The Vegetation of Suisun Marsh, Solano County, California: First Permanent Plot Resample Study 1999 vs. 2006

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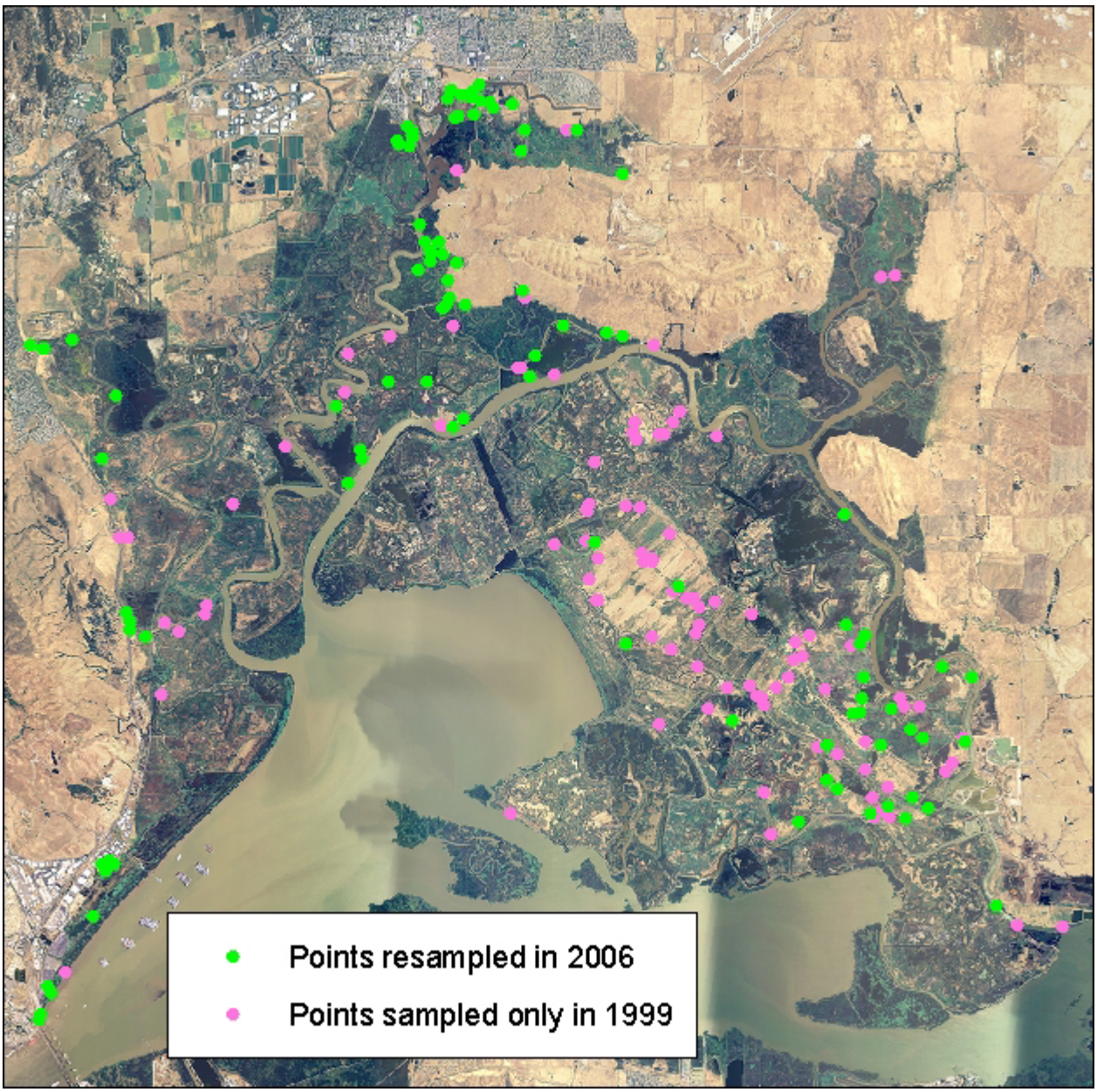
METHODS

In keeping with the monitoring focus of the Suisun Marsh Vegetation Surveys (Keeler-Wolf and Vaghti 2000), in 2006, 100 of the original 198 Suisun Marsh vegetation plots were selected to be revisited for the first time since their establishment in the summer of 1999. To enable regular re-sampling into the future without any access issues, only those plots located on DFG land, Rush Ranch, or other publicly-accessible lands were considered for resampling. Of these plots, 100 were selected by the DFG Vegetation Classification and Mapping Program to capture the diversity of vegetation types that represent the Marsh's vegetation as a whole. Due to the construction of the new Benicia-Martinez Bridge, two of the selected 100 plots are no longer in existence. Therefore, 98 plots were resampled (Figure 1). Each plot was located based on careful interpretation of GPS coordinates, field sample photos, aerial photos, and plot descriptions provided in the original 1999 field data.

Figure 1. Location of resampled points and points not resampled in 2006



Relocating (Finding) the Original Suisun Marsh Relevé Plots in 2006

In 1999, the location of field plots was recorded with Trimble Geoexplorer GPS units that were differentially corrected using a nearby base station to typically ±3 m. In 2006, these coordinates were loaded into the Garmin 12XL unit and were navigated to directly. The general location of each plot was relatively easy to find with a GPS unit, aerial photo, and the 1999 data sheet. Driving directions (and sometimes boat directions) were usually explicitly stated on the 1999 data sheets. More problems occurred when trying to determine the exact location of the plots. No standard was implemented in 1999 for the GPS recording point within each plot. Therefore, in 2006 we had to make a best guess based on the 1999 photos and the 1999 GPS point. This was not always accurate or reliable due to the error of the original GPS point, the error in the 2006 GPS reading, and the lack of precise location landmarks in many of the 1999 photos.

The orientation of the rectangular plots was also difficult to determine. It was never stated explicitly on any of the rectangular plot data sheets which way the long or short axis was oriented. Many times it was obvious (a narrow strip of vegetation along a levee or road), but sometimes field crews had to make an educated guess (especially if the ground photos were not useful).

In 2006 these standardization problems were addressed to enable future resampling to proceed more smoothly. The GPS point was almost always taken from the SW corner of the plot along with four additional photos that were taken of the cardinal directions. This was always recorded on the data sheet. Also, the orientation of each rectangular plot was stated explicitly. The corners of each plot were placed in the SW, NW, SE, and NE unless otherwise stated. If it was determined that in 1999 the plot was laid out so that the corners were in the exact cardinal position, or that the axis of the plot paralleled a road, levee, slough, etc., then this was also done in 2006 and recorded on the datasheet. To further aid future surveyors in relocating these plots, more photos were taken which were thought to give a better indication as to the position of the plots. All other elements of the original 1999 sampling protocol were replicated as best as possible.

Sampling Protocol in Both the 1999 and 2006 Efforts

Sites dominated by vegetation taller than 5 m were sampled in 1000 m sq plots. All other vegetation, including graminoids, shrubs and herbs, was sampled in 400 m sq plots. Plots were typically square but other shapes were used depending on the general dimensions of the vegetation to be sampled (e.g., long riparian corridors were typically sampled as long strips that totaled 1000 m sq). Plot size and shape were recorded on each field form. The variable size and shape of the plot based on the physiognomy of the vegetation and the fact that we collected estimates of cover for species rather than exact measurements exemplify characteristics of a phytosociological relevé (Barbour et al. 1998) rather than a fixed plot or point-intercept sample.

Global positioning systems were used to record the sample plots. Information regarding GPS file name and duration of data collection, which aided accuracy for the Trimble unit, was noted on the field form for 1999 plots; this was not necessary in 2006.

In 1999, record keeping was based on the assignment of plots to a particular vegetation polygon number. First, a preliminary number was given to the sample based on the aerial photo covering

the area of the sample and individual numbers of polygons within that photo. The polygon numbers were re-assigned following entry of all polygons into the GIS system. In 2006, the final plot number from 1999 was used.

Estimates of percent cover were required for all species greater than or equal to 1 percent cover; if less than 1 percent cover, cover was noted as "less than 1 percent." Additional estimates for total vegetation cover, and total tall, medium and low cover are included. These were thought to be important for such polygon attributes as total cover estimates. A separate entry for non-natives was noted to help with assessing impacts of invasive species.

Cover estimates for seven height classes were assigned based on a six-point scale. The dominant species for each height class was also recorded.

As with plant species, the cover values for open water, bedrock, gravel, cobble, stone, and litter were estimated in cover classes and actual percent of plot.

Appendix A contains a sample field form and the full sampling protocol.

Table 1 presents the number of person-hours required to resample the 98 plots in 2006.

Table 1. Person-hours spent resampling 98 plots at Suisun Marsh

Date	# of People	# of Hrs Worked/Person	Total Person Hrs/Day
17-Jul-06	4	8	32
18-Jul-06	4	8	32
19-Jul-06	5	8	40
20-Jul-06	4	8	32
24-Jul-06	2	8	16
25-Jul-06	2	8	16
26-Jul-06	2	8	16
27-Jul-06	2	8	16
31-Jul-06	2	8	16
1-Aug-06	2	8	16
2-Aug-06	3	8	24
3-Aug-06	2	8	16
7-Aug-06	2	8	16
8-Aug-06	2	8	16
9-Aug-06	2	8	16
10-Aug-06	2	8	16
5-Sep-06	2	8	16
7-Sep-06	2	8	16
11-Sep-06	2	8	16
12-Sep-06	2	8	16
13-Sep-06	2	8	16
19-Sep-06	3	6	18
Total Person Hours			**434**

Issues of Plot Change

The original 1999 plots were located based on stand homogeneity and were thought to represent the larger stand of a particular type. However, with the combination of management-induced changes such as flooding regime, mechanical manipulation (disking, ditching, etc.), burning, or seeding of certain desirable species, some of the original stands had clearly changed internally, leading to the location of the plots currently not within homogeneous patches of vegetation. When stand boundaries had shifted from the original sample, the location was kept the same, and additional notes were taken describing the types of shifts noted from the 1999 sample.

Comparisons of the 1999 and 2006 Samples

This report compares the original 1999 samples and the 2006 resamples with regard to the following characteristics:

- Vegetation type as identified using the key developed from the 1999 field samples as displayed in Keeler-Wolf and Vaghti (2000);
- Top three dominant species comparison from 1999 to 2006;
- Shifts in non-native species composition; and
- Basic shifts in floristic diversity and water cover.

RESULTS

Vegetation Type Changes

Table 2 presents the originally classified and currently classified names for each of the resampled plots. The key to vegetation types originally developed for the marsh following the 1999 sampling (Keeler-Wolf and Vaghti 2000) was used again to identify the vegetation growing in the same plot in 2006. Names indicated in bold have shifted from their original 1999 classification at the plant association level. Those highlighted in yellow have shifted at the alliance level of the vegetation classification. Those highlighted in blue have shifted in a more fundamental level (either major life-form difference such as a shrub type to an herbaceous type, or a vegetated to a non-vegetated). Each of these signifies a more significant degree of change. Association-level changes are the most minor and tend to represent minor shifts in species composition while the major dominant species remain the same. Alliance-level changes represent a major shift in species dominance, but some of the same species are usually present. Those changes indicated by the blue highlighting indicate a fundamental shift in presence or absence of species at the life-form level and are likely to indicate major management shifts or ecological change.

Table 2. Vegetation type in resampled plots, 1999 vs. 2006
Numbers after the names are the mapping code number. Bold = shift at association level; yellow highlight = shifted at the alliance level; blue highlight = major shift, either major life-form difference such as a shrub type to an herbaceous type, or a vegetated to a non-vegetated.

Plot #	Alliance/Association 1999	Alliance/Association 2006
001	Schoenoplectus (californicus and/or acutus)-Typha sp.	Schoenoplectus (californicus and/or acutus)-Typha sp. Association 157
002	Schoenoplectus maritimus/Salicornia virginica	Typha angustifolia-latifolia-domingensis /Distichlis association 126

Plot #	Alliance/Association 1999	Alliance/Association 2006
003	Typha species (generic)	Typha angustifolia-latifolia-domingensis /Distichlis association 126
004	Salix laevigata/S. lasiolepis association	Salix laevigata/S. lasiolepis association 702
009	Schoenoplectus californicus/S. acutus association 116	Schoenoplectus californicus/S. acutus association 116
010	Phragmites australis association 103	Phragmites australis association 103
011	Phragmites australis association 103	Water
012	Salix laevigata/S. lasiolepis association 702	Salix laevigata/S. lasiolepis association 702
013	Centaurea solstitialis alliance (generic) 413	Vulpia sp. /Euthamia occidentalis association 235
014	Salicornia/Distichlis 351	Typha species (generic) 123
015	Salicornia virginica association 346	Salicornia virginica association 346
016	**Salicornia/Polypogon 355**	**Salicornia virginica association 346**
020	**Schoenoplectus maritimus alliance 137**	**Schoenoplectus maritimus/Salicornia virginica association (138)**
021	Schoenoplectus maritimus/Salicornia virginica association	Salicornia virginica association 346
023	Atriplex/Distichlis association 312	Distichlis/Schoenoplectus americanus association 149
024	**Distichlis/A. triangularis 143**	**Distichlis/Salicornia association 148**
025	**Lolium/Bromus 217**	**Lolium/Lepidium association 220**
026	**Distichlis/Cotula association 153**	**Distichlis/Salicornia association 148**
034	Rubus discolor alliance 606	Rubus discolor alliance 606
036	Polygonum-Xanthium strumarium Association	Distichlis/Annual Grasses association 142
037	Cotula coronopifolia alliance (generic) 342	Cotula coronopifolia alliance (generic) 342
038	Atriplex/S. maritimus association 315	Schoenoplectus maritimus/Salicornia virginica association 138
039	**Salicornia/Atriplex association 348**	**Salicornia/Sesuvium 356**
040	**Salicornia/Sesuvium 356**	**Salicornia virginica association 346**
042	**Distichlis/Glaux 144**	**Distichlis/Salicornia association 148**
043	Distichlis/Juncus association 145	Juncus balticus/Potentilla anserina association 135
044	Rubus discolor alliance 606	Rubus discolor alliance 606
045	Typha species (generic) 123	Schoenoplectus (californicus and/or acutus)-Typha sp. association 157
046	Distichlis/Salicornia association 148	Distichlis/Salicornia association 148
047	Distichlis/Juncus association 145	Salicornia virginica Alliance
048	Schoenoplectus americanus (generic) 114	Schoenoplectus americanus alliance
049	Typha species (generic) 123	Typha angustifolia-latifolia-domingensis /S. americanus 121
050	Sesuvium verrucosum 357	Sesuvium verrucosum association 357
051	Schoenoplectus californicus/S. acutus association 116	Schoenoplectus californicus/S. acutus association 116
052	Baccharis/Annual Grasses 603	Baccharis/Annual Grasses 603
053	Salicornia/Distichlis 351	Salicornia/Distichlis 351
054	Rosa/Baccharis association 605	Rosa/Baccharis association 605
056	**Distichlis/Lactuca 146**	**Distichlis/Annual Grasses association 142**
058	Bromus spp. /Hordeum spp. association 232	Distichlis spicata/Annual Grasses association 142
059	Distichlis/Salicornia association 148	Distichlis/Salicornia association 148
060	Lepidium/Distichlis stands 323	Lepidium/Distichlis stands 323
061	**Distichlis/Lotus association**	**Distichlis/Salicornia association 148**
062	Leymus triticoides alliance (generic) 215	Leymus triticoides alliance (generic) 215
063	Schoenoplectus americanus (generic) 114	Schoenoplectus americanus (generic) 114
064	**Distichlis/Salicornia association 148**	**Distichlis-Juncus-Triglochin-Glaux association 160**

