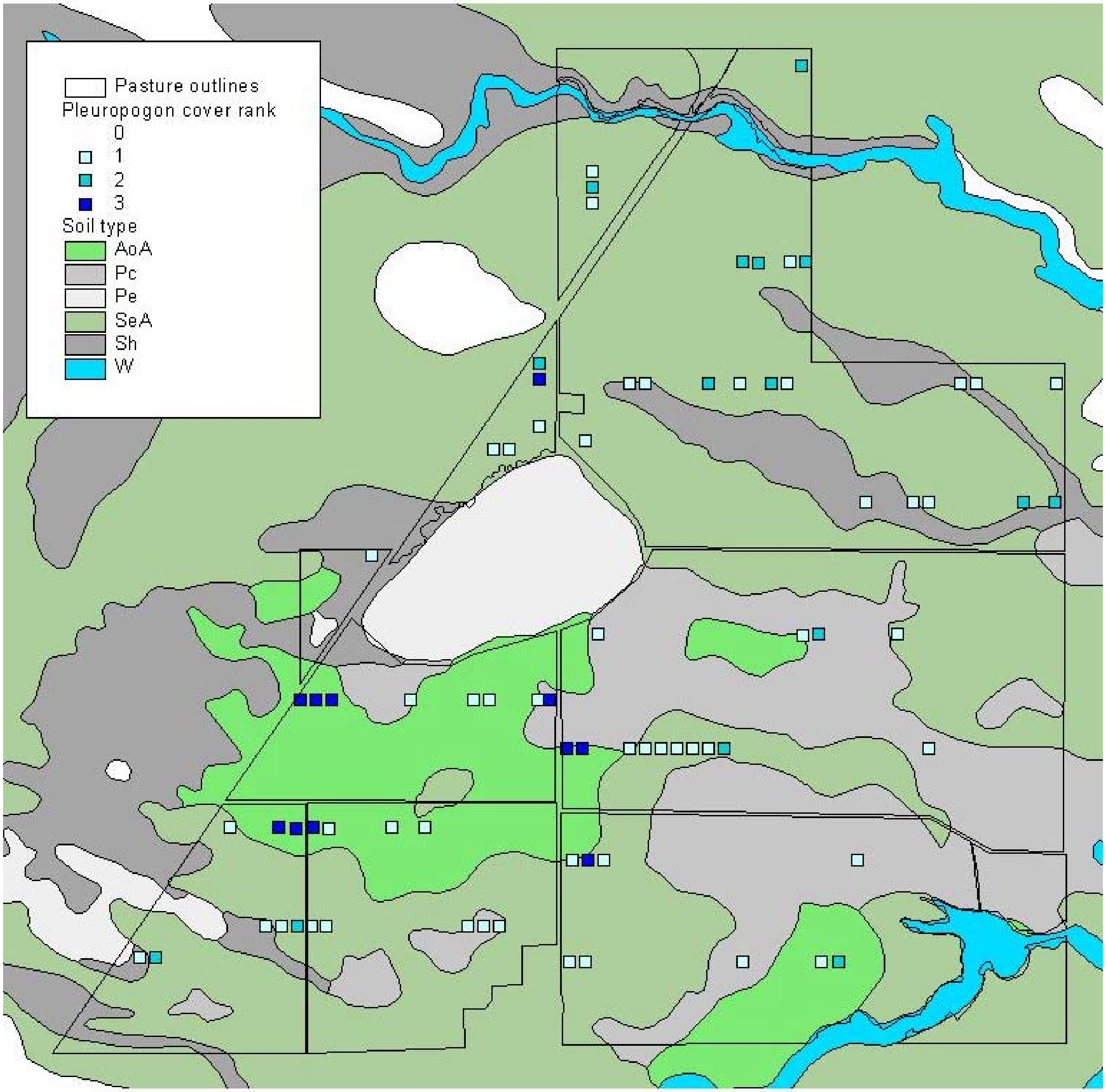


Figure 14. *Pleuropogon californicus* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

