Title

Life History Strategies of California Native Wetland Plants : Implications for Wetland Creation and Restoration

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Life History Strategies of California Native Wetland Plants: Implications for Wetland Creation and Restoration

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ABSTRACT

This project focused on obtaining data on life history strategies of wetland plants from the California Central Valley wetlands. We have attempted to obtain comprehensive information and functional assessment of representative native and exotic wetland plants from inland wetlands of northern California. Thirty four species were selected for assessment of their germination and seedling establishment characteristics. Information on biomass of mature plants together with data on tissue nutrient concentration, species cover, species richness, and soil properties was collected for a set of 22 species throughout the range of twelve Central Valley wetlands. In addition, a controlled experiment including combinations of two water levels and two nitrogen and phosphorus concentrations was conducted using five species.

Germination properties were studied under both a growth-chamber and greenhouse conditions. Seedlings obtained from the green house germination experiment were further used for assessment of early life history traits such as biomass and leaf area at day 7 and 21 and several growth characteristics such as relative growth rate (RGR) and leaf are rate (LAR). Biomass of mature plants, tissue nutrient content, average plant height and percent cover were used as mature plants characteristics. Comparisons to Grime's triangular ordination model using his dichtomous key and observations of adult plants resulted in assigning the majority of species to the competitive-ruderal (C-R) strategy (*Cyperus eragrostis, Rumex crispus, Lepidium latifolium, Conium maculatum,* Mentha *pulegium,* and *Artemisia douglasiana*). The *Scirpus* spp. and *Juncus balticus* were placed among competitors (C). *Polypogon monspeliensis, Echinochloa crus-galli, Bidens frondosa,* and *Eclipta prostrata* were found to be ruderals (R). *Lythrum hyssopifolium* was characterized as the tress-tolerating-ruderal (S-R) and the *Polygonum* spp. were found to represent the stress-tolerating-CSR strategy.

The aboveground biomass ranges found in this study compare well with values reported for emergent macrophytes in other temperate wetlands. *Scirpus acutus* was the most productive species with the mean biomass of 1146 g m^{-2} (range of 60 to 3738 g m^{-2}). *Scirpus fluviatilis, Juncus balticus, Cyperus Eragrostis* and *Typha domingensis* were average biomass producers with the mean values in the range of 600 to 800 g m^{-2}. The mean biomass of broadleaved macrophytes (e.g., *Polygonum* spp., *Bidens frondosa*) ranged from 200 to 400 g m^{-2}. Biomass in most species was closely correlated with plant cover. Less tight but still significant correlation was found between the amount of nitrogen in soil and biomass. Stronger correlation between biomass and soil nitrogen rather than soil phophorus indicates that plants are probably more limited by nitrogen than by phosphorus.

The information for 34 species has been summarized in species information sheets.

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15. TITLE: Life History Strategies of California Native Wetland Plants: Implications for Wetland Creation and Restoration

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PROBLEM AND RESEARCH OBJECTIVES

This project focused on obtaining data on life history strategies of wetland plants from the California Central Valley wetlands. Wetland plants have been recognized as one of the crucial components of wetland ecosystems. The plants not only provide critical habitats for waterfowl and other biota (amphibians, insects, mammals), they have also been shown to perform essential functions in wastewater treatment processes. The flora of marshes of the California Central Valley is quite species rich. Yet most constructed wetlands in this region (as in other parts of the world) are species poor. We feel this is because wetland designers have access to only a limited information and selection of potential plant species. Wetland restoration/creation projects are designed by engineers who lack the proper ecological background. It is difficult for them to acquire the necessary information with a limited literature available. A good example of this situation are the inland marshes of California whose vegetation has never been described in a comprehensive publication. The situation is much better for California salt marshes, mainly due to an excellent wetland restoration project directed by Zedler (1996). An example of poor species selection comes from a model wastewater treatment project in Sacramento where a short statured species, *Scirpus americanus*, was planted as an alternative species to robust *Scirpus acutus*. Within the first year taller, more robust *Typha domingensis* became the dominant. Time and money were unnecessarily expended when a complete species conversion was carried out the following year (Post, personal communication).

We have attempted to obtain comprehensive information and functional assessment of representative native and exotic wetland plants from inland wetlands of northern California. A suite of papers on the life histories of wetland plants from eastern North America (e.g., Wisheu & Keddy 1992, Boutin & Keddy 1993) and Europe (Maltby 1997; Murphy et al. 1990) has been available to provide material for comparison with data on Californian species. The information for 34 species has been summarized in species information sheets.

In order to correctly evaluate the role of plants in various ecosystems, we have to study traits that determine the functions of plants in their communities. These include dispersal ability, growth rates, competitive ability, stress tolerance, herbivory, disease, and regeneration. Based on these traits, plants or functional groups (guilds) of plants can then be selected for actual projects. In addition, the information can be used for simple predictive ecological models. Traits related to growth and resource acquisition (e.g., the relative growth rate), germination and seedling establishment, above-belowground biomass allocation, capacity to occupy space, etc. have been assessed.

The specific objectives of this project were:

1) Select wetlands plants from inland marshes of northern California to represent the widest range of life history types possible.
2) Define the functions of these plants in respective wetland ecosystems.
3) Select traits that are responsible for these functions and screen plants for those traits.
4) Based on the trait matrices, define functional groups of plants.
5) Prepare short comprehensive information sheets on each plant species.
6) Evaluate the potential reference wetlands for different inland wetland types.

The research was conducted at the UC Davis Wetland Cultivation Facility, in the controlled laboratory environment and in various Central Valley wetlands.

METHODS

Seed Germination and Seedling Establishment

Many germination studies vary the environmental conditions while restricting the number of species. The approach taken in this study is different: A large number of species is examined under a single set of environmental conditions. This 'community' based approach is pertinent to most wetland plants since they achieve maximum germination under widely similar conditions. However, these conditions do not include a cold stratification due to the fact that all seeds were harvested from California Central Valley wetlands where winter temperatures never reach freezing. Some species were exposed to a bleach scarification treatment in order to soften the hard seed coat or fruit wall.

Seed collection and storage

Seed samples were collected during the summer of 1998 from northern Central Valley wetlands and placed in paper bags. Thirty-four species of seeds from wetland plants were collected. After collection, seeds were left to air dry at room temperature. Seeds were cleaned, weighed, and placed in glass vials and kept at room temperature until the germination experiments.

Growth chamber experiment

A preliminary germination experiment was performed in a growth chamber in order to assess the viability of the seeds. In February 1999, seeds were placed on filter paper in 10-cm diameter Petri dishes and kept saturated with distilled water (three replicates x thirty-four species x ten seeds per dish). The seeds were incubated for 7 weeks. Germination counts were made approximately every 3 days. Once all ten seeds had germinated in a Petri dish, the dish was removed. Seeds were considered germinated when the radicle emerged. Temperature was held constant at 25 °C. Petri dishes were arranged at random in the growth chamber. The light treatment involved a regime of 12-h light followed by 12 h of darkness.

Polygonum and *Scirpus* spp. have extremely tough and thick seed coats and were therefore subjected to scarification treatments. Their seed coats are extremely tough and thick. Clevering (1994) performed germination experiments of *Scirpus* spp. and found that household bleach scarification worked well in improving germination and recommended using a sodium hypochlorite concentration of at least 2% and a minimum soaking period of 2 days. Because both *Polygonum* and *Scirpus* spp. fruits have similar characteristics, a treatment of sodium hypochlorite was used for both. Additionally, species in which there were no and very little germination (excluding the light delicate seeds) different strengths of sodium hypochlorite were used as scarification treatments. One treatment was a 3.5% solution in which the seeds were soaked for two days. For many species, this solution proved to be too strong. Another treatment was tried in which the seeds of *Sagittaria* and *Polygonum* spp. were soaked in 3.5% sodium hypochlorite solution until the seed coat looked adequately softened or soaked in 0.525% sodium hypochlorite solution for two days.

Greenhouse experiment

Ten replicates of ten seeds per species were set up in a greenhouse in April 1999 for a period of 12 weeks. Each pot was 10 cm x 10.5 cm x 9.5 cm (tall). Netting was placed in the bottom to prevent the substrate from escaping. The substrate consisted of 7 cm deep commercial washed sand covered with 1 cm. layer of potting soil (UC mix: 48% by volume water holding capacity, 10% air filled porosity in a 6" pot, 1 part ground Canadian sphagnum, 1 part uniform coarse sand (no silt), 1 part white pumice, 1 part redwood compost, 3# oyster shell/yd, 3# dolomite/yd, and 3# single super phosphate/yd). There was a 1.5-cm. gap between the top of the substrate to the top of the pot. The pots were placed in large tray in order to provide uniform subsurface irrigation. Each tray could hold up to 170 pots. Ten seeds were placed evenly spaced on the surface of the substrate. Equal proportions of distilled and tap water was used initially to irrigate the pots. When ~30% of the species began germinating, an equal proportion of distilled water and nutrient solution (nitrogen concentration of 273 ppm ($Ca(NO_3)_2$); N:P:K ratio is 2:1:2 (GrowMore 4-18-38), pH=5.6) was used. Water levels were monitored daily and maintained at a constant depth (4 cm deep). Germination was monitored daily. For each day of the week different color flagging was used to mark each germinated seed. Roman numerals on the flagging noted which week germination occurred. Sodium hypochlorite scarification was done prior to the setup for *Scirpus* (3.5% sodium hypochlorite for two days) and *Polygonum* (0.5% sodium hypochlorite for two days) species.

One-week old seedlings (10 replicates for each species) were removed, washed, and photographed. The seedlings were dried at 80 °C for 48 hours and weighed. The root structure was measured and described for each species. A photograph of each species' seedling in the pot was taken as well. Phenological changes were recorded for each species. Three-week old seedlings (10 replicates for each species) were removed and washed. Leaf area (5 replicates for each species) was measured by photocopying the leaves and then scanning the photocopies in and then using SCION image program to determine the leaf area. The root structure was measured and described for each species. In June 1999, the greenhouse experiment was terminated and representative plants for each species were transplanted to 5-gallon buckets and moved outdoors to the wetland cultivation facility.

Species attributes

Several properties for each species were measured and recorded: average seed weight, lag time (L, the time in days between the sowing of the seeds and the commencement of germination), the final germination proportion at the end of the experiment (G, for greenhouse; Pre-G, for growth chamber), maximum germination rate (G_{max}, maximum proportion of germinated seeds that germinate in a single day), time to 50% germination (t_{50}), relative growth rate (RGR), leaf area ratio (LAR, amount of leaf area per unit total plant mass) (Lambers et al., 1998), specific leaf area (SLA, amount of leaf per unit leaf mass) (Lambers et al., 1998), net assimilation rate (NAR, rate of increase in plant mass per unit leaf area) (Lambers et al., 1998), and leaf mass ratio (LMR, fraction of the total plant biomass allocated to leaves) (Lambers et al., 1998). Measurements of total height and root length were periodically made throughout the experiment. Phenological characteristics and other adult characteristics (when first flowered, first clone, set seed, etc.) were recorded.

For the few species that had less than 10% final germination, there was not enough replication for statistical tests to be accurately performed. For this reason, all species with less than 10% final germination proportions were excluded from the statistical analysis.

Statistical analysis

The transformation of growth chamber (Pre-G) and greenhouse (G) final germination percentages and maximum germination rates to the natural logarithm of their odds ratios and the transformation of seed weight, lag time (L), and time to 50% germination (t_{50}) to their natural logarithms stabilized the variance. Correlations between quantitative variables were calculated using the Pearson correlation coefficient. Systematic differences in the mean values of the continuous variables when contrasted with categorical variables were tested using an analysis of variance. Homogeneity of variance was tested using F-test. Post hoc tests between group means were done using the Scheffé test. Principal Component Analysis (PCA) was used to identify the major axes of variation in the matrices of juvenile traits and to group the different species. Data was ranked and arranged in matrices for the PCAs. PCAs were performed for the entire matrix of species (all 34 species) and for smaller matrix of species (21 species) in which more parameters were known. PCAs were calculated using PC-ORD version 4. Comparisons were made to Grime's CSR (1974) triangular ordination using his dichtomous key (1986) and observations to adult plants. Hodgson et al.'s (1999) rapid spreadsheet method could not be utilized due to limited data on adult characteristics of the selected species. All other statistical analysis was done using SYSTAT 9.0 statistics package.

Nutrient Enrichment Experiment

Five wetland plant species were used in the experiment: *Bidens frondosa* (native annual in Asteraceae family), *Cyperus eragrostis* (native perennial in Cyperaceae family), *Echinochloa crus-galli* (exotic annual in Poaceae family), *Lepidium latifolium* (exotic perennial in Brassicaceae family), and *Phragmites australis* (native perennial in Poaceae family). These five species are from three different groups. *Echinochloa crus-galli, L. latifolium*, and *B. frondosa* have characteristics of the ruderal strategy. *Lepidium latifolium* is a perennial species so it may not be a true ruderal. McJannet et al. (1995) had found that plants from different functional groups had different tissue N:P ratio. They found that ruderals had significantly lower N and P tissue concentrations that species from other functional groups.

There were three main objectives for this experiment. The first one was to determine the differences in parameters for each species between the eight different treatments. The second objective was to determine the potential differences in nutrient content and ratios in the above-ground tissue between species for each treatment. The third objective was to determine the potential effects of different water levels.

Each species was germinated from seed in the greenhouse prior to the experiment. Four-week-old seedlings were transplanted into 2-L pots filled with commercially washed sand. There was two levels of N (high and low) and P (high and low) treatments and two water levels (flooded and drawdown). Nitrogen was supplied as calcium nitrate and phosphorus as potassium dihydride phosphate. The following combinations of nitrogen and phosphorus were applied:

Nutrient treatments

Tub #	Nitrogen (mg N/ pot)	Phosphorus (mg P/pot)	Nitrogen/ Phosphorus	Water levels
1	5.0	0.5	10	Flooded
2	5.0	0.5	10	Drawdown
3	5.0	10.0	0.5	Flooded
4	5.0	10.0	0.5	Drawdown
5	100.0	0.5	200	Flooded
6	100.0	0.5	200	Drawdown
7	100.0	10.0	10	Flooded
8	100.0	10.0	10	Drawdown

- * Micronutrients will be added to each tub in the following concentrations: Micronutrients: 0.5 ml/l Hoagland solution; Iron: 1.0 ml/l Hoagland solution; MgSO4: 1.0 mg/l Hoagland solution; KCl: 50 mg/pot (Hoagland & Arnon, 1950)

There was four replicates of each species for each treatment giving 20-pots/ tub (total volume of tub = 60L). Nitrogen and phosphorus solutions were injected into each pot using a syringe and all other nutrients were directly added to the water. Water was changed and nitrogen and phosphorus solutions were injected every ten days. Measurements of total height, number of leaves, and other phenological characteristics were recorded every ten days for each plant. After two months, all plants were be harvested. The plants were separated into leaves, stems, and below-ground. Leaf area was measured using a LICOR-3000 leaf area meter. Leaf Area Ratio (LAR), Specific Leaf Area (SLA), and Leaf Mass Ratio (LMR) was calculated (Lambers et al., 1998). Plant material was dried for 48 hours at 70 °C. Dry weights were obtained for leaf, stem, and below-ground masses. The replicates for each treatment were bulked and ground. Subsamples from each treatment were taken and analyzed for nitrogen and phosphorus.

Lab procedures

Standard methods were followed to analyze for total particulate phosphorus (Allen 1989). This method converts all phosphorus in organic phases into orthophosphate, which can be readily measured. A CHN elemental analyzer was used to analyze for particulate nitrogen and carbon contents. This process involves the complete combustion of the particulate organic matter and the eventual detection of carbon dioxide and nitrogen gas.

Statistical Analysis

Data were transformed using the natural logarithm and this stabilized the variance. Different parameters were analyzed by different groupings using ANOVAs and Scheffe tests (parameters: total biomass, leaf mass, stem mass, below-ground biomass, root/shoot, total length, number of leaves, leaf area, LAR, SLA, LMR, above-ground carbon concentration, above-ground nitrogen concentration, above-ground phosphorus concentration, and above-ground nitrogen/ phosphorus ratios. There were four groupings. The groupings include: (1) species; (2) water level (3) nitrogen, phosphorus, and water level (treatment); and (4) nitrogen and phosphorus (N*P).

Plant biomass and soil samples

Sampling of aboveground biomass of emergent wetland plants and underlying soil samples were performed during the summer 2000 in wetlands of the Central Valley of California, USA. Study locations were chosen to represent the entire Central Valley. Individual sampling sites were chosen by locating species that had been used in the seed germination and establishment experiment and several replicates were taken for each species.

Quadrats of 0.5 m x 0.5-m size were used. All species within the quadrat were identified. Average plant height and percent cover was recorded for each species of interest. Soil samples were taken within the quadrat. Soil was taken for analyses of bulk density, soil moisture content, and total carbon, nitrogen and phosphorus. All the above-ground biomass was cut and placed into paper bags for drying. Young healthy leaves and senesced leaves were separated and placed in bags separately. All plant material was dried for 48 hours at 80 °C. Young leaves, senesced leaves, and soil samples were ground and analyzed for total carbon, nitrogen, and phosphorus. (See lab procedures).

Description of Sampling Sites

* = Potential Reference Wetland

*** Cosumnes River Preserve**

The Cosumnes River Preserve is located in Sacramento County on the eastern edge of the Sacramento-San Joaquin delta in California. The Nature Conservancy, California Department Fish and Game, Bureau of Land Management, and Ducks Unlimited jointly own the Preserve. In the past, settlers had cleared most of the land for farming and cattle grazing which are the present use of the surrounding land. There are no major dams on the Cosumnes River, allowing frequent flooding in response to the heavy winter rains. The load of rich silt carried by floodwaters introduces nutrients to the adjacent wetlands. The Preserve protects two plant communities: riparian forest and freshwater marsh. Most of the sampling occurred in either unmanaged natural or managed freshwater marshes.

A natural marsh is found adjacent to a slough on the Preserve. This marsh is surrounded by (willows) *Salix* spp. and consists primarily of bulrushes (*Scirpus californicus* and *Scirpus acutus*), cattails (*Typha* domingensis and *T. domingensis* hybrids) dotted smartweed (*Polygonum punctatum*), arrowhead (*Sagittaria latifolia*) and several other species. Bordering the natural marsh are thickets of cocklebur (*Xanthium strumarian*) and sticktight (*Bidens frondosa*).

A natural slough in between the managed constructed marshes and the natural marsh is relatively open and surrounded by grasslands. The upper portion of the slough is made up of made up cocklebur (*Xanthium strumarian*), sticktight (*Bidens frondosa*), and swampgrass (*Crypsis schoenoides*). The middle portion of the slough contains a community of smartweeds (*Polygonum* spp.), arrowhead (*S. latifolia*), and water primrose (*L. peploides*). The lowest portion of the slough consists of patches of *Scirpus acutus* and *Scirpus californicus* with *Ludwigia peploides* in between.

The managed marshes have their water levels controlled throughout the year allowing for the creation of specific habitats for particular waterfowl. The edges of the managed marshes support communities of curly dock (*Rumex crispus*), pepperweed (*Lepidium latifolium*), tall flatsedge (*Cyperus Eragrostis*), water primrose (*Ludwigia peploides*), burhead (*Echinodorus berteroi*), rushes (*Juncus* spp.), and various exotic grasses and other species. In the interior of the marshes, there are dense stands of bulrushes (*S. acutus* and *S. californicus*) and cattails (*Typha* spp.). The open water is covered with water fern (*Azolla* spp.) and duckweed (*Lemna* spp.).

The Cosumnes River Preserve is selected as a potential reference wetland because it holds a variety of wetland types. There are riparian, natural sloughs, and managed freshwater marshes. Each wetland type supports a diversity of different wetland plants.

Yolo Bypass Wildlife Area

Newly restored and constructed permanent and seasonal marshes west of Davis and east of West Sacramento, California provide over-wintering habitat for migratory waterfowl. These wetlands are adjacent to grasslands, riparian, and agricultural lands.

The seasonal marsh along a drainage creek consists of *Cyperus Eragrostis*, *Paspalum distichum*, *Scirpus acutus*, *Scirpus fluviatilis*, and *Typha domingensis*. The permanent ponds consist of deep open water areas with patches of *Scirpus acutus* and *Echinochloa crus-galli*, and dense stands of *Typha domingensis* around the perimeter. There are a few, shallow, small ponds around the seasonal marshes. They are mostly surrounded by a dense monoculture of *Scirpus acutus*.

