VEGETATION

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INTRODUCTION

Desert wetland vegetation is uncommon, isolated, and infrequently studied even though striking patterns are typical. Few environments encompass the moisture continuum that may be found in desert wetlands such as Fish Slough. Soils at Fish Slough also vary widely in salinity, as illustrated by the extensive alkali flats (with thickly and variably salt-encrusted soil) that surround freshwater marsh habitat. Vegetation patterns that reflect moisture and salinity gradients are of great interest because of the general importance of these in limiting plant growth. Fish Slough is clearly an excellent location for the study of such patterning and underlying causes.

As a result of the need for a current evaluation of the Fish Slough Ecosystem, we studied its vegetation to inventory and describe existing plant associations, and to link vegetation and species patterns with soil properties. The quantitative analyses complement the inventory of Fish Slough vegetation and flora provided by Forbes et al. (1988).

We related the distribution of plant associations to mapped substrate and hydrology classes (vegetation habitats) to provide a conceptual model of the vegetation in relation to the environment. The data collected should be useful for the existing and potential managerial agencies, as well as persons interested in vegetation and conservation biology.

METHODS

Vegetation and Soil Sampling. To document the floristic composition of the Fish Slough vegetation and to identify plant associations, we chose an approach based on indicator species. Indicator species have been considered the unifying characteristic of inland saline marshes because of their broad distributions (Ungar 1974). Accordingly, we chose to sample and classify the vegetation using the traditional relèvè approach developed by Braun-Blanquet [1932, see also Shimwell (1971), Whittaker (1973), Westhoff and van der Maarel (1973), and Mueller-Dombois and Ellenberg (1974)]. The strength of this approach is efficiency, which is facilitated by *a priori* knowledge of the vegetation under study. One member of our sampling team, Wayne Ferren, was already familiar with the vegetation of Fish Slough (see Forbes, Ferren, and Haller 1988).

Because samples are located subjectively and enumerated by visual estimation, the relèvè approach can be influenced by observer bias. To minimize this, four to five botanists were involved in locating plots, and at least two performed the actual sampling. Subjective sampling is contrary to the assumptions necessary to allow application of inferential statistics, so we have not undertaken testing for statistical significance with the plot data. Despite this shortcoming, the relèvè method has proven to be an especially effective means of describing vegetation utilizing all of its floristic components, and identifying patterns for subsequent detailed quantitative study.

Reconnaissance of the study area, included mapping general vegetation patterns using true color 1:24,000 1981 aerial photo coverage of Fish Slough obtained from Los Angeles Department of Water and Power. Map units were included in reconnaissance trips during spring, 1989, when dominant and special interest species and general vegetation assemblages were noted, and briefly described. Although there were relatively few dominant species, a wide variety of species combinations were noted. Stands considered representative of all the subtle variations found were re-visited, and two to three 5 x 20 m relèvès (plots) were located within each of these, generally in different parcels of the study area. A total of 39 plots were located in upland habitat and 95 plots were located in wetland, alkali flat, and alkali scrub (Fig. IV-1a) . Thirty-three of the 95 wetland plots were located along three representative transects. The transects were perpendicular to the main axis of Fish Slough, and served to align some of the plots along actual elevational gradients. Transect plots were also intended to serve for long-term monitoring purposes.

We visually estimated cover of each plant species in each plot. Upland plots were sampled 11-19 May 1989, whereas wetland areas were sampled over the 1989 summer using a schedule based on the timing of plant growth. In the plots located along transects, we tallied the frequency of each species found in sixteen 2.5 x 2.5 meter sub-plots. In plots located in upland areas, we also determined total density for all shrubs within the 100 m^2 area, and for herbs in five 1 m^2 plots systematically located within the main plot. Herb data were later discarded because of the paucity of herb growth in the spring of 1989, which followed a season of relatively low rainfall.

Soils were sampled from each field plot. In upland plots, three 5 cm diameter x 7 cm deep randomly located cores were taken from under the dominant shrub species, and three from in the open. In the plots located where salt deposits occurred on the soil surface, soils were collected at 0-5 cm and 5-15 cm depths at four meter intervals across the length of the plot using a soil probe. Where the soil was saturated and there was no evidence of surface salt accumulation, 0-10 cm deep samples were collected only. Upland soils were collected May 11-17; remaining soils were collected June 1-5. Soils were recollected from transect plots on two additional occasions (August 16-19, October 8-10). Methods for analyses of soil samples are reported by Setaro (1991) in this report (see: Part III, Physical Environment—"Soil Chemistry").

Data Analysis. Vegetation was related to soil variables using canonical correspondence analysis (CCA) (Ter Braak 1986, 1987), Detrended Correspondence Analysis (DCA) (Hill 1979), direct ordination (Whittaker 1967), and regression analysis. While this was useful for relating species and plots to soil attributes, Two Way INdicator SPecies ANalysis (TWINSPAN) (Hill 1973) is the most appropriate automated analytical method for classification of relèvè data, and the one we chose to use for this purpose.

We analyzed data from upland and wetland areas separately. The upland data set is less comprehensive in terms of soil attributes than the wetland data set. Seven plots from the upland/wetland ecotone were included in both groups in the ordination and classification analyses, as well as in the summary statistics for each data set. The more comprehensive set of measurements were also obtained for these ecotonal samples. Although the data sets are referred to as "wetland" and "upland", each contains the transitional samples.

Data representing each soil variable were transformed to approximate normal distributions, most often using a Log transform. Some variables were not used in regression, correlation and CCA analyses because normal distributions could not be achieved through transformation (eg. nitrogen, phosphorus, and sulfate, which were found at very low levels in all but a few plots).

All possible combinations of soil variables were regressed against the first two ordination axes produced by DECORANA. All inter-correlations among soil variables were then analyzed. After accounting for inter-correlated variables, and discounting those not capable of being normalized, we then chose the eight variables that provided the best regression model to use with CCA as environmental variables.

Mapping. We mapped the hydrologic/geomorphic classes described in Table IV-1. It was not possible to distinguish among all plant associations using available air photos, thus the floristically-based classification could not be represented on the map. The hydrologic/geomorphic classes were defined to take vegetation structure into account. We have chosen to refer to the classes as vegetation habitats. The aforementioned 1:24,000 air photos were used to interpret the classes that occurred in wetland areas, and the information was transferred onto an enlargement of the USGS Ortho-photo White Mountain and Bishop Quadrangles. Upland areas were mapped based on the geologic map provided by the State of California Department of Water Resources Dam and Reservoir Feasibility Report (1964). Information was transferred from the photos and geologic map to the enlarged Ortho-photo using a Zoom-transfer scope at the UC Santa Barbara Map and Imagery Library.

Interpretation of the 1981 photos was a straightforward process in some areas, and difficult in others. The boundaries of the wetland habitat areas are dynamic seasonally and possibly over a time scale of decades. An example of this is possible subsidence along the Fish Slough Fault in recent years. Because of the dynamic boundaries, the scale and relatively old date of the 1981 air photos, areal calculations must be considered estimates, and some of the boundaries on Figure IV-1b may not represent the present boundaries, and could become significantly inaccurate over a time scale of decades.

Areas were considered to be in the permanently-flooded category if water or dark, wet soil could be observed on the surface of the land. Occasionally dark, lush wetland vegetation characteristic of these areas was observed with white underlying soil (actually dried algae), and these low-lying areas were placed into category 2 (Channels and low, wet areas). Category 3 (Meadows) was distinguished from #2 subjectively based on color and salt deposits. Because the imagery was taken in mid-summer, the interpreted boundary between permanently and seasonally flooded or saturated areas on the map should be a good representation of this difficult and dynamic transition zone. Meadows were separated from more alkaline habitats again based on color. Alkali meadows and category 5 (Alkali Flats) intergrade or overlap greatly, and are not suited to the traditional mapping approach. Another difficult map category was number 8 (Eolian), which was virtually impossible to distinguish definitively from 7 (Alluvium) on the photos. We therefore relied on field observations to delineate eolian areas. The remainder of the categories were straightforward to map, or, in the case of upland areas, were mapped based on the previously mentioned geologic map.

Vegetation maps were digitized and plotted using the Arc Info Geographic Information System (ESRI Corporation, Redlands California) and a Calcomp pen plotter.

RESULTS AND DISCUSSION

SOILS. The previous section on soil chemistry (see "Physical Environment-Soil Chemistry" in this report) describes the raw data obtained from analysis of the large number of soil samples we collected at Fish Slough. We are not aware of a more detailed chemical analysis of soils from a comparable-sized area. We have compiled the data in their entirety; they are presented in Appendix I. Summary statistics are provided in Appendix II. A brief interpretation of these data is provided in this section.

In areas where salt deposits occurred on the soil surface at Fish Slough, we sampled 0-5 cm and 5-15 cm depths separately. In our quantitative analyses, we chose to use the 5-15 cm samples, which had salinity levels only 10-25 percent as high as the surface samples, which included the salt crust. The recommended procedure in USDA's *Diagnosis and Improvement of Saline and Alkali Soils* (USDA 1954), is to separate salt crusts from soil samples. The conditions in the least saline portion of a plants rooting volume are most important (Daubenmire 1967).

Wide variation in the concentrations of all ions, even within similar plant associations or habitat groups, was found in our study. Subsampling at three time intervals also demonstrated temporal variation in soil salt content. Due to the sampling design, we cannot adequately account for how much of the variation among samples from analogous habitats is due to actual variation, and how much is due to sampling error.

The dominant cation in all samples, except those from localized eolian and chemically-altered, fossil fumarole substrata in the uplands, is calcium. Sulfate is the dominant anion. Levels of sodium and chloride, the dominant factors in halophytism (Sen and Rajpurohit 1982), are low by comparison. The mineral composition of the surrounding Bishop Tuff undoubtedly has played an important role in the development of the Fish Slough soil salt composition.

The dominance of calcium and sulfate among the cations and anions respectively suggests that salt-affected Fish Slough soils may be relatively high in gypsum. This mineral was detected in most upland soil samples (Table A.I.1), but was not inventoried elsewhere. Gypsiferous soils are characterized by a large number of endemic plant species in the deserts of the southwestern United States (MacMahon 1988). A small portion of the Death Valley Salt Pan is characterized by gypsum (Hunt 1975); however, within the desert regions of North America, Calcium sulfate salts mainly occur in the Chihuahuan Desert (MacMahon 1988). In general, calcium dominated soils are well known for supporting unusual floras (Calciphiles), although these are generally found on calcium carbonate substrata (Jeffrey 1987).

Sulfates are the least toxic of the readily soluble salts, and the hydrophysical properties of sulfates are considered generally less detrimental than other salts because they do not alkalize. Among cations, calcium does not have the negative influence on plant metabolism of sodium, and is important in plant membrane function and cell development (Jeffrey 1987).

Exchangeable levels of sodium are especially significant in their negative influence on plants. Exchangeable sodium was measured in this study. Measurement of exchangeable sodium can be difficult, and is often fraught with inaccuracy, as has been noted in the literature (Bohn et al. 1985). Thus caution must be exercised in making conclusions regarding "sodium hazard"; however, techniques used in this study avoid the usual pitfalls (see "Physical Environment—Soil Chemistry" in this report). The extent to which sodium dominates adsorbed colloids is an index of the soil sodium hazard. This can be expressed by the exchangeable-sodium-percentage (see Bohn et al. 1985 for calculation). Soils with an exchangeable-sodium percentage greater than 15 are considered extremely detrimental to plant growth. There is no habitat at Fish Slough (except at chemically-altered sites [Table A.I.1]) where soil at 5-15 cm exceeds or even approaches this threshold on average (Appendix II, Table A.II.1). This is because of the overwhelming dominance of calcium. Nonetheless, considering measurement error, wide sample to sample variation, and our observation of localized salt flats devoid of vegetation (these were rare), it is possible sodium hazard does occur, although rarely.

Electrical conductance is an important measure for overall salinity, which overcomes many of the ambiguities of other salinity measures (Bohn et al. 1985). Soils having an electrical conductivity greater than 4 dS/m for water extracts from saturated pastes are considered saline (Jeffrey 1987), although conductivity between 2 and 4 dS/m can affect glycophytes, which are plants normally found only in non-saline habitats (Bohn et al. 1985). For the treatment of salinity from soil pastes, fresh water contains less than 50 mg/l total dissolved salts (= < 0.78 dS/m); subsaline conditions are characterized by 500-3000 mg/l TDS (= 0.78-4 dS/m); and saline conditions generally exceed 4 dS/m. Conductivity in our study was measured on a filtered extract of a 1:5 soil to water suspension. This is a more accurate procedure, but, the results cannot be directly compared to those obtained using the saturated extract. Soils in some Alkali Scrub habitats (especially those dominated by *Allenrolfea*) have an average conductivity of 4 dS/m in the 1:5 extract, and are unequivocally saline. In other areas conductivity is much lower, and conditions range from subsaline to moderately saline (Appendix II, Table A.II.1).

The terms "saline soil" (as opposed to saline-alkali), "white alkali", and "Solonchak" refer to soils high in solutes (conductivity > 4 dS/m), but relatively low in exchangeable sodium (USDA Agriculture Handbook #60). These soils are considered the least detrimental to plant growth of the salt-affected soil types. Salt-affected soils accumulate salts in amounts or types detrimental to plant growth. If they contain large quantities of soluble salts (sulfate and/or chloride), salt-affected soils can limit plant growth, mainly of glycophytes (Daubenmire 1967). Salt-affected soils at Fish Slough fall mainly in this category. "Saline-Alkali" soils have conductivity in excess of 4 dS/m, solute concentrations detrimental to glycophytes, as well as enough sodium to be injurious to glycophytes (>15 exchangeable-sodium percentage). Based on our sampling, these soils are rare at Fish Slough. "Alkali", "Solonetz" or "black alkali" soils are the most detrimental to plant growth. These have negligible free salts (conductivity < 4 dS/m), as sodium dominates the colloids (Daubenmire 1967). We have no reason to suspect Solonetz occurrence at Fish Slough.

The variation in salinity at Fish Slough follows the general concentric pattern of inland saline areas. We describe this in terms of Vegetation Habitats defined in this study (see below) from the middle of the Slough outward. Summary statistics for soil attributes in each Vegetation Habitat are provided in Appendix II, Table A.II.1. Lake soils, pond soils, etc. had salinity that was far below .78 dS/m in the 1:5 extract, and are thus freshwater habitats (Husband and Hickman 1989). Channels and low, wet areas are subsaline on average (conductivity = .85 +/- .45 dS/m). Anaerobic soil conditions were noted in the field in flooded areas (except locally at the spring sites). The predominance of plants with aerenchyma in these areas is further evidence of anaerobicity. At slightly higher elevations than the water table there is large expanse of Fish Slough characterized by a salt crust on the soil surface. This is connected with the groundwater through film-capillary flow of salt solutions. This process may keep the soil continually moistened where the water table is within 0.5 m or so of the surface. There is a steady increase in salinity from the high water-table zone (seasonally flooded and alkali meadow habitat) to a maximum in areas where the water table apparently fluctuates between about 1.25-2.25 m in depth based on permanent, monitored soil cores (Alkali Scrub Habitat). The genesis and classification of soils with an active salt crust is described by Szabolcs (1989). Only within the Alkali Scrub Habitat did conductance exceed the 4 dS/m salinity threshold at 5-15 cm in the 1:5 extract (average conductivity = 4.0 +/- 4.6 dS/m). High soil salt levels predominantly occurred in association with the shrub *Allenrolfea occidentalis*. Exchangeable sodium did not reach high levels. The sparse vegetation cover (approximately 10 percent) on salt-encrusted soils, especially considering water availability, does suggest substantial negative salt affects on plant growth.