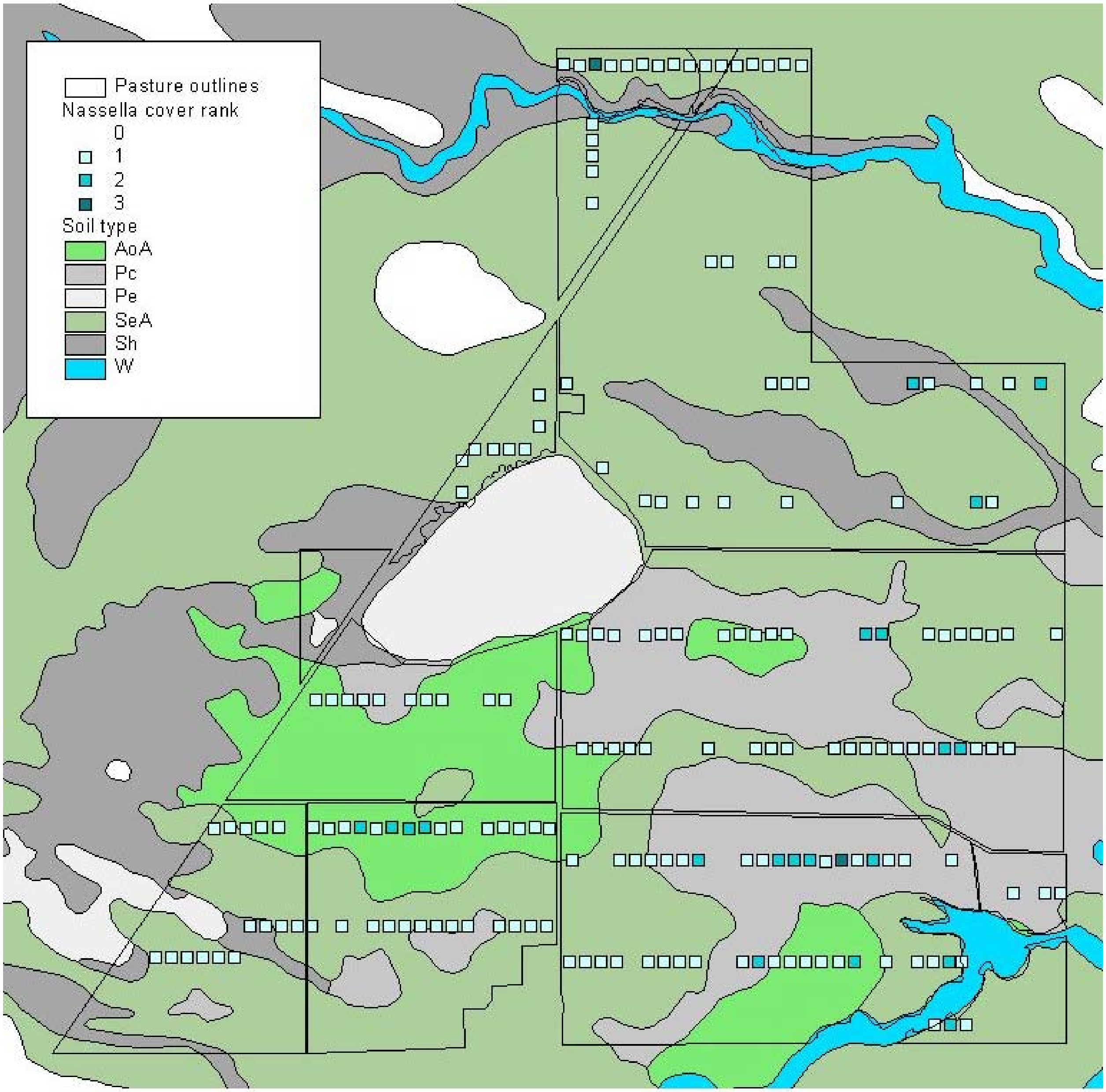


Figure 15. *Nassella pulchra* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