*** Delevan National Wildlife Refuge**

Delevan National Wildlife Refuge is located in the Sacramento Valley of California, a few kilometers northwest of the Sutter Buttes. The landscape is very flat and bordered by intensive agriculture (rice, walnuts, almonds, prunes, and grain). This refuge is composed of managed seasonal marshes, permanent ponds, grasslands, and alkali meadows. These wetlands are managed primarily to support migratory waterfowl habitats. There are also areas that are planted with the invasive *Echinochloa crus-galli* and other exotic grass species that are food sources of waterfowl. *Bidens frondosa, Lycopus americanus, Lythrum hyssopifolium, Scirpus fluviatilis, Paspalum distichum, Polygonum hydropiperoides*, and *Polygonum lapathifolium* often occupy edges of permanent ponds. Floating-leaves macrophytes, *Scirpus acutus* and *Typha domingensis* dominate the deeper areas. Newer, shallow, permanent ponds often support *Echinodorus berteroi* in the interior as well.

Delevan National Wildlife Refuge is selected as a potential reference wetland because even though it contains primarily managed freshwater marshes; the wetland plant communities are still quite diverse. The diversity is dependent on several factors: the age of the wetland, the management of the hydrologic regime (water level and flooding frequency), management of undesirable species, and diversity of geomorphology of a wetland. The newer marshes are more diverse because *Typha domingensis* has not had the chance to form dense stands. It should be noted that the exclusive planting of exotic invasive species such *Echinochloa crus-galli* is strongly cautioned even though waterfowl eats it. These exotic grasses are highly invasive and have a reproductive capacity and will potentially displace many native grasses. Native non-invasive species should be planted instead and therefore provide food for waterfowl without the threat of invasion.

Colusa National Wildlife Refuge

Colusa National Wildlife Refuge is located in the Sacramento Valley of California. It is a few kilometers west of the Sutter Buttes. The landscape is very flat and bordered by intensive agriculture (rice, walnuts, almonds, prunes, and grains). This refuge consists of managed permanent ponds, seasonal marshes, *Echinochloa crus-galli* production areas, grasslands, alkali meadows, vernal pools, and riparian forest. These wetlands are managed primarily to support migratory waterfowl habitats. Along early drying seasonal marshes, *Artemisia douglasiana, Paspalum distichum*, and *Polygonum lapathifolium* can be found. *Cyperus Eragrostis, Paspalum dilatatum, Polygonum hydropiperoides*, and *Scirpus acutus* dominate edges of permanent ponds. *Echinodorus berteroi* and *Scirpus fluviatilis* are found in the interior of late drying seasonal marshes.

Pleasant Grove slough

A small natural slough near the town of Pleasant Grove, California in the Sacramento Valley surrounded by rice and other agricultural fields. This slough was dominated by *Scirpus acutus* and trails of *Ludwigia peploides* in the deeper areas and *Bidens frondosa, Epilobium ciliatum,* and *Polygonum hydropiperoides* in the drier areas.

Pleasant Grove canal

An agriculture water canal near the town of Pleasant Grove, California was dominated by trailing *Polygonum hydropiperoides* in the deeper areas. In the drier areas Typha *domingensis*, erect *Polygonum hydropiperoides, Bidens frondosa, Cyperus eragrostis,* and *Scirpus acutus* communities were found.

Sutter National Wildlife Refuge

Sutter National Wildlife Refuge is a small refuge in the Sacramento Valley, a few kilometers southeast of the Sutter Buttes in California. It is surrounded by intensive agriculture (rice, walnuts, almonds, prunes, and grains). The refuge is made up of managed forested areas, grasslands, seasonal marshes, and permanent ponds. These wetlands are managed primarily to support migratory waterfowl habitats. All of the permanent ponds and most of the drainage ditches were dry by the time of sampling so there were no standing water left. The late drying seasonal ponds consisted of *Typha domingensis, Scirpus acutus,* and *Echinodorus berteroi* and along the edges are *Scirpus fluviatilis*. The early drying seasonal marsh consisted of *Polygonum hydropiperoides* and *Paspalum dilatatum*. There were large patches of *Typha domingensis* and *Scirpus acutus*. Along the edges, the species *Cyperus eragrostis* and *Bidens frondosa* can be found. Along the drainage ditches are dense stands of *Scirpus acutus.*

*** Stone Lakes National Wildlife Refuge**

The Stone Lakes National Wildlife Refuge is 10 miles south of Sacramento in the northern part of the Sacramento-San Joaquin Delta in California. This refuge has seasonal wetlands, permanent ponds, riparian forest, and grasslands. These wetlands are managed primarily to support migratory waterfowl habitats. There are also natural lakes and a natural slough. Agricultural lands, suburban development, a large interstate highway, and a golf course surround the refuge. In the late drying seasonal depressions, *Polygonum lapathifolium, Echinochloa crus-galli,* and *Typha domingensis* can be found. In the larger dried seasonal marshes, *Lepidium latifolium* and *Rumex crispus* are found. In the permanent ponds there are dense stands of *Scirpus acutus* and *Typha domingensis*. Along the edges and the shallower areas, a community of *Cyperus eragrostis, Bidens frondosa, Polygonum lapathifolium, Echinodorus berteroi*, and *Echinochloa crus-galli* can be found.

Stone Lakes National Wildlife Refuge is selected as a potential reference wetland due to its diversity of wetland habitats. This fairly new refuge has seasonal wetlands, vernal pools, managed permanent ponds and marshes, riparian forest, grasslands, and a natural lake and slough. There is a great potential for a very high diversity of wetland plant communities if the proper management is followed.

Sacramento National Wildlife Refuge

The Sacramento National Wildlife Refuge is located in the Sacramento Valley, California and is a few kilometers northwest of the Sutter Buttes. This refuge is surrounded by intensive agriculture (rice, walnuts, almonds, prunes, and grains). This refuge has managed seasonal wetlands, grasslands, and permanent ponds. These wetlands are managed primarily to support migratory waterfowl habitats. Along the edge of permanent ponds, *Scirpus fluviatilis, Polygonum lapathifolium*, and *Echinochloa crus-galli* can be found. In the interior and edges of the permanent ponds, *Scirpus acutus* and *Typha domingensis* form dense stands. The late drying seasonal marshes have plant communities consisting of *Echinodorus berteroi, Rumex crispus*, and *Polygonum hydropiperoides.*

West Bear Creek Unit (Part of the San Luis National Wildlife Refuge Complex)

The West Bear Creek Unit lies within the historic floodplain of the San Joaquin River in the central San Joaquin Valley, California. The San Luis National Wildlife Refuge is surrounded by intensive agriculture lands, dairies, and ranches. The West Bear Creek lies less than a kilometer south of the intersection of routes 140 and 165. This unit consists of managed permanent lakes, seasonal marshes, and grasslands. These wetlands are managed primarily to support migratory waterfowl habitats. Raccoon marsh, a permanent pond, consists of primarily Typha *domingensis* within the interior of the marsh and *Juncus balticus, Echinochloa crus-galli,* and *Polygonum lapathifolium* along the edges. Sacaton Pond, a late drying pond, also has dense stands of *Typha domingensis* and small communities of *Echinodorus berteroi.*

*** Merced National Wildlife Refuge**

The Merced National Wildlife Refuge is in Merced County, northern San Joaquin Valley, California. This refuge has approximately 700 acres of seasonally flooded marsh and 600 acres of corn, alfalfa, irrigated pasture, and wheat. These wetlands are managed primarily to support migratory waterfowl habitats. Within the three clustered permanent ponds, stands of *Typha domingensis* and

Scirpus acutus can be found. Along the edges, communities of *Cyperus eragrostis, Lepidium latifolium, Polygonum lapathifolium, Juncus balticus*, and *Scirpus fluviatilis* are found.

Along the floodplain of Mariposa Creek, marshes can be found. Here, stands of *Scirpus acutus* can be found closest to the creek. Along the floodplain, *Polygonum lapathifolium* and *Cyperus eragrostis* are found more upland. Along the edge of Duck Slough, communities of *Polygonum lapathifolium, Echinochloa crus-galli,* and *Scirpus maritimus* can be found. Duck Slough feeds into Snow Goose Lake, which is a permanent pond. Along the edge of Snow Goose Lake, dense patches of *Scirpus acutus* and *Typha domingensis* are found.

The Merced National Wildlife Refuge is selected as a potential wetland due to its variety of wetland habitats. There is a natural creek that flows along the refuge that supports a natural wetland along the floodplain. This refuge also supports permanent ponds, seasonal wetlands, and wetlands along man-made sloughs. A variety of wetland plant communities is found in each of the wetlands.

San Joaquin Wildlife Refuge

The San Joaquin Wildlife Refuge is 9 miles west of Modesto in Stanislaus and San Joaquin Counties, California. This refuge is within the historic floodplain of the confluences of the San Joaquin, Stanislaus, and Tuolumne rivers. The refuge consists of oak-cottonwood-willow riparian forest, pastures, agricultural fields, vernal pools, seasonal wetlands, and permanent ponds. These wetlands are managed primarily to support migratory waterfowl habitats. A natural permanent wetland, Lake White, is fed through groundwater. This wetland consists of dense stands of *Scirpus acutus* and *Typha domingensis*. In the more upland areas around Lake White, *Polypogon monspeliensis* can be found.

Information Sheets

One page information sheets were compiled for 34 species including information on their general characteristics, taxonomic description (Hickman 1993), habitat, range in California, life histories, and potential for use in restored and constructed wetlands (see Appendix). Their life histories were based on information obtained from the course of this project. For most species, one page of photographs are provided for seeds, seedlings, mature plants, and habitat.

PRINCIPAL FINDINGS AND SIGNIFICANCE

Seed Germination and Seedling Establishment

Twelve out of the original 34 species had less than 10% germination during the growth chamber and greenhouse experiments (Table 1). Two species (*Alisma plantago-aquatica* L., *Sagittaria latifolia* Willd.) are known to have low germination proportions (Shipley *et al.*, 1989). Baskin (1991) reported that *Sagittaria latifolia* has recalcitrant seeds that need to be used immediately after collection or they may die. It also has been reported that *S. latifolia* has much higher germination percentages when under flooded conditions (Leck 1996). *Polygonum* and *Scirpus* species have hard seed coats and fruit walls that offer protection against adverse conditions but also may prevent germination due to its impermeability. Little is known about *Aster subulatus, Crypsis schoenoides, Echinodorus berteroi,* and *Paspalum* spp. so it is presumed that either the necessary stratification or scarification treatments were not performed to break dormancy or the seeds were defective. It is assumed that *Typha domingensis* seeds were from a sterile hybrid.

Functional Groups

Principle Component Analyses

Principle Component Analyses (PCA) were performed in order to spatially distribute each species using the germination and growth parameters. The PCA performed on **21 species** using 18 traits (Figure 1) on ranked data shows several groupings. The *Scirpus* species, *Juncus balticus,* and *Phragmites australis,* and *Conium maculatum* are grouped together. The *Polygonum* species are grouped together. There is a large cluster consisting of *Lepidium latifolium, Echinochloa crus-galli, Lythrum hyssopifolium, Bidens frondosa, Rumex crispus, Eclipta prostrata, Epilobium ciliatum,* and *Polypogon monspeliensis.* These are mostly annual species or exotic perennial species with high final germination proportions and short lag times and time to 50% germination values. The final group consists of *Cyperus eragrostis, Epilobium ciliatum, Artemisia douglasiana,* and *Mentha pulegium.*

The PCA (Figure 1) explained 67.9 % of the variance within the first three axes. The first axis (Eigenvalue=5.965, Broken-stick Eigenvalue=3.495, % of Variance=33.14) was primarily composed of seed weight (r=0.717), plant weight (r=0.881), leaf weight (r=0.805), leaf area of a 21-day-old seedling (r=0.743), time to 50% germination (r=-0.811), LAR (r=-0.678), and NAR (r=0.738). In Axis 1, the top three positions are occupied by three species that have high seedling and leaf (21-day-old) weights, high leaf areas (21-day-old seedlings), heavy seeds, high NAR values, and long time to 50% germination values. The bottom three positions are occupied by three perennials that have low seedling and leaf (21-

day-old) weights, low leaf areas (21-day-old seedlings), short time to 50% germination values, light seeds, low NAR values, and short time to 50% germination values.

The second axis (Eigenvalue=3.669, Broken-stick eigenvalue=2.495, % of Variance= 20.38) was primarily composed of greenhouse final germination proportion (r=0.729), seedling mortality (r=-0.774), and RGR (r=0.764). In Axis 2, the top three positions are held by species that had high final greenhouse germination, low seedling mortality, and high RGR values while the bottom three positions are held by species with opposite characteristics.

The third axis (Eigenvalue=2.585, Broken-stick eigenvalue=1.995, % of Variance= 14.36) was primarily composed of LMR (r=0.798) and LAR (r=0.637). In Axis 3, the top three positions are held by species with high values of LMR and LAR and the bottom three positions are held by species with low LMR and LAR values.

The combination of all of these attributes result in the *Polygonum* species occupying the right-hand-side of the diagram (Group 1) (Figure 1). *Polygonum* species have high seedling and leaf weights (21-day-old), leaf areas, seed weights, low LAR values, and long time to 50% germination values. This group has medium values for final greenhouse germination and mortality proportions and RGR values.

This group has characteristics of CSR- stress-tolerators strategies (sensu Grime). The CSR strategy has characteristics of each of the three strategies (ruderal, stress-tolerator, competitor) while this group of *Polygonum* spp. is situated closer to stress-tolerators. That means that may have a longer life-span, lower reproduction and growth, and smaller, more leathery leaves than a species found in the CSR strategy. Compared to Boutin and Keddy's (1993) functional classes, this group may be considered as interstitial. Interstitials are rather poorly defined and mainly serve as a transition from clonal dominants (matrix) to species that have a high reproductive capacity and no lateral spread. The interstitial group consists of three subclasses: reeds, clonals, and tussock. *Polygonum* spp. are neither reeds nor tussocks so they would be considered clonals.

The *Scirpus* species, *Juncus balticus*, and *Conium maculatum* are grouped (Group 2) (Figure 1) together in the bottom left of the diagram. These perennial species have low seedling and leaf weights (21-day-old), low leaf areas, and medium time to 50% germination values. This group has low final germination proportions. They have higher NAR values and lower LAR values. They have the lowest RGR values and the highest mortality.

This group has characteristics of the competitor strategy (sensu Grime) or matrix (sensu Boutin & Keddy). This group is mostly comprised of tall dominants that have extensive lateral spread. It is interesting to see *Conium maculatum* in this group because they are thought of as forming dense monocultures. These species are robust and have a high density in their plant canopy. They have a low sexual reproductive capacity because they primarily spread by rhizomes. When compared to Boutin and Keddy's (1993) matrix subgroups, *Conium maculatum* would fall under the clonal stress-tolerators. These are shorter species with shallow rooting system. The other species would fall under the other subgroup: clonal dominants. These are tall species with deep rooting systems.

An another group (Figure 1) (Group 3) consists *of Lepidium latifolium, Polypogon monspeliensis, Lythrum hyssopifolium, Bidens frondosa, Rumex crispus, Eclipta prostrata, and Echinochloa crus-galli.* These are mostly annual or exotic perennial species that have mediume to high final greenhouse germination proportions and low seedling mortality. They have high RGR values. They have short to medium time to 50% germination values and low seedling weights, leaf areas, and leaf weights (21-day-old). This group has medium values for NAR and LAR. This group has characteristics of ruderal strategies in that it has high seed germination, high seedling establishment, and high growth.

This group has characteristics of the ruderal strategy. They have a high reproductive capactiy and reproduce readily from seeds. They are usually short-stature, have limited lateral spread and life-span, and flower early. They put almost all of their energy to reproduction. This means they need to mature as quickly as possible in order to start reproduction as fast as possible. They are the strategy that tolerates disturbance the best. It is interesting to note the number of perennial species in this group. According to Grime's triangular ordination, ruderals are made up of annuals. But these perennials found in this group are exotic perennials. So this may the reason why they are found in this group.

The fourth group consists of *Cyperus eragrostis, Epilobium ciliatum, Mentha pulegium*, and *Artemisia douglasiana*. This group consists of perennial species that have low seed weights, low seedling weights, low leaf weights, and low leaf area (21-day-old). They have short lag times, high LAR values, and low NAR values. This group has characteristics of competitive-ruderal strategies. This group is characterized by having high seedling establishment and seed production but also having more robust leaves and leaf canopy.

This group has characteristics of competitive-ruderal (C-R) strategy. This group does not fit well into Boutin and Keddy's functional groups. There would be overlap between matrix and interstitial groups. Grime's triangular ordination seems to work better because there can be more intermediate subgroups between the three primary strategy. The competitive-ruderal strategy has traits that are from both the competitor and ruderal strategies. They can be moderately tall, have a moderate density of canopy, spread laterally, and also have prolific reproduction through sexual reproduction. Many emergent wetland plant species would find this intermediate strategy the best. Most wetlands have intermittent flooding which would make it desirable for a species to mature quickly and have germinable seeds that can float away to more desirable locations. Just as it would be desirable to spread laterally, be long-lived, and tall.

The PCA performed on **34 species** (Figure 2) using ranked data with 9 attributes showed a similar trend. The *Scirpus* species are grouped together and the *Polygonum* species are grouped loosely together. The two *Paspalum* species are near each other and the two *Sagittaria* species are together. Five groups are found. The **first** group is situated in the upper right corner and consists of annual species that have high final germination proportions, high maximum germination, low seedling mortality, and short lag times and time to 50% germination values. The **second** group is found in the upper left corner and consists of species that had very low final germination proportions, low maximum germination, and long lag times and time to 50% germination values. The upper portion of this group are annuals and the lower portion of the group are perennials. The **third** group consists of the *Scirpus* spp. and *Conium maculatum.* This group consists of perennial species that have high seedling mortality and medium values for final germination proportion, maximum germination, lag times, and time to 50% germination. The **fourth** group consists of the *Polygonum* and *Paspalum* species and *Typha domingensis.* This group consists of species that have medium to low values for final germination proportion and medium to high values for lag time and time to 50% germination. The **fifth** group consists of *Rumex crispus, Mentha pulegium, Cyperus eragrostis, Artemisia douglasiana, Epilobium ciliatum, Eclipta prostrata,* and *Bidens frondosa.* These are species that are mostly perennials that have medium to high values for final germination proportion and maximum germination. They have mèdium to low values for lag times and time to 50% germination. *Juncus balticus* is positioned in between group five and three. *Phragmites australis* is positioned between groups five and four.

The PCA (Figure 2) explained 73.2% of the variance within the first three axes. The first axis (Eigenvalue=3.812, Broken-stick eigenvalue=2.829, % of Variance=42.4) was primarily compromised of growth chamber final germination proportion (r=0.874), greenhouse final germination proportion (r=0.926), maximum germination (r=0.704), lag time (r=-0.889), and time to 50% germination (r=-0.861). In Axis 1, the top three positions are held by species with high final germination proportions, high maximum germination, and short lag times and time to 50% germination values while the bottom three positions are vice versa.

The second axis (Eigenvalue=1.556, Broken-stick eigenvalue=1.829, % of Variance=17.3) was primarily compromised of annual/perennial (r=-0.683) and proportion of seedling mortality (r=-0.819). In Axis 2, the top three positions are held by annual species that had low seedling mortality and the bottom three positions are held by perennial species that had high seedling mortality.

The third axis (Eigenvalue=1.220, Broken-stick eigenvalue=1.329, % of Variance=13.56) was primarily compromised of seed weight (r=-0.796). In Axis 3, the top three positions are held by species that had light seeds and the bottom three positions are held by species that had heavy seeds.

For the PCA for 34 species (Figure 2) using 9 attributes, Axis 1 separates the species according to final germination proportions, maximum germination rates, lag times, and time to 50% germination. Axis 2 separates species according to annual/perennial and seedling mortality. Axis 3 separates species according to their seed weights.

Group one (Figure 2) is comprised of *Lepidium latifolium, Polypogon monspeliensis, Lythrum hyssopifolium,* and *Echinochloa-crus-galli.* This group consists of species that have high final germination proportions. This group also has short lag times and time to 50% germination. Seedling mortality was very low in this group. This group has ruderal tendencies. This group has characteristics of the ruderal strategy.