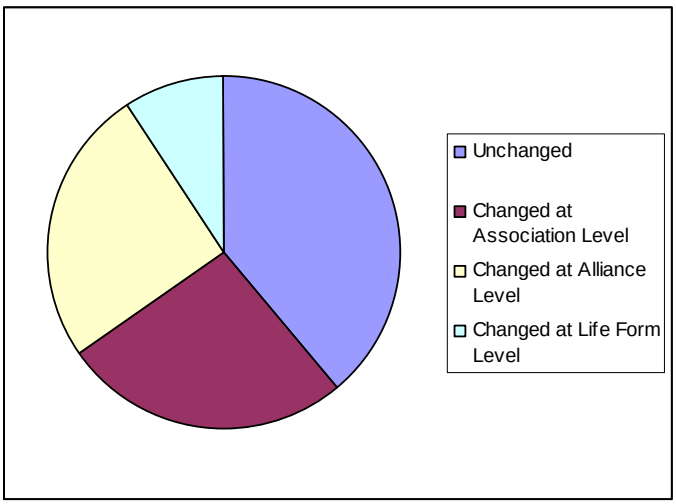
Plot #	Alliance/Association 1999	Alliance/Association 2006
065	Leymus triticoides alliance (generic) 215	Leymus triticoides alliance (generic) 215
067	Typha species (generic) 123	Typha angustifolia-latifolia-domingensis alliance
068	Salicornia/Lolium 354	Distichlis spicata/Annual Grasses association 142
070	Lolium/Salicornia 224	Hordeum/Lolium association 234
071	Distichlis/Juncus association 145	Typha angustifolia-latifolia-domingensis alliance
072	Schoenoplectus americanus (generic) 114	Schoenoplectus americanus alliance
073	Distichlis/Juncus association 145	Typha angustifolia-latifolia-domingensis /S. americanus 121 or just Schoenoplectus americanus alliance
074	**Frankenia/Rumex crispus 319**	**Frankenia salina Alliance or Lolium multiflorum alliance**
075	Frankenia/Distichlis 318	Distichlis/Annual Grasses association 142
076	Lolium/Rumex association 222	Lotus corniculatus alliance 344
077	Lolium (generic) 218	Salicornia virginica association 346
078	Grindelia stricta var. stricta stands 321	Lepidium latifolium alliance
079	**Salicornia/Polypogon 355**	**Salicornia virginica association 346**
083	**Distichlis/Schoenoplectus americanus association 149**	**Distichlis/Cotula association 153**
086	**Salicornia/Distichlis 351**	**Salicornia virginica association 346**
087	Apocynum/Schoenoplectus 302	Schoenoplectus (californicus or acutus)/Rosa 162
088	Schoenoplectus americanus (generic) 114	Typha species (generic) 123
089	**Salicornia/Polypogon 355**	**Salicornia/Annual Grasses 347**
090	Salicornia/Atriplex association 348	Distichlis spicata (generic) 156
091	**Lolium/Bromus 217**	**Lolium (generic) 218**
092	**Salicornia/Atriplex association 348**	**Salicornia virginica association 346**
099	Lepidium/Distichlis stands 323	Lepidium/Distichlis stands 323
107	**Salicornia/Distichlis 351**	**Salicornia virginica association 346**
108	Leymus triticoides alliance (generic) 215	Leymus triticoides alliance (generic) 215
110	**Salicornia/Distichlis 351**	**Salicornia virginica association 346**
111	Distichlis/Salicornia association 148	Distichlis/Salicornia association 148
118	Atriplex lentiformis (generic) 514	Atriplex lentiformis (generic) 514
136	**Distichlis/Lotus association**	**Distichlis spicata/Annual Grasses association 142**
145	**Schoenoplectus californicus/S. acutus association 116**	**Schoenoplectus californicus/S. acutus association 116**
147	Lolium (generic) 218	Distichlis spicata/Annual Grasses association 142
148	Lolium (generic) 218	Lolium (generic) 218
154	Atriplex/Distichlis association 312	Distichlis/Salicornia association 148
159	**Atriplex triangularis association 311**	**Atriplex/Annual Grasses stands 337**
161	Typha angustifolia-latifolia-domingensis /Echinochloa-Polygonum-Xanthium	Typha angustifolia-latifolia-domingensis /Echinochloa-Polygonum-Xanthium 120
168	Xanthium/Polypogon 332	Typha angustifolia-latifolia-domingensis /Phragmites australis 129
169	**Distichlis spicata 141**	**Distichlis spicata/Annual Grasses association 142**
170	Schoenoplectus maritimus/Sesuvium 139	Phragmites/Schoenoplectus association 104
171	Frankenia (generic) 320	Bromus spp. /Hordeum spp. association 232
172	Sesuvium verrucosum 357	Sesuvium verrucosum association 357
175	Phragmites/Xanthium 104	Echinochloa-Polygonum-Xanthium 159
176	Juncus balticus/Conium maculatum association 133	Juncus balticus/Conium maculatum association 133

Plot #	Alliance/Association 1999	Alliance/Association 2006
177	Juncus balticus/Conium maculatum association 133	Conium maculatum 402 or Juncus balticus/Conium maculatum association 133
180	Bare ground 001	Salicornia virginica association 346
181	Rosa/Baccharis association 605	Rosa/Baccharis association 605
184	Schoenoplectus californicus/S. acutus association 116	Schoenoplectus (californicus and/or acutus)-Typha sp. association 157
185	Atriplex triangularis association 311	Elytrigia pontica stands 211
186	Xanthium/Polypogon 332	Lotus corniculatus
189	**Salicornia/Sesuvium 356**	**Salicornia virginica association 346**
190	Bare ground 001	Open water
192	**Frankenia/Agrostis 317**	**Frankenia salina Alliance**
194	Juncus balticus association 132	Polypogon monspeliensis stands (generic) 238
195	Rosa californica alliance 604	Rosa californica alliance 604
197	Schoenoplectus (californicus and/or acutus)-Typha sp. association	Schoenoplectus (californicus and/or acutus)/Wetland Herbs 158

Summary of Vegetation Type Changes. The vegetation type of 38 plots remained unchanged. Twenty-six plots shifted at the association level, while 25 shifted at the alliance level, and 9 shifted at the fundamental life form level. Figure 2 depicts these changes graphically.

Note that changes from "Typha spp. Generic" to "Typha (latifolia-angustifolia-domingensis)" (Plots 003, 049 and 067) do not constitute a true change but a shift in name for the same vegetation type.

Figure 2. Vegetation Type Changes



Species Dominance Changes

Table 3 displays the 98 resampled plots compared to their 1999 original data with regard to the species with the highest cover estimates in each sample. This comparison addresses the major floristic similarities between the two sampling efforts. In the case where less than three species exist in the plot, missing species are indicated by "none." *Phragmites australis* is highlighted because even though it is treated as a native, technically the race that is predominant in the marsh is non-native and is thus important to keep track of for management purposes.

Table 3. The top species by % cover in 1999 versus 2006
Only those plots that were resampled in 2006 are listed. Those species with percent cover highlighted red indicate that there are other species within that plot with the same percent cover; the highlighted red ones were chosen for this table based on alphabetical order. Yellow highlight indicates *Phragmites australis* cover where it was recorded solely or, if in both the 1999 and 2006 paired sample, whichever plot had the higher cover.

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
1	57	*Schoenoplectus californicus*	35	*Schoenoplectus acutus* var. *occidentalis*
1	28	*Typha angustifolia*	15	*Schoenoplectus californicus*
1	10	*Schoenoplectus acutus*	8	*Typha angustifolia*
2	85	*Schoenoplectus maritimus*	55	*Typha angustifolia*
2	3	*Salicornia virginica*	2	*Schoenoplectus maritimus*
2	2	*Typha angustifolia*	0.2	*Distichlis spicata*
3	83	*Typha angustifolia*	50	*Typha angustifolia*
3	0.2	*Atriplex triangularis*	12	*Distichlis spicata*
3	0	None	8	*Schoenoplectus maritimus*
4	56	*Salix laevigata*	40	*Leymus triticoides*
4	41	*Leymus triticoides*	25	*Salix gooddingii*
4	16	*Salix lasiolepis*	10	*Salix lasiolepis*
9	70	*Schoenoplectus californicus*	40	*Schoenoplectus californicus*
9	30	*Spartina foliosa*	5	*Spartina foliosa*
10	100	*Phragmites australis*	95	*Phragmites australis*
10	0.2	*Lepidium latifolium*	0.2	*Scirpus acutus var. occidentalis*
11	95	*Phragmites australis*	0	None
12	60	*Salix laevigata*	55	*Salix laevigata*
12	13	*Cynodon dactylon*	40	*Salix lasiolepis*
12	10	*Salix lasiolepis*	6	*Schoenoplectus americanus*
13	70	*Centaurea solstitialis*	30	*Vulpia myuros*
13	20	*Distichlis spicata*	22	*Centaurea solstitialis*
13	12	*Bromus hordeaceus*	8	*Lolium multiflorum*
14	80	*Salicornia virginica*	30	*Typha latifolia*
14	6	*Distichlis spicata*	2	*Salicornia virginica*
14	3	*Schoenoplectus maritimus*	1	*Schoenoplectus maritimus*
15	91	*Salicornia virginica*	65	*Salicornia virginica*
15	4	*Frankenia salina*	3	*Frankenia salina*
15	1	*Polypogon monspeliensis*	8	*Distichlis spicata*
16	90	*Salicornia virginica*	60	*Salicornia virginica*
16	6	*Polypogon monspeliensis*	2	*Atriplex triangularis*
16	2	*Distichlis spicata*	4	*Distichlis spicata*
20	87	*Elytrigia pontica*	27	*Salicornia virginica*
20	5	*Lolium multiflorum*	2	*Schoenoplectus maritimus*
20	2	*Hordeum marinum*	0.2	*Typha angustifolia*
21	75	*Schoenoplectus maritimus*	60	*Salicornia virginica*
21	25	*Salicornia virginica*	3	*Sesuvium verrucosum*
21	0.2	*Cotula coronopifolia*	0.2	*Atriplex triangularis*
23	35	*Atriplex triangularis*	28	*Distichlis spicata*
23	32	*Distichlis spicata*	24	*Schoenoplectus americanus*
23	12	*Aster subulatus var. cubensis*	20	*Phragmites australis*
24	87	*Distichlis spicata*	45	*Distichlis spicata*

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
24	3	*Atriplex triangularis*	20	*Atriplex triangularis*
24	3	*Salicornia virginica*	15	*Salicornia virginica*
25	45	*Lolium multiflorum*	60	*Lolium multiflorum*
25	16	*Vulpia myuros*	10	*Bromus diandrus*
25	7	*Vicia sativa*	7	*Raphanus sativus*
26	30	*Distichlis spicata*	60	*Distichlis spicata*
26	16	*Cotula coronopifolia*	25	*Salicornia virginica*
26	15	*Schoenoplectus maritimus*	0.2	*Atriplex triangularis*
34	100	*Rubus discolor*	85	*Rubus discolor*
34	0.2	*Bromus diandrus*	10	*Raphanus sativus*
34	0.2	*Distichlis spicata*	1	*Carduus pycnocephalus*
36	52	*Polygonum argyrocoleon*	26	*Distichlis spicata*
36	15	*Rumex conglomeratus*	17	*Sonchus oleraceus*
36	9	*Cotula coronopifolia*	6	*Polypogon monspeliensis*
37	48	*Rumex conglomeratus*	33	*Phragmites australis*
37	45	*Cotula coronopifolia*	26	*Cotula coronopifolia*
37	20	*Polygonum argyrocoleon*	16	*Polypogon monspeliensis*
38	82	*Atriplex triangularis*	32	*Schoenoplectus maritimus*
38	25	*Schoenoplectus maritimus*	18	*Polypogon monspeliensis*
38	3	*Polypogon monspeliensis*	10	*Salicornia virginica*
39	76	*Salicornia virginica*	15	*Sesuvium verrucosum*
39	4	*Cotula coronopifolia*	10	*Salicornia virginica*
39	7	*Atriplex triangularis*	7	*Atriplex triangularis*
40	70	*Salicornia virginica*	1	*Salicornia virginica*
40	6	*Sesuvium verrucosum*	0.2	*Sesuvium verrucosum*
42	48	*Distichlis spicata*	30	*Salicornia virginica*
42	40	*Glaux maritima*	25	*Glaux maritima*
42	20	*Grindelia stricta*	20	*Grindelia stricta*
43	75	*Distichlis spicata*	42	*Juncus balticus*
43	40	*Juncus balticus*	25	*Distichlis spicata*
43	12	*Potentilla anserina*	20	*Grindelia stricta*
44	98	*Rubus discolor*	75	*Rubus discolor*
44	0.2	*Typha angustifolia*	6	*Distichlis spicata*
44	0.2	*Typha latifolia*	0.2	*Bromus diandrus*
45	55	*Typha angustifolia*	70	*Typha angustifolia*
45	40	*Schoenoplectus acutus*	25	*Schoenoplectus acutus*
45	1	*Schoenoplectus californicus*	0.2	*Distichlis spicata*
46	64	*Distichlis spicata*	40	*Distichlis spicata*
46	26	*Triglochin maritimum*	25	*Salicornia virginica*
46	8	*Jaumea carnosa*	15	*Jaumea carnosa*
47	38	*Juncus balticus*	30	*Salicornia virginica*
47	36	*Distichlis spicata*	18	*Juncus balticus*
47	28	*Glaux maritima*	14	*Glaux maritima*
48	76	*Schoenoplectus americanus*	65	*Schoenoplectus americanus*
48	55	*Calystegia sepium*	30	*Calystegia sepium*
48	30	*Euthamia occidentalis*	25	*Euthamia occidentalis*
49	92	*Typha angustifolia*	55	*Typha angustifolia*
49	6	*Schoenoplectus americanus*	20	*Schoenoplectus americanus*

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
49	1	*Schoenoplectus californicus*	13	*Typha latifolia*
50	98	*Sesuvium verrucosum*	30	*Sesuvium verrucosum*
50	1	*Atriplex triangularis*	12	*Schoenoplectus maritimus*
50	0.2	*Schoenoplectus maritimus*	12	*Digitaria sanguinalis*
51	80	*Schoenoplectus californicus*	98	*Schoenoplectus acutus*
51	0	None	1	*Schoenoplectus americanus*
52	60	*Hordeum marinum*	26	*Baccharis pilularis*
52	55	*Baccharis pilularis*	22	*Hordeum marinum*
52	14	*Bromus diandrus*	11	*Avena barbata*
53	65	*Salicornia virginica*	70	*Salicornia virginica*
53	19	*Distichlis spicata*	20	*Distichlis spicata*
53	5	*Atriplex triangularis*	2	*Cotula coronopifolia*
54	80	*Rosa californica*	70	*Rosa californica*
54	9	*Baccharis pilularis*	25	*Baccharis pilularis*
54	6	*Schoenoplectus californicus*	7	*Lolium multiflorum*
56	85	*Distichlis spicata*	50	*Distichlis spicata*
56	27	*Lactuca serriola*	25	*Bromus diandrus*
56	14	*Frankenia salina*	20	*Frankenia salina*
58	30	*Hordeum marinum*	48	*Bromus diandrus*
58	28	*Bromus hordeaceus*	26	*Distichlis spicata*
58	24	*Bromus diandrus*	5	*Lactuca serriola*
59	85	*Distichlis spicata*	55	*Distichlis spicata*
59	20	*Salicornia virginica*	50	*Salicornia virginica*
59	13	*Cuscuta salina* var. *major*	5	*Triglochin maritimum*
60	62	*Lepidium latifolium*	60	*Lepidium latifolium*
60	18	*Distichlis spicata*	15	*Distichlis spicata*
60	6	*Schoenoplectus americanus*	10	*Salicornia virginica*
61	49	*Distichlis spicata*	52	*Distichlis spicata*
61	28	*Lotus corniculatus*	25	*Salicornia virginica*
61	10	*Jaumea carnosa*	20	*Lotus corniculatus*
62	95	*Leymus triticoides*	52	*Leymus triticoides*
62	1	*Bromus hordeaceus*	14	*Lactuca serriola*
62	1	*Lepidium latifolium*	6	*Bromus hordeaceus*
63	88	*Scirpus americanus*	50	*Schoenoplectus americanus*
63	2	*Atriplex triangularis*	11	*Juncus balticus*
63	2	*Frankenia salina*	8	*Typha latifolia*
64	57	*Distichlis spicata*	35	*Distichlis spicata*
64	16	*Juncus balticus*	30	*Jaumea carnosa*
64	13	*Triglochin maritimum*	25	*Salicornia virginica*
65	85	*Leymus triticoides*	53	*Leymus triticoides*
65	22	*Distichlis spicata*	25	*Distichlis spicata*
65	7	*Bromus hordeaceus*	7	*Bromus hordeaceus*
67	80	*Typha latifolia*	85	*Typha latifolia*
67	20	*Juncus balticus*	2	*Schoenoplectus americanus*
67	10	*Atriplex triangularis*	0.2	*Atriplex triangularis*
68	48	*Salicornia virginica*	50	*Distichlis spicata*
68	30	*Lolium multiflorum*	20	*Lepidium latifolium*
68	17	*Frankenia salina*	10	*Lolium multiflorum*