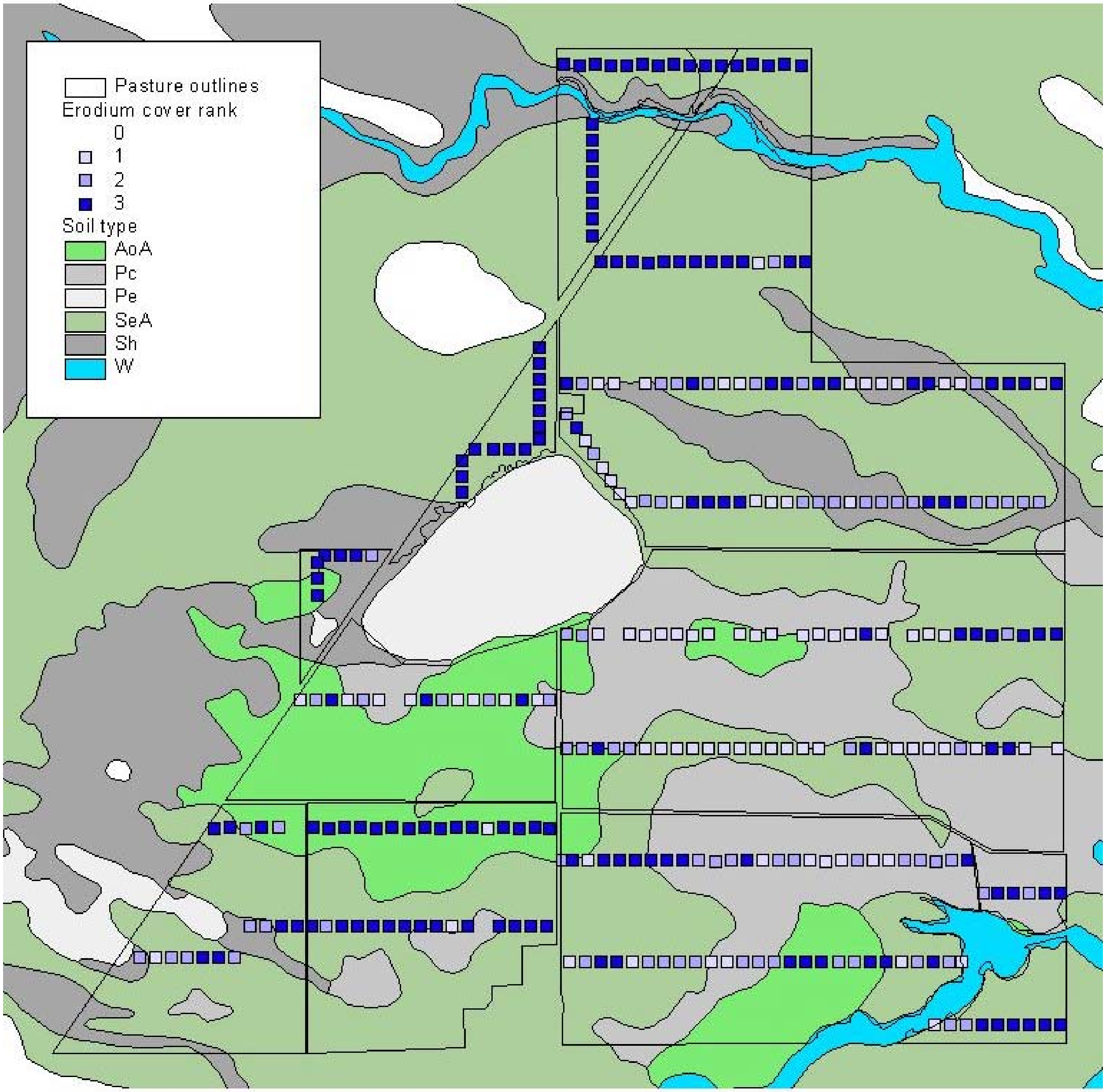


Figure 16. *Erodium* spp. cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

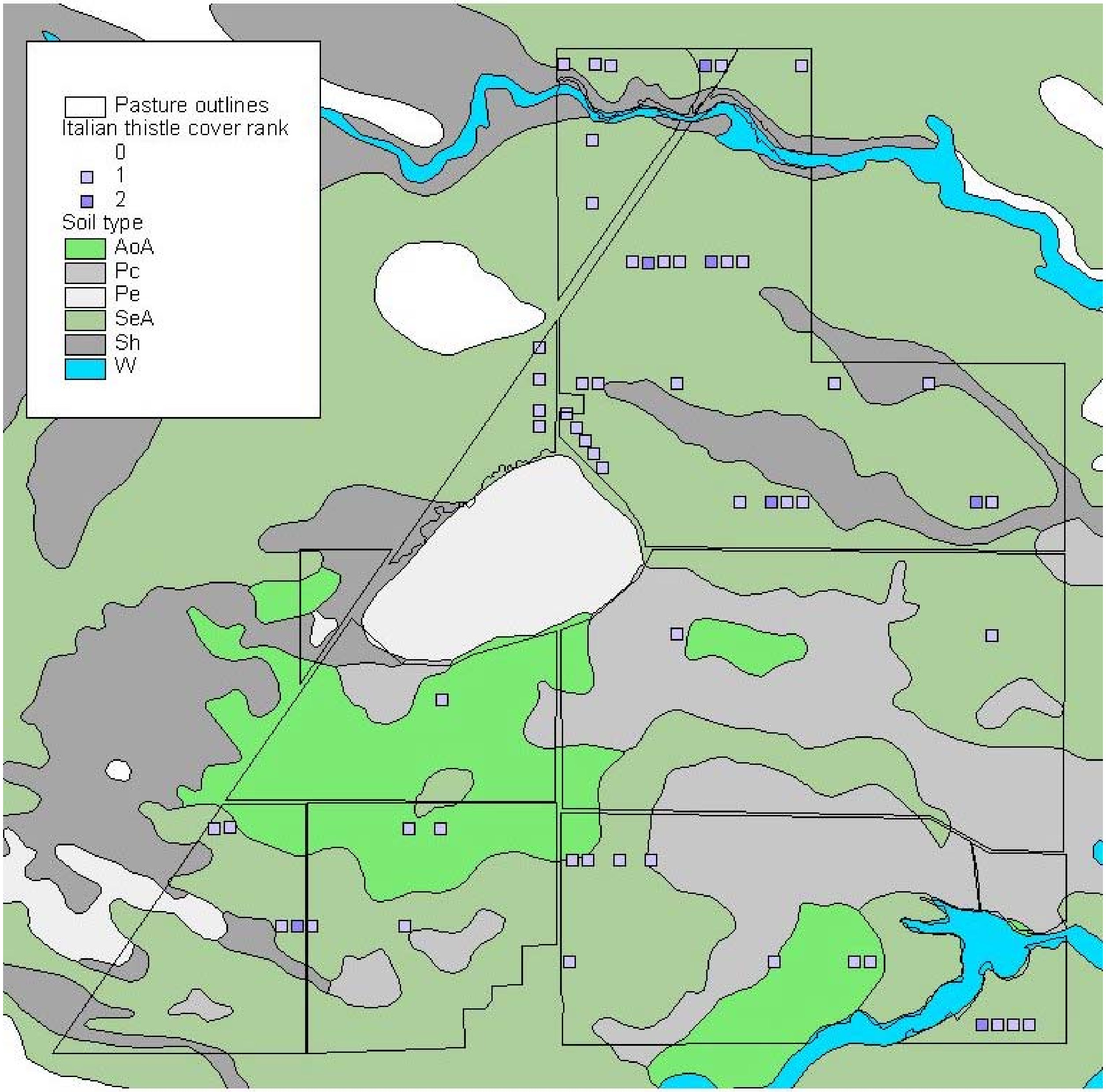


Figure 17. *Carduus pycnocephalus* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