Group two (Figure 2) is comprised of *Baccharis douglasii, Aster subulatus, Juncus bufonis, Sagittaria* spp., *Echinodorus berteroi, Carex barbarae, Alisma plantago-aquatica,* and *Crypsis schoenoides.* This group consists of species that either never germinated or had very low final germination proportions that have light seeds. It unclear what strategy this group has characteristics of due to the lack of germination.

Group three (Figure 2) consists of perennial (and biennial) species that had short to medium values for final germination proportions and short to medium lag times and time to 50% germination. This group consists of *Scirpus* spp. and *Conium maculatum.* This group has high seedling mortality. This group has characteristics of the competitor strategy.

Group four (Figure 2) consists of *Polygonum* species, *Typha domingensis*, and *Paspalum* species. This group is distinguished between group three by having less seedling mortality and lower final germination proportions and maximum germination rates. This group has medium to high values for lag times and time to 50% germination. This group has characteristics of the CSR- stress-tolerators (except Typha domingensis which should be in the competitor group).

Group 5 (Figure 2) consists of *Mentha pulegium, Rumex crispus, Cyperus eragrostis, Artemisia douglasiana, Epilobium ciliatum, Eclipta prostrata* and *Bidens frondosa.* This group has medium to high final germination proportions and maximum germination rates. Lag times and time to 50% germination values are lower. This group also has lower seedling mortality than group three. This group has characteristics of the competitive-ruderal strategy.

Juncus balticus, which is between groups three and five, has less seedling mortality than group five but more seedling mortality than group three. It also has slightly final germination proportions and maximum germination rates than group three. *Phragmites australis*, which is between groups four and five, has lower final germination proportions than group five but higher than group four.

Comparison's to Grime's CSR triangular ordination

Comparisons to Grime's (1974) triangular ordination model using his dichtomous key (1986) and observations of adult plants gave mixed results (Figure 3). The majority of species were found to be of competitive-ruderal (C-R) strategy (*C. eragrostis, R. crispus, L. latifolium, C. maculatum, M. pulegium,* and *A. douglasiana*). The *Scirpus* spp. and *J. balticus* were found to be competitors (C). *P. monspeliensis, E. crus-galli, B. frondosa,* and *E. prostrata* were found to be ruderals (R). *L. hyssopifolium* was found to be stress-tolerating-ruderal (S-R) and the *Polygonum* spp. were found to be stress-tolerating-CSR strategy.

The majority of the species were found to be competitive-ruderals. There were no stress-tolerators. There were no real short-stature species or species that are found in bogs. Stress-tolerators have low reproduction capabilities which may impact seed viability and scarification and stratification needs. A specific environment may be necessary in order for these seeds to germinate. Because ruderals devote a large proportion of their energy to seed production and reproduction, these seeds are more likely to germinate and more rapidly. Competitors produce some seed but also may require specific scarification and/or stratification in order for their seeds to germinate. The combination of these two strategies may produce plants that are in varying degrees large, long-lived and possess easily germinable seeds. This competitve-ruderal strategy may be most desirable for emergent wetland plants.

Germination

Studies by Grime et. al (1981), Shipley et. al (1989), and Shipley and Parent (1991) have found five trends: (1) annuals have shorter time to 50% germination values than perennials; (2) time to 50% germination values and lag times increased with average seed weight in interspecific comparisons; (3) species with high seedling RGR values tended to have shorter time to 50% germination values and lag times; (4) annuals have greater final germination proportions than perennials; and (5) annuals have greater RGR values than perennials.

This study corroborated many trends that other authors of similar studies had found: (1) Seed weight is positively correlated with time to 50% germination and lag times (excluding *Scirpus* spp., *Bidens frondosa*, and *Echinochloa crus-galli*); (2) time to 50% germination is negatively correlated with seedling RGR (excluding *Polygonum* spp., *Eclipta prostrata*, and *Rumex crispus*; (3) Annuals have a greater seedling RGR than perennials.

We did not find that annual species had significantly shorter time to 50% germination values or that annuals had significantly higher final germination proportions than perennials. The reason for this may be due to the scarification of the *Polygonum* and *Scirpus* species. This increased the likelihood of germination and speeded up the process by softening the fruit wall or seed coat. This study did not find any relationship between lag time and RGR.

Some of the relationships found in other similar studies were found in this study. Species with high final germination proportions had higher maximum germination rates and shorter lag times and time to 50% germination. Species that took longer to first start germinating (longer lag times) took longer to get 50% of their germinable seeds to germinate (time to 50% germination). Species that had more seeds germinating in one day (high maximum germination rate) had shorter time to 50% germination values. This study had found that native species had a lower final growth chamber germination proportion than exotic species.

There was a difference in final germination of the growth chamber between native and exotic species. Exotic species had a higher final germination proportion (Figure 4B) (p=0.095). Native species had a mean final germination in the growth chamber of 31.0% while exotic species had a mean final germination in the growth chamber of 59.4%.

Several species had higher final germination proportions in the growth chamber experiment than the greenhouse experiment. These include: *Bidens frondosa* (+6.%), *Conium maculatum* (+46%), *Echinochloa crus-galli* (+11%), *Eclipta prostrata* (+15%), *Lythrum hyssopifolium* (+38%), *Polypogon monspeliensis* (+10%), *Epilobium ciliatum* (+8%), *Phragmites australis* (+4%), *Polygonum hydropiperoides* (+22%), *Sagittaria sanfordii* (47%), *Scirpus acutus* (+10%), and *Rumex crispus* (+15%). This may be due to more optimum conditions in the growth chamber (increased moisture, less oxygen, less daylight, and constant temperatures) or it could be attributed to the aging of the seeds. It is known that recalcitrant seeds such as *Sagittaria* species age quickly and soon die and also germinate more under flooded conditions.

Several species had higher final germination proportions in the greenhouse than the growth chamber. These species include *Juncus bufonis* (+16%), *Polygonum lapathifolium* (+16%), *Polygonum punctatum* (+8%), *Polygonum persicaria* (+52%), *Cyperus eragrostis* (+10%), *Mentha pulegium* (+28%), *Scirpus maritimus* (incorrectly identified as *Scirpus fluviatilis*) (+23%), and *Lepidium latifolium* (+7%). The increased final germination proportion for the greenhouse experiment may be due to a longer incubation period (12 weeks for greenhouse and 7 weeks for growth chamber). This is probably the case for the *Polygonum* spp. in which most of their germination occurred towards the end of the greenhouse experiment. Conditions were different for the greenhouse. Natural light was used as well as the natural light and dark regime. Temperatures fluctuating between day and night and the seeds were subjected to ample quantities of oxygen. The seeds were not flooded but rather drawdown conditions with nutrient enriched water as compared to distilled water. UC Mix was used rather than filter paper as a substrate for the seeds to germinate upon. There are numerous parameters that may have caused these differences between the two experiments. Each species responds to each of these parameters differently and has it's own optimum conditions.

Correlations (n=34 species unless otherwise noted) were found between final germination proportions, maximum germination rates, and lag times. Species with high final growth chamber germination proportions had higher maximum germination rates (r=0.652) and shorter lag times (r=-0.553) and time to 50% germination (n=21 species r=-0.587). Similar correlations were found between final greenhouse germination proportions and maximum germination rates (r=0.794), lag times (n=21 species, r=-0.811), and time to 50% germination (n=21 species r=-0.557). A positive correlation was found between lag time and time to 50% germination (r=0.784). Species with higher maximum germination rates had lower time to 50% germination values (n=21 species, r=-0.623). Positive correlations were found between time to 50% germination values and leaf area (21-day-old seedling) (n=21 species r=0.722), leaf weight (21-day-old seedling) (n=21 species r=0.751), and plant weight (21-day-old) (n=21 species r=0.726).Annuals (0.004) were found to have a lower mean seedling mortality proportion than perennials (0.046) (total n=21 species, r=0.098).

A very weak positive relationship was found between **seed weight** and **time to 50% germination** values (n=21 species, r=0.605). When seed weight is plotted against time to 50% germination, some outliers appear (Figure 5). The *Scirpus* species, *Echinochloa crus-galli*, and *Bidens frondosa* all have heavier seeds and short time to 50% germination values. When these species are removed, a stronger positive correlation is found between seed weight and time to 50% germination (n=16 species r=0.738) and lag time (n=16 species r=0.741). But when analyzed as one group, seed weight was not as strongly associated with time to 50% germination and not correlated at all with lag time. Seed weight was not correlated with any other attributes. It has been reported that seed weight does not relate to other generation attributes in which there are widely overlapping ranges of seed weight between annuals and perennials (Shipley & Parent 1991). In this study, there was no significant difference between seed weights of annual and perennial species. Shipley and Parent (1991) found that annuals with large seeds showed germination attributes typical of other annuals and obligate perennials with small seeds exhibited germination attributes typical of other obligate perennials.

When native and exotic species were analyzed separately (total n=34 species), native annuals (27.6 days) had longer mean **time to 50% germination** values than native perennials (11.08 days)

(Figure 6J) (p=0.011). A less strong but consistent relationship was found using the smaller sample size (n=21 species) (r=0.080).

Growth Characteristics

This study also recorded several regeneration parameters the other studies did not. By measuring leaf area of 21-day-old seedlings and dry weight of 7- and 21-day-old seedlings, several parameters could be calculated. Relative growth rate (RGR), leaf area ratio (LAR), specific leaf area (SLA), leaf mass ratio (LMR) and net assimilation rate (NAR) were calculated. This study found many trends that corroborated other studies' findings. Such trends include a negative correlation with seedling RGR and time to 50% germination and that annuals have greater RGR values than perennials.

Annual species (260.3 mg) had greater values for mean seedling weight (21-day-old) than perennials species (98.9 mg) (Figure 6B) (total n=21 species, p=0.092). When native and exotic species were analyzed separately, native annuals (289.6 mg) had larger mean values for **seedling weight** (21-day-old) than native perennials (79.0 mg) (p=0.066). When natives and exotics were analyzed separatedly, native annual (46.5 cm^2) species had greater mean **leaf area** (21-day-old) (Figure 6D) than native perennial species (14.0 cm^2) (r=0.068). Positive correlations were found between seedling and leaf weights (21-day-old) (n= 21 species r=0.981) and leaf area (21-day-old) (n=21 species r=0.959).

Several differences in growth characteristics between annual and perennial species were found. Annuals (0.296 $gg^{-1}day^{-1}$) were found to have higher mean **RGR** values than perennials (0.231 $gg^{-1}day^{-1}$) (Figure 6K) (total n=21 species p= 0.026). When native and exotics were analyzed separatedly, it was found that native annuals (0.308 $gg^{-1}day^{-}1$) had higher mean RGR values than native perennials (0.222 $gg^{-1}day^{-1}$) (total n=13 p=0.053). Other studies had shown that annuals have higher seedling **RGR** values and this study found an interaction between native/exotic and annual/perennial on seedling RGR values. The highest seedling RGR mean values were found for the native annuals and the lowest seedling RGR mean values were found for native perennials. There are some potential outliers such as *Lepidium latifolium*, *Cyperus eragrostis* and *Polygonum hydropiperoides* that are perennials but had significantly high seedling RGR values. It may be questioned whether these species should be considered facultative annuals. RGR was also found to be weakly negatively correlated with seedling mortality (r=-0.597).

When **RGR** is plotted **against time to 50% germination** two groups emerge (Figure 7). The small group consists of *Polygonum* species, *Rumex crispus*, and *Eclipta prostrata*. The large group consists of the remainder of the species. Negative correlations are found between RGR and time to 50% germination (n=15 species r=-0.732) in the large group and in the small group (n=6 species r=-0.972). Though, the relationship between RGR and time to 50% germination is much stronger in the large group, slope of –0.0128 while the slope of the small group is –0.0047). Because the *Polygonum* species had been subject to scarification, this may have decreased the time to 50% germination values or indirectly affected the seedling RGRs.

Annuals (0.431 gg^{-1}) were found to have lower mean **LMR** (Figure 6O) values than perennials (0.535 gg^{-1}) (total n= 21 species p=0.061). This trend was also detected when natives and exotics were analyzed separatedly. Exotic perennials (0.408 $gg^{-1}day$) had higher mean LMR values than exotic annuals (0.570 gg^{-1}) (total n=7 p=0.040).

Annuals (18.47 $gm^{-2}day^{-1}$) were found to have higher mean **NAR** (Figure 6P) values than perennials (12.33 $gm^{-2}day^{-1}$) (total n=21 p=0.017). A similar trend was found when natives and exotics were analyzed separately. Exotic annuals (18.39 $gm^{-2}day^{-1}$) had higher mean NAR values than exotic perennials (11.71 $gm^{-2}day^{-1}$) (total n=7 species p=0.040). Relative growth rate is equal to the product of LAR and NAR. NAR is mainly the net result of the rate of carbon gain in photosynthesis per unit leaf area and that of carbon use in respiration of leaves, stems, and roots. High NAR values reflect high photosynthesis and/or low plant respiration. Slow-growing species use relatively more of their carbon for respiration, whereas fast-growing species use a relatively greater proportion of assimilated carbon in new growth, especially leaf growth. It was found that annuals had higher mean NAR values than perennial species.

A positive correlation (all n=21 species) was found between LAR and LMR (r=0.821). A negative correlation was found between LAR and NAR (r=-0.730). Negative correlations were found between NAR and SLA (r=-0.550) and LMR (r=-0.554 p=0.091). NAR was positively correlated with seedling weight (r=0.639). Additionally, some weak correlations were found between growth characteristics and germination characteristics. Seed weight was negatively correlated with LAR (r=-0.610). Maximum germination rate is positively correlated with LAR (r=0.646).

Biomass Production of Mature Plants

The aboveground biomass of nineteen species was collected during the time of maximum biomass development from various locations throughout the Central Valley (see Table 2 for list of locations and names of plant species sampled). In addition to biomass sampling, we recorded the average plant height and percent cover. Data for the twelve species for which we have replicated values are summarized in Figure 8. *Scirpus acutus* was the most productive species with the mean biomass of 1146 g m^{-2} in the range of 60 to 3738 g m^{-2}. High biomass of this species is a result of a robust, tall growth of its stems often reaching over 2m in length. *Scirpus fluviatilis, Juncus balticus, Cyperus Eragrostis* and *Typha domingensis* were mean biomass producers with the mean values in the range of 600 to 800 g m^{-2}.

The mean biomass of broadleaved macrophytes (e.g., *Polygonum* spp., *Bidens frondosa*) ranged from roughly 200 to 400 g m^{-2}. Surprisingly, the rapidly growing invasive species *Lepidium latifolium* collected at two locations was found to have a low biomass of only about 50 g m^{-2}. This low biomass was probably a result of low percent cover (*Lepidium* was not dominant at the two sampled locations) and relatively low stature of the plants (see Figure 8). The aboveground biomass ranges found in this study compare well with values reported for emergent macrophytes in other temperate wetlands (Dykyjova and Kvet 1978).

When the plants were grouped according to their perennial/annual and native/exotic status into four groups: native perennial (NP), native annual (NA), exotic perennial (EP), and exotic annual (EA), there was a significant difference in biomass between annual and perennial species, while there was no difference in biomass between native and exotic species (Figure 9).

Biomass in most species was closely correlated with plant cover. Less tight but still significant correlation was found between the amount of nitrogen in soil and biomass. There was a trend of increasing biomass with increasing concentration of phosphorus in soil. Figures 10 and 11 show these correlations for *Typha domingensis* and *Cyperus eragrostis*.

Stronger correlation between biomass and soil nitrogen rather than soil phophorus indicates that plants are probably more limited by nitrogen than by phosphorus (see next chapter). In the areas where phopshorus is the main limiting nutrients, biomass is more strongly correlated with soil phopshorus than with soil nitrogen (Rejmankova, unpublished data).

Soil and Plant Nutrient Content

All the wetlands where the plant biomass was collected (for the complete list see Table 2) are characterized by mineral soils with quite low proportion of organic material (0.9 to 5.2% of total carbon). The total soil nitrogen is relatively low (0.05 to 0.37%), while total soil P is relatively high (0.03 to 0.1%). This results in a low N:P ratio ranging from 1.4 to 6.8. Mean values of soil characteristics for individual sampling locations are summarized in Table 3. Carbon, nitrogen and phosphorus in soils are tightly correlated indicating that most of N and P is present in organic material (Figure 12)

Tissue nitrogen and phosphorus content of the species sampled is presented in Table 5. The highest amount of nitrogen was found in an aquatic species, *Echinodorus berteroi*, while *Juncus balticus* had the lowest N content. *Juncus balticus* had also the lowest P tissue content. Both tissue nitrogen and phosphorus are well above the critical concentration of these nutrients (1.3% and 0.13% for N and P respectively; Gerloff and Krombholz 1966). This means that there is generally enough nutrients available for these wetland plants in the Central Valley wetland ecosystems and their growth is limited by other factors than nutrients, most probably light and water availability during the summer drought. If there is a nutrient limitation then it would be rather nitrogen than phosphorus (see the N:P ratio in plant biomass ranging from 5 to 12).

Tissue nitrogen and phosphorus found in mature leaves and the amount of these elements resorbed from leaves after senescence does not show significant differences between individual growth forms (Figure 13) with the exception of higher nitrogen content in leaves of aquatic emergents represented by *Echinodorus berteroi* (see above). When plants are grouped based on their native *vs.* exotic origin and perennial *vs.* annual status, native annuals and exotic perennials tend to have more N and P in their tissue (see Figure 14). Nitrogen resorption from senescing tissues is relatively high compared to phosphorus. This again indicates that nitrogen may be slightly limiting in these wetland ecosystems.

Nutrient Experiment

For abbreviation purposes, lowercase letters represent a low nutrient treatment and uppercase letters represent a high nutrient treatment. For example, np-flooded indicates the low nitrogen, low phosphorus flooded treatment and NP-drawdown indicates the high nitrogen high phosphorus drawdown treatment. Additionally, the grouping that consists of nitrogen, phosphorus, and water level will be referred to as treatment and the grouping that consists of nitrogen and phosphorus (no water level) will be referred to as N*P.

<u>Separation by species (Grouping one)</u>

Comparisons were performed between species (Table 6) in order to determine the inherent differences between each species. It showed some significant differences in biomass (total, leaf, stem and below-ground biomasses), size (root/shoot ratios, total length and number of leaves) and growth parameters (leaf area, LAR, SLA, and LMR) between the five species regardless of the treatment. Because these ANOVAs separated all the parameters only by species, few significant differences were found in nutrient tissue concentrations. There were differences in above-ground nitrogen concentrations between *E. crus-galli* and *L. latifolium* (p=0.009), *C. eragrostis* (p=0.007), and *P. australis* (p=0.008). *E. crus-galli* (1.16 %) had the lowest nitrogen concentration while *P. australis* had the highest nitrogen concentration (2.30 %). *L. latifolium,* which could be a ruderal, had a high nitrogen concentration in the above-ground tissue (2.29) and *B. frondosa* had a low N concentration in the above-ground tissue (1.69%). No differences were found between species for above-ground carbon (C) and phosphorus concentrations and nitrogen/phosphorus ratios (N:P).

Separation by water level (Grouping two)

When the data set was separated by treatment, there was a difference in leaf mass between NP-flooded and NP-drawdown (p=0.016) (Table 7). Most of the significant differences caused by water level were found for *C. eragrostis* (Table 10) for the NP-treatments. There were differences for *C. eragrostis* as well as other species between the NP-flooded and NP-drawdown treatments for biomass (*C. eragrostis* p=0.008, *P. australis* p=0.021), leaf mass (*C. eragrostis* p=0.001, *P. australis* p=0.042), stem mass (*C. eragrostis* p=0.012, *P. australis* p=0.026), below-ground mass (p=0.038), total length (*C. eragrostis* p=0.035, *P. australis* p=0.003), number of leaves (*C. eragrostis* p=0.001, *P. australis* p=0.006), leaf area (p<0.001), LAR (*C. eragrostis* p<0.001, *L. latifolium* p=0.032), and SLA (p<0.001). There were some difference between the Np-flooded and Np-drawdown treatments for leaf area (*B. frondosa* p=0.019, *L. latifolium* p=0.046,). There were additional differences between the nP-flooded and nP-drawdown for SLA (p=0.002) and LMR (p<0.001) for *L. latifolium*.