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
70	68	*Lolium multiflorum*	65	*Lolium multiflorum*
70	13	*Frankenia salina*	25	*Hordeum marinum*
70	10	*Atriplex triangularis*	20	*Frankenia salina*
71	71	*Distichlis spicata*	76	*Typha latifolia*
71	10	*Juncus balticus*	2	*Atriplex triangularis*
71	7	*Typha*	0.2	*Distichlis spicata*
72	80	*Schoenoplectus americanus*	75	*Schoenoplectus americanus*
72	7	*Atriplex triangularis*	2	*Salicornia virginica*
72	1	*Salicornia virginica*	0.2	*Atriplex triangularis*
73	60	*Distichlis spicata*	50	*Schoenoplectus americanus*
73	16	*Juncus balticus*	18	*Typha latifolia*
73	7	*Sonchus oleraceus*	18	*Atriplex triangularis*
74	40	*Frankenia salina*	60	*Lolium multiflorum*
74	25	*Rumex crispus*	40	*Frankenia salina*
74	20	*Lolium multiflorum*	4	*Hordeum marinum*
75	51	*Frankenia salina*	30	*Distichlis spicata*
75	45	*Distichlis spicata*	25	*Atriplex triangularis*
75	10	*Atriplex triangularis*	15	*Frankenia salina*
76	70	*Rumex crispus*	45	*Lotus corniculatus*
76	20	*Lolium multiflorum*	20	*Lepidium latifolium*
76	5	*Distichlis spicata*	12	*Lolium multiflorum*
77	45	*Hordeum marinum*	45	*Salicornia virginica*
77	40	*Lolium multiflorum*	10	*Frankenia salina*
77	12	*Frankenia salina*	2	*Lolium multiflorum*
78	77	*Grindelia stricta* var. *angustifolia*	70	*Lepidium latifolium*
78	10	*Lolium multiflorum*	35	*Grindelia stricta*
78	5	*Lotus corniculatus*	30	*Frankenia salina*
79	90	*Salicornia virginica*	70	*Salicornia virginica*
79	1	*Polypogon monspeliensis*	1	*Polypogon monspeliensis*
79	0.2	*Hordeum marinum*	0	None
83	50	*Distichlis spicata*	60	*Distichlis spicata*
83	35	*Schoenoplectus americanus*	17	*Cotula coronopifolia*
83	5	*Juncus balticus*	8	*Polypogon monspeliensis*
86	53	*Salicornia virginica*	60	*Salicornia virginica*
86	16	*Distichlis spicata*	20	*Distichlis spicata*
86	12	*Polypogon monspeliensis*	10	*Picris echioides*
87	35	*Apocynum cannabinum*	45	*Schoenoplectus acutus*
87	20	*Schoenoplectus acutus*	30	*Rosa californica*
87	18	*Rosa californica*	15	*Apocynum cannabinum*
88	60	*Schoenoplectus americanus*	85	*Typha latifolia*
88	35	*Typha angustifolia*	4	*Schoenoplectus americanus*
88	6	*Polypogon monspeliensis*	2	*Schoenoplectus acutus*
89	60	*Salicornia virginica*	51	*Salicornia virginica*
89	15	*Polypogon monspeliensis*	18	*Poaceae*
89	10	*Rumex crispus*	16	*Salicornia virginica*
90	85	*Salicornia virginica*	90	*Distichlis spicata*
90	7	*Atriplex triangularis*	4	*Lepidium latifolium*
90	1	*Lepidium latifolium*	7	*Phragmites australis*

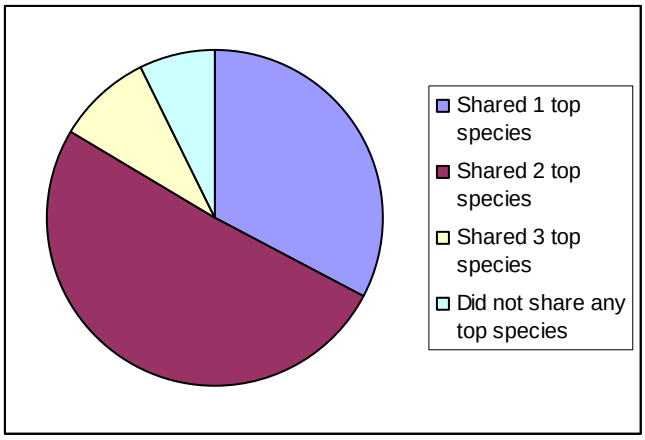
Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
91	75	*Lolium multiflorum*	68	*Lolium multiflorum*
91	7	*Bromus hordeaceus*	16	*Frankenia salina*
91	4	*Hordeum marinum* ssp. *gussonianum*	10	*Hordeum marinum*
92	85	*Salicornia virginica*	85	*Salicornia virginica*
92	14	*Atriplex triangularis*	2	*Polypogon monspeliensis*
92	2	*Rumex pulcher*	3	*Rumex dentatus*
99	78	*Lepidium latifolium*	40	*Lepidium latifolium*
99	53	*Distichlis spicata*	40	*Distichlis spicata*
99	4	*Salicornia virginica*	3	*Cotula coronopifolia*
107	48	*Salicornia virginica*	54	*Salicornia virginica*
107	10	*Distichlis spicata*	5	*Distichlis spicata*
107	2	*Atriplex triangularis*	1	*Limonium californicum*
108	45	*Leymus triticoides*	40	*Leymus triticoides*
108	30	*Bromus diandrus*	12	*Taeniatherum caput-medusae*
108	15	*Bromus hordeaceus*	10	*Bromus diandrus*
110	89	*Salicornia virginica*	75	*Salicornia virginica*
110	6	*Cuscuta salina* var. *major*	6	*Cuscuta salina*
110	2	*Distichlis spicata*	2	*Hainardia cylindrica*
111	70	*Distichlis spicata*	49	*Salicornia virginica*
111	20	*Salicornia virginica*	49	*Distichlis spicata*
111	13	*Cordylanthus mollis* ssp. *mollis*	2	*Cuscuta salina*
118	28	*Atriplex lentiformis*	33	*Atriplex lentiformis*
118	28	*Atriplex triangularis*	22	*Conium maculatum*
118	24	*Conium maculatum*	3	*Hordeum marinum*
136	76	*Distichlis spicata*	70	*Lolium multiflorum*
136	8	*Lolium multiflorum*	22	*Distichlis spicata*
136	6	*Lotus corniculatus*	10	*Frankenia salina*
145	98	*Schoenoplectus californicus*	93	*Schoenoplectus californicus*
145	1	*Atriplex triangularis*	7	*Distichlis spicata*
145	0.2	*Juncus balticus*	0.2	*Agrostis avenacea*
147	44	*Lolium multiflorum*	25	*Distichlis spicata*
147	35	*Agrostis avenacea*	15	*Polypogon monspeliensis*
147	23	*Xanthium strumarium*	10	*Lolium multiflorum*
148	96	*Lolium multiflorum*	97	*Lolium multiflorum*
148	2	*Atriplex triangularis*	2	*Bromus diandrus*
148	0.2	*Lactuca serriola*	1	*Distichlis spicata*
154	28	*Atriplex triangularis*	20	*Salicornia virginica*
154	15	*Distichlis spicata*	15	*Distichlis spicata*
154	8	*Schoenoplectus maritimus*	12	*Polypogon monspeliensis*
159	97	*Atriplex triangularis*	35	*Atriplex triangularis*
159	1	*Polypogon monspeliensis*	30	*Phragmites australis*
159	1	*Phragmites australis*	5	*Polygonum*
161	50	*Typha angustifolia*	40	*Xanthium strumarium*
161	30	*Polygonum lapathifolium*	30	*Typha angustifolia*
161	30	*Echinochloa crus-galli*	16	*Atriplex triangularis*
168	52	*Polypogon monspeliensis*	50	*Phragmites australis*
168	28	*Xanthium strumarium*	25	*Typha angustifolia*

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
168	10	*Lotus corniculatus*	3	*Juncus balticus*
169	93	*Distichlis spicata*	51	*Lolium multiflorum*
169	1	*Lolium multiflorum*	20	*Bromus diandrus*
169	1	*Salicornia virginica*	20	*Distichlis spicata*
170	62	*Schoenoplectus maritimus*	20	*Phragmites australis*
170	12	*Sesuvium verrucosum*	14	*Rumex conglomeratus*
170	7	*Polygonum argyrocoleon*	10	*Schoenoplectus maritimus*
171	85	*Frankenia salina*	56	*Bromus diandrus*
171	27	*Lolium multiflorum*	35	*Lolium multiflorum*
171	1	*Juncus balticus*	3	*Frankenia salina*
172	100	*Sesuvium verrucosum*	70	*Sesuvium verrucosum*
172	1	*Schoenoplectus maritimus*	14	*Polygonum lapathifolium*
172	0	None	2	*Atriplex triangularis*
175	35	*Xanthium strumarium*	70	*Xanthium strumarium*
175	30	*Phragmites australis*	12	*Polygonum lapathifolium*
175	27	*Polygonum lapathifolium*	9	*Phragmites australis*
176	34	*Juncus balticus*	42	*Conium maculatum*
176	33	*Conium maculatum*	40	*Juncus balticus*
176	8	*Centaurea solstitialis*	5	*Centaurea solstitialis*
177	80	*Juncus balticus*	70	*Juncus balticus*
177	48	*Conium maculatum*	53	*Conium maculatum*
177	7	*Raphanus sativus*	2	*Sonchus oleraceus*
180	0.2	*Sesuvium verrucosum*	0.2	*Salicornia virginica*
180	0.2	*Salicornia virginica*	0	None
181	60	*Baccharis pilularis*	60	*Baccharis pilularis*
181	20	*Rosa californica*	50	*Rosa californica*
181	4	*Euthamia occidentalis*	2	*Calystegia sepium*
184	50	*Schoenoplectus californicus*	40	*Typha angustifolia*
184	12	*Schoenoplectus americanus*	30	*Schoenoplectus acutus*
184	7	*Typha angustifolia*	15	*Schoenoplectus americanus*
185	88	*Atriplex triangularis*	90	*Elytrigia pontica*
185	0.2	*Lactuca serriola*	3	*Conium maculatum*
185	1	*Elytrigia pontica*	3	*Brassica nigra*
186	80	*Xanthium strumarium*	51	*Xanthium strumarium*
186	7	*Cotula coronopifolia*	25	*Cotula coronopifolia*
186	5	*Polypogon monspeliensis*	10	*Salicornia virginica*
189	33	*Salicornia virginica*	65	*Salicornia virginica*
189	1	*Cotula coronopifolia*	1	*Schoenoplectus maritimus*
189	6	*Sesuvium verrucosum*	0.2	*Atriplex triangularis*
190	1	*Echinochloa crus-galli*	0	None
190	0.2	*Sesuvium verrucosum*	0	None
190	0.2	*Cotula coronopifolia*	0	None
192	92	*Frankenia salina*	30	*Frankenia salina*
192	35	*Agrostis avenacea*	20	*Bromus diandrus*
192	7	*Distichlis spicata*	16	*Distichlis spicata*
194	92	*Juncus balticus*	85	*Polypogon monspeliensis*
194	12	*Salicornia virginica*	1	*Rumex conglomeratus*
194	1	*Frankenia salina*	3	*Cotula coronopifolia*

Plot #	Percent Cover 1999	Top Species 1999	Percent Cover 2006	Top Species 2006
195	76	*Rosa californica*	49	*Rosa californica*
195	7	*Frankenia salina*	37	*Poa*
195	4	*Lepidium latifolium*	12	*Frankenia salina*
197	70	*Schoenoplectus acutus*	40	*Schoenoplectus acutus*
197	70	*Typha angustifolia*	30	*Typha angustifolia*
197	60	*Euthamia occidentalis*	15	*Rubus discolor*

Summary of Table 3. A total of 32 plots shared a single top species; 50 plots shared two top species; 9 shared 3 top species; and 7 did not share any of the 3 top species. Figure 3 represents this graphically. Note that those species shared are not necessarily in the same order of dominance.

Figure 3. Number of shared top species within each plot in 1999 vs. 2006



Non-Native Species Comparison

Another way to compare the data is to focus on the non-native plants. The marsh is home to a high diversity of non-native species. These include "new natives" that have become well integrated into the California ecosystems over the past 200 years (including grasses such as *Bromus* spp., *Avena* spp., *Lolium multiflorum*, and *Vulpia myuros*) and also include more recent introductions such as *Arundo donax*, *Lepidium latifolium*, and *Elytrigia* spp.). These latter species are actively increasing in many parts of the state and are especially invasive in wetlands such as Suisun Marsh. Table 4 displays the top (up to 3) species of non-native species on each of the resampled plots compared to the original top (up to 3) species sampled in 1999. *Lepidium latifolium*, one of the most worrisome non-natives, is highlighted in yellow where it attains its highest value in the plot by plot comparison. Comparisons between cover of the partially non-native species *Phragmites australis*, which is represented by both native and non-native forms, was not made because the native and non-native genotypes were not differentiated in the 1999 surveys. This will now be possible because field crews identified the non-native *P. australis* when encountered in the 2006 surveys. However, assuming that the majority of *P. australis* in Suisun Marsh is the non-native European ecotype, referring back to Table 1, there appears to be a sobering increase in the cover of this species. In 1999, 226% *Phragmites* cover was noted in 4 plots. In 2006, 264% cover was noted in 7 plots for a net increase of 3 plots and 58% cover. Plot

11 was the only sample where a substantial reduction in *Phragmites* was noted and this was a result of complete flooding of the plot.

Table 4. Top non-native species by percent cover for each plot in 1999 versus 2006
Only those plots that were resampled in 2006 are listed. Not all plots contained exotic species and are, therefore, not included in the table. Those species with percent cover highlighted red indicate that there are other non-native species within that plot with the same percent cover and they were chosen for this table based on alphabetical order. Presence of *Lepidium latifolium* and its highest cover in the pair-wise plot comparisons are highlighted in yellow.