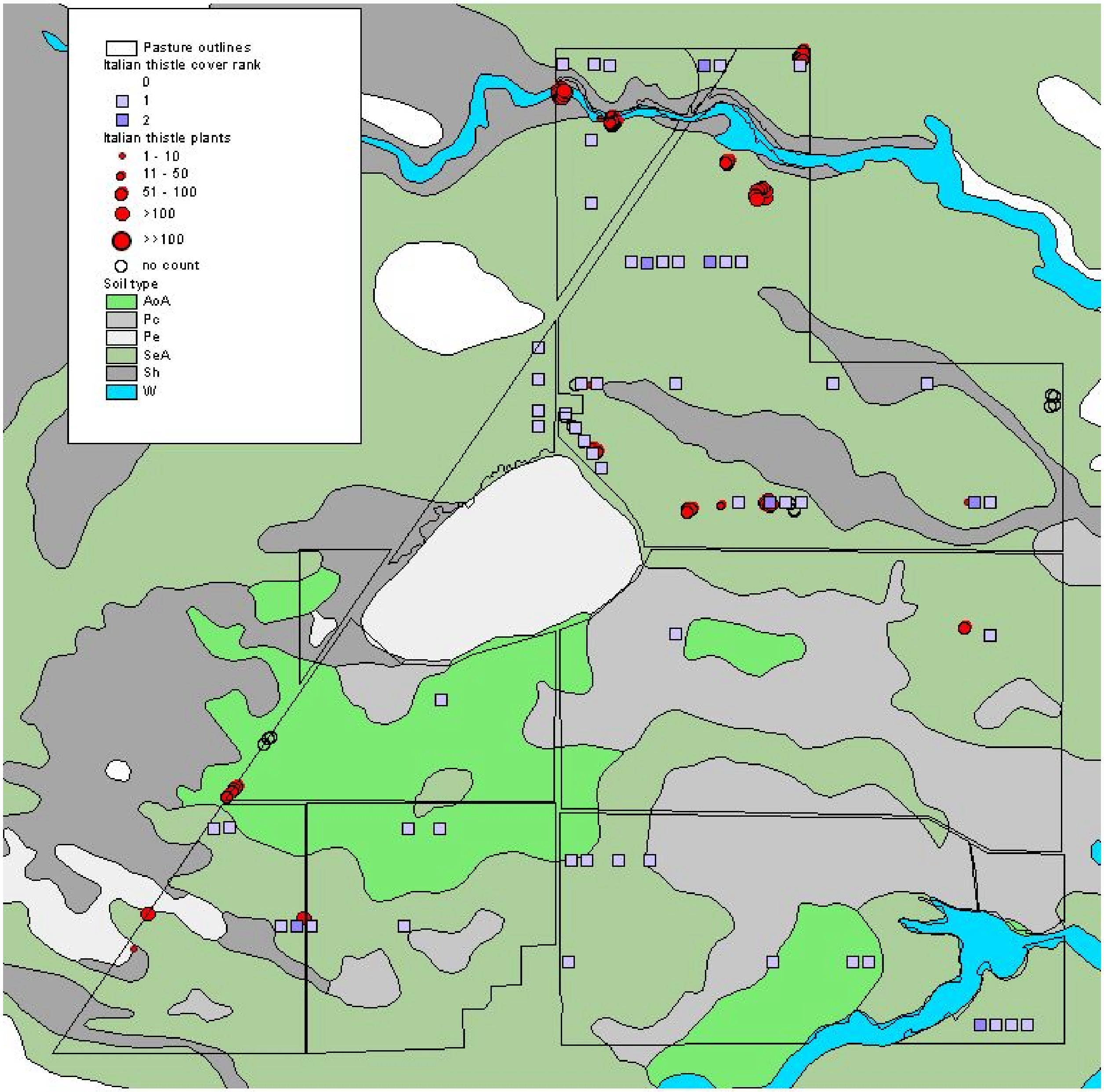


Figure 18. *Carduus pycnocephalus* cover ranks in transect segments with mapped point/polygon populations, April 2001. Not all visible populations have been mapped. Markers for transect segments are centered over the midpoint of the segment. Markers are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

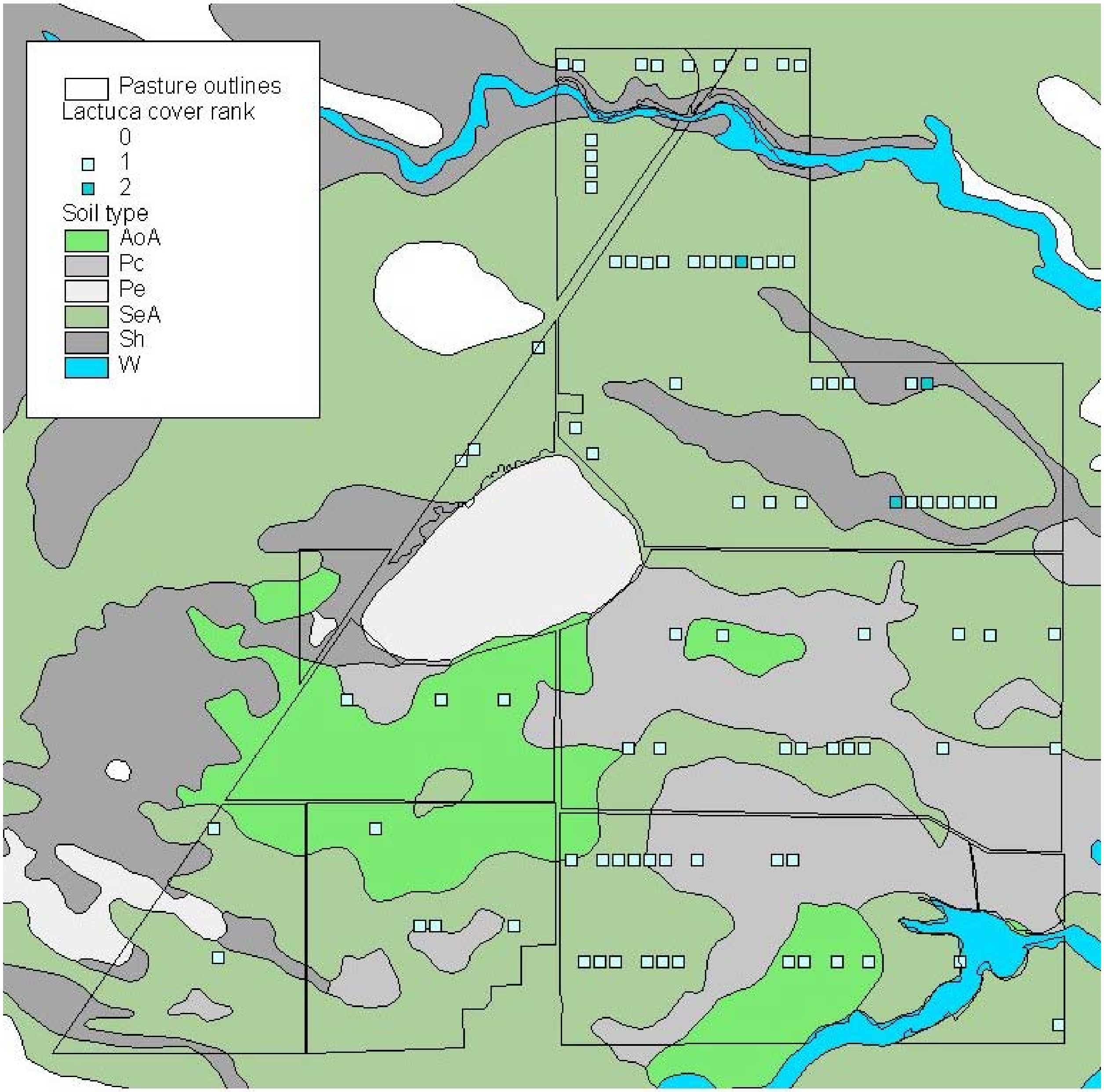


Figure 19. *Lactuca serriola* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