When each parameter was analyzed separately, water level had a few effects. Differences in root/shoot (*B. frondosa* p=0.003), number of leaves (*E. crus-galli* p=0.046, *L. latifolium* p=0.046), leaf area (*C. eragrostis* p=0.044), LAR (*C. eragrostis* p=0.003, *L.latifolium* p=0.004), LMR (*L. latifolium* p=0.018) and SLA (*C. eragrostis* p=0.020, *L. latifolium* p<0.001) were found when separated by water level. Clearly, water level alone is not a strong enough factor to significantly change any of the parameters. But when in conjunction with N and/or P, differences are found in most of the parameters. There also may be an interaction with water level and high concentrations of nutrients because there were no differences in parameters between the low nutrient treatments (np-flooded and np-drawdown).

Separation by treatment (N,P, and water level) (Grouping three)

There were a total of eight treatments and comparisons between them showed many differences (Table 7). There were many differences in biomass measurements between treatments. For total biomass, it appears that water level did not play a very significant role as compared to nitrogen and then on a lesser level phosphorus. The np-flooded treatment was significantly different from the NP treatments (flooded p<0.001, drawdown p=0.001). A weaker relationship was found for np-drawdown. Np-drawdown was significantly different from nP- flooded (p=0.010). nP-drawdown was significantly different from NP-flooded (p<0.001). Similar results were found for the root/shoot ratios and leaf, stem, and below-ground biomasses. Weaker relationships were found for the total length and number of leaves as well. No differences were detected for leaf area, SLA, LAR, and LMR. This is due to the inherently large differences in each of these between species.

When comparing nutrient concentrations, very few differences were found among treatments. There were no differences in above-ground C concentrations. For above-ground phosphorus concentrations, several differences were found. np-drawdown was different from Np-flooded ($p=0.016$) and Np-drawdown ($p=0.024$). Np-flooded was different from nP-flooded ($p=0.004$) and nP-drawdown ($p=0.003$). Np-drawdown was different from nP-flooded ($p=0.006$) and nP-drawdown ($p=0.005$). The treatments with nP had much higher phosphorus concentrations than the Np treatments.

Many differences were found between treatments for above-ground N:P. The np treatments had significantly lower N:P than the Np treatments (all four $p<0.001$). The Np treatments had significantly higher N:P than the nP treatments (all four $p<0.001$). These treatments also had marginally higher N:P than NP-drawdown ($p=0.021$, $p=0.025$). nP-flooded had lower N:P than NP-flooded ($p=0.008$) and NP-drawdown ($p=0.018$). nP-drawdown had lower N:P than the NP-flooded ($p=0.004$).

When separated by treatment (Table 7), many significant differences were found. It seems for the most part water level did not significantly affect most of the parameters. The biggest differences in total biomass were between the NP and nP-flood and between np and NP treatments with NP-flooded being more significant. This trend carries over for all the other biomass parameters, root/shoot, total length and number of leaves. This seems to point towards plants being more limited for nitrogen. When a plant receives equal treatments of phosphorus, but different treatments of nitrogen the differences are much more dramatic for the majority of the parameters than vice-versa. For the nutrient parameters, the majority of the differences were found for above-ground N:P. These individual differences are found between the np and Np treatments, between Np and nP (and some NP) treatments, and between nP and NP treatments. So, in another words, there were no differences between the np and NP treatments for N:P. Some of these trends are echoed in the above-ground phosphorus concentrations.

Separation by Nitrogen and Phosphorus treatments (excluding water level)

Looking at the different biomasses, many significant differences were found between the four N*P groups (Table 8). For total biomass ($p<0.001$), the np group was significantly different from the Np group ($p>0.001$) and the NP group ($p<0.001$). The Np group was significantly different from the nP group ($p<0.001$). The nP group was significantly different from the NP group ($p<0.001$). Similar results were found for the leaf, stem, and below-ground biomasses.

A weaker and mostly similar relationship was found for root/shoot (Table 8) ($p<0.001$). The np group was different from the Np group ($p=0.021$) and the NP group ($p<0.001$). The NP group was significantly different from the Np group ($p=0.001$) and the nP group ($p<0.001$). For total length ($p<0.001$), the NP group was significantly different from the np group ($p=0.001$) and the nP group

($p<0.001$). For total number of leaves ($p<0.001$), the np group was different from the Np group ($p=0.004$) and the NP group ($p<0.001$). The Np group was different from the nP group ($p=0.003$). The nP group was significantly different from the NP group ($p<0.001$).

For the nutrient parameters (Table 8), no differences were found for C concentrations. For above-ground N concentrations ($p<0.001$), differences were found between the np group and the Np group ($p=0.001$) and the NP group ($p=0.013$). There was a significant difference between the Np group and the nP group ($p=0.001$). There was a difference between the nP group and the NP group ($p=0.012$). For above-ground P concentrations ($p<0.001$), there was a significant difference between the np group and the Np group ($p<0.001$). There were significant differences between the Np group and the nP group ($p<0.001$) and the NP group ($p=0.001$). A marginal difference was found between the nP group and the NP group ($p=0.048$). For above-ground N:P ($p<0.001$), each group was significantly different from each other (all $p<0.001$).

When separated by N*P (Table 8) regardless of water level, some of the similar trends are found as compared to separating by treatment. For total biomass, the only groups that did not have significant differences are between np and nP and between Np and NP. This again shows that different treatments of nitrogen seem to have a much greater effect of plant size and mass while different treatment of phosphorus do not. This pattern is found for the most part for all the biomass parameters, total length, and number of leaves. For root/shoot this pattern is slightly altered by having no significant difference between Np and nP but having a significant difference between Np and NP. No differences were once again detected for leaf area, LMR, SLA, and LAR parameters.

For nutrient parameters, the pattern is slightly altered for each parameter. No differences were detected for either of the C concentrations. For above-ground nitrogen concentration the same pattern is found as total biomass. For above-ground phosphorus concentrations, almost all the groups are different from each other except between np and nP and NP. For above-ground N:P, all the groups are significantly different from each other. So, differences were found for N:P between every group while this is not the case for nitrogen or phosphorus concentrations. No differences were detected between np and nP for both nitrogen and phosphorus concentrations.

Biomass parameters

During the course of the experiment, there were repeated cases of herbivory of varying degrees. When the experiment was first set up, Californian Ground Squirrels (*Spermophilus beecheyi*) grazed *Bidens frondosa, Echinochloa crus-galli*, and *Phragmites australis* in varying degrees. Herbivory later occurred towards the end of the experiment when the plants became too large to be completely enclosed by the protective screening of chicken wire and bird netting.

Each species displayed similarly individual differences as did the entire group. When separated by treatment, the largest differences in total biomass are between np and NP treatments and between NP (flooded) and nP treatments. Each species has other differences between specific treatments as well. *C. eragrostis*, additionally, had a difference in total biomass (leaf, stem, and below-ground biomasses as well) between NP-flooded and NP-drawdown. *Latifolium latifolium* had the most amount of individual differences among the eight treatments. This basic trend is found in leaf, stem, and below-ground biomasses.

When separated by N*P, the only individual comparisons that are not significant are between np and nP and between Np and NP. However, *L. latifolium* does have a difference between nP and Np for total biomass. *P. australis* has no differences between N*P groups. It appears that nitrogen may play a weaker role for biomass of *P. australis* than the other four species.

Root/Shoot

When root/shoot is separated by treatment, similar results as those for total biomass are expected. Only a handful of individual differences are apparent. Most of those are between NP and np and between NP and nP. When separated by N*P, more individual differences are found between groups. *B. frondosa* (Table 9) has no individual differences while *C. eragrostis* (Table 10) has differences between all the groups except between np and nP and between NP and Np. *E. crus-galli* (Table 11) has differences among all the groups except between Np and nP. *L. latifolium* (Table 12) only has differences between np and NP and between np and Np. *P. australis* (Table 13) has only one difference and that is between np and NP. So, it appears that root/shoot is not as strictly controlled by only nitrogen as all the biomass parameters are. There is a higher degree of variability when it comes to treatment and N*P levels as compared to the biomass parameters. Each species chooses to allocate their nutrients slightly differently.

Total length and Number of leaves

When total length is separated by treatment, many differences between individual comparisons are found. However for *B. frondosa* (Table 9), only np-flood and NP-flood are marginally different from each other. For *C. eragrostis* (Table 10), there are significant differences between np (both) and Np (both) and Np (both). There are also significant differences between Np (both) nP (both) and NP-flood and between nP (both) and NP-drawdown. Additionally, there is a difference between NP-drawdown and NP-flooded. *L. latifolium* (Table 12) shows less but a similar pattern of differences as *C. eragrostis* (except there is no difference between the two NP treatments). *P. australis* (Table 13) only shows two differences between individual treatments. There is a difference between Np-drawdown and NP-drawdown and between NP-drawdown and NP-flooded. So it appears that the water level may play a larger role for higher nutrient scenarios.

When total length is separated by N*P, a similar pattern as the biomass parameters is found. For *B. frondosa*, only np and Np are different from one another. For *C. eragrostis* and *L. latifolium*, almost all the groups are significantly different from another except between np and nP. For *E.crus-galli* (Table 11) and *P. australis*, a separation by N*P gives no differences in total length.

When number of leaves is separated by treatment, a similar pattern is found as compared to total length. *B. frondosa* shows no differences among individual treatments. *C. eragrostis* shows a similar pattern of differences among the individual treatments including a difference between NP-flooded and NP-drawdown. All of the differences among individual treatments *for E. crus-galli* are between both the NP treatments and np-flooded and both nP treatments. *L. latifolium* shows many differences among individual treatments. *P. australis* shows a similar pattern of differences among individual treatments as for total length.

When separated by N*P, *B. frondosa* shows the same pattern of differences among individual groups as for total biomass. *C. eragrostis* and *P. australis* shows no differences among individual groups. *E. crus-galli* shows several differences among individual groups while *L. latifolium* only shows two.

Leaf area, LAR, SLA, and LMR

Differences in leaf area are found for all species except *P. australis* when separated by N*P. Differences in leaf area are found for all species when separated by treatment. Each species is affected by varying degress dependent on how leafy a particular species is. *L. latifolium*, is perhaps the most leafy species out of the five so it has the most amount of differences among individual treatments (when separated by treatment).

For *B. frondosa* (Table 9), SLA had the most amount of differences among individual treatments (when separated by treatment) as compared to LAR and LMR. Some of the differences in individual treatments are between np and nP and NP and between nP and NP.

For *C. eragrostis* (Table 10), leaf area itself has the most amount of differences among individual treatments (when separated by treatment) as compared to SLA, LAR, and LMR. The other three parameters only have few differences. The majority of the differences are between NP-drawdown and the other treatments.

For *E. crus-galli* (Table 11), differences were only found for leaf area and LMR. The differences for LMR were very minor and no individual differences were found. The majority of the differences are found when looking at leaf area separated by treatment. The NP treatments had the most individual differences with np and nP.

For *L. latifolium* (Table 12), leaf area had the majority of the differences between individual treatments. Water level seems to have more of an effect for *L. latifolium* as compared to other species for all the leaf area parameters. There was a difference between leaf areas of Np-flooded and Np-drawdown. So therefore, water level may play a significant role in leaf area when in similar nutrient regimes.

When looking at *P. australis* (Table 13), there were only a few differences found for LAR and leaf area. No differences were found for LMR and SLA. *P. australis* was severly impacted by repeatedly herbivory and the plants in treatment six eventually turned yellow.

Nutrient parameters

Differences in nutrient tissue concentration were expected with different levels of nutrient enrichment for each species. For *B. frondosa* (Table 9) , there were differences in above-ground C, nitrogen, and phosphorus concentrations when separated by N*P. The greatest difference in above-ground nitrogen and phosphorus concentrations was between Np and nP. For above-ground N:P, the greatest difference was also between Np and nP. Differences in above-ground N:P were found for all N*P groups except between np and nP.

For *C. eragrostis* (Table 10), there were differences in above-ground C, nitrogen and phosphorus concentrations when separated by N*P for the most part. The greatest difference in above-ground nitrogen concentration was between np and Np. The greatest difference in above-ground phosphorus concentration was between nP and Np. The greatest difference was found in above-ground N:P was between nP and Np or np and Np. So the N:P echoed both the nitrogen and phosphorus concentrations' greatest differences.

CONCLUSIONS

This project provides information on life history strategies of a broad range of inland wetland plants of northern California. This information complements the existing database for eastern North America. It is available for wetland planners, individuals and authorities from various agencies in California to aid in the development of more sophisticated designs for created and restored wetlands.

Comparisons to Grime's triangular ordination model using his dichtomous key and observations of adult plants resulted in assigning the majority of species to the competitive-ruderal (C-R) strategy (*Cyperus eragrostis, Rumex crispus, Lepidium latifolium, Conium maculatum, Mentha pulegium*, and *Artemisia douglasiana*). The *Scirpus* spp. and *Juncus balticus* were placed among competitors (C). *Polypogon monspeliensis, Echinochloa crus-galli, Bidens frondosa*, and *Eclipta prostrata* were found to be ruderals (R). *Lythrum hyssopifolium* was characterized as the stress-tolerating-ruderal (S-R) and the *Polygonum* spp. were found to represent the stress-tolerating-CSR strategy.

The aboveground biomass ranges found in this study compare well with values reported for emergent macrophytes in other temperate wetlands. *Scirpus acutus* was the most productive species with the mean biomass of 1146 g m^{-2} (range of 60 to 3738 g m^{-2}). *Scirpus fluviatilis, Juncus balticus, Cyperus Eragrostis* and *Typha domingensis* were average biomass producers with the mean values in the range of 600 to 800 g m^{-2}. The mean biomass of broadleaved macrophytes (e.g., *Polygonum* spp., *Bidens frondosa*) ranged from 200 to 400 g m^{-2}. Biomass in most species was closely correlated with plant cover. Less tight but still significant correlation was found between the amount of nitrogen in soil and biomass. Stronger correlation between biomass and soil nitrogen rather than soil phophorus indicates that plants are probably more limited by nitrogen than by phosphorus.

While this Technical Completion Report presents most of the information that has been collected over the duration of the project, some data analysis has not been completed yet. A master thesis (Karin Tekel) is close to completion and two papers are in preparation. The information for 34 species summarized in species information sheets has to be viewed as a "work in progress". Additional information will be added as more data are being analyzed.

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Table 1: Growth Chamber and Greenhouse Germination and Seedling Establishment

Species	Native/ Exotic	Annual/ Biennial/ Perennial	Family	Seed weight (mg)	Growth Chamber Pre-G (%)	Green-house G (%)	Died (%)	L (days)	G max (%/day)	t50 (days)	RGR (gg-1day-1)	LAR (m2/kg)	SLA (m2/kg)	LMR (m2/kg)	NAR (g/m2day)	Shoot/ Root 21-day-old
Alisma plantago-aquatica *	N	P	Alismataceae	0.499	0	0										
Artemisia douglasiana	N	P	Asteraceae	0.179	87	86	0	4	0.256	7	0.153	29.02	39.71	0.73	5.27	6.53
Aster subulatus *	N	A	Asteraceae	0.052	0	1	0	42		42						
Baccharis douglasii *	N	P	Asteraceae	0.01	0	0										
Bidens frondosa	N	A	Asteraceae	3.258	63	56	3.6	5	0.161	10	0.267	19.06	50.16	0.38	14.01	2.12
Carex barbarae *	N	P	Cyperaceae	0.351	0	3	0	18		18						
Conium maculatum	E	B	Apiaceae	2.473	63	17	11.8	11	0.294	16	0.148	19.09	33.93	0.56	7.75	5.12
Crypsis schoenoides *	E	A	Poaceae	0.208	0	0										
Cyperus eragrostis	N	P	Cyperaceae	0.101	67	77	0	5	0.273	7	0.321	29.21	50.83	0.57	10.99	3.28
Echinochloa crus-galli	E	A	Poaceae	1.869	97	86	0	4	0.302	6	0.283	16.44	48.14	0.34	17.22	1.97
Echinodorus berteroi *	N	A	Alismataceae	0.277	0	1	0	11		11						
Eclipta prostrata	N	A	Asteraceae	0.350	100	85	0	6	0.129	14	0.382	19.53	43.57	0.45	19.56	2.56
Epilobium ciliatum	N	P	Onograceae	0.104	70	62	0	4	0.339	5	0.255	31.13	42.95	0.72	8.19	3.76
Juncus balticus	N	P	Juncaceae	0.032	53	37	8.1	7	0.324	9	0.252	20.17	36.71	0.55	12.49	4.26
Juncus bufonis &	N	A	Juncaceae	0.025	3	19	0	27	0.316	49						
Lepidium latifolium	E	P	Brassicaceae	0.189	90	97	0	4	0.660	5	0.312	28.77	42.23	0.68	10.84	3.10
Lythrum hyssopifolium	E	A	Lythraceae	0.112	100	62	0	5	0.210	9	0.295	16.10	37.66	0.43	18.33	4.19
Mentha pulegium	E	P	Lamiaceae	0.071	37	65	3.1	4	0.185	7	0.245	22.18	41.31	0.54	11.05	2.67
Paspalum dilatatum *	E	P	Poaceae	0.723	7	4	0	9		35						
Paspalum distichum *	N	P	Poaceae	0.902	3	4	0	7		9						
Phragmites australis	N	P	Poaceae	0.237	60	56	0	6	0.143	12	0.216	16.90	34.99	0.48	12.78	3.73
Polygonum hydropiperoides	N	P	Polygonaceae	2.985	40	18	0	12	0.167	25	0.312	17.80	32.28	0.55	17.53	2.95
Polygonum lapathifolium	N	A	Polygonaceae	1.234	20	36	0	5	0.139	26	0.324	10.77	27.48	0.39	30.07	3.98
Polygonum persicaria	E	A	Polygonaceae	1.813	10	62	0	10	0.113	39	0.283	12.39	30.60	0.41	22.83	2.77
Polygonum punctatum	N	A/P	Polygonaceae	1.105	10	18	0	14	0.278	39	0.259	24.55	40.74	0.60	10.55	4.85
Polypogon monspeliensis	E	A	Poaceae	0.116	93	83	0	4	0.217	7	0.275	18.14	40.73	0.45	15.16	3.04
Rumex crispus	E	P	Polygonaceae	1.486	97	82	0	5	0.073	33	0.299	17.39	34.92	0.50	17.19	4.26
Sagittaria latifolia *	N	P	Alismataceae	0.457	0	0										
Sagittaria sanfordii !	N	P	Alismataceae	0.186	47	0										
Scirpus acutus	N	P	Cyperaceae	1.316	50	40	5.0	6	0.175	14	0.120	16.04	57.89	0.28	7.48	1.40
Scirpus californicus *	N	P	Cyperaceae	0.694	3	3	33.3	9		14						
Scirpus maritimus(ID as *fluviatilis*)	N	P	Cyperaceae	3.242	16	39	10.3	7	0.179	13	0.200	10.77	22.47	0.48	18.58	2.84
Scirpus maritimus	N	P	Cyperaceae	3.060	50	52	20.9	7	0.135	14	0.166	8.26	25.95	0.32	20.09	4.39
Typha domingensis *	N	P	Typhaceae	0.061	3	2	0	4		4						

* = less than 10% final germination proportion for both growth chamber and greenhouse

& = less than 10% final growth chamber germination proportion

! = less than 10% final greenhouse germination proportion

Table 2: List of species sampled in summer 2000 and their abbreviations

	Used in Seed Germination Exp.	Native/ Exotic	Annual/ Biennial/ Perennial	Abbreviation
Artemsia douglasiana	X	N	P	Ad
Bidens frondosa	X	N	A	Bf
Cyperus eragrostis	X	N	P	Ce
Echinochloa crus-galli	X	E	A	Ec
Echinodorus berteroi	X	N	A	Eb
Epilobium ciliatum	X	N	P	Eci
Juncus balticus	X	N	P	Jb
Lepidium latifolium	X	E	P	Ll
Ludwigia peploides		N	P	Lp
Lycopus americanus		N	P	La
Lythrum hyssopifolium	X	E	A	Lh
Paspalum dilatatum	X	E	P	Pdl
Paspalum distichum	X	N	P	Pds
Polygonnum hydropiperoides	X	N	P	Ph
Polygonum lapthifolium	X	N	A	Pl
Polygonum punctatum	X	N	A or P	Pp
Rumex crispus	X	E	P	Rc
Sagittaria latifolia	X	N	P	Sl
Scirpus acutus	X	N	P	Sa
Scirpus fluviatilis		N	P	Sf
Scirpus maritimus	X	N	P	Sm
Typha domingensis	X	N	P	Td