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
1	0	None	0.2	*Apium graveolens*
4	7	*Echinochloa crus-galli*	1	*Bromus diandrus*
4	2	*Foeniculum vulgare*	1	*Malva neglecta*
4	1	*Polypogon monspeliensis*	1	*Paspalum dilatatum*
12	13	*Cynodon dactylon*	4	*Agrostis viridis*
12	0.2	*Acacia*	1	*Rubus discolor*
12	0.2	*Cotula coronopifolia*	0.2	*Hedera*
13	70	*Centaurea solstitialis*	30	*Vulpia myuros*
13	12	*Bromus hordeaceus*	22	*Centaurea solstitialis*
13	3	*Hordeum marinum*	8	*Lolium multiflorum*
14	2	*Cotula coronopifolia*	0.2	*Cotula coronopifolia*
14	0.2	*Polypogon monspeliensis*	0	None
15	1	*Polypogon monspeliensis*	1	*Polypogon monspeliensis*
15	0	None	0.2	*Cotula coronopifolia*
15	0	None	0.2	*Rumex pulcher*
16	6	*Polypogon monspeliensis*	0.2	*Cotula coronopifolia*
16	1	*Cotula coronopifolia*	0.2	*Bromus hordeaceus*
16	0.2	*Rumex pulcher*	0.2	*Bromus diandrus*
20	87	*Elytrigia pontica*	0	None
20	5	*Lolium multiflorum*	0	None
20	2	*Hordeum marinum*	0	None
21	0.2	*Cotula coronopifolia*	0.2	*Crypsis schoenoides*
23	7	*Lactuca serriola*	2	*Polypogon monspeliensis*
23	6	*Cotula coronopifolia*	1	*Rumex conglomeratus*
23	0.2	*Sonchus oleraceus*	0.2	*Cotula coronopifolia*
24	1	*Lactuca serriola*	0.2	*Lepidium latifolium*
24	1	*Cotula coronopifolia*	0.2	*Cotula coronopifolia*
24	0.2	*Polypogon monspeliensis*	0.2	*Lactuca serriola*
25	45	*Lolium multiflorum*	60	*Lolium multiflorum*
25	16	*Vulpia myuros*	10	*Bromus diandrus*
25	7	*Vicia sativa*	7	*Raphanus sativus*
26	16	*Cotula coronopifolia*	0.2	*Cotula coronopifolia*
26	15	*Polypogon monspeliensis*	0	None
26	0.2	*Rumex conglomeratus*	0	None
34	100	*Rubus discolor*	85	*Rubus discolor*
34	0.2	*Bromus diandrus*	10	*Raphanus sativus*
34	0.2	*Lepidium latifolium*	1	*Carduus pycnocephalus*
36	52	*Polygonum argyrocoleon*	17	*Sonchus oleraceus*
36	15	*Rumex conglomeratus*	6	*Polypogon monspeliensis*

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
36	9	*Cotula coronopifolia*	4	*Cotula coronopifolia*
37	48	*Rumex conglomeratus*	28	*Polypogon monspeliensis*
37	45	*Cotula coronopifolia*	26	*Cotula coronopifolia*
37	20	*Polygonum argyrocoleon*	1	*Chenopodium album*
38	3	*Polypogon monspeliensis*	22	*Polypogon monspeliensis*
38	1	*Rumex conglomeratus*	1	*Rumex conglomeratus*
38	0.2	*Cotula coronopifolia*	0	None
39	4	*Cotula coronopifolia*	2	*Polypogon monspeliensis*
39	1	*Rumex pulcher*	1	*Cotula coronopifolia*
39	0.2	*Polypogon monspeliensis*	1	*Rumex conglomeratus*
42	3	*Apium graveolens*	3	*Lepidium latifolium*
42	1	*Lepidium latifolium*	1	*Apium graveolens*
42	0.2	*Sonchus oleraceus*	0.2	*Polypogon monspeliensis*
43	0.2	*Lepidium latifolium*	1	*Lepidium latifolium*
43	0.2	*Cirsium*	0.2	*Rumex crispus*
43	0.2	*Lotus corniculatus*	0.2	*Polygonum sp.*
44	98	*Rubus discolor*	75	*Rubus discolor*
44	0.2	*Lepidium latifolium*	0.2	*Lepidium latifolium*
44	0	None	0.2	*Bromus diandrus*
45	0	None	0.2	*Lepidium latifolium*
46	0	None	0.2	*Lotus corniculatus*
46	0	None	0.2	*Apium graveolens*
47	0	None	1	*Apium graveolens*
47	0	None	0.2	*Potentilla anserina ssp. pacifica*
47	0	None	0.2	*Lotus corniculatus*
48	0.2	*Sonchus oleraceus*	5	*Apium graveolens*
48	0	None	0.2	*Polypogon monspeliensis*
48	0	None	0.2	*Asparagus officinalis*
50	0	None	12	*Digitaria sanguinalis*
50	0	None	0.2	*Xanthium strumarium*
52	60	*Hordeum marinum*	22	*Hordeum marinum*
52	14	*Bromus diandrus*	11	*Bromus diandrus*
52	9	*Hypochaeris radicata*	11	*Avena barbata*
53	0.2	*Polypogon monspeliensis*	2	*Cotula coronopifolia*
53	0.2	*Rumex crispus*	1	*Polypogon monspeliensis*
54	3	*Bromus diandrus*	7	*Lolium multiflorum*
54	0.2	*Lactuca serriola*	4	*Foeniculum vulgare*
54	0	None	3	*Cynodon dactylon*
56	27	*Lactuca serriola*	25	*Bromus diandrus*
56	6	*Bromus diandrus*	3	*Lolium multiflorum*
56	0.2	*Sonchus oleraceus*	2	*Centaurea solstitialis*
58	30	*Hordeum marinum*	48	*Bromus diandrus*
58	28	*Bromus hordeaceus*	5	*Lactuca serriola*
58	24	*Bromus diandrus*	4	*Centaurea solstitialis*
59	0	None	2	*Apium graveolens*
59	0	None	1	*Lotus corniculatus*
59	0	None	0.2	*Polypogon monspeliensis*

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
60	62	*Lepidium latifolium*	60	*Lepidium latifolium*
60	0.2	*Lactuca serriola*	0.2	*Apium graveolens*
60	0	None	0.2	Polypogon monspeliensis
61	28	*Lotus corniculatus*	20	Lotus corniculatus
61	2	*Rumex crispus*	1	Polypogon monspeliensis
61	0.2	*Picris echioides*	0.2	*Apium graveolens*
62	1	*Bromus hordeaceus*	14	*Lactuca serriola*
62	1	*Lepidium latifolium*	6	*Bromus hordeaceus*
62	0.2	*Rumex crispus*	4	*Avena*
63	1	*Cirsium vulgare*	6	*Lepidium latifolium*
63	1	*Polygonum argyrocoleon*	1	*Picris echioides*
63	1	*Picris echioides*	0.2	*Apium graveolens*
65	7	Bromus hordeaceus	7	*Bromus hordeaceus*
65	5	Convolvulus arvensis	5	*Bromus diandrus*
65	1	*Bromus diandrus*	3	*Convolvulus arvensis*
68	30	*Lolium multiflorum*	20	*Lepidium latifolium*
68	1	*Rumex crispus*	15	*Lolium multiflorum*
68	0.2	*Lepidium latifolium*	5	*Rumex crispus*
70	68	*Lolium multiflorum*	65	*Lolium multiflorum*
70	5	*Hordeum marinum ssp. gussonianum*	25	*Hordeum marinum*
70	3	*Bromus hordeaceus*	2	*Rumex crispus*
71	5	*Cotula coronopifolia*	0	None
71	0.2	*Sonchus oleraceus*	0	None
71	0.2	*Rumex crispus*	0	None
73	7	*Sonchus oleraceus*	2	*Sonchus oleraceus*
73	5	*Lactuca serriola*	0.2	*Rumex crispus*
73	0	None	0	None
74	25	*Rumex crispus*	60	*Lolium multiflorum*
74	20	*Lolium multiflorum*	4	*Hordeum marinum*
74	3	*Bromus diandrus*	3	*Rumex crispus*
75	0.2	*Lactuca serriola*	15	*Lolium multiflorum*
75	0.2	*Sonchus oleraceus*	6	*Lactuca serriola*
75	0.2	*Polygonum arenastrum*	1	*Polygonum baldschuanicum*
76	70	*Rumex crispus*	45	*Lotus corniculatus*
76	20	*Lolium multiflorum*	20	*Lepidium latifolium*
76	1	*Lepidium latifolium*	12	*Lolium multiflorum*
77	45	*Hordeum marinum*	2	*Lolium multiflorum*
77	45	*Lolium multiflorum*	0.2	*Cotula coronopifolia*
77	0	None	0.2	*Polypogon monspeliensis*
78	10	*Lolium multiflorum*	70	*Lepidium latifolium*
78	5	*Lotus corniculatus*	1	*Lotus corniculatus*
78	5	*Lepidium latifolium*	1	*Apium graveolens*
79	1	*Polypogon monspeliensis*	1	*Polypogon monspeliensis*
79	0.2	*Hordeum marinum*	0.2	*Lolium multiflorum*
83	5	*Polypogon monspeliensis*	17	*Cotula coronopifolia*
83	0.2	*Sonchus oleraceus*	8	*Polypogon monspeliensis*
83	0.2	*Rumex crispus*	3	*Lotus corniculatus*

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
86	12	*Polypogon monspeliensis*	10	*Picris echioides*
86	6	*Apium graveolens*	2	*Cressa truxillensis*
86	5	*Picris echioides*	2	*Apium graveolens*
87	2	*Foeniculum vulgare*	5	*Foeniculum vulgare*
87	0.2	*Sonchus oleraceus*	3	*Cynodon dactylon*
87	0.2	*Rumex crispus*	3	*Picris echioides*
88	8	*Polypogon monspeliensis*	0.2	*Lotus corniculatus*
88	0.2	*Cotula coronopifolia*	0.2	*Polypogon monspeliensis*
88	0	None	0.2	*Cirsium vulgare*
89	15	*Polypogon monspeliensis*	18	Poaceae
89	10	*Rumex crispus*	7	*Lolium multiflorum*
89	5	*Lolium multiflorum*	0	None
90	1	*Lepidium latifolium*	4	*Lepidium latifolium*
90	0.2	*Rumex pulcher*	0	None
90	0.2	*Rumex crispus*	0	None
91	75	*Lolium multiflorum*	68	*Lolium multiflorum*
91	7	*Bromus hordeaceus*	10	*Hordeum marinum*
91	4	*Hordeum marinum ssp. gussonianum*	1	*Bromus hordeaceus*
92	2	*Rumex pulcher*	3	*Rumex dentatus*
92	0.2	*Rumex conglomeratus*	2	*Polypogon monspeliensis*
92	0.2	*Cotula coronopifolia*	0.2	*Sonchus oleraceus*
99	78	*Lepidium latifolium*	40	*Lepidium latifolium*
99	1	*Polypogon monspeliensis*	3	*Cotula coronopifolia*
99	0.2	*Sonchus oleraceus*	2	*Polypogon monspeliensis*
107	0	None	0.2	*Polypogon monspeliensis*
108	30	*Bromus diandrus*	12	*Taeniatherum caput-medusae*
108	15	*Bromus hordeaceus*	10	*Bromus diandrus*
108	5	*Taeniatherum caput-medusae*	5	*Bromus hordeaceus*
110	1	*Polypogon monspeliensis*	2	*Hainardia cylindrica*
110	0.2	*Lolium multiflorum*	1	*Polypogon monspeliensis*
110	0	None	0.2	*Bromus diandrus*
111	0.2	*Picris echioides*	2	*Lotus corniculatus*
111	0.2	*Polypogon monspeliensis*	0.2	*Apium graveolens*
111	0.2	*Lepidium latifolium*	0.2	*Lolium multiflorum*
118	24	*Conium maculatum*	22	*Conium maculatum*
118	6	*Polypogon monspeliensis*	3	*Hordeum marinum*
118	5	*Bromus diandrus*	3	*Vulpia bromoides*
136	8	*Lolium multiflorum*	73	*Lolium multiflorum*
136	6	*Lotus corniculatus*	3	*Raphanus sativus*
136	4	*Sonchus oleraceus*	0	None
145	0.2	*Sonchus oleraceus*	0.2	*Agrostis avenacea*
145	0	None	0.2	*Cotula coronopifolia*
145	0	None	0.2	*Conium maculatum*
147	44	*Lolium multiflorum*	15	*Polypogon monspeliensis*
147	35	*Agrostis avenacea*	10	*Lolium multiflorum*
147	23	*Xanthium strumarium*	1	*Cotula coronopifolia*
148	96	*Lolium multiflorum*	97	*Lolium multiflorum*

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
148	0.2	*Xanthium strumarium*	2	*Bromus diandrus*
148	0.2	*Lactuca serriola*	1	*Lactuca serriola*
154	7	*Polypogon monspeliensis*	15	*Polypogon monspeliensis*
154	2	*Lolium multiflorum*	3	*Cotula coronopifolia*
154	1	*Cotula coronopifolia*	1	*Lolium multiflorum*
159	1	*Polypogon monspeliensis*	5	*Polygonum*
159	0.2	*Rumex crispus*	2	*Sonchus oleraceus*
159	0.2	*Sonchus oleraceus*	2	*Rumex crispus*
161	30	*Echinochloa crus-galli*	40	*Xanthium strumarium*
161	3	*Xanthium strumarium*	4	*Raphanus sativus*
161	2	*Polypogon monspeliensis*	2	*Lactuca serriola*
168	52	*Polypogon monspeliensis*	2	*Cotula coronopifolia*
168	28	*Xanthium strumarium*	0	None
168	10	*Lotus corniculatus*	0	None
169	1	*Lolium multiflorum*	51	*Lolium multiflorum*
169	1	*Sonchus oleraceus*	30	*Bromus diandrus*
169	0	None	1	*Lactuca serriola*
170	7	*Polygonum argyrocoleon*	14	*Rumex conglomeratus*
170	2	*Rumex pulcher*	2	*Raphanus sativus*
170	0.2	*Polypogon monspeliensis*	0.2	*Chenopodium album*
171	28	*Lolium multiflorum*	56	*Bromus diandrus*
171	0.2	*Polypogon monspeliensis*	35	*Lolium multiflorum*
171	0.2	*Raphanus sativus*	1	*Hordeum murinum ssp. leporinum*
172	0	None	2	*Rumex conglomeratus*
172	0	None	0.2	*Chenopodium album*
172	0	None	0.2	*Cotula coronopifolia*
175	38	*Xanthium strumarium*	70	*Xanthium strumarium*
175	30	*Phragmites australis*	1	*Rumex*
175	2	*Echinochloa crus-galli*	1	*Echinochloa crus-galli*
176	33	*Conium maculatum*	42	*Conium maculatum*
176	8	*Centaurea solstitialis*	5	*Centaurea solstitialis*
176	6	*Cirsium vulgare*	5	*Raphanus sativus*
177	48	*Conium maculatum*	53	*Conium maculatum*
177	7	*Raphanus sativus*	2	*Sonchus oleraceus*
177	3	*Picris echioides*	1	*Raphanus sativus*
181	0	None	0.2	*Lepidium latifolium*
181	0	None	0.2	*Asparagus officinalis*
184	0.2	*Polygonum arenastrum*	0.2	*Lepidium latifolium*
184	0.2	*Polypogon monspeliensis*	0	None
185	1	*Elytrigia pontica*	90	*Elytrigia pontica*
185	0.2	*Sonchus oleraceus*	3	*Conium maculatum*
185	0.2	*Lactuca serriola*	3	*Brassica nigra*
186	80	*Xanthium strumarium*	51	*Xanthium strumarium*
186	7	*Cotula coronopifolia*	25	*Cotula coronopifolia*
186	5	*Polypogon monspeliensis*	2	*Polypogon monspeliensis*
189	1	*Cotula coronopifolia*	0.2	*Rumex dentatus*
189	0	None	0.2	*Cotula coronopifolia*

Plot #	% Cover 1999	Top Non-Natives 1999	% Cover 2006	Top Non-natives 2006
189	0	None	0.2	*Rumex crispus*
192	35	*Agrostis avenacea*	20	*Bromus diandrus*
192	6	*Bromus diandrus*	8	*Lactuca serriola*
192	1	*Lolium multiflorum*	2	*Centaurea solstitialis*
194	0	None	85	*Polypogon monspeliensis*
194	0	None	3	*Cotula coronopifolia*
194	0	None	1	*Rumex conglomeratus*
195	4	*Lepidium latifolium*	37	*Poa*
195	3	*Bromus hordeaceus*	2	*Conium maculatum*
195	3	*Lolium multiflorum*	0.2	*Bromus diandrus*
197	25	*Rubus discolor*	15	*Rubus discolor*
197	1	*Lepidium latifolium*	4	*Lepidium latifolium*
197	0.2	*Rumex conglomeratus*	0.2	*Agrostis avenacea*

Summary of Table 4. There are 85 total plots represented in Table 4; of these, 75 plots in 1999 had non-natives and 83 plots have non-natives in 2006. Six 1999 plots had higher *Lepidium* and twelve 2006 plots had higher *Lepidium*. Based on simple additive cover, there was 45.5 % greater cover in the six 1999 plots that had higher cover relative to 2006. Conversely, there was a total percentage cover of 119.2 % more in the twelve 2006 plots with greater cover. Thus, *Lepidium* appears to have had an overall increase of 73.7% (112.2% minus 45.5%) cover on the re-sampled plots in the 7-year interval. This same kind of comparison can be made with other species. A summary of the number of plots containing all 56 top non-native species and their average covers when present is provided in Table 5.