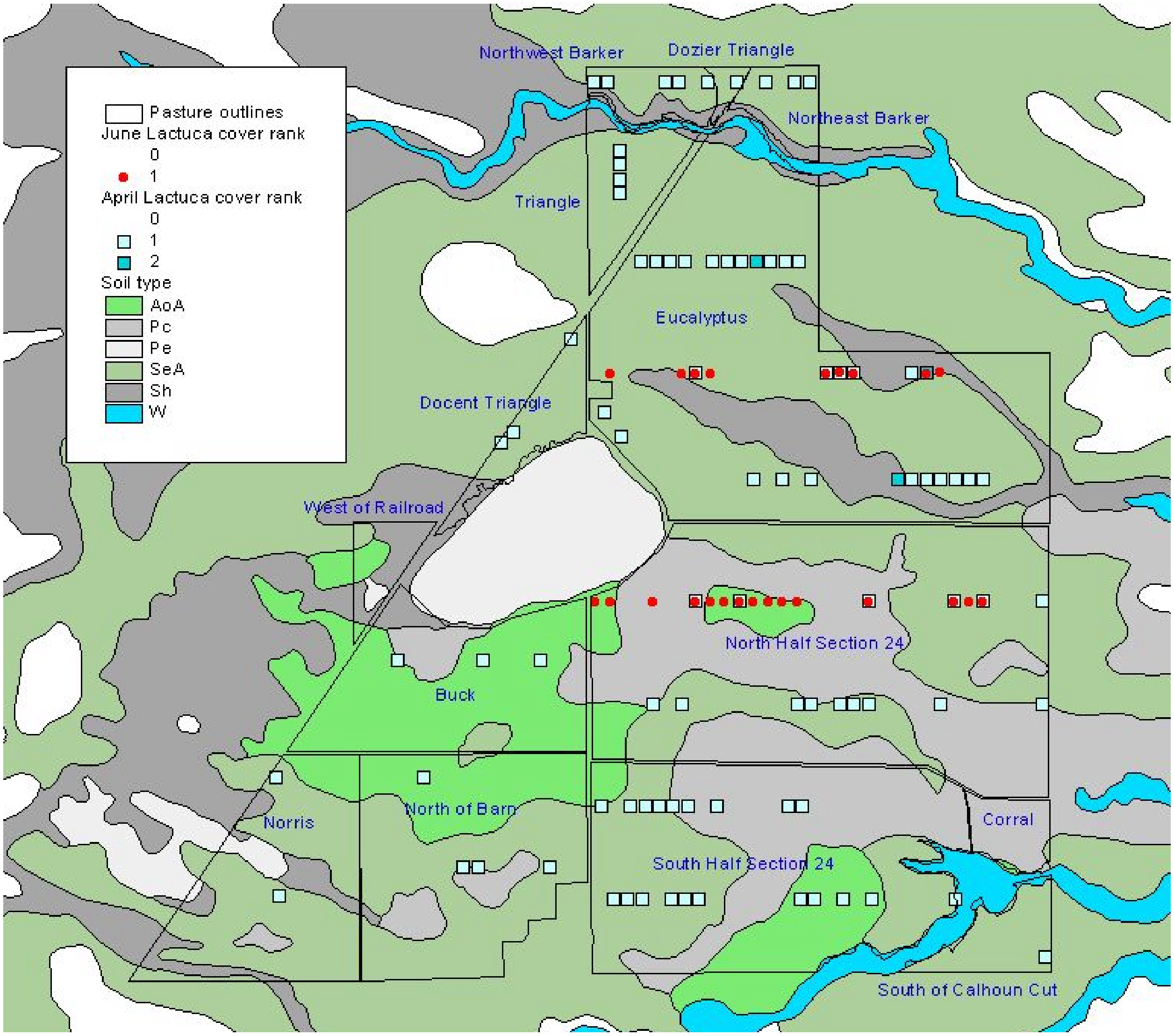


Figure 20. June 2001 monitoring of transects 6 and 8 for *Lactuca serriola* (red dots), superimposed on results of monitoring in April 2001 (blue squares). Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