Poor aeration of soils is another important factor influencing vegetation in inland salt basins, especially where moisture levels are high. High concentrations of soluble salts and poor aeration are probably both involved in limiting plant growth at Fish Slough. In addition, some authors have claimed that nutrient limitation can have a strong effect on vegetation patterns in salt marshes (Valiela and Teal 1974). We did not investigate soil aeration or nutrient levels in this study.

At elevations above those influenced by upward capillary movement of soil solutes, soil salinities declined, but were still high. In fact, in chemically altered sites, high levels of sodium were found, accounting for the nearly complete lack of plant growth in these localized areas. The abundance of *Atriplex confertifolia*, and obligate halophyte (Schirmer and Breckle 1982), in most of the upland area is further evidence of the importance of salts in the upland soils.

In summary of the discussion of soils, flooded vegetated areas have low to moderate salinity, generally not enough to limit glycophytes. Despite thick white alkali over the extensive area within about 2.5m of the water-table, our results indicate that salinity here is rarely high (except in the soil crust). Although surface salt crust would affect non-vegetative plant establishment, in general, it appears that salinity does not greatly limit plant growth at Fish Slough, except in the most alkaline areas, which are uncommon. Evidence in support of this hypothesis includes (1) relatively high species richness on the great majority of salt-encrusted soil, but very low richness in the most alkaline areas, and (2) the observation that areas devoid of vegetation are almost nonexistent on salt flats at Fish Slough, unlike most alkaline desert areas. Soil aeration and soil moisture may play a larger role in limiting plant growth in these situations at Fish Slough than in typical desert salt marsh ecosystems, which are more saline. In the uplands, salinity appears to be moderate, except in some eolian and chemically altered sites where it is high. Moderate salinity may, however, contribute significantly in producing highly negative upland soil water potential.

VEGETATION HABITATS. The distribution and abundance of the mapped vegetation habitats are shown in Figure IV-1b. Means and standard deviations of the soil attributes in each Vegetation Habitat are provided in Appendix II, Tables A.II.1 and A.II.2, and are summarized in the descriptions below. Vegetation composition (associations) occurring within each of the habitats are also listed below; however, the reader is referred to the subsequent section for detailed descriptions of the composition and physiognomy of these. The approximate areal extent that each habitat occupies within the area mapped in Fig IV-1b is given below. It is important to note that there is substantial variation in virtually every soil attribute within each habitat type, and the within-habitat pattern of variation was not systematically investigated in this study.

In the descriptions of soil characteristics that follow, our interpretations of soil salt content (percent salt in soil) rely on our measurement of conductivity, which is based on a

1:5 water extract. A 1:5 ratio of air-dried soil to deionized water was filtered through a 0.45 micron glass fiber filter to produce the aqueous extract on which the conductivity was measured. The 1:5 ratio is more appropriate for determining relative difference in conductivity extract of a saturated-soil paste with large numbers of samples (Szaboles 1979). Most soil conductivity measurements reported in the literature have been obtained from the saturated paste extract, and no straightforward conversion exists to allow direct comparison of results from the two methods (Szaboles 1979). Values of the 1:5 extract will vary according to soil texture and soluble salt composition making it difficult to establish a correlation between saturated paste extract and 1:5 water extract data.

The dividing line between saline and subsaline soils was established at 4 dS/m (see previous discussion in "Soils") for water extracts from saturated soil pastes (USDA 1954, Bohn et al. 1985). Dilution of a saturated extract by a factor of five would reduce conductivity, so 1 dS/m in this solution approximates the salinity boundary of 4 dS/m in a saturated paste extract. The Terminology Committee of the Soil Science Society of America has recommended lowering the boundary from 4 to 2 dS/m. Where the conductivity of a solution ranges from 3 to 30 dS/m the osmotic potential of the solution equals the product of the conductivity and -.36 (Bohn et al. 1985). The osmotic potential of soils (based on the 1:5 extracts) are provided below for soils with fairly high conductivities (see Bohn et al. 1985, pg. 241). Bohn et al. state that, "the osmotic pressure or osmotic potential most directly measures the effects of salinity on plant growth."

1. **Lakes, ponds, springs, etc.** [Approximately 5.6 ha (13.9 acres) in low lying areas along the center of the Slough]. These soils are characterized by high sand content, pH 7.5, and permanent saturation with low salinity (conductivity = .29+/-.17 dS/M in the 1:5 extract, .1+/.1 percent salt by weight). Soil is anaerobic, except locally at the springs. The dominant cation is calcium (total = 15.6 +/- 14.7 meq/100g). At Fish Slough, there is dense, lush growth of emergent vegetation within this habitat. There are also areas of open water with sparse to dense growth of submerged aquatic macrophytes. In general, the plants involved are known, or are considered to be at least somewhat salt-tolerant (e.g. *Ruppia* sp. (Husband and Hickman 1989), *Potamogeton pectinatus* (Ungar 1974), *Typha, and Scirpus americanus* (Ezucurra et al. 1988). Plants growing in water-logged areas of salt basins (e.g. *Scirpus* spp.) have been termed marshy halophytes (Sen et al. 1982). The emergent species are characterized by aerenchyma, an anatomical adaptation for growing in anaerobic soils (Esau 1977). Associations occurring within this habitat are 1 (*Ruppia*-alga), and 2 (*Scirpus-Typha*).

2. **Channels and low, wet areas.** [Approximately 72.1 ha (178.2 acres) mainly along the center of Fish Slough]. These areas are also characterized by permanently saturated anaerobic soil. Mean soil moisture was found to be highest in this habitat (72 +/- 8 percent), presumably higher than the previous vegetation habitat due to high organic content (D. Odion, R. Callaway, personal observation). Conversely, sand was lowest in this habitat (21 +/- 24 percent). Conductivity was a relatively consistent .85 +/-.45 dS/m in the 1:5 extract (.3+/-.1 percent salt), indicating subsaline to saline conditions (osmotic potential of the soil is equivalent to about -1.5 +/-.81 bars). Calcium levels were about three times that of lakes, ponds, etc. This habitat supports lush growth of 1-2.5 m tall emergent vegetation composed of species mainly from association 2 (*Scirpus-Typha*), all possessing aerenchyma. In addition, the channel bottom in more open areas supports a submerged aquatic plant association that was not sampled in this study. This consists mainly of *Potamogeton illinoensis* and *Potamogeton latifolius*.

3. **Seasonally flooded and alkali meadow.** [Approximately 219.4 ha (542.1 acres) in a concentric zone around Habitats 1 and 2]. Here the term meadow refers to a green, relatively lush, grass, sedge, and/or rush dominated area. Other authors have extended the term to include sparsely vegetated alkaline areas, but we do not follow that here. Soil moisture was found to be high in this habitat (44 +/- 17 percent), and the fluctuating water table is at or near the soil surface all year long based on our observations and soil cores. Anaerobicity is probably an important factor. A salt crust does occur on the soil surface. This may be seasonal in some areas. Soil salinity was extremely variable (conductance = 1.3 +/- 2.1 dS/m, in the 1:5 extract, .4 to .6 percent salt, osmotic potential of the soil approximately -2.34 +/- 3.76 bars). Some areas within this habitat have saline soil, while others hare subsaline soil. Calcium levels were similar to the previous habitat, but sulfate was higher (5.3+/-11.8 meq/100g). Vegetation in this habitat ranges from a dense monoculture of *Eleocharis rostellata* (aerenchymous) in the areas flooded longest (Association 3 *Scirpus-Eleocharis*) to patches of the spreading *Anemopsis californica* at margins of springs and the other variants of Association 4 (*Eleocharis-Muhlenbergia*), to the grass dominated *Elymus-Poa* association 5. In all cases, however, plant cover is high (50-100%).

4. **Alkali Flat.** [Approximately 216.3 ha (534.5 acres); forms a mosaic with Habitat 5, Alkali Scrub, in a concentric zone around Habitat 3]. Surprisingly, this habitat has salinity levels, as well as individual solute levels, that are about the same as the previous, even though there is a more conspicuous salt crust on the soil. Soil moisture levels in this

habitat are, however, lower than the previous, and conditions for plant growth much more limiting based on the fairly sparse cover. The water table fluctuates from .5-1.5 m below the surface. Plant cover consists of Association 6 (*Juncus-Distichlis*), and Association 7 (*Spartina-Sporobolus*). Most of the species found in these associations are known to be extremely salt tolerant, and many are widespread across North America (e.g. *Distichlis spicata* and *Sporobolus airoides*) (Ungar 1974). Most are monocots, which tolerate saline conditions by excluding ions, rather than tolerating high internal concentrations like dicots (Matoh et al. 1988).

5. **Alkali Scrub**. [Approximately 137.6 ha (340.0 acres) forming a mosaic with Habitat 4, but generally more common farther from marshy areas]. Occurs at slightly higher elevations than the previous, and this probably contributes to its much higher salinity (conductance = 4.0 +/- 4.6 dS/m, percent salinity of the 1:5 extract equals 1.5 +/-1.6, soil osmotic potential is approximately -8.1 +/- 8.3 bars). The water table occurs from .75-2.25 m below the soil surface. Again, calcium and sulfate dominate the cation and anion composition of the soil respectively (109.7 +/- 93.1 meg/100g and 62.7 +/- 143.6 meq/100g). Relatively high levels of other ions include sodium (20.4 +/- 23.7 meq/100 g), and chloride (14.6 +/- 48.9 meq/100 g). The salt crust is thick. The vegetation of this habitat includes Association 8 (*Sporobolus-Allenrolfea*), and 9 (*Distichlis-Chrysothamnus*), which includes a sparse cover of shrubs, two species of which are extremely salt tolerant succulent-leaved dicots (*Allenrolfea occidentalis* and *Sarcobatus vermiculatus*) (Ungar 1974). *Chrysothamnus albidus* is characteristic of the more widespread form of this vegetation habitat.

6. **Mosaic of 4 and 5**. [Approximately 17.7 ha (43.6 acres)]. Although mosaics of Associations 4 (Alkali Flat) and 5 (Alkali Scrub) occur practically the entire length of Fish Slough wherever ecological conditions are appropriate, a unique combination of physical features south of the Northeast Spring is worthy of separate consideration. South of the artificial game fish pond and west of the channel is an area of undulating topography that contains basins without drainage. Some of these flood as a result of winter rainfall and can be considered vernal wetlands. A distinct flora occurs in these basins (including plants such as *Eleocharis parvula* ssp. *coloradoensis*, *Juncus longistylis*, and *Jungus bufonius*) that have not been found elsewhere in the Fish Slough Ecosystem. Banks and flats in the area are characterized by the Alkali Flat vegetation habitat, and mounds are characterized by the Alkali Scrub vegetation habitat.

7. **Alluvium.** [(Approximately 381.8 ha (943.0 acres). Conductance was not measured in upland soil samples, so salinity must be ascertained from the abundance of individual cations for this and the remaining habitats.]. Moderate levels of the cations occur in this habitat, and there is usually no salt crust. Soils are very sandy (65+/-9%). The water table is greater than 2m below the soil surface. Nonetheless, the vegetation of this habitat, Association 10 (*Chrysothamnus-Distichlis*), Association 11 (*Distichlis-Sarcobatus*), and Association 12 (*Sarcobatus-Atriplex*), contains shrubs that appear to be phreatophytic based on their size and density, at least at elevations closest to the water table. *Chrysothamnus nauseosus* and *Suaeda moquinii* are common in some associations within this vegetation habitat.

8. **Eolian.** [Approximately 87.7 ha (216.8 acres) in the north and northwestern portions of the study area]. The Eolian Habitat is not one of major active dune systems such as those of neighboring basins, and elsewhere in the Owens Valley (e.g. near Olancha). Rather, the "dunes" are 1-2.5 m tall (too small to be depicted in the topographic maps in this report, which have a 10 foot contour interval), and shrub covered and presumably stationary. The geologic map provided in the Fish Slough Dam and Reservoir investigation (CDWR 1964) includes our Eolian Habitat within their alluvium category. The Eolian Habitat intergrades strongly with the Alluvium Habitat, and has a similar soil texture and vegetation characteristics. Certain annual plants are restricted to the Eolian Habitat at Fish Slough (e.g. *Abronia villosa* on dunes west of Fish Slough Lake). Interestingly, some eolian soils are characterized by high levels of sodium (35.9 +/- 34.0 meq/100 g), particularly at sites with transitional areas of salt-encrusted soils and eolian sand between the NE Spring and the NW Springs. This is the only habitat other than Chemically Altered in which sodium is the dominant cation in some areas.

9-11. **Bishop Tuff, Unit 1, including talus slopes and washes.** [Approximately 1,457.3 ha (3,602.1 acres total); 1,120.7 ha (2,769.2 acres) of tableland; 281.2 ha (695.0 acres) of talus slope; 55.4 ha (136.9 acres) of wash; (see Fig. IV-1b for distribution]. This habitat is characterized by very shallow or nonexistent soil over a rock substrate. The rock consists of hard, consolidated, orange, gray, tan, or brown, welded tuff. It is massive and highly jointed, and many of the joints are filled with silt, sand or debris. "Soils" are subsaline. The Bishop Tuff is described in detail by Izett (1988). Tableland terrain is generally level, whereas talus slopes vary from about 20 degrees to nearly vertical. Talus varies from cobble to large boulders at the base of sheer cliffs. Vegetation is mainly that of Association 13 (*Atriplex-Ephedra*) and 14 (*Artemisia-Chrysothamnus*), and is sparse and low growing on the tablelands. In washes, relatively large shrubs of *Artemisia tridentata* and *Purshia glandulosa* occur. Perennial grasses are abundant also on this substrate. *Chrysothamnus* species characteristic of this vegetation habitat are *C. viscidiflorus* and *C. teretifolius*.

12-13. **Bishop Tuff, Unit 2, including talus.** [Approximately 190.4 ha (470.7 acres) total; 178.4 ha (441.0 acres) tableland; 12.0 ha (29.7 acres) talus slope; see Fig. IV-1b for distribution]. Only one soil sample was collected from this habitat, so the chemical properties cannot be accurately described. Substrate is loose, fine- to coarse-grained, friable, pale grayish-brown to pink or white. Vegetation characterizing this habitat is mostly Association 13 (*Atriplex-Ephedra*), with low-growing *Menodora spinescens*, *Artemisia spinescens* and *Ephedra nevadensis* strongly dominant.

14. **Bishop Tuff, Unit 3.** [Approximately 143.7 ha (355 acres) adjacent to Fish Slough Fault, on the eastern side; only in the southern half of the study area]. This substrate outcrops on a west facing fault scarp slope. The slope is steep (about 20-30 degrees). Unit 3 of the Bishop Tuff is composed of unconsolidated fine-grain ash, dust, and pumice, and is light gray to white in color. Only two soil samples were obtained from this habitat. These were characterized by moderate levels of cations. Vegetation on this substrate consists of a homogeneous, sparse (about 5 percent) cover of *Psorothamnus polydenius* and *Atriplex confertifolia*, with other species only occasionally present.

15. **Chemically Altered.** [Approximately 2.8 ha (7.0 acres)]. These distinctive areas are not described in the 1964 Dam feasibility report. We presume they are fossil fumaroles. There are conspicuous loose, insoluble crystals on the soil surface, which is otherwise similar to Bishop Tuff Unit 3, and very sparse plant growth. This is the only area other than some Eolian Habitats at Fish Slough where Sodium is the dominant cation (12.8 +/- 20.1 meq/100 g). Vegetation consists of occasional *Atriplex parryi*, *Aster intricatus*, *Suaeda moquinii*, and *Distichlis spicata*, congregated together where they do occur. Cover is less than 5 percent overall.