Table 5. Summary information for 56 non-native species with major cover
Note: statistics for plots with no non-native species are indicated in red.

Species	# Plots species present 1999 (of 78 total)	Frequency of species in 1999 plots	# Plots species present 2006 (of 84 total)	Frequency of species in 2006 plots	1999 mean % cover when present	2006 mean % cover when present
Polypogon monspeliensis	28	0.36	28	0.33	5.1	7
No non-natives	20	0.26	14	0.25	n/a	n/a
Lolium multiflorum	20	0.26	21	0.17	25.3	27.6
Cotula coronopifolia	16	0.21	21	0.25	6.2	4.2
Sonchus oleraceus	16	0.21	5	0.06	0.9	4.6
Lepidium latifolium	14	0.18	15	0.18	11.1	15.3
Rumex crispus	12	0.15	6	0.07	9.1	1.3
Bromus diandrus	10	0.13	16	0.19	8.8	13.7
Lactuca serriola	10	0.13	7	0.08	4.1	5.2
Bromus hordeaceus	8	0.10	5	0.06	17.75	3.8
Xanthium strumarium	7	0.09	4	0.05	24.6	40.3
Hordeum marinum	6	0.08	5	0.06	23.4	12.8
Rumex conglomeratus	6	0.08	5	0.06	10.7	3.8
Picris echioides	5	0.06	3	0.04	1.9	4.7
Rumex pulcher	5	0.06	1	0.01	1.1	0.2

Species	# Plots species present 1999 (of 78 total)	Frequency of species in 1999 plots	# Plots species present 2006 (of 84 total)	Frequency of species in 2006 plots	1999 mean % cover when present	2006 mean % cover when present
Polygonum argyrocoleon	4	0.05	0	0.11	20	n/a
Lotus corniculatus	4	0.05	9	0	9.8	8.1
Rubus discolor	3	0.04	4	0.1	74.3	44
Conium maculatum	3	0.04	8	0.05	35	15.3
Echinochloa crus-galli	3	0.04	1	0.01	13	1
Elytrigia pontica	2	0.03	1	0.14	44	90
Centaurea solstitialis	2	0.03	6	0.07	39	5.8
Agrostis avenacea	2	0.03	2	0.02	35	0.2
Apium graveolens	2	0.03	12	0.02	4.5	1.1
Hordeum marinum ssp. gussonianum	2	0.03	1	0.01	4.5	1
Cirsium vulgare	2	0.03	1	0.01	3.5	0.2
Foeniculum vulgare	2	0.03	2	0.01	2	4.5
Polygonum arenastrum	2	0.03	0	0	0.2	n/a
Vulpia myuros	1	0.01	1	0.06	16	30
Cynodon dactylon	1	0.01	2	0.02	13	3
Hypochaeris radicata	1	0.01	0	0.01	9	n/a
Raphanus sativus	1	0.01	5	0.01	7	5.2
Vicia sativa	1	0.01	0	0.01	7	n/a
Convolvulus arvensis	1	0.01	1	0	5	3
Taeniatherum caput-medusae	1	0.01	1	0	5	12
Acacia sp.	1	0.01	0	0	0.2	n/a
Cirsium sp.	1	0.01	0	0	0.2	0.2
Agrostis viridis	0	0	1	0.02	n/a	4
Asparagus officinalis	0	0	2	0.02	n/a	0.2
Avena sp.	0	0	1	0.02	n/a	4
Avena barbata	0	0	1	0.02	n/a	11
Brassica nigra	0	0	1	0.01	n/a	3
Carduus pycnocephalus	0	0	1	0.01	n/a	1
Chenopodium album	0	0	2	0.01	n/a	0.2
Crypsis schoenoides	0	0	1	0.01	n/a	0.2
Digitaria sanguinalis	0	0	1	0.01	n/a	12
Hainardia cylindrica	0	0	1	0.01	n/a	2
Hedera helix	0	0	1	0.01	n/a	0.2
Malva neglecta	0	0	1	0.01	n/a	1
Paspalum dilatatum	0	0	1	0.01	n/a	1
Poa sp.	0	0	1	0.01	n/a	37
Poaceae	0	0	1	0.01	n/a	18
Polygonum sp.	0	0	2	0.01	n/a	5
Polygonum baldschuanicum	0	0	1	0.01	n/a	1
Rumex dentatus	0	0	2	0.01	n/a	1.6
Rumex sp.	0	0	1	0.01	n/a	1
Vulpia bromoides	0	0	1	0.01	n/a	3

Summary of Table 5. Interestingly, only one species, *Polypogon monspeliensis*, occurred in more than 1/3 of all the samples in either 1999 or 2006. This species averaged similar cover (5 – 7 %) both years. In 1999, 15 species averaged > 10 percent cover in the plots in which they occurred. However only 3 of these, *Lolium multiflorum, Lepidium latifolium*, and *Bromus hordeaceus*, were present in more than 10 percent of the sample plots. Similarly, in 2006, 14 species averaged >10 percent cover in the plots in which they occurred, and only three species, *Lolium multiflorum, Lepidium latifolium*, and *Bromus diandrus*, were in more than 10 percent of the sample plots. Individual species with the highest cover included *Elytrigia pontica, Rubus discolor, Xanthium strumarium*, and *Conium maculatum*, all averaging more than 15% when they occurred in both 1999 and 2006. However, these species are restricted to only a few sample plots. Substantial decreases appeared to occur in *Centaurea solstitialis, Bromus hordeaceus*, and *Agrostis avenacea*. Increases were recorded for *Elytrigia pontica* and *Vulpia myuros*.

Probably the most worrisome exotic species in this group, *Lepidium latifolium*, appeared to increase slightly since 1999 occurring in 15% of the plots (versus 14% in 1999) and averaging about 15% cover as opposed to 11 % in 1999. This species has been actively managed with herbicides and other treatments in some of the DFG managed areas. It is uncertain if any treatments were applied in the resampled areas.

Overall, based on these samples, there is no clear increase or decrease in the percentage of exotic cover in Suisun Marsh.

Vegetative Cover, Total Non-Native Cover, Species Richness, and Inundation

Table 6 presents statistics for comparison between plots sampled in 1999 and 2006, and Table 7 summarizes these statistics. Table 8 shows the statistics for the plots that showed more than one cover class difference in total vegetation cover in the two sample years.

Table 6. Total percent (%) vegetation cover, non-native cover, species richness, and water cover, 1999 vs. 2006 Only those plots that were resampled in 2006 are listed. Those figures in red indicate which year has highest value.

Plot #	% Veg Cover 1999	% Veg cover 2006	% Non-native cover 1999	% Non-native cover 2006	# of Species/ Plot 1999	# of Species/ Plot 2006	% Water 1999	% Water 2006
001	90	65	0	0.2	5	8	10	22
002	88	57	0	0	5	3	0	90
003	83	65	0	0	2	3	0	78
004	95	60	15	5	27	34	10	10
009	85	40	0	0	2	2	15	96
010	100	95	100	95	2	2	0.2	8
011	95	0	95	0	1	0	3	100
012	95	75	0	5	33	19	1	18
013	99	70	77	52	13	17	0	0
014	91	32	2	0.2	7	6	0	93
015	96	70	1	1	4	8	0	97
016	97	65	7	2	7	20	0	50
020	95	28	95	0	6	3	18	99
021	85	63	0	3	4	5	15	0
023	95	81	15	21	10	9	5	0
024	96	70	3	1	11	13	3	6
025	98	82	97	82	16	14	0	0

Plot #	% Veg Cover 1999	% Veg cover 2006	% Non-native cover 1999	% Non-native cover 2006	# of Species/ Plot 1999	# of Species/ Plot 2006	% Water 1999	% Water 2006
026	94	70	32	0.2	9	6	0	25
034	100	95	100	95	4	14	0	0
036	90	62	80	30	18	21	0	0
037	88	85	99	55	16	14	0	4
038	100	70	5	20	9	9	0	0
039	85	45	7	5	11	10	0	0
040	76	1	6	0	2	2	0	0
042	100	95	12	4	23	17	0	40
043	100	99	0	1	17	19	0	15
044	98	80	98	75	4	6	0	0
045	95	95	0	0.2	4	4	5	96
046	100	90	0	0.2	8	12	0	36
047	100	96	0	1	12	15	0	4
048	92	99	30	6	8	17	0	0
049	100	99	0	0	3	9	0	4
050	99	45	98	35	3	5	0	0
051	80	99	0	0	1	2	20	0
052	93	92	85	50	13	17	0	4
053	94	85	1	3	11	6	0	4
054	100	95	3	11	11	22	0	15
056	95	96	30	36	9	17	0	0
058	99	60	60	55	12	14	0	0
059	100	92	0	3	6	12	0	65
060	100	85	60	61	14	15	0.2	30
061	99	92	31	21	12	16	0	15
062	96	90	2	35	8	18	0	0
063	96	85	4	8	14	13	0	82
064	98	99	4	0	9	9	1	72
065	96	75	7	10	9	12	0	0
067	100	87	1	0	6	5	0	0
068	100	88	31	45	8	12	0	78
070	97	96	75	75	8	6	0	0
071	97	78	4	0	10	4	0	0
072	85	77	0.2	0	5	4	0	90
073	*	80	0	2	11	7	0	0
074	80	95	51	70	9	11	0	0
075	96	85	0.2	23	6	8	0	0
076	95	95	90	75	14	18	0	20
077	98	62	90	4	7	8	0	0
078	98	88	20	70	12	17	0	30
079	91	70	1	1	3	4	0	0
083	93	82	6	28	12	14	7	0
086	98	96	24	15	15	20	0	0
087	98	85	2	20	11	33	0	20
088	82	95	9	1	6	11	7	0
089	95	92	35	8	11	9	0	0
090	95	90	3	7	14	8	0	0
091	90	75	80	82	7	9	0	0

Plot #	% Veg Cover 1999	% Veg cover 2006	% Non-native cover 1999	% Non-native cover 2006	# of Species/ Plot 1999	# of Species/ Plot 2006	% Water 1999	% Water 2006
092	97	92	3	4	6	6	0	0
099	98	85	80	47	13	13	0	0
107	60	62	0	0.2	10	13	0	53
108	98	75	57	40	7	11	0	0
110	92	80	7	4	6	15	0	1
111	100	100	5	3	18	16	0	96
118	92	60	42	30	14	14	0	2
136	100	95	22	74	14	16	0	0
145	99	98	0	1	6	12	0	4
147	100	75	65	43	16	13	0	0
148	98	100	97	99	10	9	0	3
154	67	50	12	15	11	11	0	0
159	100	75	1	5	12	19	0	3
161	98	92	35	60	13	15	0	0
168	96	75	40	2	16	5	0	90
169	99	92	4	90	13	11	0	0
170	88	48	2	32	15	18	0	0
171	93	90	27	90	14	6	0	0
172	100	85	0	71	2	16	0	0
175	95	72	40	1	12	11	0	0
176	88	91	50	40	13	13	0	0
177	98	85	60	51	17	13	0	0
180	0.2	1	0.2	0	2	1	0	99.5
181	88	99	0	0.2	8	13	0	3
184	75	87	0.2	0.2	7	5	10	95
185	90	97	1	97	7	5	0	0
186	90	90	89	30	7	10	1	0
189	39	65	1	0.2	3	8	0	0
190	1	0	1	0	4	0	0	100
192	100	86	42	35	15	13	0	0
194	98	92	0	91	4	17	0	0
195	97	99	11	39	9	7	0	0
197	95	88	0	20	15	28	5	10

*Total cover was not entered for this plot in the field in 1999, so this plot has been omitted from comparison of vegetation cover.

Table 7. Summary statistics for Table 6

Criteria	N	Percent	Range
Number of plots with total cover > 1 cover-class difference	8	8%	
Number of plots with total cover within one cover class difference	29	30%	
Number of plots with total cover in same cover class between years	60	62%	
Number of plots with more cover in 2006 (of 97 total)	16	16%	
Number of plots with less cover in 2006 (of 97 total)	77	79%	
Number of plots with same cover in both years (of 97 total)	4	4%	
Mean percent cover of non-natives per plot 1999 (n=98)		27.3	0 - 100
Mean percent cover of non-natives per plot 2006 (n=98)		25.8	0 - 100

Criteria	N	Percent	Range
Number of all species per plot 1999	9.7		1 - 33
Number of all species per plot 2006	11.3		1 - 34
Mean percent water cover in 1999 (n=98)		1.4	0 - 20
Mean percent water cover in 2006 (n=98)		21.2	0 - 100
Mean total vegetation cover in 1999 (n=97)		93.2	0- 100
Mean total vegetation cover in 2006 (n=98)		78.1	0- 100

Table 8. Plots with more than one cover class difference in total vegetation cover between sample years

Plot #	% Veg Cover 1999	% Veg cover 2006	% Exotic Cover 1999	% Exotic Cover 2006	# of Species/ Plot 1999	# of Species/ Plot 2006	% Water 1999	% Water 2006	Explanation for major shift
9	85	40	0	0	2	2	15	96	Much more water
11	95	0	95	0	1	0	3	100	Completely inundated recently
14	91	0	2	0.2	7	6	0	93	Completely inundated recently
20	95	28	95		6	3	18	99	Almost entirely flooded
39	85	45	7	5	11	10	0	0	Change in flooding regime? Much dead pickleweed.
40	76	1	6	0	2	2	0	0	Change in flooding regime? Pickleweed in 1999, in 2006 it was loose dirt with salty crust.
50	99	45	98	35	3	5	0	0	Site burned in 2001.
170	88	48	2	32	15	18	0	0	Change in flooding regime?

Discussion of Tables 6, 7, and 8. Water cover in 2006 increased many-fold compared to 1999 (Table 7). It is uncertain if this signifies a management shift to maintaining inundation for longer periods in the managed areas sampled or if it is simply an artifact of the plots selected for resampling.

Average species richness per plot was higher by about 2 species in 2006. It is unclear why this might be or if it is significant. Possible influencing factors could include: greater heterogeneity of stands in 2006, temporal or yearly effects in the ability to detect species, variation in field crews sampling intensity, etc.

Relative percent cover of non-natives remains the about the same from 1999-2006. In 2006, 43 plots had higher non-native cover than in 1999, while 46 had lower than in 1999.