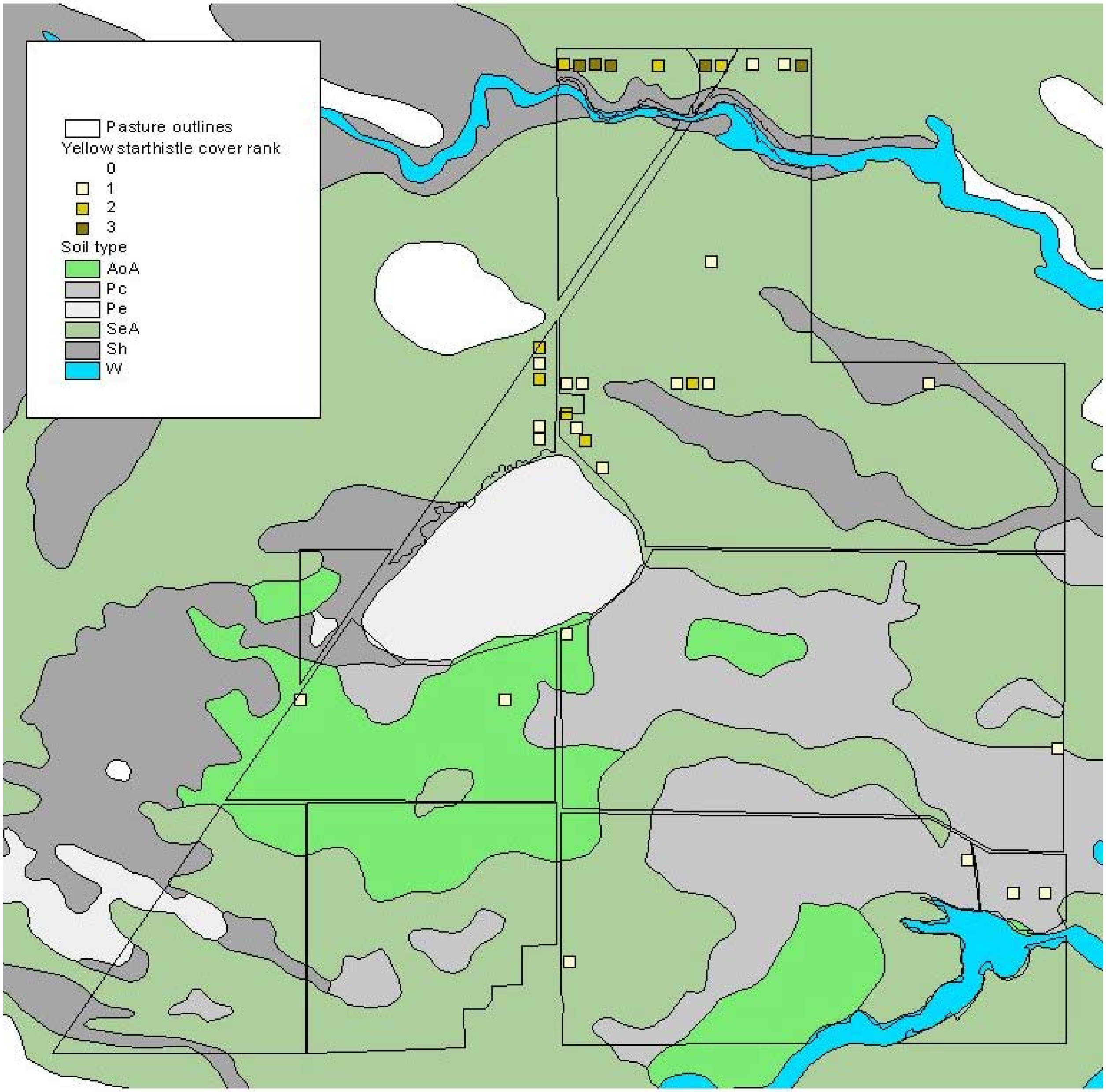


Figure 21. *Centaurea solstitialis* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

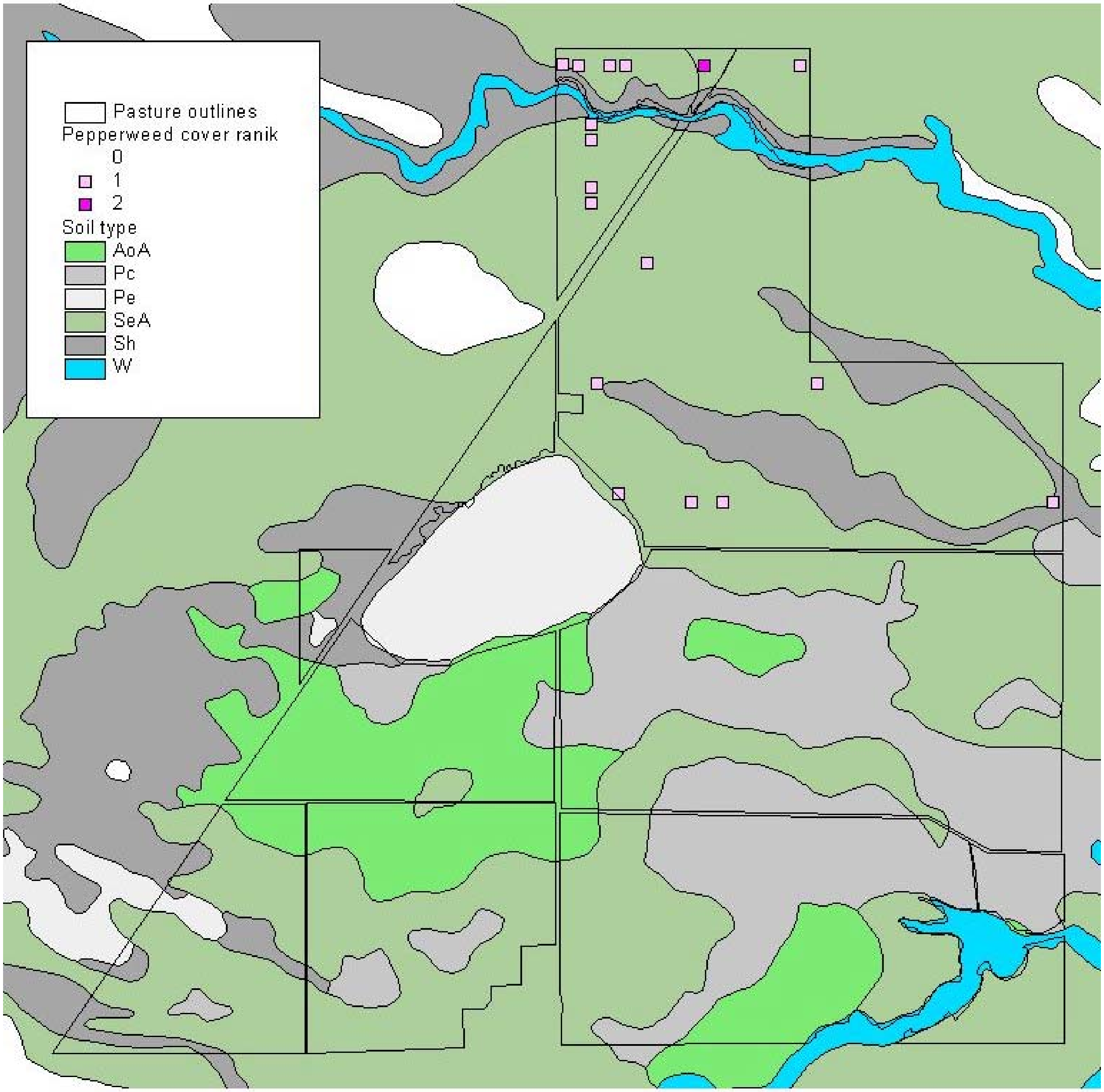


Figure 22. *Lepidium latifolium* cover ranks in transect segments, April 2001. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