Table 3: Soil moisture and bulk density of field samples from summer 2000

date	location	site	species	can vol. (cm3)	can #	tot. wet soil (g)	tot. dry soil (g)	can wt. (g)	% soil moisture	bulk density (g/cm3)	can vol. (cm3)	can #	tot. wet soil (g)	tot. dry soil (g)	can wt. (g)	% soil moisture	bulk density (g/cm3)
29-Jun-00	Yolo Bypass	seasonal marsh along agr creek	*Cyperus eragrostis*	360	96	169.75	125.69	27.55	44.90	0.273							
29-Jun-00	Yolo Bypass	seasonal marsh along agr creek	*Typha domingensis*	360	5	212.49	191.69	27.38	12.66	0.456							
29-Jun-00	Yolo Bypass	seasonal marsh along agr creek	*Scirpus fluviatilis*	360	22	208.76	153.32	28.79	44.52	0.346							
29-Jun-00	Yolo Bypass	seasonal marsh along agr creek	*Paspalum distichum*	360	92	204.50	143.68	27.71	52.45	0.322							
29-Jun-00	Yolo Bypass	along permanent pond	*Echinochloa crus-galli*	360	4	291.70	179.33	28.47	74.49	0.419							
29-Jun-00	Yolo Bypass	along permanent pond	*Polygonum lapathifolium*	360	90	292.72	190.05	28.50	63.55	0.449							
29-Jun-00	Yolo Bypass	edge of Bud Pail Pond	*Scirpus acutus*	360	8	268.63	154.32	27.71	90.29	0.352							
13-Jul-00	Delevan	edge of permanent pond	*Scirpus fluviatilis*	360	98	203.05	143.36	28.06	51.77	0.320							
13-Jul-00	Delevan	edge of permanent pond	*Bidens frondosa*	360	96B	251.72	168.19	27.73	59.47	0.390							
13-Jul-00	Delevan	edge of permanent pond	*Polygonum lapathifolium*	see Sci flu													
13-Jul-00	Delevan	edge of permanent pond	*Lycopus americanus*	see Sci flu													
13-Jul-00	Delevan	edge of permanent pond	*Lythrum hyssopifolium*	see Sci flu													
13-Jul-00	Delevan	edge of permanent pond 2	*Polygonum hydropiperoides*	N/A	Z	246.01	212.29	54.62	21.39		N/A	Z	212.90	175.60	55.02	30.93	
13-Jul-00	Delevan	edge of permanent pond 2	*Paspalum distichum*	360	3	250.59	178.73	28.19	47.73	0.418	360	9B	294.11	218.25	28.99	40.09	0.526
13-Jul-00	Delevan	*Echinochloa* garden	*Echinochloa crus-galli*	360	2	240.24	185.58	27.87	34.66	0.438	360	16B	234.64	188.13	28.61	29.15	0.443
13-Jul-00	Delevan	young permanent pond	*Echinodorus berteroi*	360	90	299.51	182.58	28.07	75.68	0.429	360	13B	313.29	201.29	29.28	65.11	0.478
13-Jul-00	Delevan	edge of young permanent pond	*Scirpus acutus*	360	17	263.94	164.93	29.00	72.83	0.378	360	22B	284.42	158.31	29.11	97.61	0.359
19-Jul-00	Colusa	dry seasonal marsh edge	*Polygonum lapathifolium*	125.66		166.92	147.38	53.96	20.92	0.743							
19-Jul-00	Colusa	dry seasonal marsh edge	*Artemisia douglasiana*	116.24		235.71	209.90	55.07	16.67	1.332							
19-Jul-00	Colusa	edge of permanent pond	*Paspalum dilatatum*	125.66		250.45	201.22	54.59	33.57	1.167							
19-Jul-00	Colusa	edge of permanent pond	*Polygonum hydropiperoides*	125.66		182.04	152.42	53.43	29.92	0.788							
19-Jul-00	Colusa	inside dry seasonal marsh	*Scirpus fluviatilis*	125.66		243.21	210.56	54.98	20.98	1.238							
19-Jul-00	Colusa	inside dry seasonal marsh	*Paspalum distichum*	360	2	247.96	184.28	27.98	40.74	0.434	360	16B	289.61	217.33	29.04	38.39	0.523
19-Jul-00	Colusa	*Echinochloa* garden	*Echinochloa crus-galli*	73.83		169.60	140.08	53.92	34.27	1.167							
19-Jul-00	Colusa	edge of permanent pond	*Cyperus eragrostis*	125.66		184.72	136.40	28.12	44.62	0.862							
19-Jul-00	Colusa	late drying seasonal marsh	*Echinodorus berteroi*	94.25		201.68	172.94	52.85	23.93	1.274							
19-Jul-00	Colusa	edge of permanent pond	*Typha domingensis*	94.25		175.11	141.52	54.40	38.56	0.924							
19-Jul-00	Colusa	edge of permanent pond	*Scirpus acutus*	see Typ dom													
27-Jul-00	Pleasant Grove	slough	*Scirpus acutus*	140		150.00	60.37		148.45	0.431							
27-Jul-00	Pleasant Grove	slough	*Epilobium ciliatum*	74.01		110.00	88.77		23.91	1.199							
27-Jul-00	Pleasant Grove	slough	*Bidens frondosa*	see Epi cil													
27-Jul-00	Pleasant Grove	slough	*Polygonum hydropiperoides*	see Epi cil													
27-Jul-00	Pleasant Grove	canal	*Typha domingensis*	140		170.00	93.20		82.40	0.666							
27-Jul-00	Pleasant Grove	canal	*Polygonum hydropiperoides*	see Typ dom													
27-Jul-00	Pleasant Grove	canal	*Bidens frondosa*	88.1712		128.40	83.69		53.42	0.949							
27-Jul-00	Pleasant Grove	canal	*Polygonum hydropiperoides*	see Bid fro													
27-Jul-00	Pleasant Grove	canal	*Cyperus eragrostis*	see Bid fro													
27-Jul-00	Pleasant Grove	canal	*Scirpus acutus*	140		172.00	93.55		83.87	0.668							
2-Aug-00	Sutter	late-drying seasonal marsh	*Echinodorus berteroi*	141.37		297.72	245.78	54.58	27.17	1.352							
2-Aug-00	Sutter	edge of late-drying seasonal marsh	*Scirpus fluviatilis*	56.55		133.91	119.50	54.35	22.11	1.152							
2-Aug-00	Sutter	inside dried seasonal marsh	*Polygonum hydropiperoides*	109.96		200.92	164.31	53.92	33.17	1.004							
2-Aug-00	Sutter	inside dried seasonal marsh	*Paspalum distichum*	see Pol hyd													
2-Aug-00	Sutter	dried late drying marsh edge	*Cyperus eragrostis*	109.96		203.73	172.53	54.98	26.54	1.069							
2-Aug-00	Sutter	2nd dried marsh edge	*Bidens frondosa*	84.82		140.12	128.31	52.82	15.64	0.890							
2-Aug-00	Sutter	inside dried creek supplying ponds	*Scirpus acutus*	157.08		297.10	224.59	53.39	42.35	1.090							
23-Aug-00	Stone Lakes	near dried small depression	*Polygonum lapathifolium*	130	4	206.65	198.55	28.39	4.76	1.309							
23-Aug-00	Stone Lakes	late drying small depression	*Echinochloa crus-galli*	135.09	60	319.99	265.87	54.99	25.66	1.561							
23-Aug-00	Stone Lakes	late drying small depression	*Typha domingensis*	see Ech cru													
23-Aug-00	Stone Lakes	edge of dried seasonal marsh	*Lepidium latifolium*	131.95	69	220.75	194.31	52.94	18.70	1.071							
23-Aug-00	Stone Lakes	edge of dried seasonal marsh	*Rumex crispus*	see Lep lat													
23-Aug-00	Stone Lakes	edge of Mitigation 2 (semi-perm)	*Cyperus eragrostis*	106.81	116	238.98	170.31	53.92	59.00	1.090							
23-Aug-00	Stone Lakes	upslope of Mitigation 2	*Bidens frondosa*	125.66	129	248.67	186.07	53.40	47.19	1.056							
23-Aug-00	Stone Lakes	upslope of Mitigation 2	*Echinochloa crus-galli*	see Bid fro													
23-Aug-00	Stone Lakes	upslope of Mitigation 2	*Polygonum lapathifolium*	see Bid fro													
23-Aug-00	Stone Lakes	edge of Mitigation 2 (semi-perm)	*Typha domingensis*	94.25	90	190.15	143.04	54.61	53.26	0.938							
23-Aug-00	Stone Lakes	edge of Mitigation 2 (semi-perm)	*Scirpus acutus*	see Typ dom													
23-Aug-00	Stone Lakes	edge of Lewis 4 (semi-perm. pond)	*Echinodorus berteroi*	100.53	71	211.65	149.63	54.36	65.10	0.948							
30-Aug-00	Sac Refuge	edge of permanent pond	*Scirpus acutus*	135.09	60	295.56	234.16	54.98	34.27	1.326							
30-Aug-00	Sac Refuge	edge of permanent pond	*Typha domingensis*	see Sci acu													
30-Aug-00	Sac Refuge	edge of permanent pond	*Scirpus fluviatilis*	125.66	69	302.28	243.83	52.82	30.60	1.520							
30-Aug-00	Sac Refuge	edge of permanent pond	*Echinochloa crus-galli*	see Sci flu													
30-Aug-00	Sac Refuge	dried seasonal marsh	*Polygonum hydropiperoides*	109.96	116	267.98	227.22	54.16	23.56	1.574							
30-Aug-00	Sac Refuge	dried seasonal marsh	*Echinodorus berteroi*	169.65	90	349.10	301.80	54.78	19.15	1.456							
30-Aug-00	Sac Refuge	dried seasonal marsh	*Rumex crispus*	141.37	129	305.82	273.32	53.39	14.77	1.556							
30-Aug-00	Sac Refuge	inside of permanent pond	*Polygonum lapathifolium*	81.68	71	209.55	161.81	54.68	44.56	1.312							
6-Sep-00	Merced	permanent pond	*Typha domingensis*	119.38	27	234.40	167.78	26.98	47.32	1.179							
6-Sep-00	Merced	permanent pond	*Scirpus acutus*	see Typ dom													
6-Sep-00	Merced	edge of permanent pond	*Cyperus eragrostis*	150.80	92	277.12	196.51	27.56	47.71	1.120							

Table 3: Soil moisture and bulk density of field samples from summer 2000

date	location	site	species	can vol. (cm3)	can #	tot. wet soil (g)	tot. dry soil (g)	can wt. (g)	% soil moisture	bulk density (g/cm3)
6-Sep-00	Merced	edge of permanent pond	*Lepidium latifolium*	see Cyp era						
6-Sep-00	Merced	edge of permanent pond	*Polygonum lapathifolium*	163.36	52	315.18	225.08	53.87	52.62	1.048
6-Sep-00	Merced	edge of permanent pond	*Juncus balticus*	106.81	113	241.43	179.59	54.99	49.62	1.167
6-Sep-00	Merced	floating mat edge of perm. Pond	*Scirpus fluviatilis*	72.26	71	197.21	144.03	54.33	59.28	1.241
6-Sep-00	Merced	dried seasonal marsh	*Juncus balticus*	see Sci flu						
6-Sep-00	West Bear Creek	Racoon marsh (perm. Pond)	*Typha domingensis*	147.65	116	369.17	304.60	53.90	25.76	1.698
6-Sep-00	West Bear Creek	Racoon marsh (perm. Pond)	*Juncus balticus*	166.50	129	340.96	299.08	53.36	17.04	1.476
6-Sep-00	West Bear Creek	Racoon marsh (perm. Pond)	*Echinochloa crus-galli*	141.37	69	306.46	265.09	52.78	19.49	1.502
6-Sep-00	West Bear Creek	Racoon marsh (perm. Pond)	*Polygonum lapathifolium*	see Ech cru						
6-Sep-00	West Bear Creek	edge of Lake Sacaton (semi-perm)	*Echinodorus berteroi*	119.38	60	294.17	243.51	54.95	26.87	1.579
6-Sep-00	West Bear Creek	Lake Sacaton (water) semi-perm	*Echinodorus berteroi*	163.36	90	328.85	303.55	54.55	10.16	1.524
13-Sep-00	Cosumnes	Natural Marsh	*Typha domingensis*	97.39	52	191.36	111.39	53.84	138.97	0.591
13-Sep-00	Cosumnes	Natural Marsh	*Scirpus acutus*	122.52	129	203.58	115.45	53.35	141.91	0.507
13-Sep-00	Cosumnes	Natural Marsh	*Polygonum punctatum*	131.95	60	203.60	120.84	54.93	125.56	0.500
13-Sep-00	Cosumnes	Natural Marsh	*Bidens frondosa*	see Pol pun						
13-Sep-00	Cosumnes	Natural Marsh	*Sagittaria latifolia*	see Pol pun						
13-Sep-00	Cosumnes	slough	*Scirpus acutus*	100.53	90	203.02	134.27	54.53	86.22	0.793
13-Sep-00	Cosumnes	dried SE barn pond	*Polygonum lapathifolium*	103.67	69	193.75	186.43	52.76	5.48	1.289
13-Sep-00	Cosumnes	Manmade 1 -across from barn	*Typha domingensis*	100.53	71	222.68	176.28	54.32	38.04	1.213
13-Sep-00	Cosumnes	Manmade 1 -across from barn	*Cyperus eragrostis*	see Typ dom						
13-Sep-00	Cosumnes	NE barn pond	*Scirpus acutus*	97.39	116	210.65	166.61	53.88	39.07	1.157
13-Sep-00	Cosumnes	NE barn pond	*Cyperus eragrostis*	see Sci acu						
13-Sep-00	Cosumnes	NE barn pond	*Typha domingensis*	see Sci acu						
13-Sep-00	Cosumnes	Franklin permanent marsh	*Scirpus acutus*	166.50	113	378.21	311.91	54.96	25.80	1.543
13-Sep-00	Cosumnes	Franklin permanent marsh	*Cyperus eragrostis*	see Sci acu						
20-Sep-00	Merced	floodplain of Mariposa Creek	*Polygonum lapathifolium*	103.67	60	223.74	163.75	54.91	55.12	1.050
20-Sep-00	Merced	floodplain of Mariposa Creek	*Cyperus eragrostis*	100.53	116	258.38	193.08	53.86	46.90	1.385
20-Sep-00	Merced	ag canal near Mariposa Creek	*Scirpus acutus*	119.38	113	254.94	188.71	54.93	49.51	1.121
20-Sep-00	Merced	edge of Duck Slough	*Polygonum lapathifolium*	150.80	90	332.43	259.08	54.50	35.85	1.357
20-Sep-00	Merced	edge of Duck Slough	*Echinochloa crus-galli*	see Pol lap						
20-Sep-00	Merced	edge of Duck Slough	*Scirpus maritimus*	see Pol lap						
20-Sep-00	Merced	edge of Snow Goose Lake	*Typha domingensis*	109.96	69	274.59	212.47	52.73	38.89	1.453
20-Sep-00	Merced	edge of Snow Goose Lake	*Scirpus acutus*	see Typ dom						
20-Sep-00	San Joaquin	Lake White (natural GW fed)	*Typha domingensis*	138.23	129	323.70	250.74	53.34	36.96	1.428

Table 4 Soil characteristics of the sampling sites

Location	n	Total N (%)	Total C (%)	Total P (%)	N:P	C:P
Colusa	11	0.150	1.835	0.069	2.15	26.32
Cosumnes-managed	8	0.119	1.359	0.054	2.51	29.86
Cosumnes-natural	5	0.376	5.243	0.103	3.73	51.96
Delavan	10	0.178	2.594	0.068	2.63	38.07
Merced	16	0.078	1.426	0.057	1.42	26.34
Pleasant Grove	11	0.147	2.081	0.028	6.84	97.52
Sacramento refuge	8	0.083	0.943	0.027	3.10	34.42
Stone Lake	11	0.119	1.309	0.044	2.88	34.93
Sutter	7	0.133	1.820	0.044	3.06	41.87
West Bear Creek	5	0.051	0.644	0.038	1.62	19.50
Yolo Bypass	7	0.210	2.885	0.072	2.53	34.09