After a 7-year period, the average total vegetation cover appears to have dropped by about 15%, but estimates of cover tended to be higher in 1999 because of different estimating techniques (crown versus foliar cover estimation). If cover-classes rather than actual percent cover are compared, then there is no difference in 62% of the plots. The 7-point CNPS cover-class scale (see Appendix A) was used to classify the vegetation initially in 1999 and is the conservative tool often used for data analysis by vegetation ecologists. Cover-class is often used to cancel out the effects of an individual's likelihood of minor variance in estimating cover of plants.

Eight of the plots had greater than one cover class difference in total cover between the two years (Table 8). These are unlikely to be the result of variation in the field crew's ability to accurately estimate cover. For four (and possibly seven) of the plots, the difference appeared to be the result of a management change in flooding regime, where drops in cover resulted from complete inundation in 2006 versus little or no inundation in 1999. One plot burned in 2001 and its cover and composition have not changed much since, according to the observer, who is familiar with the site.

Visual Comparison of Selected Plots Surveyed in 1999 and 2006

The following photo pairs are examples of those taken for each of the plots resampled in 2006 compared to 1999. They were selected to show clearly the value of repeat photography in distinguishing similarities and differences between the sample years. The complete set of 2006 and 1999 plot photos are on file at Vegetation Classification and Mapping Program of the Biogeographic Data Branch of DFG, as are the field survey forms, electronic database, and associated GIS layers.

Suisun Marsh relevé #024 in August 1999 (top) and 2006 (bottom). Despite increased flooding in 2006 (6% standing water compared to 0% in 1999) this plot has remained a *Distichlis spicata* Alliance.

Suisun Marsh relevé #014 in 1999 (top) and 2006 (bottom). Due to the increased flooding in 2006 most of the *Salicornia virginica* (which was the dominant species in 1999 at 80% cover) has died and *Typha angustifolia* has moved in and has become the dominant species at 30% cover.

Suisun Marsh relevé #063 in October 1999 (top) and September 2006 (bottom). This plot has remained a *Schoenoplectus americanus* Alliance, even though in 2006 this plot contained 82% standing water vs. 0% in 1999.

Suisun Marsh relevé #021 in September 1999 (top) and August 2006 (bottom). *Schoenoplectus maritimus* Alliance in 1999 and a *Salicornia virginica* Alliance in 2006. The switch in dominant cover species is likely due to a shortened inundation period in 2006 (0% standing water compared to 15% standing water in 1999).

Suisun Marsh relevé #002 in 1999 (top) and 2006 (bottom). In 1999 this was a *Schoenoplectus maritimus* (77%) Alliance and in 2006 it was a *Typha angustifolia* (55%) Alliance. *T. angustifolia* had a cover of only 2% in 1999.

Suisun Marsh relevé #171 in 1999 (top) and 2006 (bottom). In 1999 this plot was a *Frankenia salina* alliance. In 2006 it was a *Bromus diandrus* alliance. In 2006 the *F. salina* cover was 3% compared to 85% in 1999.

LITERATURE CITED

Barbour, M. J. Burk, W.D. Pitts, M.W. Schwartz. And F. Gilliam. 1998. Terrestrial plant ecology. 3rd Edition. Addison Wesley Longman, Menlo Park, California

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Appendix A. Sample Field Form and Survey Protocol

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM

(Revised 4/2/04)

Page_____ of Relevé # _____

See code list for italicized fields

	FOR OFFICE USE ONLY
Polygon #_____ or Relevé # _____	Permanent Number:
Date _____/ _____/ _____ MM DD YYYY Airphoto #	Community Name: Community Number: Occurrence Number:
County	Source Code:
USGS Quad. 7.5' or 15' (Circle one)	Quad Code: Quad Name: Map Index Number:
CNPS Chapter	Update: Yes No (Circle one)

Landowner		
Contact Person		
Address		
City	Zip	Phone number
Observers		

Relevé plot shape (square, rectangle, triangle, circle, entire stand) _____

NOTE: All forest and woodland plots should be 1000m ^{2}
All shrub plots should be 400m^2. Herb plots should be 100 or 400m^2
Please consult with CNPS Vegetation Ecologist on herb plots.

Relevé plot size (length and width of rectangle, or circle-*diameter*) _____ _____ (m.)

Study Plot Revisit? Yes or No (Circle one)

Photo Interpreter Community Code for Polygon _____

Other polygons of same type? Yes or No Is plot representative of whole polygon? Yes or No (Circle one) If not, why not?
_____

GPS File # _____ GPS name (or points in file) _____ Start Time _____:_____(am or pm) GPS Datum (from GPS setup) (e.g. WGS 84, NAD 27)
_____

File type: Point or Polygon (circle one) Releve: UTMN ____ ____ ____ ____ ____ ____ ____UTME ___ ___ ___ ___ ___ ___ Error ±_____ ft/m UTM Zone
_____

Transect: Start UTME ___ ___ ___ ___ ___ ___UTMN ____ ____ ____ ____ ____ ____ ____End: UTME ___ ___ ___ ___ ___ ___ ___UTMN____ ____ ____ ____ ____ ____
____

Elevation (ft.)_____ Slope (°) _____Aspect (°) _____ Topography: *Macro* _____ *Micro*
_____

VEGETATION DESCRIPTION

Dominant Layer ___ 0-0.5 m, ___ 0.5-4 m, ___4 m Preliminary Alliance Name
_____

Stand Size ____<1 acre, ____1-5 acres, ____ >5 acres *Dominant Vegetation Group* _____ *(use codes from code list)*

Structure: Ground _____ Shrub _____ Tree _____ Phenology: Ground _____Shrub _____Tree _____
(1. Continuous 2. Intermittent 3. Open) (Early, Peak, Late)

Wetland Community Type _____ (Wetland or Upland)

If Community Type = Wetland (see Artificial Keys to Cowardin Systems and Names)

Cowardin System _____ Subsystem _____Class _____

Distance to water (m): Vertical _____ Horizontal _____ Channel form (if riverine) _____
(Straight, Meandering, Braided)

Adjacent Alliance	Location (e.g., North, South, East, or West of stand)	Description (up to 4 species by layer)

Photographs – *Note position and direction of photo(s) relative to plot*

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM

Page_____ of Relevé # _____

STAND AND ENVIRONMENTAL DESCRIPTION

Trend code _____
1. Increasing 2. Stable 3. Decreasing
4. Fluctuating 5. Unknown

Site Impact codes _____ _____ _____ _____ _____ _____ _____ _____
(List codes in order, with most significant first)

Site Intensity _____ _____ _____ _____ _____ _____ _____ _____
1. Light 2. Moderate 3. Heavy (List beneath each impact code)

Site Location and Plot Description

Site History – *including observations of fire scars, insect/disease damage, grazing/browsing, human disturbance*

Sensitive Species – *List species observed and GPS UTM's; Estimate size and extent of local populations*

Unknown Specimens – *List code, identification notes (e.g. Genus, condition of specimen) of unknowns*

Additional Comments – *Including animal observations, anthropological observations, abiotic features*

Surface Coarse Fragments and Soils Information (see cover class intervals-**below** ⇓)

Type:	Fines	Gravel	Cobble	Stone	Boulders	Bedrock	Litter	Water	Living stems	Other (Specify):
Descriptor:	Including sand, mud	2mm-7.5 cm diameter	7.5-25 cm diam	25-60cm diam.	>60cm diam.	Including outcrops	Organic matter covering ground	Standing or running water	At ground surface	
Cover class (see below):										
% Cover*:										

*note all surface fragments, non-vegetation, living stems, etc., should add up to 100%

Soil Texture _____ ***Parent Material*** _____

Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)

Height Classes for Vegetation Strata & Cover Estimates (see cover class intervals **- above** ⇑)										
Layer name:	Cryptogam Layer	0-25 cm	25-50 cm	0.5-1 m	1-2 m	2-5 m	5-10 m	10-20 m	20-30 m	>30 m.
Main species:										
Cover class:										

CALIFORNIA PLANT COMMUNITIES RELEVÉ FIELD FORM (PART 2)

SPECIES SHEET (Revised 5/17/01)

Page_____ of Relevé # _____

Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)

L=Low herbs and subshrubs (<0.5 m.), M=Medium height (0.5 m.-4.0 m.), T=Tall height (>4.0 m.)

L	M	T	Vascular plant name or moss/lichen cryptogamic crust cover	Final species determination or Tree dbh	Cover Class	%

Total Vegetation Cover (Class): _____ Total Tall_____ Total Medium _____ Total Low _____ Total Non-Native _____

percent cover of above: _____ _____ _____ _____ _____

CALIFORNIA PLANT COMMUNITIES RELEVÉ FIELD FORM (PART 2)

SPECIES SHEET (Revised 5/17/01)

Page_____ of Relevé # _____

Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)

L=Low herbs and subshrubs (<0.5 m.), M=Medium height (0.5 m.-4.0 m.), T=Tall height (>4.0 m.)

L	M	T	Vascular plant name or moss/lichen cryptogamic crust cover	Final species determination or Tree dbh	Cover Class	%

Total Vegetation Cover (Class): _____ Total Tall_____ Total Medium _____ Total Low _____ Total Non-Native _____

percent cover of above: _____ _____ _____ _____ _____

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ PROTOCOL
CNPS VEGETATION COMMITTEE
October 20, 2000 (Revised 4/2/04)

Introduction

In *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995), CNPS published a Vegetation Sampling Protocol that was developed as a simple quantitative sampling technique applicable to many vegetation types in California. Investigators use an ocular estimation technique called a relevé to classify and map large areas in a limited amount of time.

The relevé method of sampling vegetation was developed in Europe and was largely standardized by the Swiss ecologist Josias Braun-Blanquet. He helped classify much of Europe's vegetation, founded and directed a synecology center in France, and was editor of *Vegetatio* for many years. The relevé was, and is, a method used by many European ecologists, and others around the world. These ecologists refer to themselves as phytosociologists. The use of relevé in the United States has not been extensive with the exception of the US Forest Service.

The relevé is particularly useful when observers are trying to quickly classify the range of diversity of plant cover over large units of land. In general, it is faster than the point intercept technique. One would use this method when developing a classification that could be used to map of a large area of vegetation, for example. This method may also be more useful than the line intercept method when one is trying to validate the accuracy of mapping efforts.

The relevé is generally considered a "semiquantitative" method. It relies on ocular estimates of plant cover rather than on counts of the "hits" of a particular species along a transect line or on precise measurements of cover/biomass by planimetric or weighing techniques.

Selecting a stand to sample:

A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as alpine meadow or tundra types, and some may be several square kilometers in size, such as desert or forest types. A stand is defined by two main unifying characteristics:

1) It has <u>compositional</u> integrity. Throughout the site the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct, and
2) It has <u>structural</u> integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species throughout.
   For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes, but not the lower, would be divided into two stands. Likewise, a sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.

The structural and compositional features of a stand are often combined into a term called homogeneity. For an area of vegetated ground to meet the requirements of a stand it must be homogeneous.

Stands to be sampled may be selected by assessment prior to a site visit (e.g. delineated from aerial photos or satellite images), or may be selected on site (during reconnaissance to determine extent and boundaries, location of other similar stands, etc.). Depending on the project goals, you may want to select just one or a few representative stands for sampling (e.g., for developing a classification for a vegetation mapping project), or you may want to sample all of them (e.g., to define a rare vegetation type and/or compare site quality between the few remaining stands).

Selecting a plot to sample within in a stand:

Because most stands are large, it is difficult to summarize the species composition, cover, and structure of an entire stand. We are also usually trying to capture the most information with the least amount of effort. Thus, we are typically forced to select a representative portion to sample.

When sampling a vegetation stand, the main point to remember is to select a sample that, in as many ways possible, is representative of that stand. This means that you are not randomly selecting a plot; on the contrary, you are actively using your own best judgement to find a representative example of the stand.

Selecting a plot requires that you see enough of the stand you are sampling to feel comfortable in choosing a representative plot location. Take a brief walk through the stand and look for variations in species composition and in stand structure. In many cases in hilly or mountainous terrain look for a vantage point from which you can get a representative view of the whole stand. Variations in vegetation that are repeated throughout the stand should be included in your plot. Once you assess the variation within the stand, attempt to find an area that captures the stand's common species composition and structural condition to sample.

Plot Size

All releves of the same type of vegetation to be analyzed in a study need to be the same size. It wouldn't be fair, for example, to compare a 100 m2 plot with a 1000 m2 plot as the difference in number of species may be due to the size of the plot, not a difference in the stands.

A minimal area to sample is defined by species/area relationships; as the sampler identifies species present in an area of homogeneous vegetation, the number will increase quickly as more area is surveyed. Plot shape and size are somewhat dependent on the type of vegetation under study. Therefore general guidelines for plot sizes of tree-, shrub-, and herb-dominated upland, and fine-scale herbaceous communities have been established. Sufficient work has been done in temperate vegetation to be confident the following conventions will capture species richness:

Alpine meadow and montane wet meadow: 100 sq. m
Herbaceous communities: 100 sq. m plot or 400 sq. m plot (Consult with CNPS, and use one consistent size)
Grasslands and Shrublands: 400 sq. m plot
Forest and woodland communities: 1000 sq. m plot
Open desert vegetation: 1000 sq. m plot

Plot Shape

A relevé has no fixed shape, plot shape should reflect the character of the stand. If the stand is about the same size as a relevé, you need to sample the entire stand. If we are sampling a desert wash, streamside riparian, or other linear community our plot dimensions should not go beyond the community's natural ecological boundaries. Thus, a relatively long, narrow plot capturing the vegetation within the stand, but not outside it would be appropriate. Species present along the edges of the plot that are clearly part of the adjacent stand should be excluded.

If we are sampling broad homogeneous stands, we would most likely choose a shape such as a circle (which has the advantage of the edges being equidistant to the center point) or a square (which can be quickly laid out using perpendicular tapes). If we are trying to capture a minor bit of variety in the understory of a forest, for example a bracken fern patch within a ponderosa pine stand, we would want both bracken and non-bracken understory. Thus, a rectangular shape would be appropriate.

GENERAL PLOT INFORMATION

The following items appear on each data sheet and are to be collected for all plots. Where indicated, refer to attached code sheet.

Polygon or Relevé number: Assigned either in the field or in the office prior to sampling.

Date: Date of sampling.

County: County in which located.

USGS Quad: The name of the USGS map the relevé is located on; note series (15' or 7.5').

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

Landowner: Name of landowner or agency acronym if known. Otherwise, list as private.

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

Observers: Names of individuals assisting. Circle name of recorder.

Plot shape: indicate the sample shape as: square, rectangle, circle, or the entire stand.

Plot size: length of rectangle edges, circle radius, or size of entire stand.

NOTE: See page 2 for standard plot sizes.

Study Plot Revisit: If the relevé plot is being revisited for repeated sampling, please circle "Yes".

Photo interpreter community code: If the sample is in area for which delineation and photo interpretation has already been done, the code which the photointerpreters applied to the polygon. If the sample site has not been photointerpreted, leave blank.

Other polygons of same type (yes or no, if applicable), if yes, mark on map: Other areas within view that appear to have similar vegetation composition. Again, this is most relevant to areas that have been delineated as polygons on aerial photographs as part of a vegetation-mapping project. If one is not working from aerial photographs, draw the areas as on a topographic map.

Is plot representative of whole polygon? (yes or no, if applicable), if no explain: Detail what other vegetation types occur in the polygon, and what the dominant vegetation type is if there is more than one type.

Global Positioning System Readings: Due to the recent availability of very accurate and relatively low cost GPS units, we highly recommend obtaining and using these as a standard piece of sampling equipment. Now that the military intentional imprecision (known as "selective availability") has been "turned off" (as of July 2000), it is typical for all commercial GPS units these units to be accurate to within 5 m of the actual location. Also note that the GPS units can be set to read in UTM or Latitude and Longitude coordinates and can be easily translated. Thus, the following fields for Latitude, Longitude, and legal description are now optional. In order for all positional data to be comparable within the CNPS vegetation dataset We request using UTM coordinates set for the NAD 83 projection (see your GPS users manual for instructions for setting coordinates and projections).