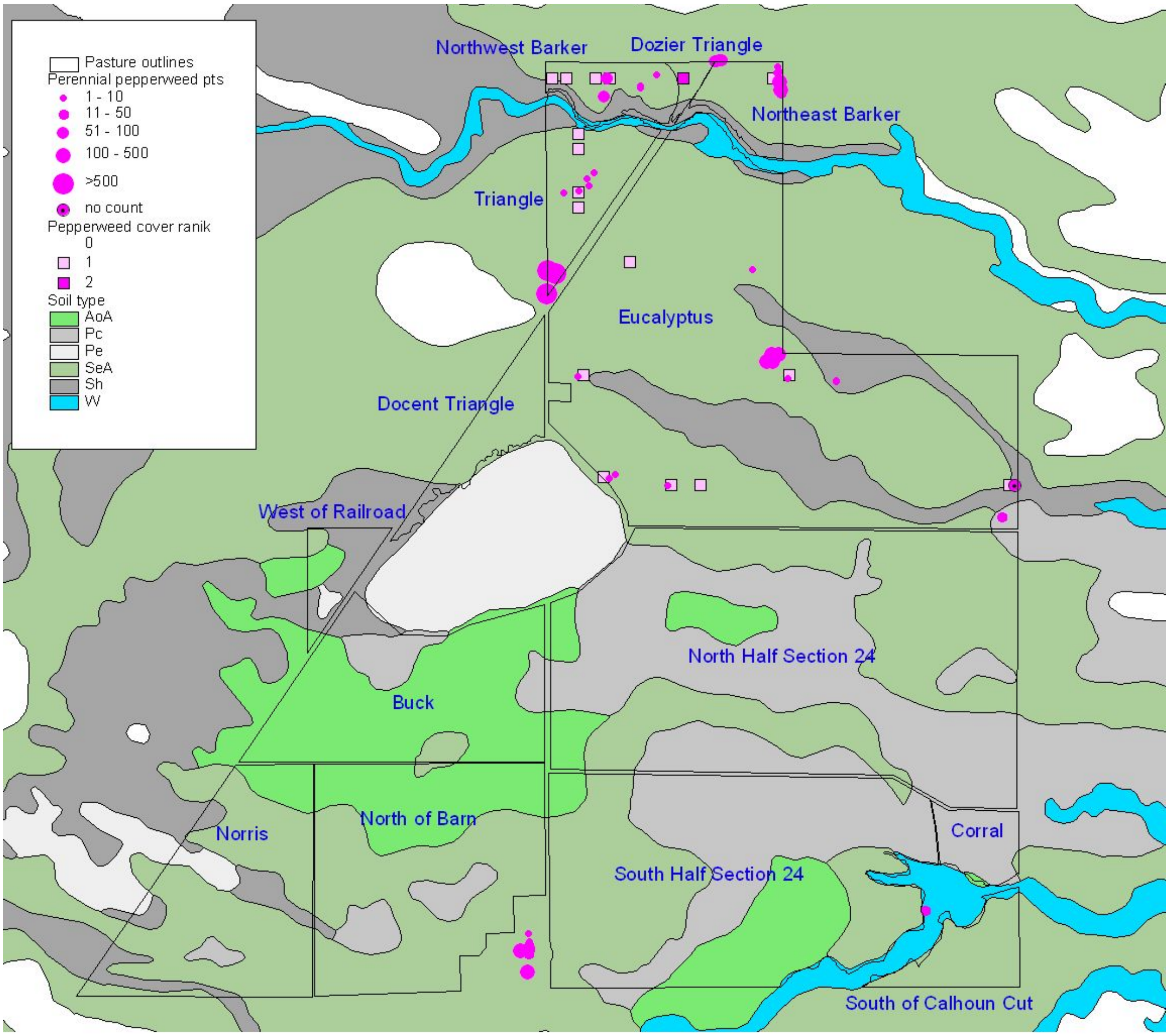


Figure 23. *Lepidium latifolium* cover ranks in transect segments April 2001 with mapped point/polygon populations,. Not all visible populations have been mapped in the heavily infested pastures north of Barker Slough. Markers for transect segments are centered over the midpoint of the segment. Point/polygon markers are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water. Markers are not to scale.