VEGETATION CLASSIFICATION. Fourteen associations were identified based on the output of TWINSPAN. The output is summarized in a dendrogram (Fig. IV-2), which also shows the relationship among the Associations and Vegetation Habitats. Grouping of associations into five major higher units (syntaxa) is explained in the text. We have not applied the Braun-Blanquet nomeclatural system to our classification. The raw data table containing all the vegetation data from wetland and upland data sets, and the classifications provided by TWINSPAN, are found in Appendix II, Tables A.II.3 and A.II.4. Summary statistics for soil attributes in each association are in Tables A.II.5 and A.II.6.

Wetlands. Except for Association 1, which is characterized by aquatic macrophytes that were not found in other associations, there is substantial overlap between each association and neighboring associations. This is because there are several important species that occur over a very wide range of conditions, most notably *Distichlis spicata*, *Juncus balticus*, *Eleocharis rostellata*, *Spartina gracilis*, *Muhlenbergia asperifolia*, and *Sporobolus airoides* in the wetland area, and *Sarcobatus vermiculatus*, and *Atriplex confertifolia* in the lowland and upland area. The tendency for dominant halophytes to occupy a wide range of habitats has been reported in the literature (Ungar 1974). Most of these species are know to tolerate high salinity. In general, there is a positive correlation between a species salinity tolerance, and the range of salinities in which it can grow in the field (Daubenmire 1967).

Association 1 (*Ruppia*-algae) shares no species with other associations, and therefore is considered to be a distinct syntaxon, or higher order group in the classification hierarchy (Westhoff and van der Maarel 1973). We refer to this syntaxon as **Submerged Aquatic Macrophyte Vegetation.** This corresponds with Aquatic Bed vegetation described in the previous inventory of Fish Slough vegetation (Forbes *et al.*, 1988). Aquatic Bed vegetation is subdivided into Fish Slough and Owens River types. The latter occurs in the McNally Canal at the lower end of Fish Slough when it has been flooded by river water for a sufficient time. This canal was dry for the duration of our study.

The general relationship among remaining associations in the wetland data set can be seen in the DECORANA ordinations (Figures IV-3 and IV-4). The ordination of 86 plots from associations 2-9 shows a high degree of aggregation, or compositional similarity, among plots from associations 5, 6,7,8, and 9. These Associations also form a distinct syntaxon in the TWINSPAN hierarchy (Fig. IV-2). Because this group contains the Alkali Scrub, Alkali Flat and Alkali Meadow vegetation (a distinctive biophysical class that grows on salt-encrusted soil where the watertable is high), we shall refer to the syntaxon as **Hydrohalophytic Vegetation.** Association 4 (*Eleocharis-Muhlenbergia*) contains 3 distinctive plots. These were located in patches of dense *Anemopsis californica*, a low growing rhizomatous herb that spreads by runners. When the three *Anemopsis*-

dominated plots were deleted from the analysis to leave a total of 83 plots, greater spread in the ordination was obtained, but plots from associations 5,6,7,8, and 9 (alkali vegetation) remained largely intermixed (Figure IV-4). Association 8 (*Sporobolus-Allenrolfea*) is somewhat distinctive, however. This is because *Sporobolus airoides* and *Allenrolfea occidentalis*, which both occur in other associations, are dramatically more abundant and dominant in Association 8 (Table A.II.3). This distinguishes association 8 from 7 and 6 (*Juncus-distichlis* and *Spartina-Sporobolus*) where dominance is more evenly distributed among 3-5 halophytes. Association 9 (*Distichlis-Chrysothamnus*) differs from the others chiefly due to the presence of *Chrysothamnus albidus*. Association 5 (*Elymus-Poa*) occurs in areas that may occasionally flood, and is characterized by the presence and abundance of *Elymus triticoides*. This Association is transitional to Associations 2, 3, and 4. The latter are distinctly separated from 6-9 in both ordinations, and form a separate branch of the dendrogram. Occurring in flooded or saturated habitats, this syntaxon is called here Marsh **Vegetation.** Marsh Vegetation is analogous to flooded Emergent Wetland used by Forbes *et al.*, while Hydrohalophytic Vegetation is equivalent to Scrub/Shrub Wetland, excluding Great Basin Riparian Scrub.

In summary, the wetland classification (Table A.II.3) and both wetland ordinations (Figs. IV-3 and IV-4) demonstrate a great degree of overlap among associations; however, there is distinct separation (especially along the x-axis) of Marsh Vegetation (Associations 2-4) from Hydrohalophytic Vegetation (Associations 5-9), although Association 5 is transitional. Submerged Aquatic Macrophyte Vegetation, which is quite distinctive, forms the third wetland syntaxon.

Uplands. Association 10 (*Distichlis-Chrysothamnus*) from the upland data set has five plots in common with association 9 from the wetland, yet they are distinct enough to separate based on *Chrysothamnus nauseosus* occurring predominantly in the former, and C. *albidus* in the latter. The remaining upland associations would be fairly distinct from one another if not for the near ubiquity of *Atriplex confertifolia* in the uplands (Appendix II, Table A.II.4). Only Association 14 (*Artemisia-Chrysothamnus*), where *A. confertifolia* is uncommon, is separated from the others in the DCA ordination (Fig. IV-5). *Artemisia tridentata* and several other species are unique to this association (Table A.II.4). Association 14 and Association 13 (*Atriplex-Ephedra*) are grouped together in the hierarchy (Fig IV-2) because they share numerous species not thought of as xerohalophytes (see West 1988; Ungar 1974), and vice-versa for Associations 10-12, which are dominated by xerohalophytic shrubs such as *Atriplex* spp. and *Sarcobatus vermiculatus*.

In summary, there are two groups of associations in the upland data set: one composed mainly of xerohalophytes and one mainly of salt-intolerant xerophytes. These groups would be distinct were it not for *A. confertifolia*, which occurs abundantly in both. Nonetheless, we recognize **Xerohalophtic Vegetation** and **Xerophytic Vegetation** as distinct syntaxa. Upland halomorphic vegetation is encompassed by the terms shadscale scrub (Cronquist et al. 1972, Forbes et al. 1988), and saltbush-greasewood (Kuchler 1970). *Artemisia tridentata* dominated vegetation in the southern Great Basin region is commonly referred to as Great basin sagebrush (Kuchler 1970; West 1988)

Even though the same dominants occur over a wide range of habitats at Fish Slough, there is a high turnover of the less common species, and overall, diversity is high for a wetland ecosystem. A total of 150 species were found in the 91 plots (100 in the wetland data set, and 73 in the upland data set). Perhaps the relatively low to moderate salinity conditions (see soil description that follows) contribute to the overall richness.

The plant associations are described in detail below in order of their occurrence along a hypothetical gradient from wettest to driest environment. The coinciding salinity gradient goes from low to moderate to fairly high in some areas, then back to moderate in the uplands. Dominant and indicator species, diversity, and physiognomy, and soil characterizing each association are included in our descriptions, along with the vegetation habitats each association occurs within. The distribution of each association at Fish Slough, along with some general information of interest are also provided. Complete summary statistics for soil attributes in each association are in Appendix 2, Tables A.II.6 and A.II.7. See also Fig. IV-6.

Plant Associations at Fish Slough

A. Syntaxon: SubmergedAquatic Macrophyte Vegetation

Association 1. *Ruppia-algae*

Dominant plants: *Ruppia maritima, Potamogeton foliosus*, algae.

Indicator species: any of the above, and *Zannichelia palustris*

Species Richness: 2.5 +/- .8 species/100 m^2. Range = 2-4 species/100 m^2.

Physiognomy: Herbaceous, submerged aquatic macrophytes.

Habitat: Lakes, ponds, etc.

Soil: Salinity low enough to be considered freshwater conditions, pH = 8.2, conductivity = .29 +/- .18 dS/m, high percent sand positively correlated with distribution, (Fig. IV-6), always flooded.

Distribution: Springs, ponds, impoundments, Fish Slough Lake. Uncommon.

General: Type of water body influences species composition. *Ruppia* occurs in lakes and ponds, while *Potamogeton foliosus* occurs only near springs. The spring sites are the least alkaline aquatic habitats at Fish Slough. The loose, coarse substrate at spring heads may limit the establishment of some species. For example, *Ruppia* distribution has been shown to be strongly influenced by sediment texture in freshwater habitats (Husband and Hickman 1989), and is absent from some spring heads. *Potamogeton-Ruppia-Characeae* dominated communities in the United States have been described by Ungar (1974), who termed this an Inland Saline Lake Community. Another aquatic macrophtye community at Fish Slough occurs along the channel bottom of Fish Slough Creek, especially at the southern end where flow is swift and deep. This community is dominated by two pondweeds, *Potamogeton illinoensis* and *Potamogeton latifolius*.

B. Syntaxon: Marsh Vegetation

Association 2. *Scirpus-Typha*

Dominant plants: *Scirpus acutus*, S. *americanus*, *Typha domingensis*, *Eleocharis rostellata*.

Indicator species: *Scirpus acutus*

Species Richness: 11.22 +/- 2.7 species/100 m^2. Range = 7-17 species/100 m^2.

Physiognomy: Dense, 1-2.5 m tall emergent aquatic vegetation. Aerenchymous.

Habitat: Channels and low, wet areas. Margins of lakes and ponds.

Soil: Subsaline, pH = 7.9, conductivity = .7 +/- .4 dS/m. Soil moisture strongly influences distribution (Fig. IV-6).

Distribution: Widespread and abundant in the central portion of Fish Slough Valley.

General: *Scirpus* spp. dominate, ranging from 50 to 100% cover.

Association 3. *Scirpus-Eleocharis*

Dominant plants: *Scirpus americanus*, *Eleocharis rostellata*. (all others of minor importance)

Indicator species: None restricted to this association

Species Richness: 6.0 +/- 6.5 species/100 m^2. Range = 1-19 species/100 m^2 (Usually only 2-4 species/100 m^2).

Physiognomy: Dense sward of .5-2 m tall sedge-like herbs, mostly with aerenchyma.

Habitat: Lakes, ponds etc., and Channels and low wet areas. Especially the latter.

Soil: Subsaline, conductivity = .33 +/- .09 dS/m, slightly lower soil moisture than previous associations, with watertable occasionally dropping below soil surface.

Distribution: Common in center of Slough, especially west of BLM spring.

General: Often about 100 percent cover of *Eleocharis*. Other species much less abundant.

Association 4. ***Eleocharis-Muhlenbergia***

Dominant plants: *Eleocharis rostellata, Muhlenbergia asperifolia, Juncus balticus, Aster hesperius, Distichlis spicata.*

Indicator species: *Anemopsis californica, Chenopodium macrospermum* (not always present)

Species Richness: 13.4 +/- 5.6 species/100 m^2. Range = 3-19 species/100 m^2.

Physiognomy: Dense cover of low (<.5 m) herbaceous perennials.

Habitat: Meadows.

Soil: More saline, and slightly drier than Association 3, but with great variation. Conductivity = .64 +/- .90 dS/m. Most attributes near mean levels for all wetland samples (Fig. IV-6).

Distribution: Uncommon, organic-rich, generally saturated, but not submerged soil. Only in grazed northern portion of Fish Slough, Especially near NE and NW springs.

General: *Muhlenbergia asperifolia* and *Distichlis spicata* are vegetatively similar in appearance, and often co-occur. Their relative abundances are best assessed when they are blooming.

C. Syntaxon: Transitional from Marsh Vegetation to Hydrohalophytic.

Association 5. ***Elymus-Poa***

Dominant plants: *Elymus triticoides, Poa nevadensis, Juncus balticus, Muhlenbergia asperifolia*

Indicator species: *Elymus triticoides*

Species Richness: 10.9 +/- 4.3 species/100 m^2. Range = 6-19 species/100 m^2.

Physiognomy: Meadow of grasses, sedges, and other perennial herbs up to .75 m tall.

Habitat: Meadows.

Soils: Subsaline to saline, with high variability. Conductivity = .90 +/- 1.17 dS/m, .28 +/- .35 percent salt in the 1:5 extract, and an esimated osmotic potential of the soil of -1.62 +/- 2.1 bars. Highest clay content of any association (19%)

Distribution: Localized patches adjacent to stream channel, especially on west side. Rare or absent in grazed area.

General: Presence of *Elymus* makes this a distinctive and easy to recognize association.

D. Syntaxon: Hydrohalophytic Vegetation.

Association 6. *Juncus-Distichlis*

Dominant plants: *Distichlis spicata, Juncus balticus, Poa nevadensis, Spartina gracilis.*

Indicator species: *Centaurium namophilum* (may be uncommon or sometimes lacking), and not totally restricted to this type.

Species Richness: 10.71 +/- 5.1 species/m^2. Range = 1-17 species/m^2.

Physiognomy: Low (<.5m), fairly dense cover of grasses, rushes, and herbs.

Habitat: Transition from Meadows to Alkali Flat. Soil seasonally salt-encrusted.

Soil: Variable, mean salinity in the moderate range (Conductivity = 2.5 +/- 3.5 dS/m, percent salt equals 2.5 +/- 3.6, osmotic potential of soil approximately -4.5 +/- 6.3 bars). Moderate moisture (30%), soil may be saturated at or near the surface much of the year due to capillary flow. Relatively high sand content (47%).

Distribution: Widespread at the edge of the saturated wetland area, but in non-flooded zone.

General: Poorly-differentiated type, much overlap in species composition with the following two types. The annual *Centaurium namophilum* which occurs locally in high densities, probably germinates when salinities are lowest seasonally like other halophytes (Ungar 1982). Thus, rainfall, which is trivial in terms of overall moisture availibility, may play an important role in determining vegetation patterns in non-flooding areas where seedling establishment is high. Seasonal flooding of adjacent marsh vegetation also may effect saturation of soils in this association.

Association 7. *Spartina-Sporobolus*

Dominant plants: *Spartina gracilis*, *Sporobolus airoides*, *Juncus balticus*, *Distichlis spicata*, *Ivesia kingii.*

Indicator species: *Astragalus lentiginosus*, *Calochortus excavatus*, (when present).

Species Richness: 12.2 +/- 3.8 species/100 m^2. Range = 7-20 species/100 m^2.

Physiognomy: Sparse cover of rhizomatous and stoloniferous herbs (esp. grasses). Occasional low growing shrubs.

Habitat: Alkali Flat, and transitional to Alkali Scrub.

Soil: Very low moisture (2%), moderate salinity considering the salt crust (conductivity=1.5 +/- 1.4 dS/m, .49 +/- .44 percent salt, estimated soil osmotic potential of -.27 +/- 2.5 bars).

Distribution: Abundant the length of Fish Slough, especially in the grazed west-central portion.

General: *Pyrrocoma racemosa* (*Haplopappus r.*) nearly ubiquitous in this type, but never dominant.

Association 8. *Sporobolus-Allenrolfea*

Dominant Plants: *Sporobolus airoides*, *Allenfolfea occidentalis*, *Glycyrrhiza lepidota*, *Juncus* and *Distichlis*.

Indicator Species: *Allenrolfea occidentalis* (can occur in other associations)

Species Richness: 8.7 +/- 3.7 species/100 m^2. Range = 1-12 species/100 m^2.

Physiognomy: 5-20% cover of low succulent-leaved shrubs and grasses with large dense rhizome system. Understory with scattered grasses, rushes or herbs, or with barren understory.

Habitat: Alkali Scrub.

Soil: Saline (conductivity=6.7 +/- 5.1 dS/m), with high salinity levels common. 2.5 +/- 1.6 percent salt, and an estimated osmotic potential of the soil of -12.06 +/- 9.2 bars.

Distribution: Abundant between the creeks flowing from NE and NW springs in heavily grazed area, uncommon or lacking elsewhere.

General: Strongly associated, intermixed with compositionally similar Association 7.

Association 9. *Distichlis-Chrysothamnus*

Dominant plants: *Distichlis spicata, Chrysothamnus albidus, Sporobolus airoides, Spartina gracilis, Juncus balticus.*

Indicator species: *Chrysothamnus albidus* (can occur in other associations)

Species Richness: 8.8 +/- 3.7 species/100 m^2. Range = 1-12 species/100 m^2.