Caveat: Although GPS units are valuable tools, they may not function properly due to the occasionally poor alignment of satellites or due to the complexity of certain types of terrain, or vegetation. We thus also recommend that you carry topographic maps and are aware of how to note your position on them in the event of a non-responsive or inaccurate GPS.

UTMN and UTME: Northing and easting coordinates using the Universal Transverse Mercator (UTM) grid as delineated on the USGS topographic map, or using a Global Positioning System.

UTM zone: Universal Transverse Mercator zone. Zone 10S for California west of the 120th longitude; zone 11S for California east of 120th longitude.

Legal Description: Township/Range/Section/Quarter Section/Quarter-Quarter section/Meridian: Legal map location of the site; this is useful for determining ownership of the property. California Meridians are Humboldt, Mt. Diablo, or San Bernardino. (This is optional, see above discussion of GPS units)

Latitude and Longitude: Degrees north latitude and east longitude. This is optional (see above)

Elevation: Recorded in feet or meters. Please indicate units.

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

Aspect: Degrees from true north (adjust declination), read from a compass or estimated; averaged over relevé.

Macrotopography: Characterize the large-scale topographic position of the relevé. This is the general position of the sample along major topographic features of the area. *See attached code list.*

Microtopography: Characterize the local relief of the relevé. Choose the shape that mimics the lay of the ground along minor topographic features of the area actually within the sample. *See attached code list.*

VEGETATION DESCRIPTION

Dominant layer: Indicate whether the community is dominated by the Low layer (L), Mid-layer (M), or Tall (T) layer.

Preliminary Alliance name: Name of series, stand, or habitat according to CNPS classification (per Sawyer and Keeler-Wolf 1995); if the type is not defined by the CNPS classification, note this in the space.

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

Structure: Characterize the structure of each layer.

> Continuous = greater than 2/3 (67%) cover; crowns touching
> Intermittent = between 1/3 and 2/3 cover (33% to 66 %); interlocking or touching crowns interrupted by openings.
> Open = less than 1/3 (33%) cover; crowns not touching or infrequently touching.

Phenology: Based on the vegetative condition of he principal species, characterize the phenology of each layer as early (E), peak (P), or late (L).

WETLAND COMMUNITY TYPES

Community type: 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.

Dominant vegetation form: This is a four letter code which relates the vegetation of the plot to the higher levels of the NBS/NPS National Vegetation Classification System hierarchy. *See attached code list.*

Cowardin class: See "Artificial Keys to Cowardin Systems and Names" (attached). 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 the 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. Channels that contain oceanic-derived salts greater than 0.5% are also excluded.

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 or shrubs, persistent emergents, emergent mosses or lichens with greater than 30% aerial coverage; and 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 low tide boundary, of if the water 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); 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%.

<u>Vertical distance from high water mark of active stream channel</u>: 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.

<u>Horizontal distance from high water mark of active stream channel</u>: 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.

<u>Stream channel form</u>: 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 predominately a single primary channel, M (meandering) if it is a meandering channel, and B (braided) if it consists of multiple channels interwoven or braided.

<u>Photographs</u>: Describe the number of color photographs taken at the relevé, and the camera's view direction from compass bearings. It is helpful to take a photograph of the relevé from the intersection of the tapes (if tapes were used to define the plot), and another from inside the relevé. Additional photos of the stand may also be helpful. If using a digital camera or scanning in the image into a computer, relevé numbers and compass directions can be recorded digitally. If using a 35mm camera, please note the roll number, frame number, compass direction, and the initials of the person whose camera is being used. (e.g. Roll 5, #1, to the NW, SS)

STAND AND ENVIRONMENTAL INFORMATION

Vegetation trend: Based on the regenerating species and relationship to surrounding vegetation, characterize the stand as either increasing (expanding), stable, decreasing, fluctuating, or unknown.

Impacts: Enter codes for potential or existing impacts on the stability of the plant community. Characterize each as either 1. Light, 2. Moderate, of 3. Heavy. *See attached code list.*

Site location and plot description: A concise, but careful description that makes locating and/or revisiting the vegetation stand and plots possible; give landmarks and directions. Used in conjunction with the GPS position recorded earlier, this should enable precise re-location of the plot. Indicate where the GPS reading was taken within the plot. In general, the location of the GPS reading should be on the Southeastern corner of the plot, if the plot is square or rectangular, or in the center if the plot is circular. It is also helpful to briefly describe the topography, aspect, and vegetation structure of the site. If you can't take the GPS reading at the Southeast corner (an obstacle in the way) then note where the GPS point was taken. If you can't get a GPS reading, then spend extra time marking the plot location as precise as possible on a topo map.

Site history: Briefly describe the history of the stand, including type and year of disturbance (e.g. fire, landslides or avalanching, drought, flood, or pest outbreak). Also note the nature and extent of land use such as grazing, timber harvest, or mining.

Unknown plant specimens: List the numbers of any unknown plant specimens, noting any information such as family or genus (if known), important characters, and whether or not there is adequate material for identification. Do not take samples of plants of which there are only a few individuals or which you think may be rare. Document these plants with photographs.

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.

COARSE FRAGMENTS AND SOIL INFORMATION

Coarse fragments, litter: Estimate the cover class of each size at or near the ground surface averaged over the plot. Always remember to estimate what you actually see on the surface as opposed to what you think is hiding under, organic litter, big rocks, etc. However, rocks, organic litter, or fine material visible under the canopy of shrubs or trees should be included in the cover estimate.

One way to consider this is to assume that all of the components of coarse fragments plus the basal cross-section of living plant stems and trunks (at ground level) will add up to 100%. Thus, estimate the cover value of each of the items in the box on the form for coarse fragments (including the basal area of plant stems) so that they will add up to 100%. Remember that the basal area of plant stems is usually minimal (e.g., if there were 10 trees, each 1 m in diameter at ground level on a 1000 square meter plot, they would cover less than 1% {0.79%} of the plot).

These data are asked for because certain categories of coarse fragments of rock and other materials have been shown to correlate with certain vegetation types and are thus likely influencing the type of vegetation that is growing in a given area. These estimates should be made quickly with the main point to keep in mind being a rough estimate of the relative proportions of different coarse fragments on the plot.

Fines: Fine mineral fragments including sand, silt, soil, "dirt" < 2 mm in diameter

Gravel: rounded and angular fragments 0.2-7.5 cm (0.08 -3 in.) diameter

Cobble: rounded and angular fragments >7.5-25 cm (3 -10 in.) in diameter

Stone: rounded and angular coarse fragments >25 cm-60 cm (10 -24 in.) in diameter

Boulder: rounded and angular coarse fragments >60 cm (>24 in.) in diameter

Bedrock: continuous, exposed, non-transported rock

Litter: extent of undecomposed litter on surface of plot (this includes all organic matter, e.g. fallen logs, branches, and twigs down to needles and leaves).

Soil texture: Record the texture of the upper soil horizon, below the organic layer if one is present. *See attached key and code list*.

Parent Material: Geological parent material of site. *See attached code list*.

VEGETATION DATA

Assessment of Layers

This first step is described in the CNPS point-intercept transect protocol. Estimates the maximum height for the low and mid layers and the minimum height for the tall layer are recorded. These estimates are made after a quick assessment of the vegetation and its structure. The estimates need not be overly precise and will vary among vegetation types. A caveat: if several relevés are being sampled within the same vegetation type, it is important to be consistent when assigning layers. Some types will have more than three layers (e.g. two tree layers of different maximum height); this should be indicated in the relevé description. However, data are recorded for only three layers (low, mid, and tall). The layer a species occupies will often be determined by growth form, but exceptions do occur. For example, with trees young seedlings may occupy the low layer, saplings the mid layer, and mature individuals the tall layer for some taxa, for example.

Species List

The collection of vegetation data continues with making a comprehensive species list of all vascular plants within the relevé. This list is achieved by meandering through the plot to see all microhabitats. During list development, observers document each taxon present in each layer in

which it occurs separately, recording it on a different line of the data form and noting which layer is represented. This is important for data entry because each layer of each represented taxon will be entered separately. Each individual plant is recorded in only one layer, the layer in which the tallest portion of the individual is found. One should reach a point at which new taxa are added to the list only very slowly, or sporadically. When one has reached that point, the list is probably done.

The following sections explain how to perform the actual relevé, the Estimation of Cover Values. The sections prefaced by bold-faced titles explain the technique, and the sections with regular font titles refer to the steps needed to complete the accompanying Field Form.

Tree dbh (optional)

The CNPS protocol does not require observers to record the diameter at breast height (dbh) of each tree species in the plot. However, the dbh is important in certain studies and may be recorded next to the each tree species name, in the column labeled "Final species determination or Tree dbh". You should measure the tree dbh of every tree trunk that has diameter > or = 10 cm at breast height in the plot, and each measurement should be in centimeters (cm) using a dbh tape measure. For trunks that may be fused below breast height and branched at breast height, each trunk at breast height gets a separate measurement.

Depending on the density of trees in each plot, you can record dbh of trees for every tree trunk in the plot, or you can sub-sample the trunks to estimate dbh for every tree species in relatively dense plots. If you opt to sub-sample, you should do it for each tree species in a representative "quarter" or quadrant of the plot, and then you will come up with an estimated dbh for the entire plot (once data is processed).

When sub-sampling, make sure to denote this as a sub-sample (can note in the Additional comments field) and record the sub-sample of dbh's for each tree species in the appropriate row on the Field Form. Once the data are post-processed and entered into a database, then you will need to record each sub-sampled dbh reading three additional times to come up with a full sample of dbh readings. For example, with a sub-sampled tree dbh of 15 cm, this value of 15 should be entered four times (not just once) when it is entered in the database.

Estimating Cover:

There are many ways to estimate cover. Many people who have been in the cover estimation "business" for a long time can do so quickly and confidently without any props and devices. However, to a novice, it may seem incomprehensible and foolhardy to stand in a meadow of 50 different species of plants and systematically be able to list by cover value each one without actually "measuring" them in some way.

Of course, our minds make thousands of estimates of various types every week. We trust that estimating plant cover can be done by anyone with an open mind and an "eye for nature." It's just another technique to learn.

It is very helpful to work initially with other people who know and are learning the technique. In such a group setting, typically a set of justifications for each person's estimate is made and a

"meeting of the minds" is reached. This consensus approach and the concomitant calibration of each person's internal scales is a very important part of the training for any cover estimate project.

An underlying point to remember is that estimates must provide some level of reliable values that are within acceptable bounds of accuracy. If we require an accuracy level that is beyond the realm of possibility, we will soon reject the method for one more quantitative and repeatable. As with any scientific measurement, the requirement for accuracy in the vegetation data is closely related to the accuracy of the information needed to provide a useful summary of it. Put into more immediate perspective - **to allow useful and repeatable analysis of vegetation data, one does not need to estimate down to the exact percent value the cover of a given plant species in a given stand**.

This point relates to two facts: there is inherent variability of species cover in any environment. For example, you would not expect to always have 23% *Pinus ponderosa*, 14% *Calocedrus decurrens*, and 11% *Pinus lambertiana* over an understory of 40% *Chamaebatia foliosa*, 3% *Clarkia unguiculata*, and 5% *Galium bolanderi* to define the Ponderosa pine-Incense cedar/mountain misery/bolander bedstraw plant community. Anyone who has looked at plant composition with a discerning eye can see that plants don't space themselves in an environment by such precise rules. Thus, we can safely estimate the representation of species in a stand by relatively broad cover classes (such as <1%, 1-5 %, 5-25%, etc.) rather than precise percentages.

The data analysis we commonly use to classify vegetation into different associations and series (TWINSPAN and various cluster analysis programs, for example) is likewise forgiving. When analyzed by quantitative mutivariate statistics information on species cover responds to coarse differences in cover and presence and absence of species, but not to subtle percentage point differences. This has been proven time and again through quantitative analysis of vegetation classification. Many of the world's plant ecologists estimate cover rather than measure it precisely. Some of the seminal works in vegetation ecology have been based on cover estimates taken by discerning eyes.

With this as a preamble, below we offer some suggestions on estimating cover that have proven helpful. These are simply "tricks" to facilitate estimation, some work better for different situations. You may come up with other methods of estimation that may seem more intuitive, and are equally reliable in certain settings. All values on the relevé protocol that require a cover class estimate, including coarse fragment and vegetation layer information, may rely on these techniques. Just make the appropriate substitutions (using the coarse fragment example substitute, bedrock, stone, cobbles, gravel, and litter for vegetation).

Method 1: The invisible point-intercept transect:

This method works well in relatively low, open vegetation types such as grasslands and scrubs where you can see over the major stand components. For those who have worked with the original CNPS line intercept methodology it's like counting hits along an imaginary line at regular intervals of the 50 m tape. Here's how it goes:

> Envision an imaginary transect line starting from your vantage point and running for 50 m (or however many meters you wish, as long as you are still ending up within the same

stand of vegetation you're sampling - never keep counting outside of your homogeneous stand). Now "walk" your eye along this tape for 50 m and visually "take a point" every 0.5 m. Don't worry about precision, just try to "walk" your eye along the line and stop every 0.5 m or at any other regular interval until you reach its end and mentally tally what species you hit. Once you come up with a number of hits for each major species in one imaginary transect, take another transect in another direction and estimate the number of hits on that one. Do this several times (usually 3-4 is enough if you are in a homogeneous stand), then average your results.

This can go quickly in simple environments and in environments where the major species are easily discernable (chaparral, bunch-grassland, coastal scrub, desert scrub). Your average number of hits need not be a total of 100 as in the original transect method, but could be 50 along a 25 m imaginary line (in which case you would multiply by two to get your estimated cover), or 25 along a 12.5 m line (multiply average by 4), etc.

Method 2: Subdivision of sample plot into quadrants:

Many plots, whether they are square, circular, or rectangular, may be "quartered" and have each quadrant's plant cover estimated separately. If the plot is a given even number of square meters (such as 100, 400, or 1000 m^2) then you know that a quarter of that amount is also an easily measurable number. If you can estimate the average size of the plants in each of the quarters (e.g, small pinyon pines may be 5 m^2 (2.2m x 2.2m), creosote bush may be $2m^2$ (or 1.41 m x 1.41 m), burrobush may be $0.5m^2$) then you simply count the number of plants in each size class and multiply by their estimated size for the cover in a given quadrant. Then you average the 4 quadrants together for your average cover value.

This method works well in vegetation with open-to-dense cover of low species such as grasses or low shrubs, in open woodlands, and desert scrubs.

Method 3; "Squash" all plants into a continuous cover in one corner of the plot :

Another way to estimate how much of the plot is covered by a particular species is to mentally group (or "march", or "squash") all members of that species into a corner of the plot and estimate the area they cover. Then calculate that area as a percentage of the total plot area. This technique works well in herb and shrub dominated plots but is not very useful in areas with trees.

Method 4: How to estimate tree cover:

Cover estimates of tall trees is one of the most difficult tasks for a beginning relevé sampler. However it is possible to do this with consistency and reliability using the following guidelines.

1. Have regular sized and shaped plots that you can easily subdivide.
2. Estimate average crown spread of each tree species separately by pacing the crown diameter of representative examples of trees of each species and then roughly calculating the crown area of each representative species.