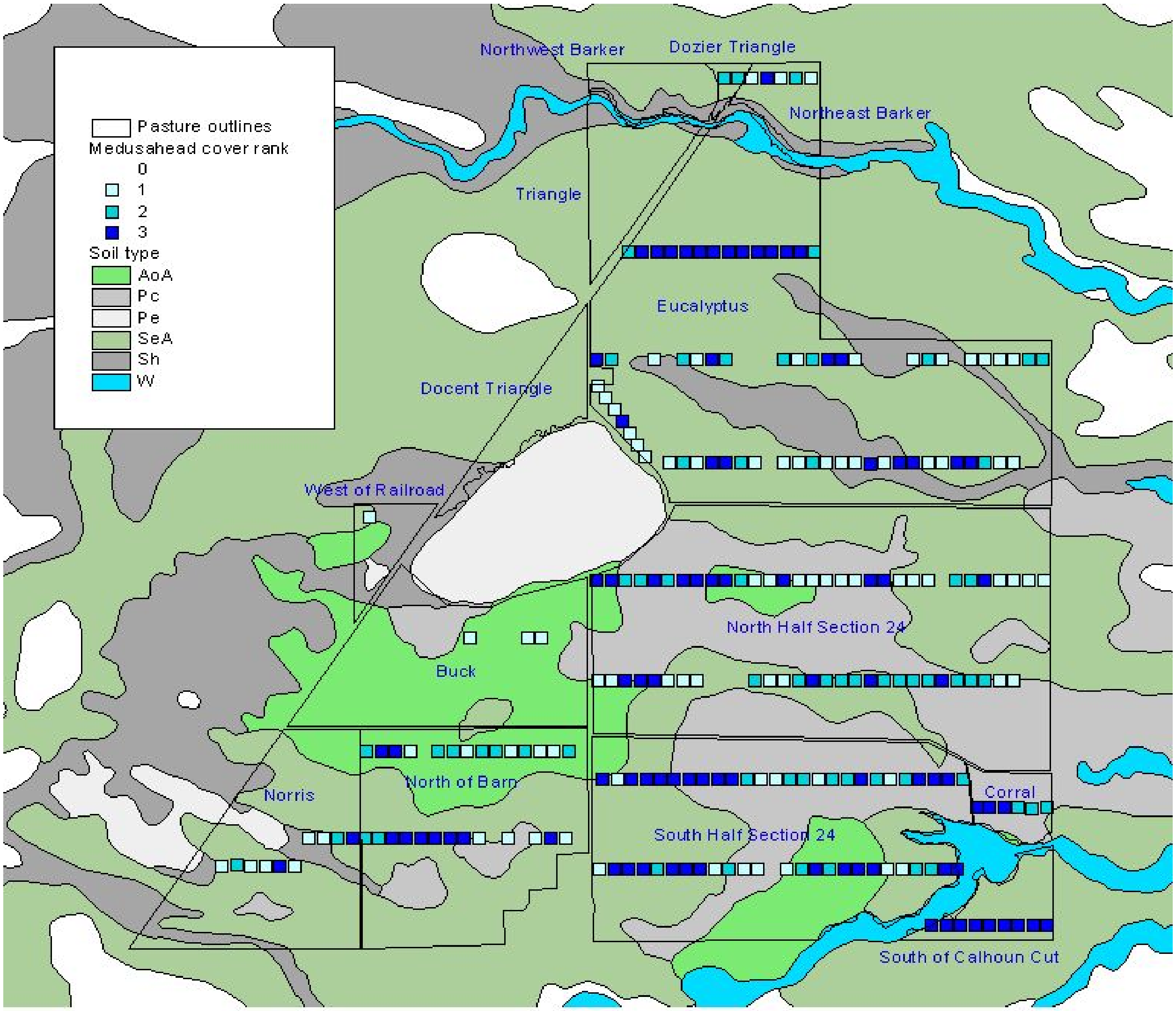


Figure 24. *Taeniatherum caput-medusae* cover ranks in transect segments, April 2001. Squares are centered at midpoints of transect segments and are not to scale. Markers for transect segments are centered over the midpoint of the segment and are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

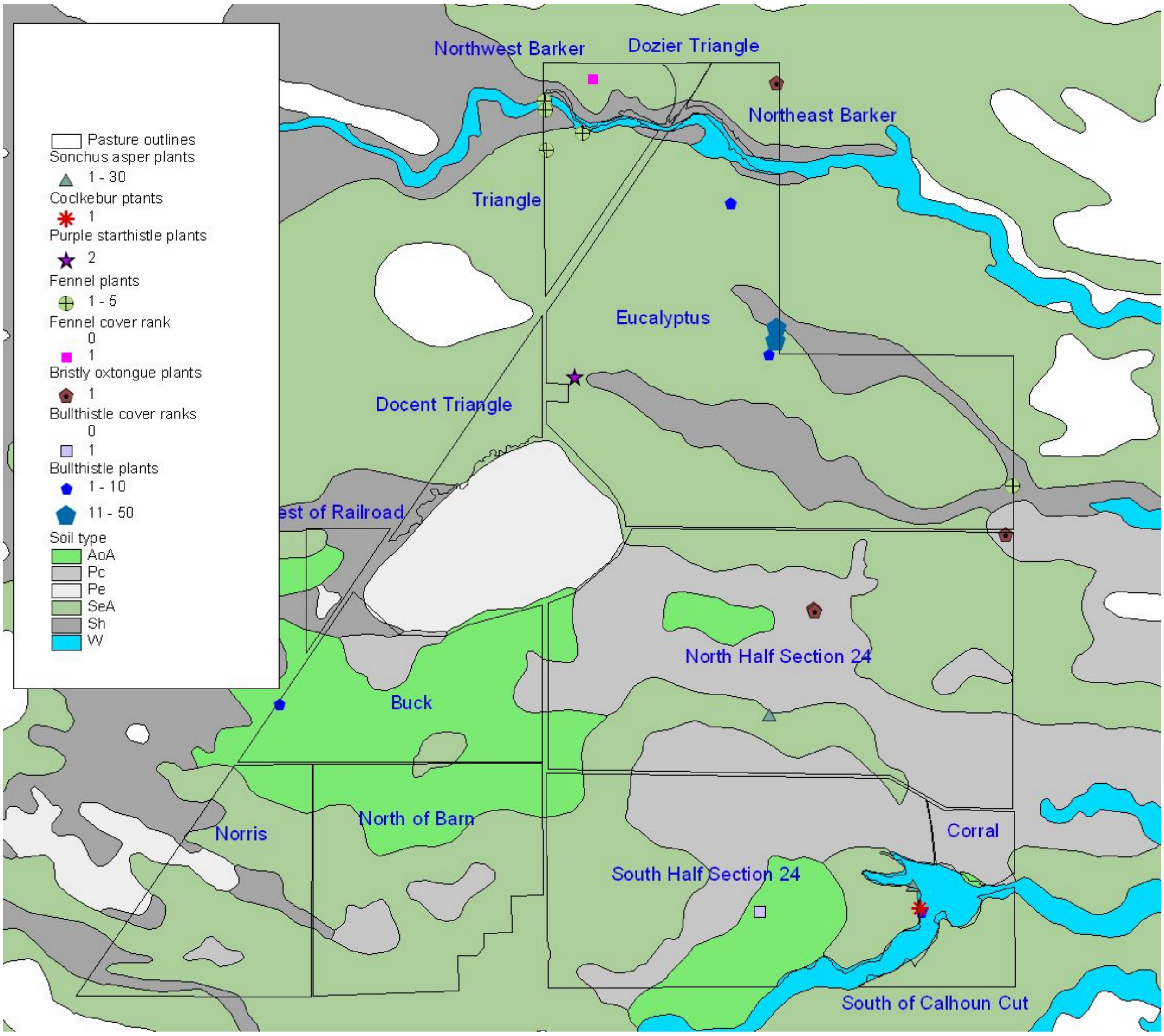


Figure 25. Rarely-occurring weeds noted during the April and June 2001 monitoring. Only one transect segment each contained *Cirsium vulgare* and *Foenicium vulgare*. Bristly ox-tongue (*Picris echioides*) is not on the target list of weeds. Markers for transect segments are centered over the midpoint of the segment. Markers are not to scale. Soil types: AoA=Antioch - San Ysidro complex, Pc=Pescadero clay loam, Pe=Pescadero clay, SeA=San Ysidro sandy loam, Sh=Solano loam, W=water.

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