Physiognomy: Widely scattered .5-1 m tall shrubs, with 5-10% cover of perennial grass.

Habitat: Alkali Scrub.

Soil: Very high pH (9.3), however, relatively low conductivity (.9 +/- .5 dS/m), and percent salt (.2 +/- .3.). Estimated osmotic potential for the soil is -1.62 +/- .9 bars.

Distribution: Widespread, forming a continuous band around the perimeter of the lower, wetter area.

General: Very similar to previous two associations except for presence of scattered shrubs.

E. Syntaxon: Xerohalophytic Vegetation.

Association 10. *Chrysothamnus-Sporobolus*

Dominant plants: *Chrysothamnus nauseosus, Sporobolus airoides, Spartina gracilis, Elymus cinereus, Distichlis spicata.*

Indicator species: None restricted to this type.

Species Richness: 12.7 +/- 4.7 species/100 m^2. Range = 7-21 species/100 m^2.

Physiognomy: Moderate cover of 1-2 m tall phreatophytic shrubs with lower growing grasses and herbs.

Soil: pH is high (9.1 in the open, 9.0 under shrub), however, overall salinity is not as great as in previous types as evidenced by the individual cation values (Appendix II, Table A.II.6). Nonetheless,.relative to the other upland associations, salinity is high, and Ca, Na, and K are all strongly correlated with the distribution of this association Fig IV-8.

Habitat: Upper edge of Alkali Scrub, but lacking surface salt deposits.

Distribution: Continuous along the east side of Fish Slough, associated with jeep trail. Common also on west side.

General: Possibly facilitated by disturbance. Distinguishing feature is abundance of *Chrysothamnus nauseosus*, a plant of disturbed areas.

Association 11. *Sarcobatus-Distichlis*

Dominant plants: *Sarcobatus vermiculatus, Distichlis spicata, Atriplex confertifolia, A. parryi.*

Indicator species: *Atriplex parryi* (not completely restricted to this association).

Species Richness: 7.7 +/- 3.0 species/100 m^2. Range = 4-13 species/100 m^2.

Physiognomy: Scattered 1-2 m tall succulent-leaved shrubs, some large and forming mounded soil. Fairly sparse understory of creeping grass.

Habitat: Alluvium, Eolian, and transitional to Alkali scrub.

Soil: High pH (9.1 open, and 9.4 from under shrub). pH, Ca, Na, and K again strongly influence distribution of this association.

Distribution: Widespread and abundant, especially on west side of Fish Slough.

General: Soil loose and mounded around individuals of *Sarcobatus.*

Association 12. *Sarcobatus-Atriplex*

Dominant plants: *Sarcobatus vermiculatus, Atriplex confertifolia, Psorothamnus polydenius* (*Dalea*).

Indicator species: None restricted to this type.

Species Richness: 5.2 +/- 2.5 species/100 m^2. Range = 3-10 species/100 m^2.

Physiognomy: Scattered 5-2 m tall shrubs, occasional grasses in understory. Little variation.

Habitat: Alluvium, and Eolian.

Soil: pH 8.4 (8.8 under shrub). Mg levels relatively high, other cations low. These levels are correlated with the distribution of this association (Fig IV-8).

Distribution: Widespread and abundant, especially on west side of Fish Slough.

General: Structurally and floristically very simple. Annual flora not documented.

F. Syntaxon: Xerophytic Vegetation

Association 13. *Atriplex-Ephedra*

Dominant plants: *Atriplex confertifolia, Ephedra nevadensis, Tetradymia glabrata.*

Indicator species: *Psorothamnus arborescens (Dalea).*

Species Richness: 7.5 +/- 2.5 species/100 m^2. Range = 3-12 species/100 m^2.

Physiognomy: Scattered .5-1.5 m tall shrubs, often sparse. Occasional herbs.

Habitat: Bishop Tuff units 1-3, including moderate talus slopes.

Soil: pH 8.4. See comments for 12.

Distribution: Widespread and abundant. Most of upland area.

General: Annual flora not documented. Variable association type.

Association 14. *Artemisia-Chrysothamnus*

Dominant plants: *Artemisia tridentata, Chrysothamnus viscidiflorus, Stipa speciosa, Chrysothamnus teretifolius.*

Indicator species: *Artemisia tridentata* .

Species Richness: 10.5 +/- 3.9 species/100 m^2. Range = 8-17 species/100 m^2.

Physiognomy: .5-2 m tall scattered shrubs, sometimes relatively dense in wash areas, understory grasses common.

Habitat: Bishop Tuff unit 1, especially washes and rocky areas.

Soil: pH lowest of upland types (7.9 open, 7.7 under shrub). Distribution of this association strongly correlated with the lowest pH values in the data set (Fig. IV-8).

Distribution: Common in the southwestern portion of the area mapped.

VEGETATION AND SOILS. Means and standard deviations of salinity, cation, anion, pH, moisture and texture levels are reported for each association in Appendix II, Tables A.II.5 and A.II.6. This same information is provided for each vegetation habitat type in Appendix II (Tables A.II.1 and A.II.2). These tables are discussed in the previous sections.

Correlations among most of the soil attributes and DECORANA ordination axes one and two from the wetland data set are listed in Table IV-2. Vegetation soil relationships are best demonstrated in biplots we produced using CCA. We used the eight variables we considered most important in the CCA analysis. In addition to the importance of moisture, salinity, K, Cl, Na, and percent sand, Table IV-2 indicates moderate importance of CO_3 in explaining variation in vegetation (r=.40 x DCA axis 1). This variable was highly correlated with others.

Interpretation of the CCA biplots, which summarize all the vegetation and soil information, is explained in the detailed figure legends. Figure IV-6 is a biplot of the wetland data set with plots labeled by their respective association type. Association 1 (*Ruppia*-algae) was correlated with low values of all soil attributes except sand. Texture has been shown to be an important determinant of *Ruppia* distribution in freshwater habitats (Husband and Hickman, 1989). Moisture levels are obviously high in the Aquatic Macrophyte Association. It was an artifact of our sampling that moisture was measured to be fairly low. That is, by the time the sample had been transferred to a plastic bag, much of the moisture had drained out of the coarse substrate. The remaining associations align themselves along a moisture/salinity gradient. These variables were strongly correlated with axis 1 (-.76 for moisture, and .75 for sodium). Associations 2 (*Scirpus-Typha*) and 3 (*Scirpus-Eleocharis*), both Marsh Vegetation, were positively correlated with high moisture and, except for one plot in Association 2, low salinity. Associations 4 (*Eleocharis-Muhlenbergia*) and 5 (*Elymus-Poa*), however, occur where moisture and salinity levels were generally average for the data set. Associations 6-9 (Hydrohalophytic Vegetation) were positively correlated with high salinity. Four plots from Associations 5,6, and 8 occurred at very high salinity levels.

Fig. IV-7 is another Canonical Correspondence analysis biplot of the wetland data set, this time showing the species/environment relationships. Although each species displayed could be discussed separately, we will limit our discussion to the dominant and rare (special interest) species. Once again, for an explanation of how to interpret this plot, the reader is referred to the figure legend. *Sarcobatus vermiculatus*, *Distichlis spicata*, *Phragmites australis*, *Allenrolfea occidentalis*, *Sporobolus airoides* and *Atriplex parryi* all have distributions centered very high on the salinity gradient. These species are all widely distributed western north American halophytes (Ungar 1974, Matoh *et al.* 1988). *Juncus balticus* and *Muhlenbergia asperifolia* were correlated with salinity levels that are average for the wetland data set. *Juncus* is tolerant of an extremely wide range of conditions at Fish

Slough. Surprisingly, the abundance of the rare species *Ivesia kingii*, *Calochortus excavatus* and *Centaurium namophilum* was correlated with relatively low subsurface (5-15 cm) salinity levels, even though there is a conspicuous surface crust of salt where these species grow. Important halophytic grasses, *Elymus triticoides* and *Poa nevadensis*, were similarly correlated with relatively low subsurface soil salinity, although they are not the most frequent associates of *Ivesia* and *Centaurium*. All five of these species as well as *Chrysothamnus nauseosus* were also associated with sandy soil. Species dominating flooded habitats (e.g. *Scirpus acutus*, *Scirpus americanus*, and *Typha domingensis*) were, as expected, highly correlated with soil moisture.

Fig. IV-8 shows the biplot with upland association types labeled. Salinity was highly correlated with vegetation patterns. Except for one plot, the Xerohalophytic Associations 10 (*Chrysothamnus-Sporobolus*) and 11 (*Sarcobatus-Distichlis*) were highly correlated with the highest salinity values in the upland data set. Xerohalophytic Association 12 (*Sarcobatus-Atriplex*) occurred at intermediate salinity conditions within the range of the data set, but never where salinities were lowest. The Xerophytic Associations 13 (*Atriplex-Ephedra*) and especially 14 (*Artemisia-Chrysothamnus*) were negatively correlated with salinity.

A species-environment biplot for the upland data set is shown in Fig. IV-9. Again *Distichlis spicata*, *Sporobolus airoides*, and *Atriplex parryi* were strongly correlated positively with soil salinity. The important dominant *Atriplex confertifolia* occurs in almost every plot and thus is tolerant of salinity over the entire range of the data set. It is centered in the biplot near the origin. Species that appear to be the least salt-tolerant are *Artemisia tridentata*, *Chrysothamnus teretifolius*, *Ephedra nevadensis*, *Tetradymia glabrata*, and *Psorothamnus polydenius*.

Plant associations and soil attributes measured along the transects are shown in Figs. IV-10, IV-11, and IV-12. The profiles shown demonstrate the patterns of change in these variables along a gradient from moist (at the edge of Fish Slough Creek) to dry (at the wetland/upland transition). A consistent trend of increasing soil pH and soil salinity was discernible. Along each of the transects we found a strong increase in salinity from low to subsaline at the creek to saline in most areas at elevations above the water table and peaking at about 0.5 m elevation above the water table on the June sampling date. Soil attributes were measured in June, August, and October along each of the transects, and are shown on Figs. IV-10, IV-11, and IV-12. These data demonstrate the dynamics of soil pH, soil salinity, and soil moisture over this period in 1989. The greatest change occurred in soil moisture, which dropped dramatically in plots greater than 0.5 m above the water table.

SUMMARY

The vegetation of Fish Slough was sampled using the relèvè approach to elucidate vegetation patterns, which are based on full floristic composition, in relation to soil attributes. A total of 100 species were found in the 91 relèvès from the lowland area (the wetland data set), and 73 species were found in the 39 relèvès from the upland data set. Relèvès were 100 m^2, and soil was sampled within each for chemical and physical analyses. Using TWINSPAN, we classified the vegetation into 14 associations. Because several dominant species (e.g. *Distichlis spicata* and *Atriplex confertifolia*) occur in many associations, the associations are not strongly distinct, and many cannot be clearly separated in the field. The associations are grouped into 5 syntaxa that are easily recognized: Submerged Aquatic Macrophyte, Marsh, Hydrohalophytic, Xerohalophytic, and Xerophytic Vegetation. Associations could not be mapped from photos due to their similar physiognomy. Instead, we mapped 15 Vegetation Habitats based on biophysical properties recognizable in the 1981 aerial photography. Variation in soil attributes is best understood in terms of these categories. In flooded areas, soils range from coarse and sandy to organic, and their conductivities range from fresh water to subsaline. Anaerobicity is common. Within these areas the Aquatic Macrophyte syntaxon varies strongly with soil texture and the Marsh Vegetation syntaxon varies strongly with soil moisture. Despite the occurrence of a white salt crust, most soils are not highly saline at 5-15 cm in depth. However, high subsurface salinity does occur in some areas in association with *Allenrolfea occidentalis*. Notably, salinity is strongly correlated with the distributions of species and associations within the Hydrohalophytic Vegetation syntaxon. Subsurface soils at Fish Slough are dominated by calcium and sulphate, and are likely gypsiferous. The high species richness of Fish Slough for a salt-affected wetland area may be a result of the preponderance of moderate to low salinity conditions. Upland soils range from strongly salt-affected fossil fumarole (chemically altered) and some eolian areas to essentially non-salt-affected on the rock substrate of Bishop Tuff, Unit 1. Alluvium, Eolian, and Chemically Altered habitats support Xerohalophytic Vegetation, whereas the remaining Bishop Tuff habitats support Xerophytic Vegetation mostly lacking halophytes.

ACKNOWLEDGMENTS

We are very grateful to Pat Shafroth for assistance in field sampling. We also extend our heartfelt thanks to Janet Rantz, Tony Kerwin, and other staff of the White Mountain Research Station for the warm and friendly accommodations. Diagnostic materials prepared by Holly Forbes and other Herbarium staff were extremely helpful for species identifications in the field. Eric Anderson provided invaluable assistance as our GIS technician.

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Table IV-1. Vegetation Habitats Mapped at Fish Slough

A. Water level near or above surface*

1. Lakes, pond, etc. (permanently-flooded)
2. Channels and low, wet rates (permanently to semi-permanently flooded)
3. Meadows (soil seasonally flooded or saturated)

B. Water below soil surface (soil salt-encrusted)*

4. Alkali flat (herbaceous vegetation, soil occasionally saturated)
5. Alkali scrub (shrubby vegetation)

C. Miscellaneous

6. Mosaic of 4 and 5 (terrain with closely spaced natural and made-caused undulations)

D. Upland areas (no salt encrusted on soil surface)

7. Alluvium
8. Eolian

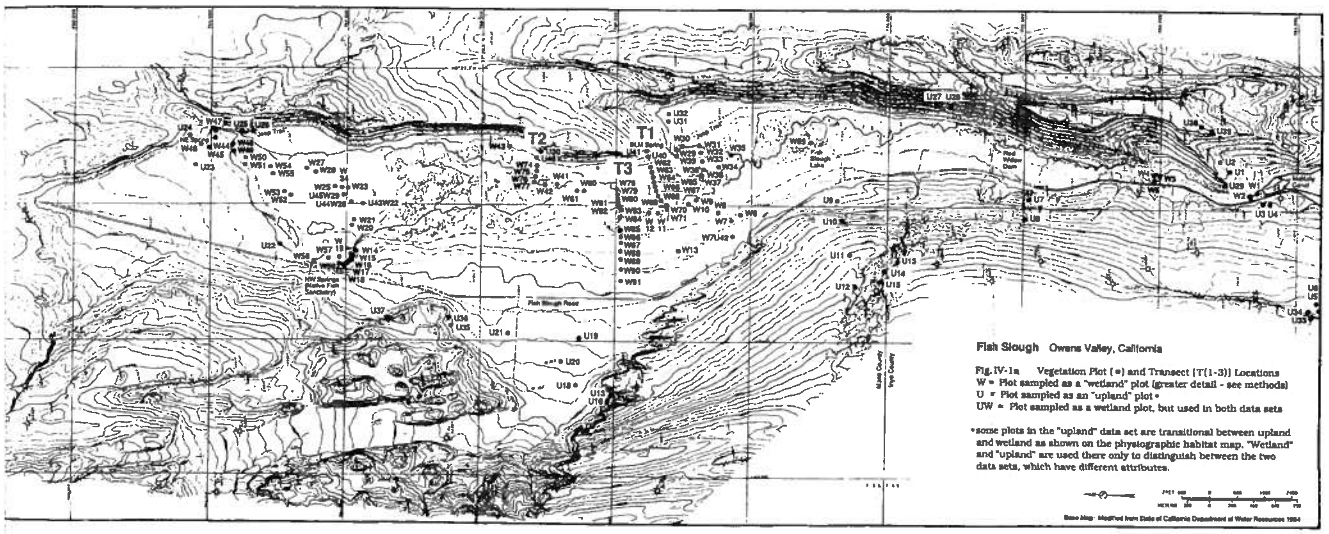
Bishop Tuff:

9. Unit 1 tableland
10. Unit 1 talus slope
11. Unit 1 wash
12. Unit 2 tableland
13. Unit 2 talus slope
14. Unit 3
15. Chemically altered soil

*Water level is seasonally dynamic

Table IV-2. Correlations (r) among transformed soil variables and DCA ordination axes for wetland data set.