3. Add together the estimated crown area of each individual of each species of tree on the plot for your total cover.

Method 5: The process of elimination technique:

This method is generally good for estimating cover on sparsely vegetated areas where bare ground, rocks, or cobbles cover more area than vegetation. In such a situation it would be advisable to first estimate how much of the ground is not covered by plants and then subdivide the portion that is covered by plants into rough percentages proportional to the different plant species present. For example, in a desert scrub the total plot not covered by plants may be estimated at 80%. Of the 20% covered by plants, half is desert sunflower (10% cover), a quarter is California buckwheat (5% cover), an eighth brittlebush (2.5% cover), and the rest divided up between 10 species of herbs and small shrubs (all less than 1% cover).

Any of these techniques may be used in combination with one another for a system of checks and balances, or in stands that have characteristics lending themselves for a different technique for each layer of vegetation.

In a relevé, cover estimates, using the techniques described above, are made for each taxon as it is recorded on the species list. Estimates are made for each layer in which the taxon was recorded. For example, if individuals of coast live oak occur in the tall, the mid, and the low layer, an estimate is made for Tall CLO, for mid CLO, and for low CLO.

In a traditional relevé, cover is estimated in "cover classes," not percentages, because of the variability of plant populations over time and from one point to another, even within a small stand. This protocol uses the following 6 cover classes:

Cover Class 1: the taxon in that layer covers < 1 % of the plot area
Cover Class 2: the taxon in that layer covers >1 % - 5 % of the plot area
Cover Class 3a: the taxon in that layer covers >5 - 15 % of the plot area
Cover Class 3b: the taxon in that layer covers >15 - 25 % of the plot area
Cover Class 4: the taxon in that layer covers >25 - 50 % of the plot area
Cover Class 5: the taxon in that layer covers >50 - 75 % of the plot area
Cover Class 6: the taxon in that layer covers > 75% of the plot area

Percentages (optional)

This CNPS protocol also encourages observers to estimate percentages if they feel confident in their estimation abilities. This optional step allows the data to be compared more easily to data collected using different methods, such as a line or point intercept. It also instills confidence in the cover estimate of borderline species that are close calls between two cover classes (e.g., a cover class 2 at 5% as opposed to a cover class 3 at 6%). It is particularly useful for calculating cover by the process of elimination techniques and for estimating total vegetation cover (see below) and coarse fragment cover.

Total Vegetation Cover by Layer

In addition to cover of individual taxa described above, total cover is also estimated for each vegetation layer (e.g. tall, medium, low). This is done using the same cover classes as described above but combines all taxa of a given category. They can be calculated from the species percent cover estimates, but please make sure to disregard overlap of species within each layer. These estimates should be absolute aerial cover, or the "bird's eye view" of the vegetation cover, in which each category cannot be over 100%.

National Vegetation Classification height Classes for Vegetation Strata

The relevé method just described calls for estimates of plant cover for each taxon. It is strongly floristically oriented. Another way of considering the relationships between plants in vegetation is by evaluating structure, or physiognomy. The underlying thinking is that life forms within a stand of vegetation occur in response to similar ecological pressures (TNC 1998). Estimation of cover within predetermined height classes is one way to describe the structure of vegetation. Structure of a stand of vegetation also is used in modeling wildlife use of the vegetation (WHR).

For information gathered using this CNPS protocol to be comparable with the wealth of information being gathered by the National Park Service and the Biological Resources Division (BRD) of the USGS it is also necessary for CNPS to estimate vegetation cover according to pre-defined vegetation strata. The following height classes are defined by the USGS/NPS:

High Tree	>30 m
Medium High Tree	20-30 m
Medium Low Tree	10-20 m
Low Tree	5-10 m
High Shrub	2-5 m
High Herb/ Medium Shrub	1-2 m
Low Shrub	0.5-1 m
Medium Herb	25-50 cm
Low Herb	0-25 cm
Moss/Lichen	

Cover in these vegetation strata is estimated using the same cover classes as were used for cover of individual taxa. Again, estimation of percentages is optional. Please note that although these strata have names in the national classification, they don't necessarily have to be populated by the type of species that are their namesake (e.g., tall herbaceous species may be diagnostic of the tall shrub category in the case of a giant reed stand). For this reason we have simply listed the strata by their height classes and have opted not to name them.

We have also requested that you list the diagnostic species for each layer. In this case the diagnostic species is the single species that seems to best characterize that layer it may be the only species found in a given layer, it may be as common as other species in that layer but is more restricted to that single layer, or it may be less common than other species in that layer, but so representative of that layer that it can't be ignored. The cover of the diagnostic species in that layer does not have to be re-estimated as it is estimated in the individual species tally already.

Caveats:

Please consult with the members of the vegetation committee for advice and feedback on proposed vegetation surveys prior on initiating projects.

Notes on the Order and Division of Labor for Data Collection: As with every procedure there are always more and less efficient ways to collect the information requested. Although we respect each field crews' option to choose in what order they collect the data, we suggest the following general rules:

- Work with teams of two for each plot collected.
- Both team members can determine the plot shape and size and lay out the tapes and mark the edges for the plot boundary (see below).
- The two person teams can also divide up tasks of data collection with one member collecting location, environmental (slope, aspect, geology, soil texture, etc.) and plot description information while the other begins the species list. Thus, two clipboards are useful and data sheets that are at first separated (not stapled).
- Following the making of the initial species list and collection of location and environmental data both team members convene to do the estimation of plant cover by species followed by the estimation of total vegetation cover and cover by layer.
- Following that process, the estimation of cover by the up to 10 height strata classes and the listing of the diagnostic species for each is done collaboratively.
- This is followed by the estimation of the coarse fragment information, again done collaboratively.

For egalitarian and familiarization purposes we suggest that the roles be switched regularly between the team members and that if multiple teams are being used in a larger project, that each team member switches frequently between teams, building all-important calibration, and camaraderie among the whole group.

Suggestions for Laying out Plots: If you are laying out a circular plot, work with two or more people. One person stands at the center of the plot and holds the tape case while the other walks the end of the tape out to the appointed distance (radium 5.6 for 100 m^2 circle, radius 11.3 m for a 400 m^2 circle, and radius 17.6 m for a 1000m^2 circle). The walker then fixes the tape end with a pin flag and walks back to the center where he/she instructs the center person to walk in the opposite direction of the already laid out tape radius, stretching the rest of the tape to an equal length (another 11.3 or 17.6 m) to the opposite edge of the plot, where he/she affixes it with another pin flag. This process is again repeated with another tape laid out perpendicular to the first so that an "+ " shape is created . The margins of the circle can be further delineated by

measuring to the center of the circle with an optical tape measure (rangefinder) and marking mid points between the four ends of the crossed tapes.

When laying out square or rectangular plots work with two or more people per team. If doing a rectangle, determine the long axis of the plot first and have one person be stationed at the zero m end of the tape while the other person walks the unrolling tape case out to the appropriate length. The stationary end person can guide the walker, keeping them moving in a straight line. Once that tape is laid out and the far end staked, the team lays out another tape perpendicular to the first, either at one end, using the same type of process. This establishes the width of the rectangle (or square). Using an optical rangefinder and pin-flags, or colored flagging the team can further mark additional points along the other parallel long axis and short axis of the plot (every 5 m for shorter plots or every 10 m for longer plots is suggested) so that the entire plot boundary can be easily visualized.

References:

Barbour M.G., J.H. Burk, and W.D. Pitts 1987. Terrestrial Plant Ecology, Second Edition. Benjamin/Cummings Publishing Co. Menlo Park, CA. 634 pages.

Sawyer and Keeler-Wolf. 1995. Manual of California Vegetation. California Native Plant Society, Sacramento, CA. 471 pages

The Nature Conservancy and Environmental Systems Research Institute. 1994. Final Draft, Standardized National Vegetation Classification System. Prepared for United States Department of the Interior, National Biological Survey, and National Park Service. Arlington, VA. Complete document available at the following website:
http||:biology.usgs.gov/npsveg/fieldmethods.html

Suggested Equipment:
Equipment List: Prices as of May 2000, toll free orders from Forestry Suppliers (1-800-647-5368) (item numbers in parentheses)

Chaining pins, surveyor steel (#39167)	$21.50
Fiberglass tapes 2 - 165’/50 m (#39972)	$42.90
Logbook cover 8 ½ “ x 12” (#53200)	$23.95
Perforated flagging (#57960)	$1.95
UTM Coordinate Grid (#45019)	$16.95
Rangefinder, 10-75m (#38973)	$51.60
Silva Compass w/ clinometer (#37036)	$43.90
Garmin GPS 12XL (#39095, #39111)	$244.90

Simplified Key to Soil Texture (Brewer and McCann, 1982)

Place about three teaspoons of soil in the palm of your hand. Take out any particles >2mm in size, and use the following key to figure out the soil texture (e.g. loamy sand). Then figure out the texture subclass by using the Code List attached (e.g. coarse loamy sand).

A1 Soil does not remain in a ball when squeezed.....…..... sand

A2 Soil remains in a ball when squeezed.....…..... B

B1 Add a small amount of water. Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Soil makes no ribbon.....….....…….loamy sand

B2 Soil makes a ribbon; may be very short.....….....C

C1 Ribbon extends less than 1 inch before breaking.....….....D

C2 Ribbon extends 1 inch or more before breaking.....….....E

D1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty .....….....loam or sandy loam

D2 Soil feels smooth.....….....silt loam

E1 Soil makes a ribbon that breaks when 1–2 inches long; cracks if bent into a ring.....F

E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring.....G

F1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty.....….sandy clay loam or clay loam

F2 Soil feels smooth.....…...silty clay loam or silt

G1 Add excess water to a small amount of soil; soil feels gritty or at least slightly gritty.....……....sandy clay or clay

G2 Soil feels smooth.....…..….....silty clay

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM CODE LIST (revised 7/8/02)

MACRO TOPOGRAPHY

00 Bench
01 Ridge top (interfluve)
02 Upper 1/3 of slope
03 Middle 1/3 of slope
04 Lower 1/3 of slope (lowslope)
05 Toeslope (alluvial fan/bajada)
06 Bottom/plain
07 Basin/wetland
08 Draw
09 Other
10 Terrace (former shoreline or floodplain)
11 Entire slope
12 Wash (channel bed)
13 Badland (complex of draws & interfluves)
14 Mesa/plateau
15 Dune/sandfield
16 Pediment
17 Backslope (cliff)

MICRO TOPOGRAPHY

01 Convex or rounded
02 Linear or even
03 Concave or depression
04 Undulating pattern
05 Hummock or Swale pattern
06 Mounded
07 Other

SITE IMPACTS

01 Development
02 ORV activity
03 Agriculture
04 Grazing
05 Competition from exotics
06 Logging
07 Insufficient population/stand size
08 Altered flood/tidal regime
09 Mining
10 Hybridization
11 Groundwater pumping
12 Dam/inundation
13 Other
14 Surface water diversion
15 Road/trail construction/maint.
16 Biocides
17 Pollution
18 Unknown
19 Vandalism/dumping/litter
20 Foot traffic/trampling
21 Improper burning regime
22 Over collecting/poaching
23 Erosion/runoff
24 Altered thermal regime
25 Landfill
26 Degrading water quality
27 Wood cutting
28 Military operations
29 Recreational use (non ORV)
30 Nest parasitism
31 Non-native predators
32 Rip-rap, bank protection
33 Channelization (human caused)
34 Feral pigs
35 Burros
36 Rills
37 Phytogenic mounding

PARENT MATERIAL

ANDE	Andesite
ASHT	Ash (of any origin)
GRAN	Granitic (generic)
GREE	Greenstone
DIOR	Diorite
BASA	Basalt
OBSI	Obsidian
PUMI	Pumice
IGTU	Igneous (type unknown)
MONZ	Monzonite
PYFL	Pyroclastic flow
QUDI	Quartz diorite
RHYO	Rhyolite
VOLC	General volcanic extrusives
VOFL	Volcanic flow
VOMU	Volcanic mud
BLUE	Blue schist
CHER	Chert
DOLO	Dolomite
FRME	Franciscan melange
INTR	General igneous intrusives
GNBG	Gneiss/biotite gneiss
HORN	Hornfels
MARB	Marble
METU	Metamorphic (type unknown)
PHYL	Phyllite
SCHI	Schist
SESC	Semi-schist
SLAT	Slate
BREC	Breccia (non-volcanic)
CACO	Calcareous conglomerate
CASA	Calcareous sandstone
CASH	Calcareous shale
CASI	Calcareous siltstone
CONG	Conglomerate
FANG	Fanglomerate
GLTI	Glacial till, mixed origin, moraine
LALA	Large landslide (unconsolidated)
LIME	Limestone
SAND	Sandstone
SETU	Sedimentary (type unknown)
SHAL	Shale
SILT	Siltstone
DIAB	Diabase
GABB	Gabbro
PERI	Peridotite
SERP	Serpentine
ULTU	Ultramafic (type unknown)
CALU	Calcareous (origin unknown)
DUNE	Sand dunes
LOSS	Loess
MIIG	Mixed igneous
MIME	Mixed metamorphic
MIRT	Mix of two or more rock types
MISE	Mixed sedimentary
CLAL	Clayey alluvium
GRAL	Gravelly alluvium
MIAL	Mixed alluvium
SAAL	Sandy alluvium (most alluvial fans and washes)
SIAL	Silty alluvium
OTHE	Other than on list

SOIL TEXTURE

COSA	Coarse sand
MESN	Medium sand
FISN	Fine sand
COLS	Coarse, loamy sand
MELS	Medium to very fine, loamy sand
MCSL	Moderately coarse, sandy loam
MESA	Medium to very fine, sandy loam
MELO	Medium loam
MESL	Medium silt loam
MESI	Medium silt
MFCL	Moderately fine clay loam
MFSA	Moderately fine sandy clay loam
MFSL	Moderately fine silty clay loam
FISA	Fine sandy clay
FISC	Fine silty clay
FICL	Fine clay
SAND	Sand (class unknown)
LOAM	Loam (class unknown)
CLAY	Clay (class unknown)
UNKN	Unknown
PEAT	Peat
MUCK	Muck

DOMINANT VEGETATION GROUP

Trees:

TBSE	Temperate broad-leaved seasonal evergreen forest
TNLE	Temperate or subpolar needle-leafed evergreen forest
CDF	Cold-deciduous forest
MNDF	Mixed needle-leafed evergreen-cold deciduous. forest
TBEW	Temperate broad-leaved evergreen woodland
TNEW	Temperate or subpolar needle-leaved evergreen woodland
EXEW	Extremely xeromorphic evergreen woodland
CDW	Cold-deciduous woodland
EXDW	Extremely xeromorphic deciduous woodland
MBED	Mixed broad-leaved evergreen-cold deciduous woodland
MNDW	Mixed needle-leafed evergreen-cold deciduous woodland

Shrubs:

TBES	Temperate broad-leaved evergreen shrubland
NLES	Needle-leafed evergreen shrubland
MIES	Microphyllus evergreen shrubland
EXDS	Extremely xeromorphic deciduous shrubland
CDS	Cold-deciduous shrubland
MEDS	Mixed evergreen-deciduous shrubland
XMED	Extremely xeromorphic mixed evergreen-deciduous shrubland

Dwarf Shrubland:

NMED	Needle-leafed or microphyllous evergreen dwarf shrubland
XEDS	Extremely xeromorphic evergreen dwarf shrubland
DDDS	Drought-deciduous dwarf shrubland
MEDD	Mixed evergreen cold-deciduous dwarf shrubland

Herbaceous:

TSPG	Temperate or subpolar grassland
TGST	Temperate or subpolar grassland with sparse tree
TGSS	Temperate or subpolar grassland with sparse shrublayer
TGSD	Temperate or subpolar grassland with sparse dwarf shrub layer
TFV	Temperate or subpolar forb vegetation
THRV	Temperate or subpolar hydromorphic rooted vegetation
TAGF	Temperate or subpolar annual grassland or forb vegetation

***Sparse Vegetation*:**

SVSD	Sparsely vegetated sand dunes
SVCS	Sparsely vegetated consolidated substrates