Table 5: Tissue nitrogen and phosphorus content

Species	Site	C% live	C % dead	N% live	N%dead	P% live	P% dead	BD g/cm3	soil C%	soil N%	soil P%	N:P live	N:P dead	N:P soil
Artemsia douglasiana	Colusa	46.826	44.793	2.058	1.172	0.406	0.405	1.332	1.676	0.148	0.086	5.06	2.89	1.73
Bidens frondosa	Cos-Nat Marsh	44.497	41.628	2.565	1.145	0.280	0.234	0.500	4.833	0.344	0.110	9.17	4.89	3.14
Bidens frondosa	Delevan	43.351		2.383		0.292		0.320	3.347	0.207	0.069	8.17		3.02
Bidens frondosa	Pl canal	44.391	40.583	1.485	0.874	0.442	0.196	0.949	2.698	0.190	0.045	3.36	4.45	4.22
Bidens frondosa	Pl slough	44.701		3.711		0.427		1.199	0.995	0.070	0.007	8.69		10.46
Bidens frondosa	Stone Lakes M2	43.617	39.751	2.747	1.271	0.562	0.377	1.056	1.283	0.128	0.061	4.89	3.37	2.09
Bidens frondosa	Sutter	45.776	41.304	4.464	1.446	0.670	0.300	0.890	2.057	0.158	0.064	6.66	4.82	2.46
Cyperus eragrostis	Colusa	41.150	39.624	1.328	0.732	0.173	0.105	0.862	1.918	0.157	0.067	7.70	6.98	2.36
Cyperus eragrostis	Cos-Franklin	41.599	40.334	1.947	0.664	0.340	0.070	1.543	0.940	0.076	0.036	5.73	9.53	2.12
Cyperus eragrostis	Cos-Mme 1	42.821	39.694	1.921	1.215	0.244	0.175	1.213	1.656	0.127	0.030	7.86	6.95	4.18
Cyperus eragrostis	Cos-NE barn	40.623	38.150	2.046	1.086	0.545	0.352	1.157	1.193	0.118	0.078	3.75	3.09	1.51
Cyperus eragrostis	Merced	37.721	36.561	1.514	0.603	0.272	0.123	1.120	1.120	0.087	0.053	5.57	4.90	1.63
Cyperus eragrostis	Merced-Mariposa	42.349	38.316	1.924	0.666	0.219	0.089	1.385	3.109	0.035	0.049	8.77	7.51	0.71
Cyperus eragrostis	Pl canal	40.662	39.133	1.214	0.886	0.274	0.135	0.949	2.698	0.190	0.045	4.44	6.58	4.22
Cyperus eragrostis	Stone Lakes M2	40.379	38.330	1.629	0.601	0.223	0.093	1.090	1.629	0.158	0.051	7.30	6.45	3.13
Cyperus eragrostis	Sutter	40.335	42.380	1.552	0.895	0.337	0.095	1.069	2.056	0.136	0.041	4.61	9.41	3.32
Cyperus eragrostis	Yolo	40.168	36.393	0.993	0.706	0.149	0.104	0.273	4.150	0.276	0.097	6.68	6.79	2.84
Echinochloa crus-galli	Colusa	42.532	38.679	1.743	0.515	0.217	0.198	1.167	1.693	0.162	0.067	8.02	2.60	2.42
Echinochloa crus-galli	Delevan	39.759	36.329	1.320	0.643	0.150	0.087	0.441	1.186	0.109	0.068	8.82	7.41	1.60
Echinochloa crus-galli	Merced-Snow Goose	36.330	34.597	1.245	0.361	0.181	0.172	1.357	1.138	0.072	0.058	6.90	2.10	1.24
Echinochloa crus-galli	Sac Refuge	42.347	37.362	2.337	0.989	0.277	0.106	1.520	0.978	0.093	0.023	8.44	9.36	4.09
Echinochloa crus-galli	Stone Lakes	38.933	38.275	2.386	1.211	0.212	0.133	1.561	0.779	0.095	0.033	11.26	9.14	2.92
Echinochloa crus-galli	Stone Lakes M2	40.016	38.164	2.295	2.018	0.411	0.315	1.056	1.283	0.128	0.061	5.58	6.41	2.09
Echinochloa crus-galli	West Bear Creek	38.861	37.593	2.839	0.940	0.231	0.088	1.502	0.878	0.077	0.028	12.32	10.64	2.78
Echinochloa crus-galli	Yolo	41.040	31.656	2.733	1.054	0.430	0.239	0.419	1.877	0.161	0.068	6.36	4.41	2.37
Echinodorus berteroi	Colusa	42.531	39.759	2.115	1.279	0.200	0.135	1.274	1.067	0.112	0.065	10.60	9.46	1.71
Echinodorus berteroi	Delevan	44.357	23.039	4.484	1.698	0.639	0.415	0.454	2.364	0.173	0.067	7.02	4.09	2.57
Echinodorus berteroi	Sac Refuge	45.063	39.802	3.395	1.121	0.141	0.084	1.456	0.644	0.062	0.022	24.09	13.29	2.84
Echinodorus berteroi	Stone Lakes L4	42.278	35.469	3.258	1.404	0.379	0.375	0.948	1.146	0.122	0.029	8.59	3.74	4.19
Echinodorus berteroi	Sutter	43.368	38.919	4.025	1.889	0.338	0.257	1.352	0.936	0.072	0.034	11.90	7.35	2.12
Echinodorus berteroi	West Bear Creek	43.474	38.021	2.194	1.924	0.272	0.157	1.524	0.317	0.038	0.027	8.06	12.24	1.43
Echinodorus berteroi (water)	West Bear Creek	43.009	29.683	2.954	1.954	0.207	0.203	1.579	0.386	0.040	0.027	14.28	9.65	1.50
Epilobium ciliatum	Pl slough	43.304	39.793	1.922	0.853	0.422	0.216	1.199	0.995	0.070	0.007	4.56	3.95	10.46
Juncus balticus	Merced	40.953	41.913	1.439	1.240	0.233	0.168	1.167	1.070	0.067	0.055	6.17	7.40	1.23
Juncus balticus	West Bear Creek	42.783	41.989	1.099	0.398	0.135	0.072	1.476	0.557	0.029	0.048	8.15	5.51	0.60
Juncus balticus w/Sci flu	Merced	44.015	43.417	1.291	0.837	0.127	0.116	1.241	1.974	0.127	0.050	10.17	7.20	2.57
Lepidium latifolium	Merced	38.855	36.638	2.175	0.835	0.424	0.300	1.120	1.120	0.087	0.053	5.14	2.78	1.63
Lepidium latifolium	Stone Lakes	37.477	32.594	1.942	0.870	0.359	0.277	1.071	1.871	0.180	0.052	5.41	3.14	3.48
Ludwigia peploides	Pl slough	43.757	41.438	2.627	1.311	0.288	0.142	0.431	0.995	0.070	0.007	9.14	9.22	10.46
Lycopus americanus	Delevan	45.550	45.398	1.816	1.813	0.421	0.266	0.320	3.347	0.207	0.069	4.31	6.82	3.02
Lythrum hyssopifolium	Delevan	44.041		1.453		0.389		0.320	3.347	0.207	0.069	3.74		3.02
Paspalum dilatatum	Colusa	41.331	35.801	1.793	0.774	0.210	0.212	0.479	2.219	0.167	0.069	8.53	3.65	2.40
Paspalum dilatatum	Sutter	42.675	39.288	2.149	0.903	0.222	0.194	1.004	2.246	0.159	0.043	9.69	4.66	3.67
Paspalum distichum	Colusa	40.519	38.755	1.008	0.594	0.108	0.039	1.167	1.264	0.110	0.066	9.31	15.42	1.68
Paspalum distichum	Delevan	42.492	39.657	1.682	1.226	0.198	0.140	0.472	1.851	0.139	0.074	8.48	8.78	1.87
Paspalum distichum	Yolo	42.911		1.512		0.187		0.322	4.555	0.273	0.097	8.08		2.82
Polygonnum hydropiperoides	Pl canal w/Cyp	45.347	42.480	1.924	0.935	0.226	0.147	0.949	2.698	0.190	0.045	8.53	6.35	4.22
Polygonum hydropiperoides	Colusa	45.210	40.441	2.198	1.133	0.293	0.196	0.788	2.251	0.174	0.073	7.51	5.78	2.40
Polygonum hydropiperoides	Delevan	43.949	39.040	1.826	1.058	0.234	0.215	0.472	1.656	0.144	0.060	7.82	4.91	2.40
Polygonum hydropiperoides	Pl slough	44.723	39.894	1.441	0.835	0.161	0.106	1.199	0.995	0.070	0.007	8.95	7.88	10.46
Polygonum hydropiperoides	Sac Refuge	45.066	43.974	3.607	1.807	0.184	0.177	1.574	0.424	0.048	0.021	19.57	10.19	2.27
Polygonum hydropiperoides	Sutter	44.849	41.558	2.475	0.992	0.215	0.179	1.004	2.246	0.159	0.043	11.52	5.54	3.67
Polygonum hydropiperoides	Pl canal w/Typ	39.859	40.324	2.035	0.639	0.270	0.111	0.666	2.832	0.213	0.048	7.54	5.78	4.41
Polygonum hydropiperoides	Pl canal water	44.868	43.045	2.463	1.052	0.243	0.127					10.12	8.29	

Table 5: Tissue nitrogen and phosphorus content

Species	Site	C% live	C % dead	N% live	N%dead	P% live	P% dead	BD g/cm3	soil C%	soil N%	soil P%	N:P live	N:P dead	N:P soil
Artemsia douglasiana	Colusa	46.826	44.793	2.058	1.172	0.406	0.405	1.332	1.676	0.148	0.086	5.06	2.89	1.73
Bidens frondosa	Cos-Nat Marsh	44.497	41.628	2.565	1.145	0.280	0.234	0.500	4.833	0.344	0.110	9.17	4.89	3.14
Bidens frondosa	Delevan	43.351		2.383		0.292		0.320	3.347	0.207	0.069	8.17		3.02
Bidens frondosa	Pl canal	44.391	40.583	1.485	0.874	0.442	0.196	0.949	2.698	0.190	0.045	3.36	4.45	4.22
Bidens frondosa	Pl slough	44.701		3.711		0.427		1.199	0.995	0.070	0.007	8.69		10.46
Bidens frondosa	Stone Lakes M2	43.617	39.751	2.747	1.271	0.562	0.377	1.056	1.283	0.128	0.061	4.89	3.37	2.09
Bidens frondosa	Sutter	45.776	41.304	4.464	1.446	0.670	0.300	0.890	2.057	0.158	0.064	6.66	4.82	2.46
Cyperus eragrostis	Colusa	41.150	39.624	1.328	0.732	0.173	0.105	0.862	1.918	0.157	0.067	7.70	6.98	2.36
Cyperus eragrostis	Cos-Franklin	41.599	40.334	1.947	0.664	0.340	0.070	1.543	0.940	0.076	0.036	5.73	9.53	2.12
Cyperus eragrostis	Cos-Mme 1	42.821	39.694	1.921	1.215	0.244	0.175	1.213	1.656	0.127	0.030	7.86	6.95	4.18
Cyperus eragrostis	Cos-NE barn	40.623	38.150	2.046	1.086	0.545	0.352	1.157	1.193	0.118	0.078	3.75	3.09	1.51
Cyperus eragrostis	Merced	37.721	36.561	1.514	0.603	0.272	0.123	1.120	1.120	0.087	0.053	5.57	4.90	1.63
Cyperus eragrostis	Merced-Mariposa	42.349	38.316	1.924	0.666	0.219	0.089	1.385	3.109	0.035	0.049	8.77	7.51	0.71
Cyperus eragrostis	Pl canal	40.662	39.133	1.214	0.886	0.274	0.135	0.949	2.698	0.190	0.045	4.44	6.58	4.22
Cyperus eragrostis	Stone Lakes M2	40.379	38.330	1.629	0.601	0.223	0.093	1.090	1.629	0.158	0.051	7.30	6.45	3.13
Cyperus eragrostis	Sutter	40.335	42.380	1.552	0.895	0.337	0.095	1.069	2.056	0.136	0.041	4.61	9.41	3.32
Cyperus eragrostis	Yolo	40.168	36.393	0.993	0.706	0.149	0.104	0.273	4.150	0.276	0.097	6.68	6.79	2.84
Echinochloa crus-galli	Colusa	42.532	38.679	1.743	0.515	0.217	0.198	1.167	1.693	0.162	0.067	8.02	2.60	2.42
Echinochloa crus-galli	Delevan	39.759	36.329	1.320	0.643	0.150	0.087	0.441	1.186	0.109	0.068	8.82	7.41	1.60
Echinochloa crus-galli	Merced-Snow Goose	36.330	34.597	1.245	0.361	0.181	0.172	1.357	1.138	0.072	0.058	6.90	2.10	1.24
Echinochloa crus-galli	Sac Refuge	42.347	37.362	2.337	0.989	0.277	0.106	1.520	0.978	0.093	0.023	8.44	9.36	4.09
Echinochloa crus-galli	Stone Lakes	38.933	38.275	2.386	1.211	0.212	0.133	1.561	0.779	0.095	0.033	11.26	9.14	2.92
Echinochloa crus-galli	Stone Lakes M2	40.016	38.164	2.295	2.018	0.411	0.315	1.056	1.283	0.128	0.061	5.58	6.41	2.09
Echinochloa crus-galli	West Bear Creek	38.861	37.593	2.839	0.940	0.231	0.088	1.502	0.878	0.077	0.028	12.32	10.64	2.78
Echinochloa crus-galli	Yolo	41.040	31.656	2.733	1.054	0.430	0.239	0.419	1.877	0.161	0.068	6.36	4.41	2.37
Echinodorus berteroi	Colusa	42.531	39.759	2.115	1.279	0.200	0.135	1.274	1.067	0.112	0.065	10.60	9.46	1.71
Echinodorus berteroi	Delevan	44.357	23.039	4.484	1.698	0.639	0.415	0.454	2.364	0.173	0.067	7.02	4.09	2.57
Echinodorus berteroi	Sac Refuge	45.063	39.802	3.395	1.121	0.141	0.084	1.456	0.644	0.062	0.022	24.09	13.29	2.84
Echinodorus berteroi	Stone Lakes L4	42.278	35.469	3.258	1.404	0.379	0.375	0.948	1.146	0.122	0.029	8.59	3.74	4.19
Echinodorus berteroi	Sutter	43.368	38.919	4.025	1.889	0.338	0.257	1.352	0.936	0.072	0.034	11.90	7.35	2.12
Echinodorus berteroi	West Bear Creek	43.474	38.021	2.194	1.924	0.272	0.157	1.524	0.317	0.038	0.027	8.06	12.24	1.43
Echinodorus berteroi (water)	West Bear Creek	43.009	29.683	2.954	1.954	0.207	0.203	1.579	0.386	0.040	0.027	14.28	9.65	1.50
Epilobium ciliatum	Pl slough	43.304	39.793	1.922	0.853	0.422	0.216	1.199	0.995	0.070	0.007	4.56	3.95	10.46
Juncus balticus	Merced	40.953	41.913	1.439	1.240	0.233	0.168	1.167	1.070	0.067	0.055	6.17	7.40	1.23
Juncus balticus	West Bear Creek	42.783	41.989	1.099	0.398	0.135	0.072	1.476	0.557	0.029	0.048	8.15	5.51	0.60
Juncus balticus w/Sci flu	Merced	44.015	43.417	1.291	0.837	0.127	0.116	1.241	1.974	0.127	0.050	10.17	7.20	2.57
Lepidium latifolium	Merced	38.855	36.638	2.175	0.835	0.424	0.300	1.120	1.120	0.087	0.053	5.14	2.78	1.63
Lepidium latifolium	Stone Lakes	37.477	32.594	1.942	0.870	0.359	0.277	1.071	1.871	0.180	0.052	5.41	3.14	3.48
Ludwigia peploides	Pl slough	43.757	41.438	2.627	1.311	0.288	0.142	0.431	0.995	0.070	0.007	9.14	9.22	10.46
Lycopus americanus	Delevan	45.550	45.398	1.816	1.813	0.421	0.266	0.320	3.347	0.207	0.069	4.31	6.82	3.02
Lythrum hyssopifolium	Delevan	44.041		1.453		0.389		0.320	3.347	0.207	0.069	3.74		3.02
Paspalum dilatatum	Colusa	41.331	35.801	1.793	0.774	0.210	0.212	0.479	2.219	0.167	0.069	8.53	3.65	2.40
Paspalum dilatatum	Sutter	42.675	39.288	2.149	0.903	0.222	0.194	1.004	2.246	0.159	0.043	9.69	4.66	3.67
Paspalum distichum	Colusa	40.519	38.755	1.008	0.594	0.108	0.039	1.167	1.264	0.110	0.066	9.31	15.42	1.68
Paspalum distichum	Delevan	42.492	39.657	1.682	1.226	0.198	0.140	0.472	1.851	0.139	0.074	8.48	8.78	1.87
Paspalum distichum	Yolo	42.911		1.512		0.187		0.322	4.555	0.273	0.097	8.08		2.82
Polygonnum hydropiperoides	Pl canal w/Cyp	45.347	42.480	1.924	0.935	0.226	0.147	0.949	2.698	0.190	0.045	8.53	6.35	4.22
Polygonum hydropiperoides	Colusa	45.210	40.441	2.198	1.133	0.293	0.196	0.788	2.251	0.174	0.073	7.51	5.78	2.40
Polygonum hydropiperoides	Delevan	43.949	39.040	1.826	1.058	0.234	0.215	0.472	1.656	0.144	0.060	7.82	4.91	2.40
Polygonum hydropiperoides	Pl slough	44.723	39.894	1.441	0.835	0.161	0.106	1.199	0.995	0.070	0.007	8.95	7.88	10.46
Polygonum hydropiperoides	Sac Refuge	45.066	43.974	3.607	1.807	0.184	0.177	1.574	0.424	0.048	0.021	19.57	10.19	2.27
Polygonum hydropiperoides	Sutter	44.849	41.558	2.475	0.992	0.215	0.179	1.004	2.246	0.159	0.043	11.52	5.54	3.67
Polygonum hydropiperoides	Pl canal w/Typ	39.859	40.324	2.035	0.639	0.270	0.111	0.666	2.832	0.213	0.048	7.54	5.78	4.41
Polygonum hydropiperoides	Pl canal water	44.868	43.045	2.463	1.052	0.243	0.127					10.12	8.29	

Table 5: Tissue nitrogen and phosphorus content

Species	Site	C% live	C % dead	N% live	N%dead	P% live	P% dead	BD g/cm3	soil C%	soil N%	soil P%	N:P live	N:P dead	N:P soil
Polygonum lapthifolium	Colusa	45.875	38.070	1.982	1.040	0.215	0.130	0.743	4.493	0.288	0.073	9.20	7.98	3.93
Polygonum lapthifolium	Cos-dry SE barn	45.100	41.008	1.581	0.908	0.104	0.064	1.289	2.098	0.195	0.069	15.27	14.23	2.84
Polygonum lapthifolium	Delevan	44.007	40.530	1.595	0.846	0.219	0.160	0.320	3.347	0.207	0.069	7.27	5.30	3.02
Polygonum lapthifolium	Merced	42.469	37.525	1.761	0.868	0.176	0.122	1.048	1.455	0.096	0.054	10.01	7.14	1.78
Polygonum lapthifolium	Merced-Mariposa	46.913	42.241	1.154	0.918	0.171	0.105	1.050	2.378	0.071	0.054	6.75	8.76	1.32
Polygonum lapthifolium	Merced-Snow Goose	43.709	42.576	1.637	0.691	0.273	0.208	1.357	1.138	0.072	0.058	6.00	3.32	1.24
Polygonum lapthifolium	Sac Refuge	46.017	45.167	2.656	1.406	0.225	0.128	1.312	2.193	0.162	0.036	11.80	10.96	4.54
Polygonum lapthifolium	Stone Lakes	46.101	42.229	2.488	1.399	0.097	0.086	1.309	1.128	0.096	0.052	25.76	16.24	1.84
Polygonum lapthifolium	Stone Lakes M2	39.912	37.037	1.312	1.080	0.258	0.253	1.056	1.283	0.128	0.061	5.08	4.26	2.09
Polygonum lapthifolium	West Bear Creek	46.374	43.954	3.266	1.809	0.230	0.228	1.502	0.878	0.077	0.028	14.18	7.93	2.78
Polygonum lapthifolium	Yolo	38.821		1.970		0.239		0.449	1.775	0.153	0.062	8.26		2.45
Polygonum punctatum	Cos-Nat Marsh	44.644	41.604	1.610	0.932	0.178	0.104	0.500	4.833	0.344	0.110	9.04	8.97	3.14
Rumex crispus	Sac Refuge	39.754	34.516	2.994	1.579	0.228	0.201	1.556	0.978	0.093	0.023	13.14	7.84	4.09
Rumex crispus	Stone Lakes	39.867	37.456	3.202	1.430	0.465	0.331	1.071	1.871	0.180	0.052	6.89	4.32	3.48
Sagittaria latifolia	Cos-Nat Marsh	44.155	43.798	3.310	1.509	0.334	0.227	0.500	4.833	0.344	0.110	9.91	6.65	3.14
Scirpus acutus	Colusa	43.332	43.646	1.095	0.533	0.129	0.095	0.924	1.245	0.120	0.074	8.49	5.64	1.61
Scirpus acutus	Cos-Franklin	43.282	40.590	1.584	0.678	0.218	0.170	1.543	0.940	0.076	0.036	7.25	3.98	2.12
Scirpus acutus	Cos-Nat Marsh	42.932	43.043	1.478	0.686	0.218	0.100	0.507	5.434	0.409	0.091	6.79	6.88	4.50
Scirpus acutus	Cos-NE barn	42.972	41.688	1.963	0.691	0.284	0.219	1.157	1.193	0.118	0.078	6.92	3.16	1.51
Scirpus acutus	Cos-slough	43.068	42.588	0.732	0.619	0.201	0.073	0.793	3.641	0.296	0.055	3.65	8.51	5.37
Scirpus acutus	Delevan	42.993	44.587	1.788	0.719	0.226	0.054	0.369	2.571	0.198	0.064	7.90	13.27	3.10
Scirpus acutus	Merced	40.905	42.869	1.727	0.854	0.231	0.187	1.179	1.038	0.071	0.052	7.48	4.56	1.35
Scirpus acutus	Merced-Mariposa	42.697	37.960	1.973	0.397	0.195	0.077	1.121	1.078	0.059	0.048	10.10	5.14	1.25
Scirpus acutus	Merced-Snow Goose	43.269	38.347	1.286	0.624	0.128	0.105	1.428	1.025	0.070	0.082	10.09	5.93	0.86
Scirpus acutus	Pl canal	45.405	44.421	1.395	1.162	0.157	0.138	0.668	2.540	0.183	0.026	8.88	8.41	7.04
Scirpus acutus	Pl slough	45.009	39.434	1.226	0.682	0.105	0.087	0.431	2.608	0.161	0.024	11.71	7.81	6.68
Scirpus acutus	Sac Refuge	40.624	38.679	1.750	0.493	0.388	0.085	1.326	0.677	0.064	0.037	4.52	5.80	1.72
Scirpus acutus	Stone Lakes M2	41.788	38.542	0.841	0.614	0.094	0.036	0.938	1.315	0.064	0.019	8.94	16.88	3.31
Scirpus acutus	Sutter	43.200	37.947	1.268	0.722	0.166	0.095	1.090	1.440	0.113	0.048	7.64	7.57	2.34
Scirpus acutus	Yolo	42.367	39.527	1.616	0.889	0.208	0.158	0.352	2.139	0.173	0.070	7.78	5.64	2.47
Scirpus fluviatilis	Colusa	38.924	36.155	1.118	0.503	0.078	0.040	1.238	1.119	0.093	0.050	14.43	12.49	1.86
Scirpus fluviatilis	Delevan	41.968	41.431	2.990	0.976	0.162	0.136	0.355	2.920	0.193	0.071	18.43	7.20	2.71
Scirpus fluviatilis	Merced	42.079	41.776	1.296	1.074	0.107	0.093	1.241	1.974	0.127	0.050	12.07	11.57	2.57
Scirpus fluviatilis	Sac Refuge	43.556	41.265	2.791	0.890	0.249	0.092	1.520	0.668	0.048	0.035	11.23	9.63	1.35
Scirpus fluviatilis	Sutter	44.193	41.975	2.118	0.702	0.197	0.058	1.152	1.757	0.136	0.036	10.77	12.06	3.83
Scirpus fluviatilis	Yolo	43.135	39.763	0.999	0.515	0.077	0.060	0.346	3.423	0.255	0.096	13.07	8.53	2.67
Scirpus maritimus	Merced-Snow Goose	41.867	41.588	1.054	0.592	0.129	0.126	1.357	1.138	0.072	0.058	8.21	4.69	1.24
Typha domingensis	Colusa	42.279	44.471	0.934	0.497	0.133	0.098	0.924	1.245	0.120	0.074	7.03	5.05	1.61
Typha domingensis	Cos-Mme 1	44.555	42.467	2.363	0.539	0.226	0.127	1.213	1.656	0.127	0.030	10.45	4.25	4.18
Typha domingensis	Cos-Nat Marsh	45.705	43.261	2.075	0.470	0.225	0.074	0.591	6.283	0.437	0.092	9.21	6.38	4.73
Typha domingensis	Cos-NE barn	46.364	41.642	2.423	1.089	0.248	0.174	1.157	1.193	0.118	0.078	9.77	6.28	1.51
Typha domingensis	Merced	44.697	44.526	2.555	1.826	0.223	0.128	1.179	1.038	0.071	0.052	11.46	14.30	1.35
Typha domingensis	Merced-Snow Goose	45.116	45.255	1.402	0.857	0.159	0.104	1.428	1.025	0.070	0.082	8.81	8.23	0.86
Typha domingensis	Pl canal	45.298	44.755	1.437	0.646	0.201	0.089	0.666	2.832	0.213	0.048	7.14	7.29	4.41
Typha domingensis	Sac Refuge	41.750		1.205		0.167		1.326	0.978	0.093	0.023	7.21		4.09
Typha domingensis	San Joaquin-White	42.117	32.398	2.720	0.896	0.341	0.303	1.453	1.078	0.086	0.060	7.97	2.96	1.43
Typha domingensis	Stone Lakes	44.404	41.954	2.023	0.432	0.203	0.042	1.561	0.779	0.095	0.052	9.99	10.30	1.84
Typha domingensis	Stone Lakes M2	45.873	45.873	1.960	0.562	0.193	0.049	0.938	1.315	0.064	0.019	10.16	11.37	3.31
Typha domingensis	West Bear Creek	43.235	37.920	1.498	0.398	0.130	0.069	1.698	0.523	0.030	0.059	11.56	5.77	0.50
Typha domingensis	Yolo	44.154	41.737	0.879	0.240	0.100	0.020	0.456	2.277	0.177	0.086	8.84	12.06	2.07