Soil attribute	DCA axis 1	DCA axis 2
% moisture	-.80	-.16
% sand	.37	.17
% silt	.08	.11
% clay	.02	-.14
pH (paste)	.46	.12
Conductance (dS/m @25°C)	.43	.16
Boron	.06	-.07
Ca (total)	.24	.06
Mg (total)	-.39	-.13
Na (total)	.53	.15
K (total)	.60	.25
HCO3	-.07	-.09
CO3	.40	.07
Cl	.46	.19



Fish Slough Owens Valley, California

Fig. IV-1a Vegetation Plot (•) and Transect [T(1-3)] Locations
W = Plot sampled as a "wetland" plot (greater detail - see methods)
U = Plot sampled as an "upland" plot *
UW = Plot sampled as a wetland plot, but used in both data sets

*some plots in the "upland" data set are transitional between upland and wetland as shown on the physiographic habitat map. "Wetland" and "upland" are used there only to distinguish between the two data sets, which have different attributes.

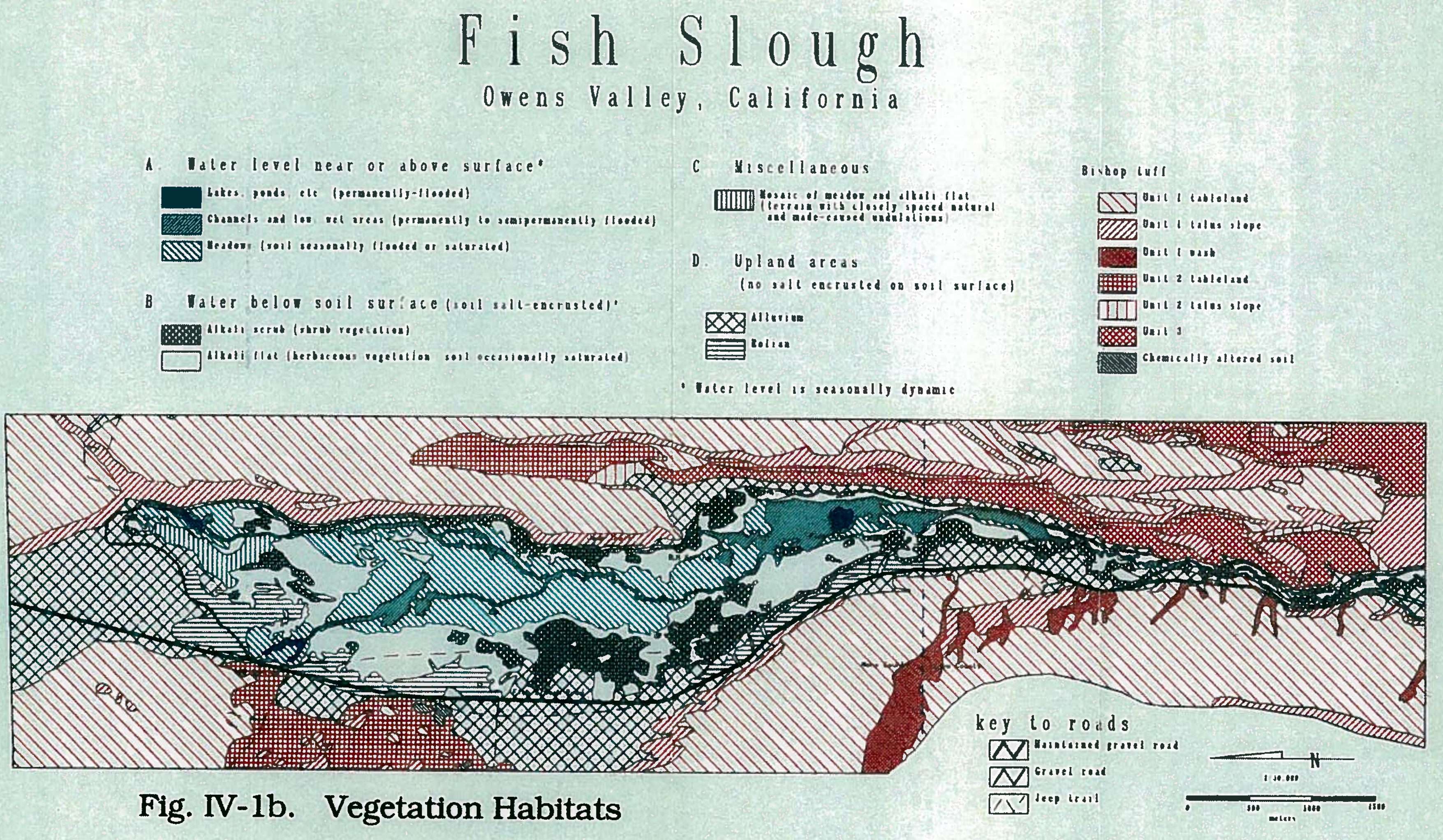


Fig. IV-1b. Vegetation Habitats

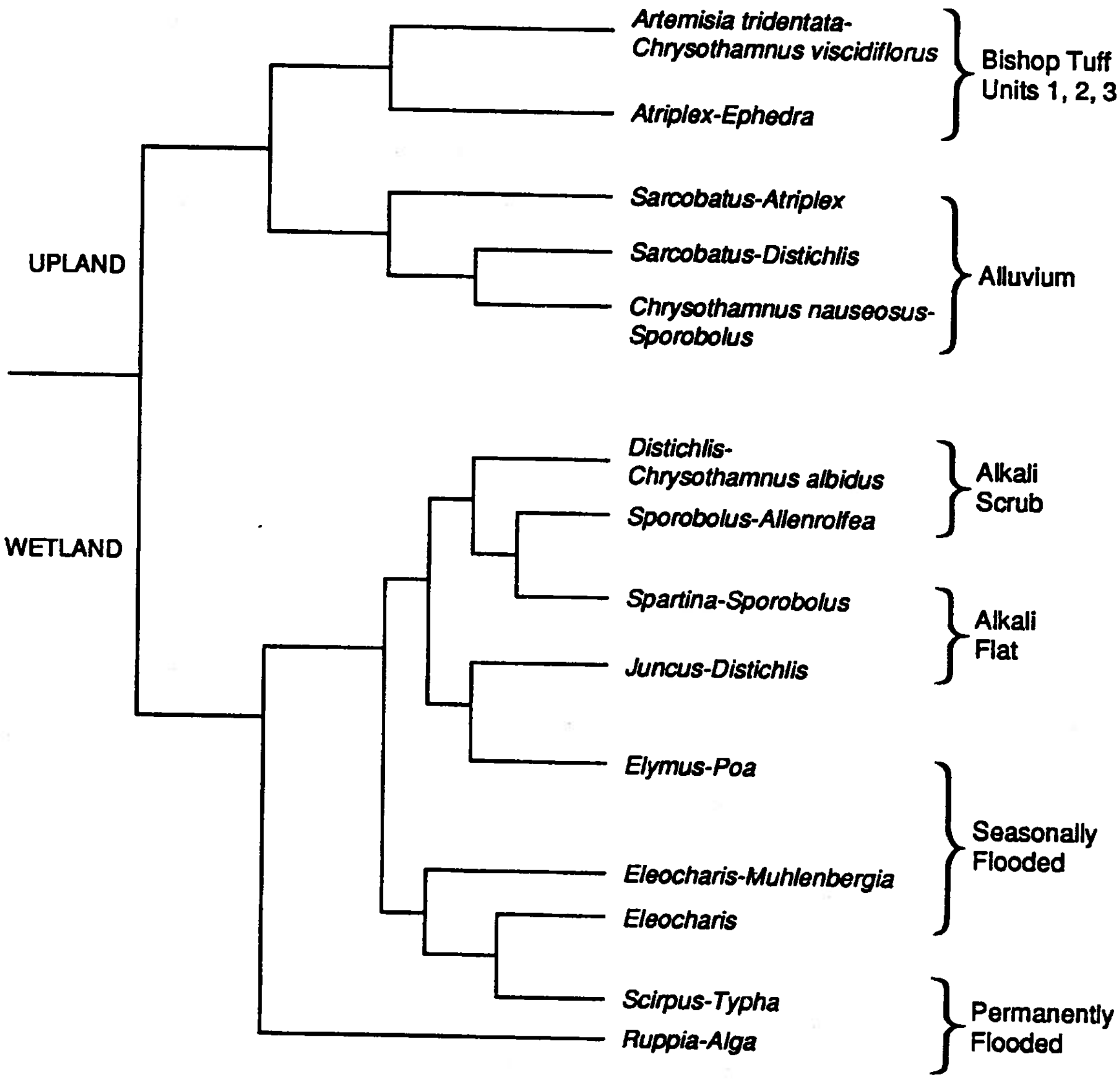


Fig. IV-2. Dendrogram summarizing plant associations at Fish Slough as identified by TWINSPAN.

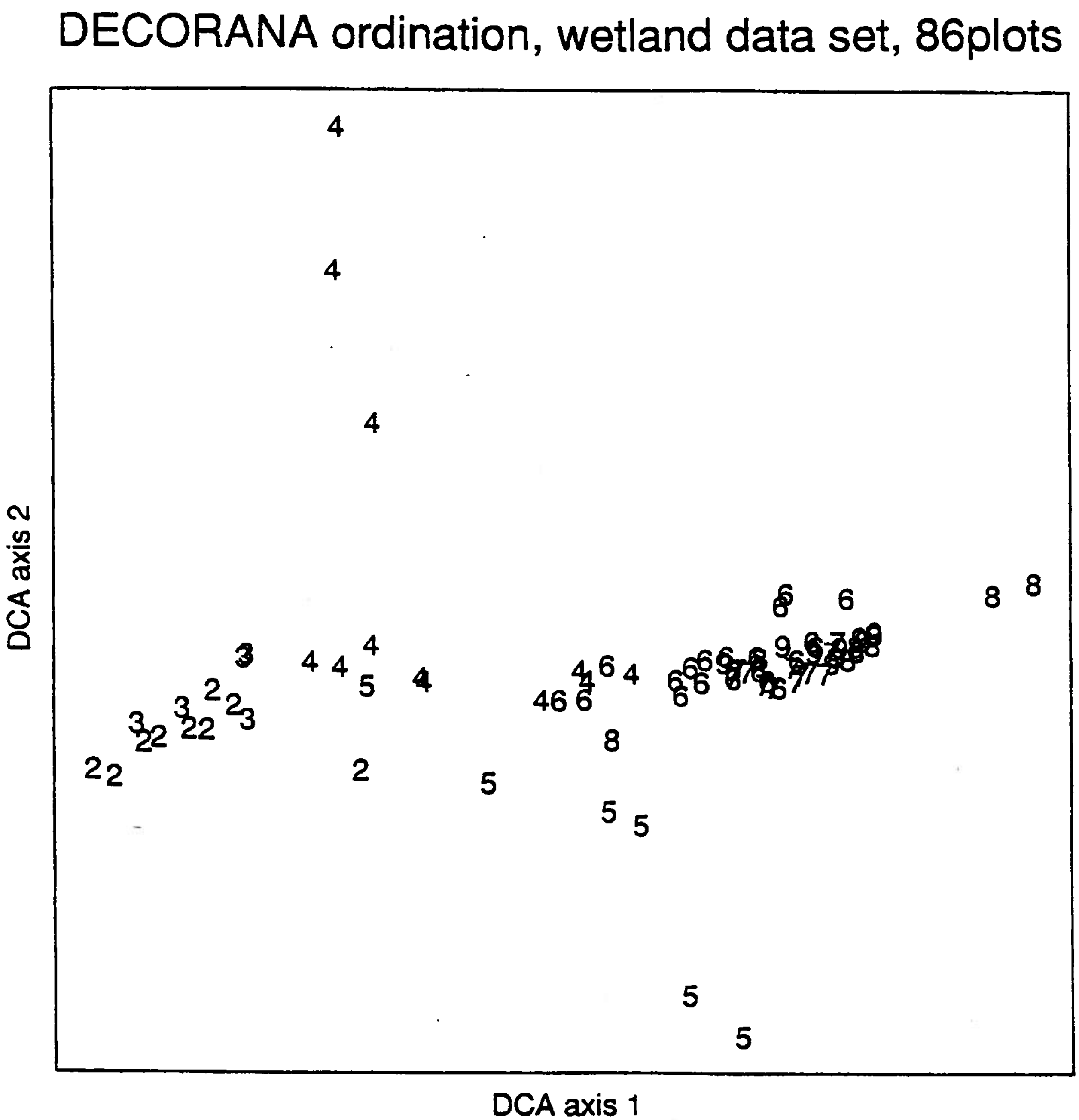


Fig. IV-3 Ordination diagram based on first and second axes from Detrended Correspondence Analysis with rare species downweighted. Plots from association 1 (*Ruppia-algae*), which share no species with other plots, had to be omitted to produce the ordination. Plot labels refer to the association type they fall into in the TWINSPAN classification (see text). 2=*Scirpus-Typha*, 3=*Scirpus-Eleocharis*, 4=*Eleocharis-Muhlenbergia*, 5=*Elymus-Poa*, 6=*Juncus-Distichlis*, 7=*Spartina-Sporobolus*, 8=*Sporobolus-Allenrolfea*, 9=*Distichlis-Chrysothamnus*.

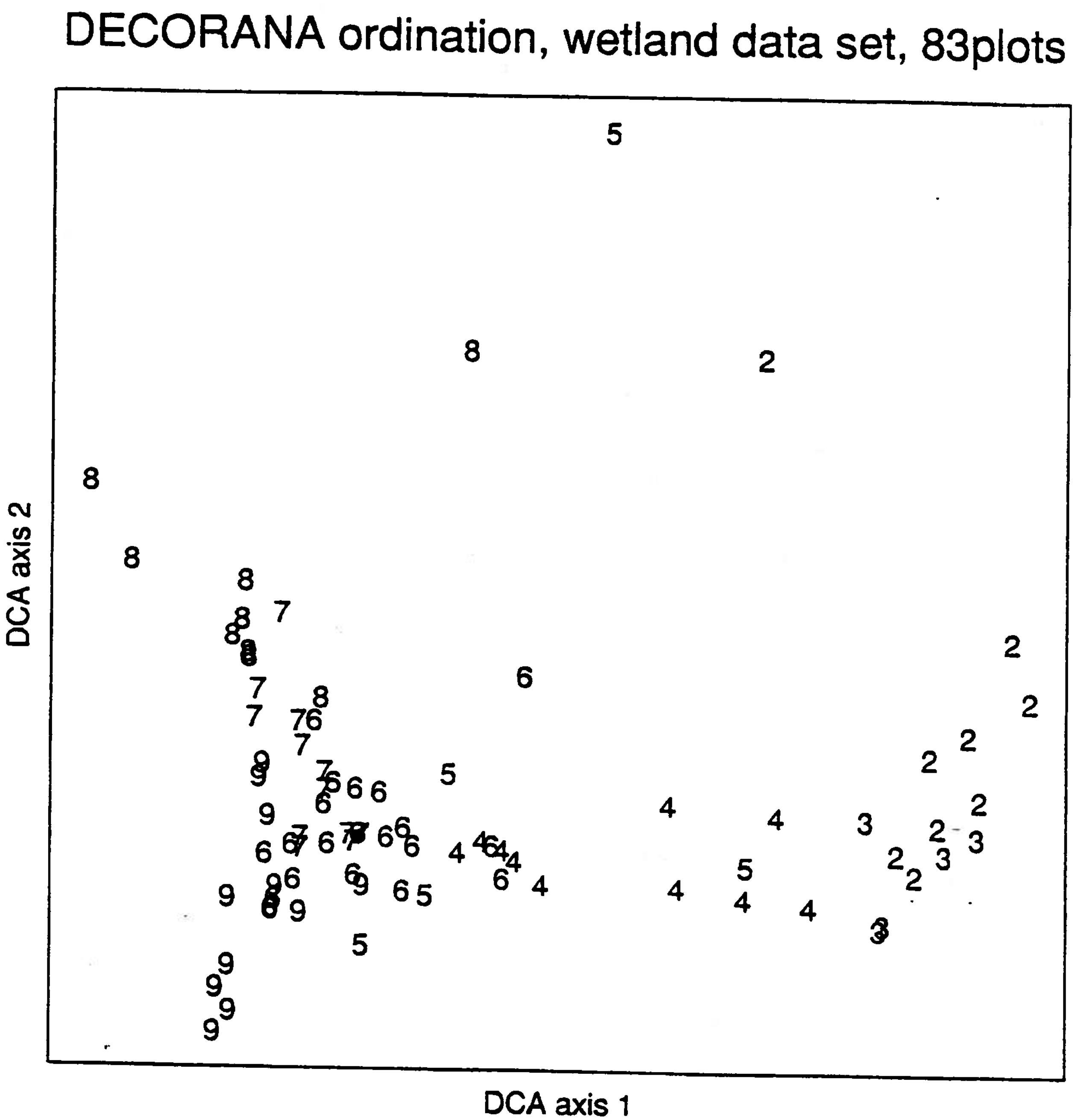


Fig. IV-4 Ordination diagram based on first and second axes from Detrended Correspondence Analysis with rare species downweighted. Plots from association 1 (*Ruppia-algae*), which share no species with other plots, had to be omitted to produce the ordination. In addition, 3 plots from association 4 (*Eleocharis-Muhlenbergia*) (see previous figure) were omitted to improve the spread of points along the y axis. Plot labels refer to the association type they fall into in the TWINSPAN classification (see text). 2=*Scirpus-Typha*, 3=*Scirpus-Eleocharis*, 4=*Eleocharis-Muhlenbergia*, 5=*Elymus-Poa*, 6=*Juncus-Distichlis*, 7=*Spartina-Sporobolus*, 8=*Sporobolus-Allenrolfea*, 9=*Distichlis- Chrysothamnus*.

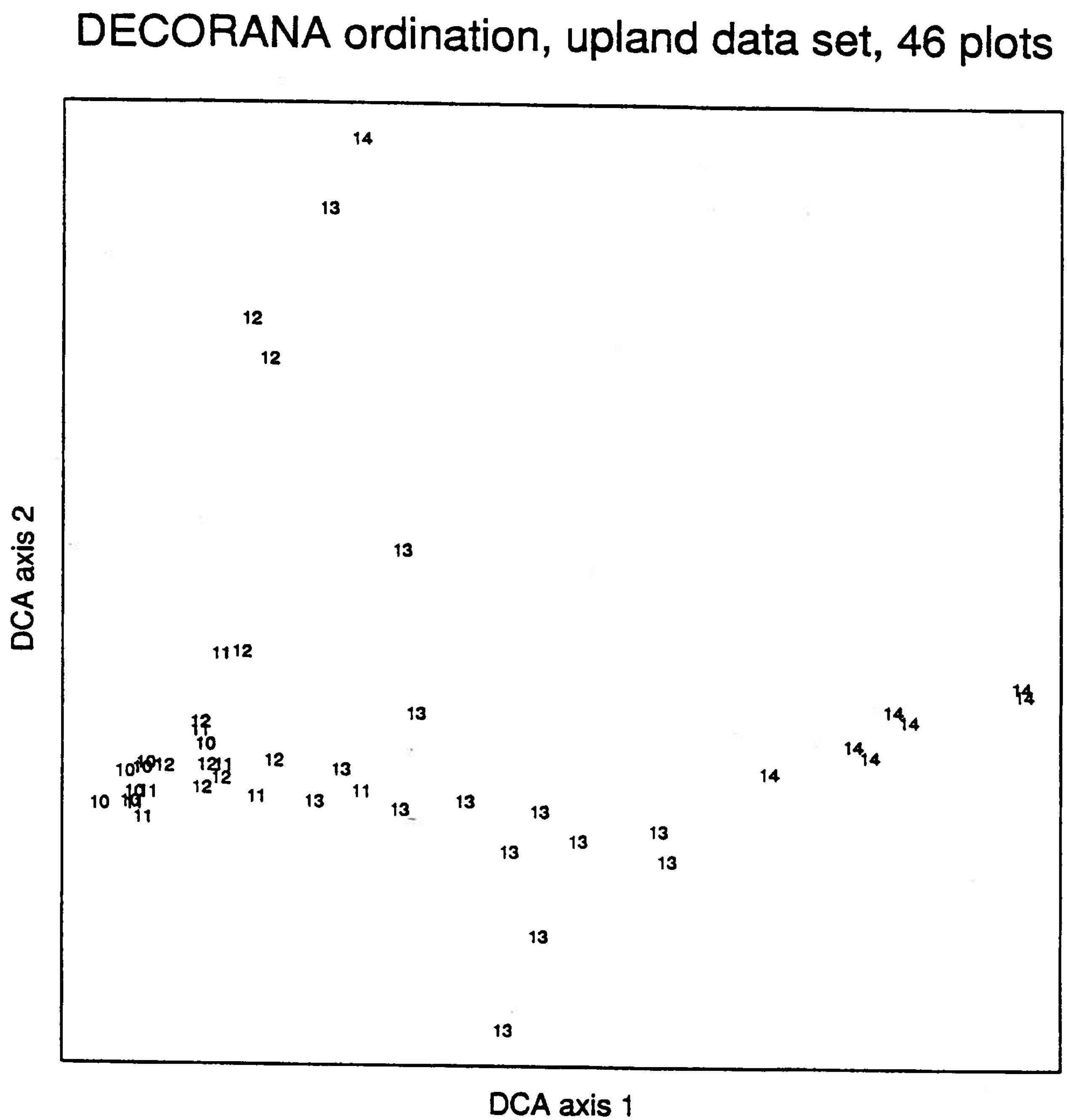


Fig. IV-5 Ordination diagram based on first and second axes from Detrended Correspondence Analysis with rare species downweighted. Plot labels refer to the association type they fall into in the TWINSPAN classification (see text). 10=*Chrysothamnus-Sporobolus*, 11=*Sarcobatus-Distichlis*, 12=*Sarcobatus-Atriplex*, 13= *Atriplex-Ephedra*, 14=*Artemisia-Chrysothamnus*.

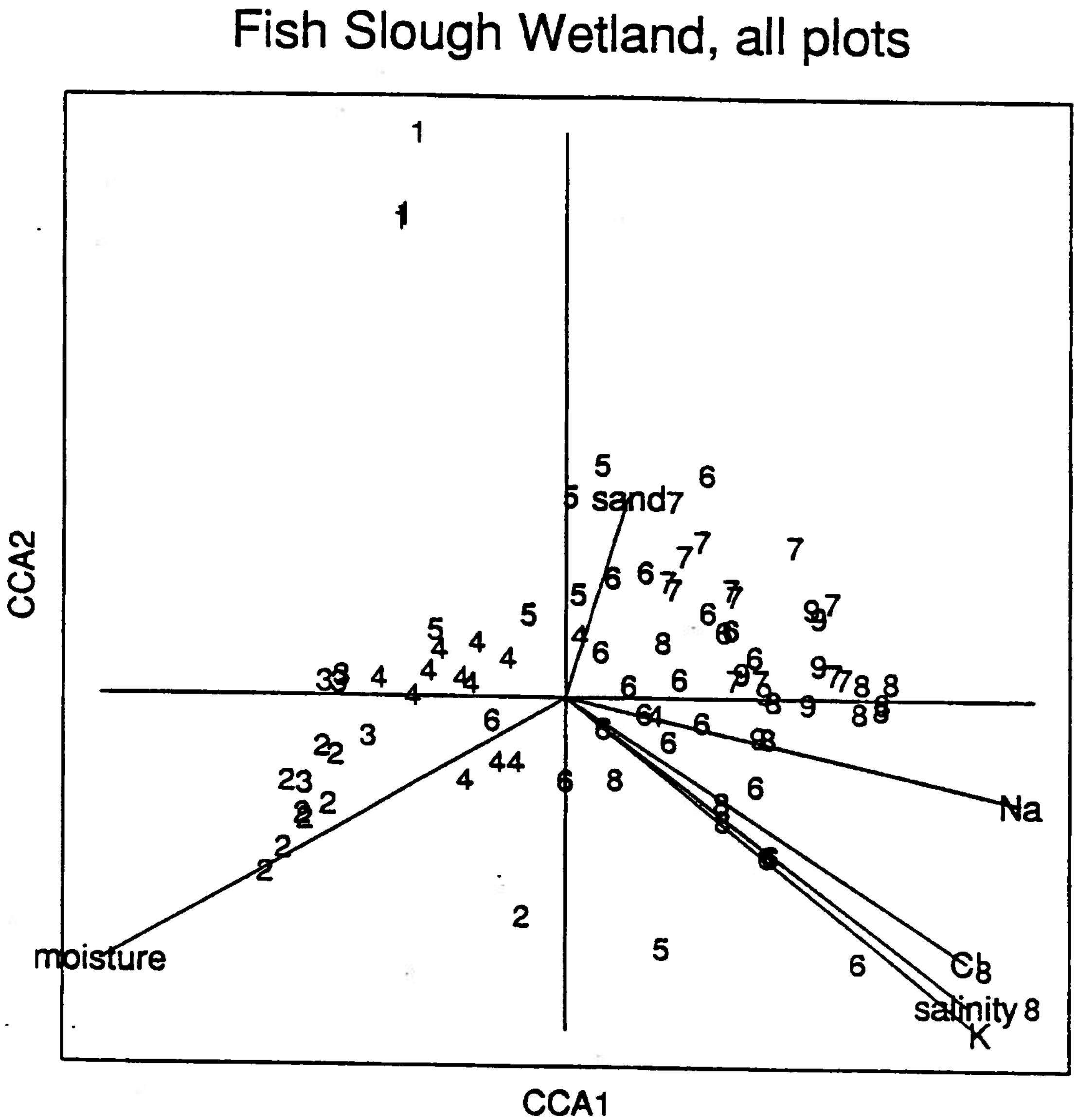


Fig. IV-6 Biplot based on Canonical Correspondence Analysis CCA of the wetland data set. Sample (plot) scores with the first two CCA axes are shown, and are labeled according to the TWINSPAN association type they fall into (see text, and below). The labeled environmental axes (soil variables) point in the direction of maximum variation in the soil variable, and the length of the axis represents its correlation with variation in species composition as represented by the ordination (x and y) axes. The position of each plot in relation to each environmental axis is therefore an estimate of the correlation (non-linear) between plot data and the soil variable. 52.5% of the variance in the wetland vegetation data set are explained by the axes shown in this ordination (1st and 2nd axis eigenvalues are .68 and .46, while the sum of all canonical eigenvalues (trace) =2.17). The overall species environment correlations (ter Braak 1986) for axes 1 and 2 are .92 and .81, while the inter set correlations of environmental variables with axes (1 and 2) are: ph (.46 and -.26), K (.68 and -.45), Na (.75 and -.14), salinity (.34 and -.25), Cl- (.34 and -.21), sand (.11 and .27), and moisture (-.763 and .356). Association types are: 1=*Ruppia-aglae*, 2=*Scirpus-Typha*, 3=*Scirpus-Eleocharis*, 4=*Eleocharis-Muhlenbergia*, 5=*Elymus-Poa*, 6=*Juncus-Distichlis*, 7=*Spartina-Sporobolus*, 8=*Sporobolus-Allenrolfea*, 9= *Distichlis-Chrysothamnus*.

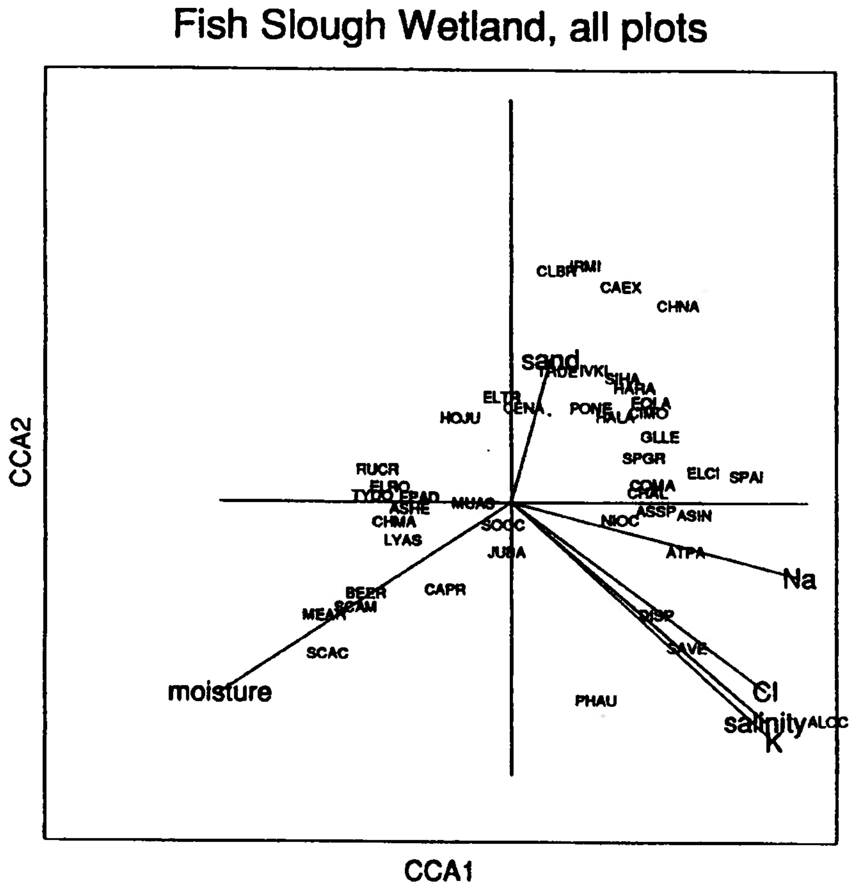


Fig. IV-7 Biplot based on Canonical Correspondence Analysis CCA of the wetland data set. Scores (weighted means) of the 44 most important species (abbreviated) on the first two CCA axes are shown. The labeled environmental axes point in the direction of maximum variation in the soil variable, and the length of the axis represents its correlation with variation in species composition as represented by the ordination (x and y) axes. The position of each species with respect to each environmental axis is an estimate of the correlation (non-linear) between the species abundance (weighted mean), and the soil variable. The correlations among each species abundance and each soil variable can be inferred by simply projecting the species onto each axis, except where species and environmental axes are on opposite sides of the origin. When this occurs, the species is centered at a lower than average level of the variable. (i.e. IVKI (*Ivesia kingii*) occurs where soil moisture levels are much lower than the overall average, and vice versa for SCAC (*Scirpus acutus*). 52.5% of the variance in the wetland vegetation data set are explained by the axes shown in this ordination (1st and 2nd axis eigenvalues are .68 and .46, while the sum of all canonical eigenvalues: trace=2.17). The overall species environment correlations (ter Braak 1986) for axes 1 and 2 are .92 and .81, while the inter set correlations of environmental variables with axes (1 and 2) are: ph (.46 and -.26), K (.68 and -.45), Na (.75 and -.14), Salinity (.34 and -.25), Cl (.34 and -.21), sand (.11 and .27) and moisture (-.763 and .356).