Table 6: ANOVA and Scheffe tests' results by species

BIOMASS	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	ns	1.000		
Lepidium latifolium	ns	0.000	0.000	1.000	
Phragmites australis	ns	0.000	0.000	ns	1.000
by species $p<0.001$					

LEAF MASS	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	ns	ns	1.000		
Lepidium latifolium	ns	ns	ns	1.000	
Phragmites australis	ns	0.000	ns	ns	1.000
by species $p<0.001$					

STEM MASS	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	ns	0.001	0.000	ns	1.000
by species $p<0.001$					

BEL.-G. MASS	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	0.000	1.000			
Echinochloa crus-galli	0.000	ns	1.000		
Lepidium latifolium	ns	0.000	0.000	1.000	
Phragmites australis	ns	0.000	0.000	ns	1.000
by species $p<0.001$					

ROOT/SHOOT	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	0.000	1.000			
Echinochloa crus-galli	0.002	ns	1.000		
Lepidium latifolium	ns	0.005	ns	1.000	
Phragmites australis	0.000	ns	ns	ns	1.000
by species $p<0.001$					

TOTAL LENGTH	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	0.000	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	0.000	ns	0.000	0.000	1.000
by species $p<0.001$					

Table 6: ANOVA and Scheffe tests' results by species

NO. OF LEAVES	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	ns	ns	1.000		
Lepidium latifolium	0.028	0.000	0.003	1.000	
Phragmites australis	ns	ns	ns	0.000	1.000

by species p<0.001

LEAF AREA	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	ns	ns	0.000	0.000	1.000

by species p<0.001

LAR	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	ns	ns	0.000	0.000	1.000

by species p<0.001

SLA	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	ns	ns	0.000	0.000	1.000

by species p<0.001

LMR	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	0.000	0.000	1.000		
Lepidium latifolium	0.000	0.000	0.000	1.000	
Phragmites australis	0.046	ns	0.002	0.000	1.000

by species p<0.001

ABOVE CARBON	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	0.000	1.000			
Echinochloa crus-galli	0.000	ns	1.000		
Lepidium latifolium	0.000	ns	ns	1.000	
Phragmites australis	ns	0.007	0.001	0.000	1.000

by species p<0.001

Table 6: ANOVA and Scheffe tests' results by species

ABOVE NITROGEN	*B. frondosa*	*C. eragrostis*	*E. crus-galli*	*L. latifolium*	*P. australis*
Bidens frondosa	1.000				
Cyperus eragrostis	ns	1.000			
Echinochloa crus-galli	ns	0.007	1.000		
Lepidium latifolium	ns	ns	0.009	1.000	
Phragmites australis	ns	ns	0.008	ns	1.000

by species p<0.001

Table 7: ANOVA and Scheffe tests' results for all species by nitrogen, phosphorus, and water levels

BIOMASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	0.009	ns	ns	1.000				
5 n P flood	ns	ns	ns	0.010	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	0.000	0.000	ns	ns	ns	0.000	1.000	
6 N P drwdn	0.001	ns	ns	ns	0.000	ns	ns	1.000
$p<0.001$								

LEAF MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	0.004	ns	1.000					
2 N p drwdn	0.000	0.009	ns	1.000				
5 n P flood	ns	ns	0.017	0.000	1.000			
7 n P drwdn	ns	ns	ns	0.012	ns	1.000		
8 N P flood	0.000	0.000	0.014	ns	0.000	0.000	1.000	
6 N P drwdn	0.005	ns	ns	ns	0.020	ns	0.016	1.000
$p<0.001$								

STEM MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	0.026	ns	ns	1.000				
5 n P flood	ns	ns	ns	0.044	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	0.000	0.000	ns	ns	0.000	0.000	1.000	
6 N P drwdn	0.043	ns	ns	ns	ns	ns	ns	1.000
$p<0.001$								

BEL.-G. MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	ns	ns	ns	1.000				
5 n P flood	ns	ns	ns	0.030	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	0.001	0.042	ns	ns	0.000	0.021	1.000	
6 N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
$p<0.001$								

Table 7: ANOVA and Scheffe tests' results for all species by nitrogen, phosphorus, and water levels

ROOT/SHOOT	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	ns	ns	ns	1.000				
5 n P flood	ns	ns	ns	ns	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	0.004	0.000	ns	ns	ns	0.024	1.000	
6 N P drwdn	0.003	0.000	ns	ns	ns	0.020	ns	1.000
p<0.001								

TOT. LENGTH	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	ns	ns	ns	1.000				
5 n P flood	ns	ns	ns	ns	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	ns	ns	ns	ns	ns	ns	1.000	
6 N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.002								

NO. LEAVES	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	ns							
3 n p drwdn	ns	1.000						
4 N p flood	ns	ns	1.000					
2 N p drwdn	0.004	ns	ns	1.000				
5 n P flood	ns	ns	ns	ns	1.000			
7 n P drwdn	ns	ns	ns	ns	ns	1.000		
8 N P flood	0.000	0.002	ns	ns	ns	0.000	1.000	
6 N P drwdn	0.034	ns	ns	ns	ns	ns	ns	1.000
p<0.001								

ABOVE P	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	ns	0.016	1.000					
2 N p drwdn	ns	0.024	ns	1.000				
5 n P flood	ns	ns	0.004	0.006	1.000			
7 n P drwdn	ns	ns	0.003	0.005	ns	1.000		
8 N P flood	ns	ns	ns	ns	ns	ns	1.000	
6 N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p<0.001								

Table 7: ANOVA and Scheffe tests' results for all species by nitrogen, phosphorus, and water levels

	1	3	4	2	5	7	8	6
ABOVE N/P	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
1 n p flood	1.000							
3 n p drwdn	ns	1.000						
4 N p flood	0.000	0.000	1.000					
2 N p drwdn	0.000	0.000	ns	1.000				
5 n P flood	ns	ns	0.000	0.000	1.000			
7 n P drwdn	ns	ns	0.000	0.000	ns	1.000		
8 N P flood	ns	ns	ns	0.047	0.008	0.004	1.000	
6 N P drwdn	ns	ns	0.025	0.021	0.018	ns	ns	1.000

p<0.001

Table 8: ANOVA and Scheffe tests's results grouped by nitrogen and phosphorus treatments

BIOMASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

ABOVE N	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.001	1.000	
NP	0.013	ns	0.012	1.000
p<0.001				

LEAF MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

ABOVE P	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	ns	0.001	0.048	1.000
p<0.001				

STEM MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

ABOVE N/P	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	0.000	0.000	1.000	
NP	0.000	0.000	0.000	1.000
p<0.001				

BEL.-G. MASS	np	Np	nP	NP
np	1.000			
Np	0.003	1.000		
nP	ns	0.001	1.000	
NP	0.001	ns	0.000	1.000
p<0.001				

ROOT/SHOOT	np	Np	nP	NP
np	1.000			
Np	0.021	1.000		
nP	ns	ns	1.000	
NP	0.001	0.001	0.000	1.000
p<0.000				

TOT. LENGTH	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	0.001	ns	0.000	1.000
p<0.001				

NO. LEAVES	np	Np	nP	NP
np	1.000			
Np	0.004	1.000		
nP	ns	0.003	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

Table 9: ANOVA and Scheffe tests's results for *Bidens frondosa*

	1	3	4	2	5	7	8	6
BIOMASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.024	ns	1.000					
N p drwdn	0.041	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.000	0.000	ns	ns	0.001	0.008	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
$p<0.001$								

BIOMASS	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.002	1.000	
NP	0.000	ns	0.000	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
LEAF MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.036	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.000	0.004	ns	0.012	0.000	0.004	1.000	
N P drwdn	0.013	ns	ns	ns	0.025	ns	ns	1.000
$p<0.001$								

LEAF MASS	np	Np	nP	NP
np	1.000			
Np	0.048	1.000		
nP	ns	ns	1.000	
NP	0.000	0.014	0.000	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
STEM MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.037	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.001	0.005	0.002	ns	ns	0.009	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
$p<0.001$								

STEM MASS	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.004	1.000	
NP	0.000	ns	0.001	1.000
$p<0.001$				

Table 9: ANOVA and Scheffe tests's results for *Bidens frondosa*

	1	3	4	2	5	7	8	6
BEL.-G. MASS	**n p flood**	**n p drwdn**	**N p flood**	**N p drwdn**	**n P flood**	**n P drwdn**	**N P flood**	**N P drwdn**
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.046	ns	1.000					
N p drwdn	0.025	ns	ns	1.000				
n P flood	ns	ns	ns	0.039	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.015	ns	ns	ns	0.024	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p<0.001								

BELOW	**np**	**Np**	**nP**	**NP**
np	1.000			
Np	0.001	1.000		
nP	ns	0.001	1.000	
NP	0.001	ns	0.000	1.000
p<0.001				

ROOT/SHOOT by water p=0.003

	1	3	4	2	5	7	8	6
ROOT/SHOOT	**n p flood**	**n p drwdn**	**N p flood**	**N p drwdn**	**n P flood**	**n P drwdn**	**N P flood**	**N P drwdn**
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	0.009	ns	0.007	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.002								

ROOT/SHOOT	**np**	**Np**	**nP**	**NP**
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	ns	ns	ns	1.000
p=0.048				

	1	3	4	2	5	7	8	6
TOT. LENGTH	**n p flood**	**n p drwdn**	**N p flood**	**N p drwdn**	**n P flood**	**n P drwdn**	**N P flood**	**N P drwdn**
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.044	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.007								

TOT. LENGTH	**np**	**Np**	**nP**	**NP**
np	1.000			
Np	0.050	1.000		
nP	ns	ns	1.000	
NP	ns	ns	ns	1.000
p=0.012				

Table 9: ANOVA and Scheffe tests's results for *Bidens frondosa*

NO. LEAVES	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.004								

NO. LEAVES	np	Np	nP	NP
np	1.000			
Np	0.021	1.000		
nP	ns	0.045	1.000	
NP	0.002	ns	0.004	1.000
p<0.001				

LEAF AREA	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	0.019	1.000				
n P flood	ns	0.001	ns	ns	1.000			
n P drwdn	ns	0.025	ns	ns	ns	1.000		
N P flood	0.000	0.000	0.000	0.000	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.004								

LEAF AREA	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	ns	ns	0.001	1.000
p=0.002				

LAR	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.002	0.002	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	0.010	ns	ns	ns	1.000	
N P drwdn	0.019	0.019	ns	ns	ns	ns	ns	1.000
p<0.001								

LAR	np	Np	nP	NP
np	1.000			
Np	0.004	1.000		
nP	0.033	ns	1.000	
NP	ns	ns	ns	1.000
p=0.002				

Table 9: ANOVA and Scheffe tests's results for *Bidens frondosa*

SLA	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	ns	ns	0.000	1.000				
n P flood	0.014	0.005	ns	0.002	1.000			
n P drwdn	0.010	0.004	ns	0.001	ns	1.000		
N P flood	ns	ns	0.000	ns	0.000	0.003	1.000	
N P drwdn	0.000	0.000	ns	0.000			0.000	1.000
p<0.001								

LMR	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.022	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.003								

LMR	np	Np	nP	NP
np	1.000			
Np	0.007	1.000		
nP	ns	0.014	1.000	
NP	ns	ns	ns	1.000
p=0.002				

ABOVE C	np	Np	nP	NP
np	1.000			
Np	0.021	1.000		
nP	ns	ns	1.000	
NP	0.023	ns	ns	1.000
p=0.007				

ABOVE P	np	Np	nP	NP
np	1.000			
Np	0.044	1.000		
nP	ns	0.009	1.000	
NP	ns	0.041	ns	1.000
p=0.007				

ABOVE N/P	np	Np	nP	NP
np	1.000			
Np	0.003	1.000		
nP	ns	0.001	1.000	
NP	0.046	0.029	0.006	1.000
p=0.001				

Table 10: ANOVA and Scheffe tests's results for *Cyperus eragrostis*

BIOMASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.027	0.024	1.000					
N p drwdn	0.025	0.022	ns	1.000				
n P flood	ns	ns	0.006	0.005	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.000	0.000	ns	ns	0.000	0.000	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	**0.008**	1.000
p<0.001								

BIOMASS	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.002	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

LEAF MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.008	0.004	ns	ns	0.002	0.008	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	**0.001**	1.000
p<0.001								

LEAF MASS	np	Np	nP	NP
np	1.000			
Np	0.047	1.000		
nP	ns	ns	1.000	
NP	ns	ns	ns	1.000
p=0.008				

STEM MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.007	0.002	1.000					
N p drwdn	0.008	0.002	ns	1.000				
n P flood	ns	ns	0.000	0.001	1.000			
n P drwdn	ns	ns	0.036	0.041	ns	1.000		
N P flood	0.000	0.000	0.030	0.026	0.000	0.000	1.000	
N P drwdn	0.017	0.005	ns	ns	0.001	ns	**0.012**	1.000
p<0.001								

STEM MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

Table 10: ANOVA and Scheffe tests's results for *Cyperus eragrostis*

	1	3	4	2	5	7	8	6
BEL.-G. MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.002	0.005	ns	ns	0.001	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	0.038	1.000
$p<0.001$								

BEL.-G. MASS	np	Np	nP	NP
np	1.000			
Np	0.010	1.000		
nP	ns	0.027	1.000	
NP	0.012	ns	0.034	1.000
$p=0.001$				

	1	3	4	2	5	7	8	6
ROOT/SHOOT	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.037	ns	0.002	ns	ns	0.001	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
$p<0.001$								

ROOT/SHOOT	np	Np	nP	NP
np	1.000			
Np	0.040	1.000		
nP	ns	0.006	1.000	
NP	0.000	ns	0.000	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
TOT. LENGTH	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.000	ns	1.000				
n P flood	ns	ns	0.000	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.000	0.000	0.000	ns	1.000	
N P drwdn	0.000	0.000	ns	ns	0.000	0.000	0.035	1.000
$p<0.001$								

TOT. LENGTH	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
$p<0.001$				

Table 10: ANOVA and Scheffe tests's results for *Cyperus eragrostis*

	1	3	4	2	5	7	8	6
NO. LEAVES	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.002	0.007	ns	ns	0.001	0.025	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	0.001	1.000
p<0.001								

NO. LEAVES	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	ns	ns	ns	1.000
p=0.021				

LEAF AREA by water p=0.044

	1	3	4	2	5	7	8	6
LEAF AREA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.044	0.012	1.000					
N p drwdn	0.048	0.013	ns	1.000				
n P flood	ns	ns	0.005	0.006	1.000			
n P drwdn	ns	ns	0.041	0.046	ns	1.000		
N P flood	0.000	0.000	0.046	0.042	0.000	0.000	1.000	
N P drwdn	ns	ns	0.000	0.001	ns	ns	0.000	1.000
p<0.001								

LEAF AREA	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	0.047	1.000	
NP	ns	ns	ns	1.000
p=0.009				

LAR by water p=0.003

	1	3	4	2	5	7	8	6
LAR	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
p<0.001								

SLA by water p=0.020

Table 10: ANOVA and Scheffe tests's results for *Cyperus eragrostis*

	1	3	4	2	5	7	8	6
SLA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
p<0.001								

SLA	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	0.045	ns	ns	1.000
p=0.016				

	1	3	4	2	5	7	8	6
LMR	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	0.010	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.004								

LMR	np	Np	nP	NP
np	1.000			
Np	0.007	1.000		
nP	ns	ns	1.000	
NP	ns	ns	0.008	1.000
p=0.004				

ABOVE C	np	Np	nP	NP
np	1.000			
Np	0.043	1.000		
nP	ns	0.013	1.000	
NP	ns	ns	ns	1.000
p=0.012				

ABOVE N	np	Np	nP	NP
np	1.000			
Np	0.029	1.000		
nP	ns	0.037	1.000	
NP	ns	ns	ns	1.000
p=0.018				

ABOVE P	np	Np	nP	NP
np	1.000			
Np	0.008	1.000		
nP	ns	0.004	1.000	
NP	ns	0.033	ns	1.000
p=0.003				

Table 10: ANOVA and Scheffe tests's results for *Cyperus eragrostis*

ABOVE N/P	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.001	1.000	
NP	0.026	0.007	0.011	1.000

$p<0.001$

Table 11: ANOVA results and Scheffe tests for *Echinochloa crus-galli*

BIOMASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.001	0.011	ns	ns	0.004	0.021	1.000	
N P drwdn	ns	0.020	ns	ns	0.007	0.035	ns	1.000
p<0.001								

BIOMASS	np	Np	nP	NP
np	1.000			
Np	0.003	1.000		
nP	ns	0.007	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

LEAF MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.002	ns	1.000				
n P flood	ns	ns	0.000	0.000	1.000			
n P drwdn	ns	ns	0.004	0.000	ns	1.000		
N P flood	0.000	0.000	0.009	ns	0.000	0.000	1.000	
N P drwdn	0.000	0.000	0.008	ns	0.000	0.000	ns	1.000
p<0.001								

LEAF MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
p<0.001				

STEM MASS	1 n p flood	3 n p drwdn	4 N p flood	2 N p drwdn	5 n P flood	7 n P drwdn	8 N P flood	6 N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.024	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.027	ns	ns	ns	ns	ns	ns	1.000
p<0.001								

STEM MASS	np	Np	nP	NP
np	1.000			
Np	0.027	1.000		
nP	ns	ns	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

Table 11: ANOVA results and Scheffe tests for *Echinochloa crus-galli*

	1	3	4	2	5	7	8	6
BEL.-G. MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.014	ns	ns	ns	0.020	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p<0.001								

BELOW	np	Np	nP	NP
np	1.000			
Np	0.038	1.000		
nP	ns	0.019	1.000	
NP	0.000	ns	0.000	1.000
p<0.001				

	1	3	4	2	5	7	8	6
ROOT/SHOOT	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.015	0.011	ns	ns	ns	ns	1.000	
N P drwdn	0.000	0.000	0.014	ns	0.010	0.008	ns	1.000
p<0.001								

ROOT/SHOOT	np	Np	nP	NP
np	1.000			
Np	0.002	1.000		
nP	0.024	ns	1.000	
NP	0.000	0.006	0.000	1.000
p<0.001				