ALOC=*Allenrolfea occidentalis*	ASHE=*Aster herperius*	ASIN=*Aster intricatus*
ASSP=*Asclepias speciosa*	ATPA=*Atriplex parryi*	BEER=*Berula erecta*
CAEX=*Calochortus excavatus*	CAPR=*Carex praegracilis*	CENA=*Centaurium namophilum*
CHAL=*Chrysothamnus albidus*	CHNA=*Chrysothamnus nauseosus*	CHMA=*Chenopodium macrospermum*
CIMA=*Cirsium mohavense*	CLBR=*Cleomella brevipes*	COMA=*Cordylanthus maritimus*
DISP=*Distichlis spicata*	ELCI=*Elymus cinereus*	ELRO=*Eleocharis rostellata*
ELTR=*Elymus triticoides*	EPAD=*Epilobium adenocaulon*	EQLA=*Equisetum laevigatum*
GLLE=*Glycyrrhiza lepidota*	HALA=*Haplopappus lanceolata*	HARA=*Haplopappus racemosa*
HOJU=*Hordeum jubatum*	IRMI=*Iris missouriensis*	IVKI=*Ivesia kingii*
JUBA=*Juncus balticus*	LYAS=*Lycopus asper*	MEAR=*Mentha arvensis*
MUAS=*Muhlenbergia asperifolia*	NIOC=*Nitrophila occidentalis*	PHAU=*Phragmites australis*
PONE=*Poa nevadensis*	RUCR=*Rumex crispus*	SAVE=*Sarcobatus vermiculatus*
SCAC=*Scirpus acutus*	SCAM=*Scirpus americanus*	SIHA=*Sisyrinchium halophilum*
SOOC=*Euthamia occidentalis*	*SPAI*=*Sporobolus airoides*	SPGR=*Spartina gracilis*
TRDE=*Triglochin debilis*	TYDO=*Typha domingensis*	

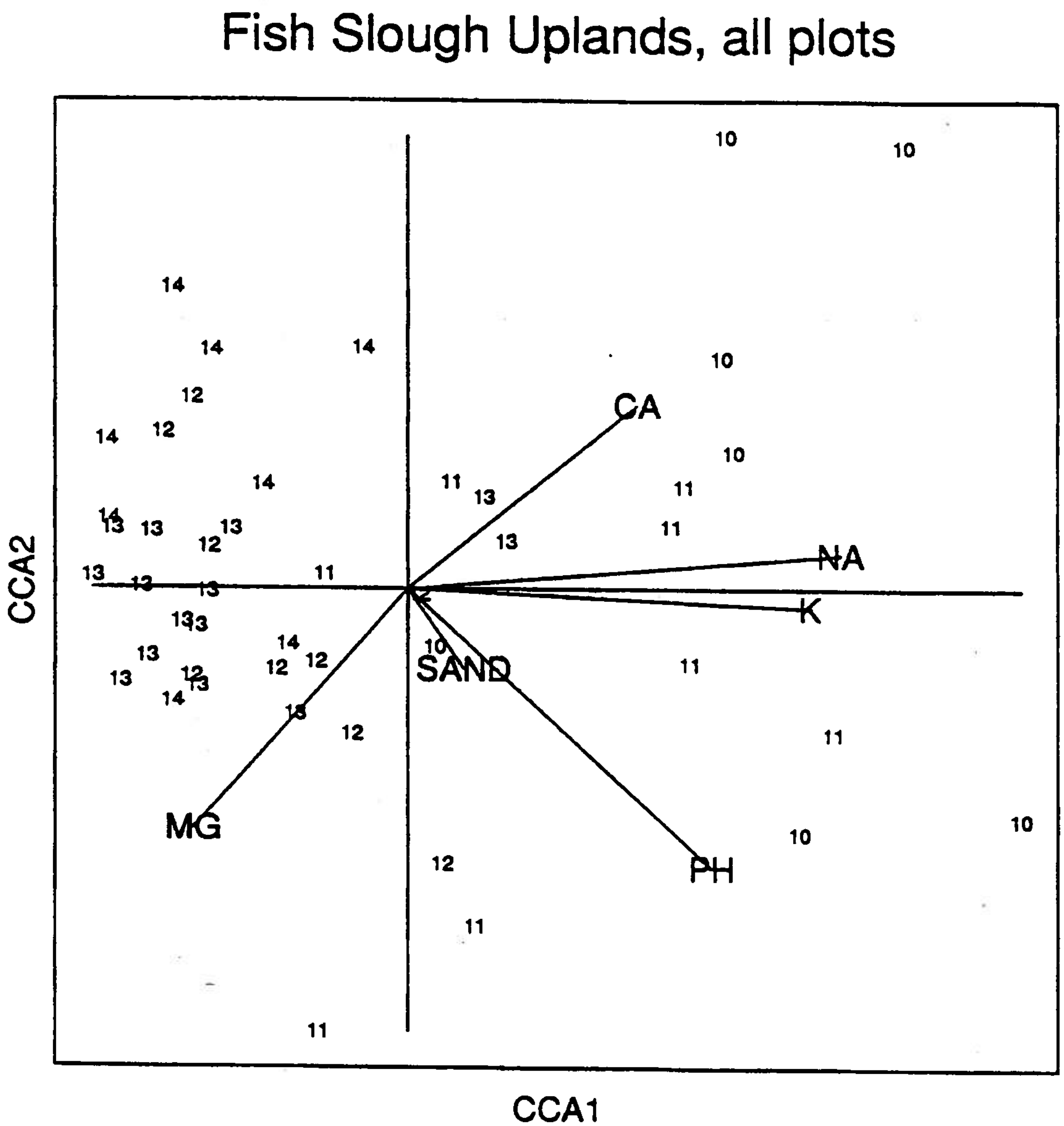


Fig. IV-8 Biplot based on Canonical Correspondence Analysis CCA of the upland data set. Sample (plot) scores on the first two CCA axes are shown, and are labeled according to the TWINSPAN association type they fall into (see text, and below). The labeled environmental axes (soil variables) point in the direction of maximum variation in the soil variable, and the length of the axis represents its correlation with variation in species composition as represented by the ordination (x and y) axes. The position of each plot in relation to each environmental axis is therefore an estimate of the correlation (non-linear) between plot data and the soil variable. 65.4% of the variance in the wetland vegetation data set are explained by the axes shown in this ordination (1st and 2nd axis eigenvalues are .60 and .30). The overall species environment correlations (ter Braak 1986) for axes 1 and 2 are environmental variables with axes 1 and 2 are: pH (.64 and -.39), Ca (.45 and .212), Mg (-.41 and -.25), Na (.87 and .03), and K (.81 and -.02). Association types are: 10=*Chrysothamnus-Sporobolus*, 11=*Sarcobatus-Distichlis* 12=*Sarcobatus-Atriplex*, 13=*Atriplex-Ephedra*, 14=*Artemisia-Chrysothamnus*, 5=*Elymus-Poa*, 6=*Juncus-Distichlis*, 7=*Spartina-Sporobolus*, 8=*Sporobolus-Allenrolfea*, 9= *Distichlis-Chrysothamnus*.

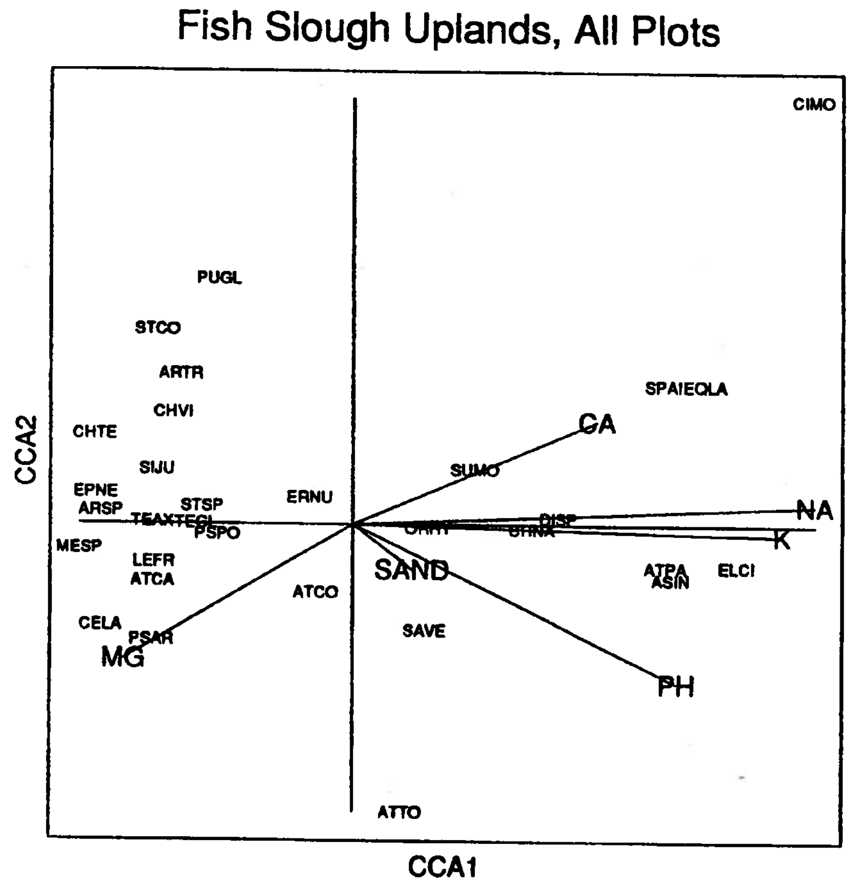
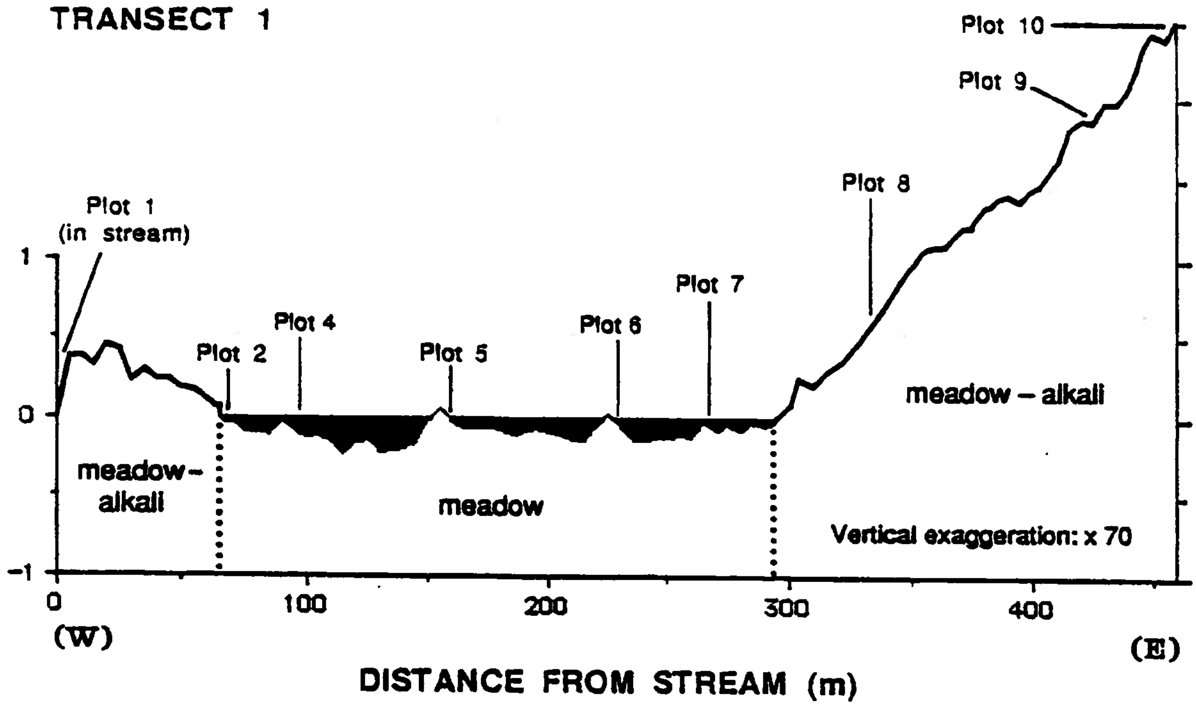


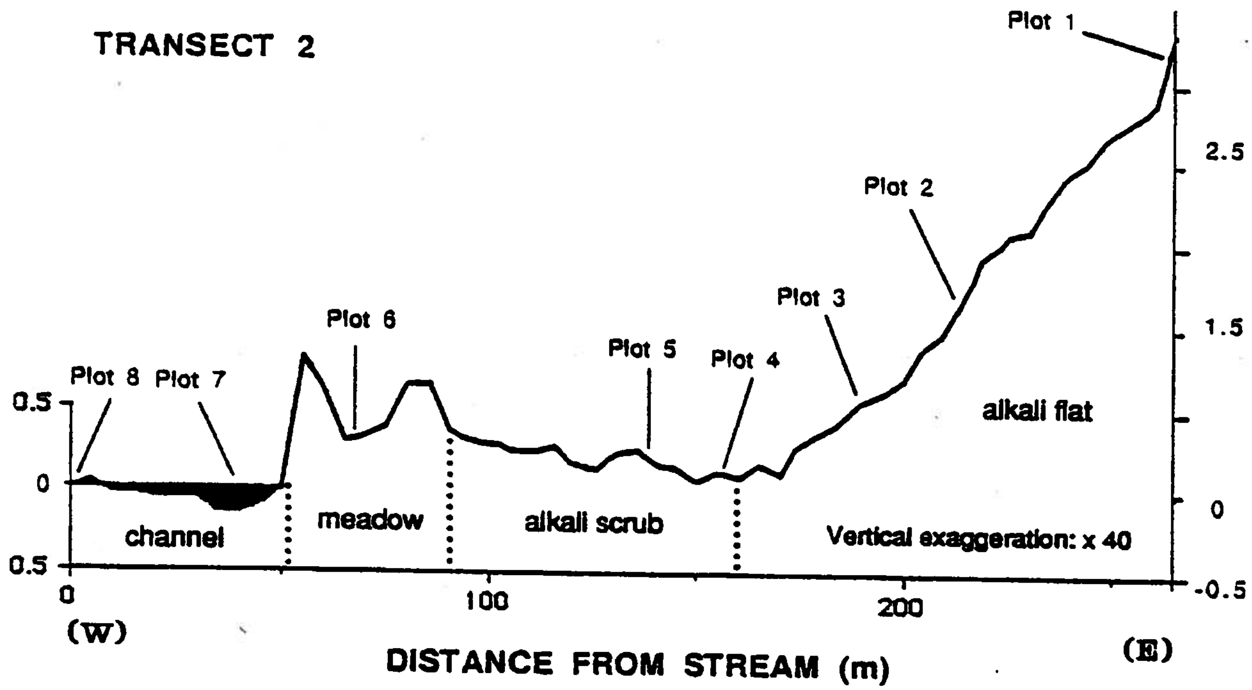
Fig. IV-9 Biplot based on Canonical Correspondence Analysis CCA of the upland data set. Scores of the 30 most important species (abbreviated) on the first two CCA axes are shown. The labeled environmental axes point in the direction of maximum variation in the soil variable, and the length of the axis represents its correlation with variation in species composition as represented by the ordination (x and y) axes. The position of each species with respect to each environmental axis is therefore an estimate of the correlation (non-linear) between the species abundance, and the soil variable. The correlations among each species and each axis can be inferred by simply projecting the species onto each axis, except where species and environmental axes are on opposite sides of the origin. When this occurs, the species is centered at a lower than average level of the variable. (i.e. ERNU (*Eriogonum nummulare*) occurs where pH levels are lower than the overall average, and vice-versa for SAVE (*Sarcobatus vermiculatus*). 65.4% of the variance in the wetland vegetation data set are explained by the axes shown in this ordination (1st and 2nd axis eigenvalues are .60 and .30). The overall species environment correlations (ter Braak 1986) for axes 1 and 2 are environmental variables with axes 1 and 2 are: pH (.64 and -.39), Ca (.45 and .212), Mg (-.41 and -.25), Na (.87 and .03), and K (.81 and -.02). Species abbreviations are:

ARSP=*Artemisia spinescens*	ATRT=*Artemisia tridentata*	*ASIN*=*Aster intricatus*
ATCA=*Atriplex canescens*	ATCO=*Atriplex confertifolia*	ATPA=*Atriplexparryi*
ATTO=*Atriplex torreyi*	CELA=*Ceratiodes lanata*	CHNA=*Chrysothamnus nauseosus*
CHTE=*Chrysothamnus teretifolius*	CHVI=*Chrysothamnus viscidiflorus*	DISP=*Distichlis spicata*
ELCI=*Elymus cinereus*	EPNE=*Ephedra nevadensis*	EQLA=*Equisetum laevigatum*
ERNU=*Eriogonum nummulare*	LEFR=*Lepidium fremontii*	MESP=*Menodora spinescens*
ORHY=*Oryzopsis hymenoides*	PSAR=*Psorothamnus arborescens*	PSPO=*Psorothamnus polydenius*
PUGL=*Purshia glandulosa*	SAVE=*Sarcobatus vermiculatus*	SIJU=*Sitanion jubatum*
SPAI=*Sporobolus airoides*	STCO=*Stipa comata*	STSP=*Stipa speciosa*
SUMO=*Suaeda moquinii*	TEAX=*Tetradymia axillaris*	TEGL=*Tetradymia glabrata*



	PLOT									
	1	2	3	4	5	6	7	8	9	10
Plant Association	1	1	1	3	5	5	5	12	12	12
June, 1989 (surface)										
% soil moisture	79	72	74	69	31	31	31	26	16	19
pH	7.2	7.8	7.2	7.7	8.9	8.2	8.5	10.1	10.3	10.5
% salt	0.4	0.1	0.2	0.1	0.3	0.1	0.1	1.1	1.2	1.0
August, 1989 (surface)										
% soil moisture	64	53	11	7	11	3	0	1	7	0
pH	7.8	6.6	7.2	7.4	9.2	8.3	8.5	10.2	9.9	10.2
% salt	0.3	0.4	0.1	0.2	0.9	0.1	1.3	1.5	0.4	0.1
October, 1989 (surface)										
% soil moisture	83	80	74	0	6	6	0	4	3	1
pH	7.0	7.1	7.6	10.5	8.6	8.2	8.2	9.7	10.5	10.4
% salt	0.3	0.2	0.1	3.3	0.3	0.1	0.7	0.6	0.6	0.6

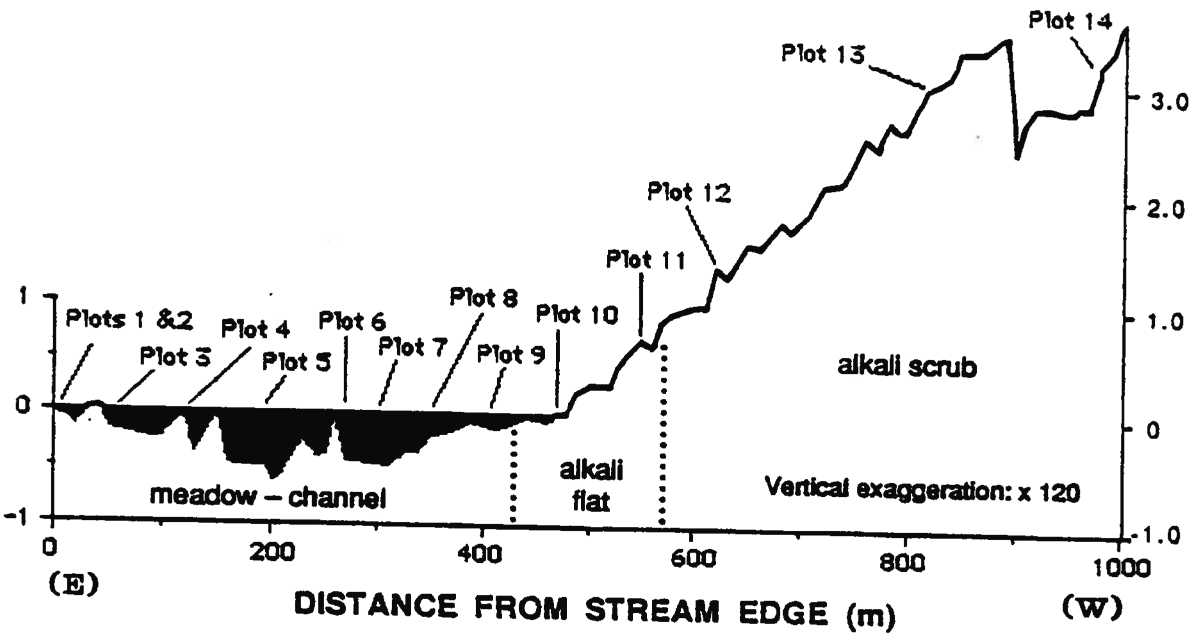
Fig. IV-10 Profile, plot locations, and selected variables by plots for transect 1 at Fish Slough. On y-axis, 0 = water level on June sampling date. Dark shadowing represents water depth. On x-axis, 0 = stream edge.



	PLOT							
	1	2	3	4	5	6	7	8
Plant Association	6	6	6	5	7	5	1	1
June, 1989 (surface)								
% soil moisture	12	0	22	31	29	31	80	-
pH	8.7	8.5	8.4	8.5	8.7	8.5	8.2	-
% salt	2.6	9.5	5.3	3.8	45.4	2.5	0.3	-
August, 1989 (surface)								
% soil moisture	3	2	3	7	2	26	86	-
pH	8.5	8.5	8.1	8.5	8.7	8.6	6.3	-
% salt	6.3	17.3	4.1	5.0	36.5	4.8	0.2	-
October, 1989 (surface)								
% soil moisture	0	-	3	9	3	30	68	85
pH	8.7	-	8.6	8.6	8.6	8.6	8.5	7.1
% salt	7.0	-	2.6	4.9	17.7	1.6	0.7	0.2

Fig. IV-11 Profile, plot locations, and selected variables by plots for transect 2 at Fish Slough. On y-axis, 0 = water level on June sampling date. Dark shadowing represents water depth. On x-axis, 0 = stream edge.

TRANSECT 3



	PLOT													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant Association	1	3	5	5	2	5	2	5	saltpan	5	8	8	5	8
June, 1989 (surface)														
% soil moisture	70	43	48	29	80	57	64	29	-	25	07	17	16	26
pH	8.0	8.0	-	9.9	8.3	9.0	8.2	10.1	9.4	10.4	10.0	10.1	10.1	10.0
% salt	0.2	0.4	-	1.4	0.6	0.3	0.1	7.4	23.7	4.0	4.1	3.5	7.0	3.6
August, 1989 (surface)														
% soil moisture	75	11	10	9	70	49	15	31	6	24	0	9	10	7
pH	8.0	8.0	8.4	9.6	7.5	8.6	8.8	10.2	9.4	10.3	10.3	10.1	10.2	10.3
% salt	0.2	0.4	0.7	0.8	0.2	0.3	0.7	4.8	27.49	4.9	1.7	0.1	1.3	0.5
October, 1989 (surface)														
% soil moisture	82	18	12	7	87	57	57	33	16	14	0	8	0	2
pH	8.0	7.9	8.2	9.2	7.1	8.6	8.7	10.1	9.7	10.5	10.3	10.1	10.1	10.4
% salt	0.3	0.3	0.6	0.9	0.3	0.2	0.1	7.1	10.9	2.9	3.5	4.3	4.1	0.5

Fig. IV-12 Profile, plot locations, and selected variables by plots for transect 3 at Fish Slough. On y-axis, 0 = water level on June sampling date. Dark shadowing represents water depth. On x-axis, 0 = stream edge.

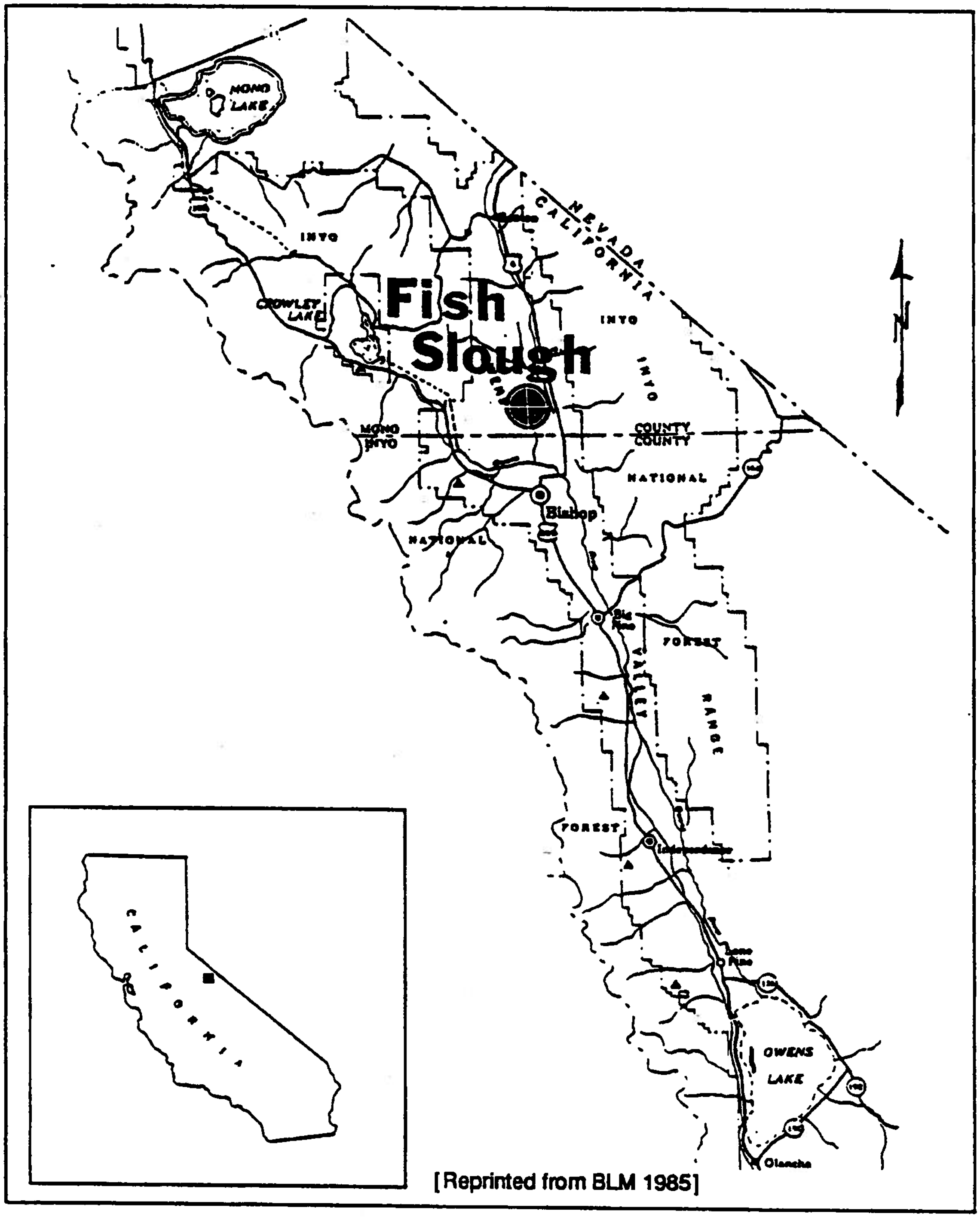


Fig. I-1. Location of Fish Slough, Inyo and Mono Counties, California.

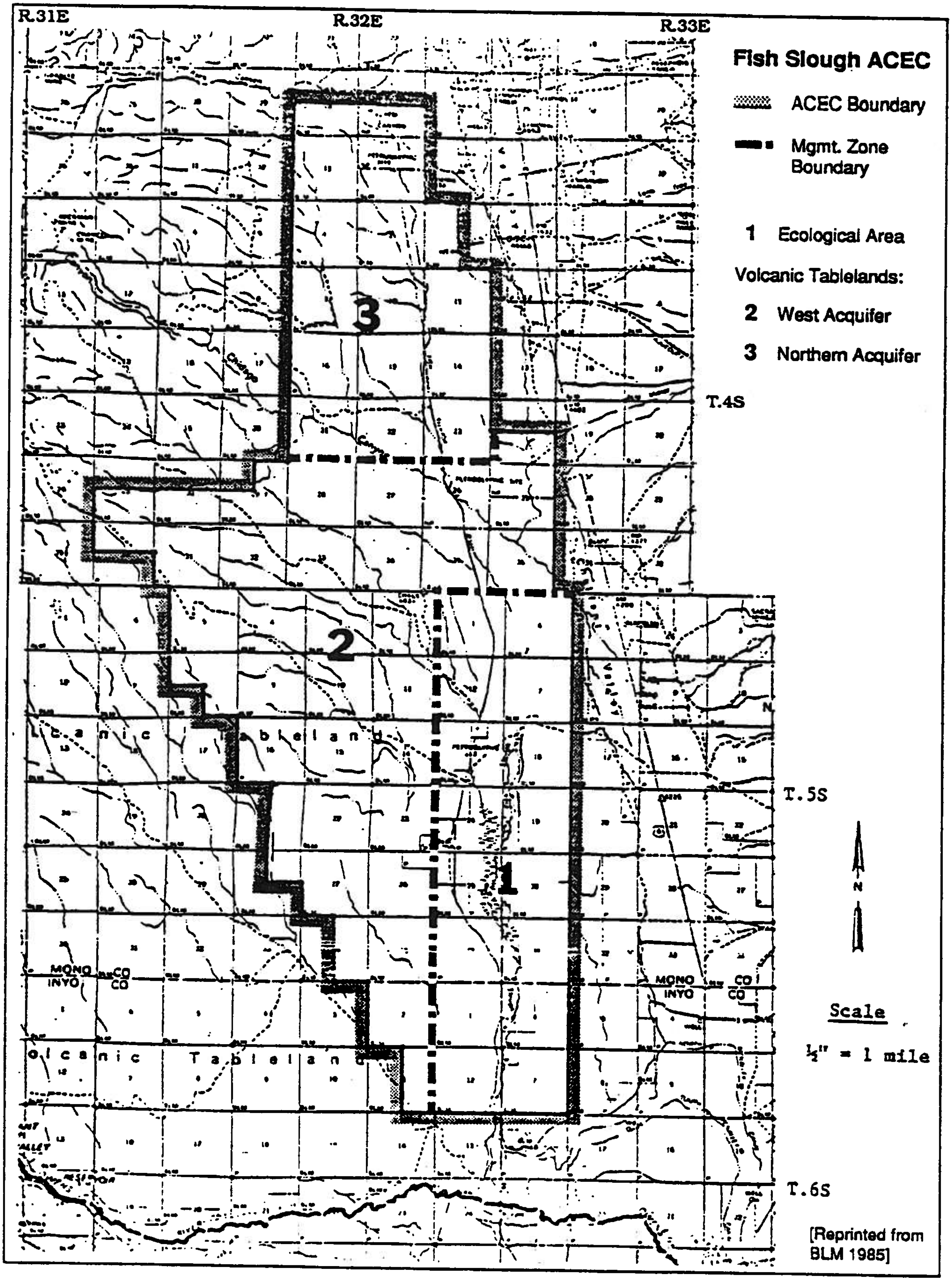


Fig. I-2. Fish Slough Area of Critical Environmental Concern. The study area was restricted generally to Zone 1 of the ACEC.