NO. LEAVES by water p=0.046

	1	3	4	2	5	7	8	6
NO. LEAVES	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.001	ns	ns	ns	0.000	0.004	1.000	
N P drwdn	0.001	ns	ns	ns	0.000	0.004	ns	1.000
p<0.001								

NO. LEAVES	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	0.023	1.000	
NP	0.000	0.003	0.000	1.000
p<0.001				

Table 11: ANOVA results and Scheffe tests for *Echinochloa crus-galli*

	1	3	4	2	5	7	8	6
LEAF AREA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	ns	1.000					
N p drwdn	0.000	0.008	ns	1.000				
n P flood	ns	ns	0.010	0.001	1.000			
n P drwdn	ns	ns	ns	0.019	ns	1.000		
N P flood	0.000	0.000	0.008	ns	0.000	0.000	1.000	
N P drwdn	0.000	0.000	ns	ns	0.000	0.000	ns	1.000
p<0.001								

LEAF AREA	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.001	0.000	1.000
p<0.001				

LMR	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	ns	ns	ns	1.000
p=0.048				

ABOVE P	np	Np	nP	NP
np	1.000			
Np	0.005	1.000		
nP	ns	0.001	1.000	
NP	ns	ns	ns	1.000
p=0.014				

ABOVE N/P	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	0.025	0.000	1.000	
NP	0.005	0.003	0.000	1.000
p<0.001				

Table 12: ANOVA results and Scheffe tests for *Lepidium latifolium*

	1	3	4	2	5	7	8	6
BIOMASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.000	ns	1.000				
n P flood	ns	ns	0.000	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.001	0.011	0.000	ns	1.000	
N P drwdn	0.000	0.000	0.001	0.011	0.000	0.000	ns	1.000
$p<0.001$								

BIOMASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
LEAF MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.000	0.000	1.000				
n P flood	ns	ns	ns	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.003	ns	0.000	0.000	1.000	
N P drwdn	0.000	0.000	0.000	0.010	0.000	0.000	ns	1.000
$p<0.001$								

LEAF MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
STEM MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.000	ns	1.000				
n P flood	ns	ns	0.000	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.008	0.020	0.000	0.000	1.000	
N P drwdn	0.000	0.000	0.005	0.013	0.000	0.000	ns	1.000
$p<0.001$								

STEM MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
$p<0.001$				

Table 12: ANOVA results and Scheffe tests for *Lepidium latifolium*

	1	3	4	2	5	7	8	6
BEL.-G. MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	0.006	0.006	1.000			
n P drwdn	ns	ns	0.023	0.022	ns	1.000		
N P flood	0.000	0.000	0.014	0.015	0.000	0.000	1.000	
N P drwdn	0.000	0.000	ns	ns	0.000	0.000	ns	1.000
p<0.001								

BEL.-G. MASS	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
p<0.001				

	1	3	4	2	5	7	8	6
ROOT/SHOOT	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.032	0.036	ns	ns	ns	ns	ns	1.000
p<0.001								

ROOT/SHOOT	np	Np	nP	NP
np	1.000			
Np	0.002	1.000		
nP	ns	ns	1.000	
NP	0.004	ns	ns	1.000
p<0.001				

	1	3	4	2	5	7	8	6
TOT. LENGTH	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	ns	ns	1.000				
n P flood	ns	0.000	0.000	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.008	0.005	0.000	0.000	1.000	
N P drwdn	0.000	0.000	0.000	0.000	0.000	0.000	ns	1.000
p<0.001								

TOT. LENGTH	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
p<0.001				

NO. LEAVES by water p=0.046

Table 12: ANOVA results and Scheffe tests for *Lepidium latifolium*

	1	3	4	2	5	7	8	6
NO. LEAVES	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.001	ns	1.000					
N p drwdn	0.002	ns	ns	1.000				
n P flood	ns	0.002	ns	0.003	1.000			
n P drwdn	ns	0.008	ns	0.012	ns	1.000		
N P flood	0.001	ns	ns	ns	0.001	0.003	1.000	
N P drwdn	0.003	ns	ns	ns	0.003	0.014	ns	1.000
p<0.001								

NO. LEAVES	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	0.008	1.000	
NP	ns	ns	0.000	1.000
p<0.001				

	1	3	4	2	5	7	8	6
LEAF AREA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	0.000	0.000	1.000					
N p drwdn	0.000	0.000	0.046	1.000				
n P flood	ns	ns	0.000	0.000	1.000			
n P drwdn	ns	ns	0.000	0.000	ns	1.000		
N P flood	0.000	0.000	0.000	0.003	0.000	0.000	1.000	
N P drwdn	0.000	0.000	0.000	0.000	0.000	0.000	ns	1.000
p<0.001								

LEAF AREA	np	Np	nP	NP
np	1.000			
Np	0.000	1.000		
nP	ns	0.000	1.000	
NP	0.000	0.000	0.000	1.000
p<0.001				

LAR by water p=0.004

	1	3	4	2	5	7	8	6
LAR	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	0.023	ns	0.035	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.000	0.001	0.000	ns	0.007	0.019	0.032	1.000
p<0.001								

LAR	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	0.002	ns	ns	1.000
p=0.002				

Table 12: ANOVA results and Scheffe tests for *Lepidium latifolium*

SLA by water p=0.000

	1	3	4	2	5	7	8	6
SLA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	0.008	ns	0.004	1.000			
n P drwdn	ns	ns	ns	ns	**0.002**	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	0.033	ns	0.001	ns	ns	1.000
p<0.001								

LMR by water p=0.018

	1	3	4	2	5	7	8	6
LMR	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	0.000	0.000	0.025	0.004	1.000			
n P drwdn	ns	ns	ns	ns	**0.000**	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	0.021	ns	ns	ns	ns	ns	1.000

LMR	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	0.036	ns	1.000	
NP	0.043	ns	ns	1.000
p=0.014				

ABOVE N	np	Np	nP	NP
np	1.000			
Np	0.010	1.000		
nP	ns	0.012	1.000	
NP	ns	ns	ns	1.000
p=0.006				

ABOVE P	np	Np	nP	NP
np	1.000			
Np	0.005	1.000		
nP	ns	0.002	1.000	
NP	0.045	ns	0.014	1.000
p=0.002				

ABOVE N/P	np	Np	nP	NP
np	1.000			
Np	0.001	1.000		
nP	ns	0.001	1.000	
NP	0.011	0.020	0.005	1.000
p<0.001				

Table 13: ANOVA and Scheffe tests's results for *Phragmites australis*

	1	3	4	2	5	7	8	6
BIOMASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	0.015	ns	ns	**0.021**	1.000
p=0.002								

	1	3	4	2	5	7	8	6
LEAF MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	0.025	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.038	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	0.028	ns	ns	**0.042**	1.000
p<0.001								

	1	3	4	2	5	7	8	6
STEM MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	0.018	ns	ns	**0.026**	1.000
p=0.002								

	1	3	4	2	5	7	8	6
BEL.-G. MASS	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	0.038	ns	ns	ns	ns	ns	1.000
p=0.006								

	1	3	4	2	5	7	8	6
ROOT/SHOOT	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
p=0.009								

Table 13: ANOVA and Scheffe tests's results for *Phragmites australis*

ROOT/SHOOT	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	0.000	ns	ns	1.000
$p<0.001$				

	1	3	4	2	5	7	8	6
LENGTH	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	0.007	ns	ns	0.003	1.000
$p<0.001$								

	1	3	4	2	5	7	8	6
LEAVES	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	0.006	ns	ns	0.006	1.000
$p<0.001$								

	1	3	4	2	5	7	8	6
LEAF AREA	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	0.046	ns	ns	ns	ns	ns	1.000	
N P drwdn	ns	ns	ns	ns	ns	ns	ns	1.000
$p=0.003$								

	1	3	4	2	5	7	8	6
LAR	n p flood	n p drwdn	N p flood	N p drwdn	n P flood	n P drwdn	N P flood	N P drwdn
n p flood	1.000							
n p drwdn	ns	1.000						
N p flood	ns	ns	1.000					
N p drwdn	ns	ns	ns	1.000				
n P flood	ns	ns	ns	ns	1.000			
n P drwdn	ns	ns	ns	ns	ns	1.000		
N P flood	ns	ns	ns	ns	ns	ns	1.000	
N P drwdn	0.041	ns	ns	ns	ns	ns	ns	1.000
$p=0.003$								

LAR	np	Np	nP	NP
np	1.000			
Np	ns	1.000		
nP	ns	ns	1.000	
NP	0.000	ns	0.005	1.000
$p<0.001$				

Table 13: ANOVA and Scheffe tests's results for *Phragmites australis*

ABOVE N	np	Np	nP	NP
np	1.000			
Np	0.007	1.000		
nP	ns	0.004	1.000	
NP	0.024	ns	0.013	1.000

p=0.002

Figure 1: PCA 21 spp. ranked data 18 variables

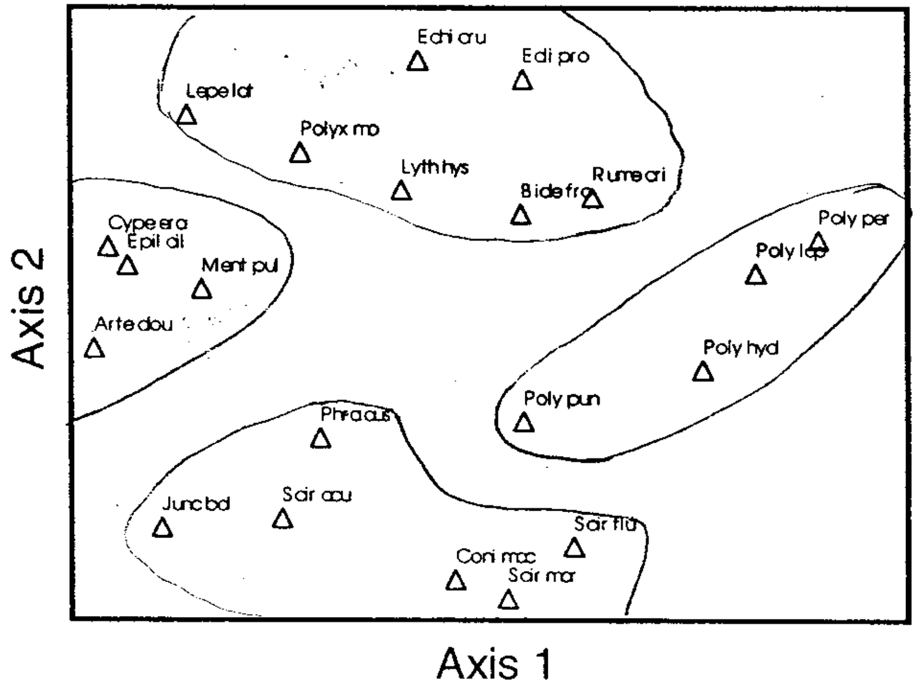


Figure 2: PCA 34 spp. ranked data 9 variables

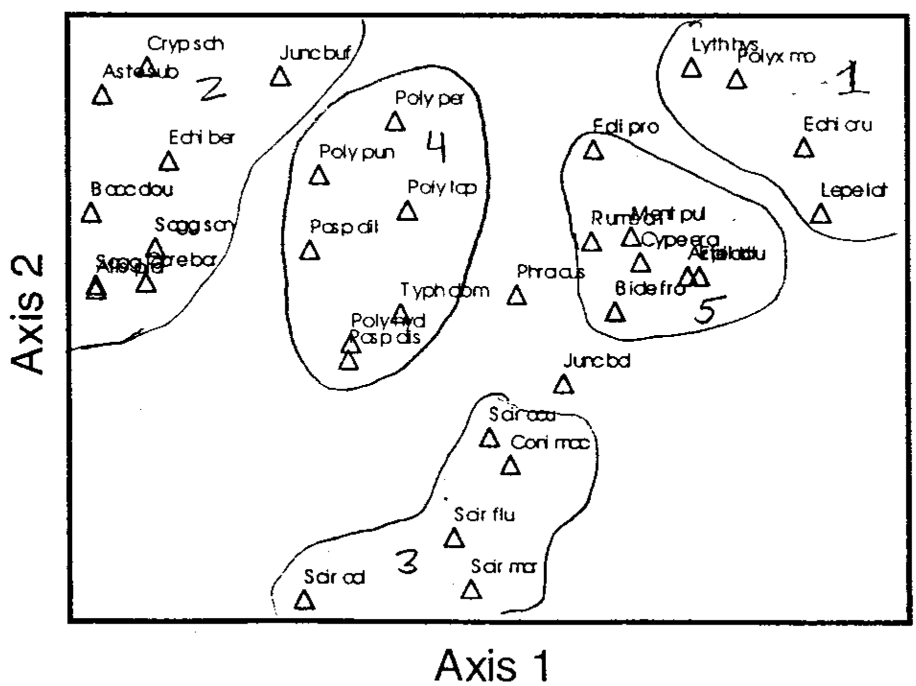


Figure 3: Grime's CSR ordination of 20 species

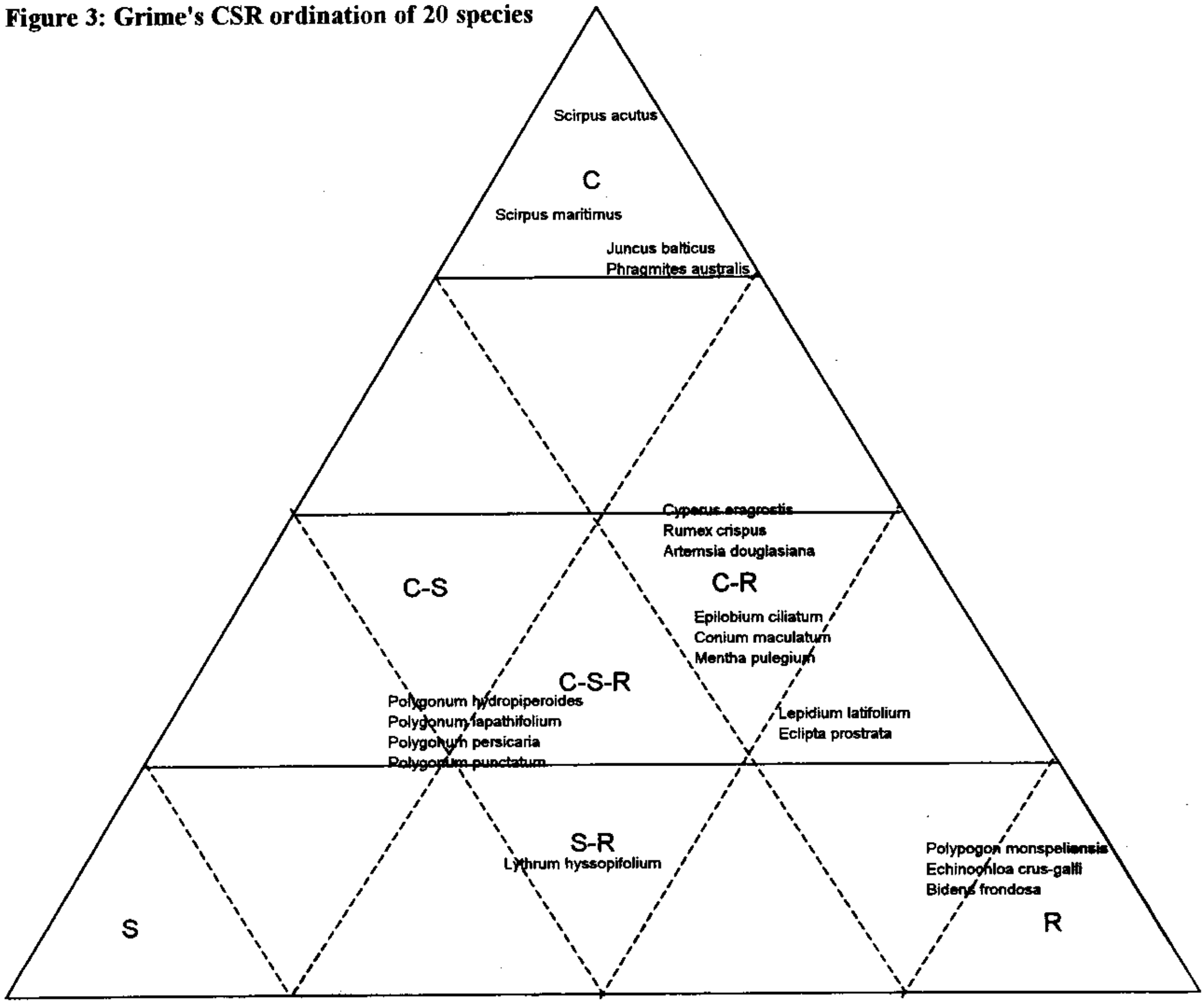
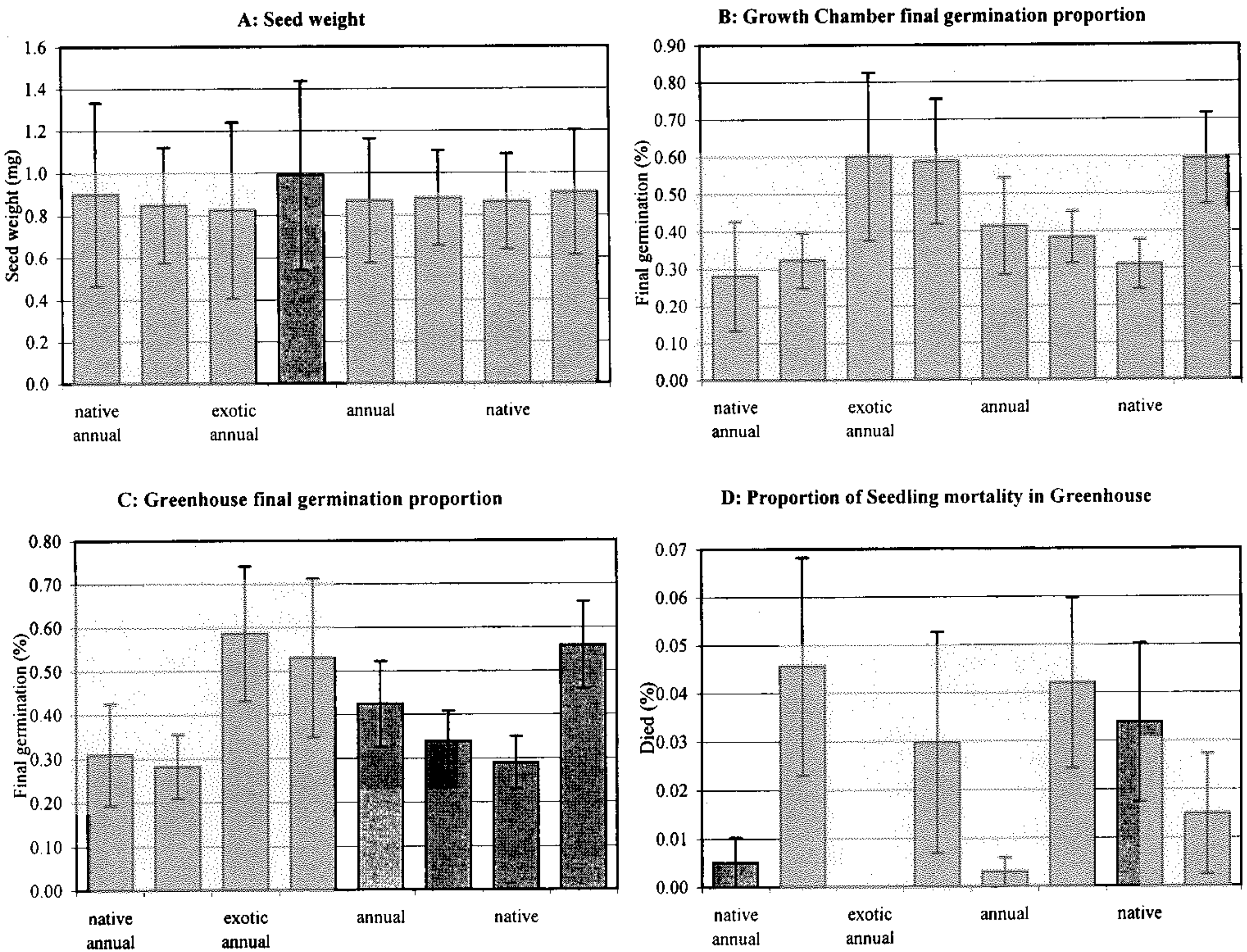
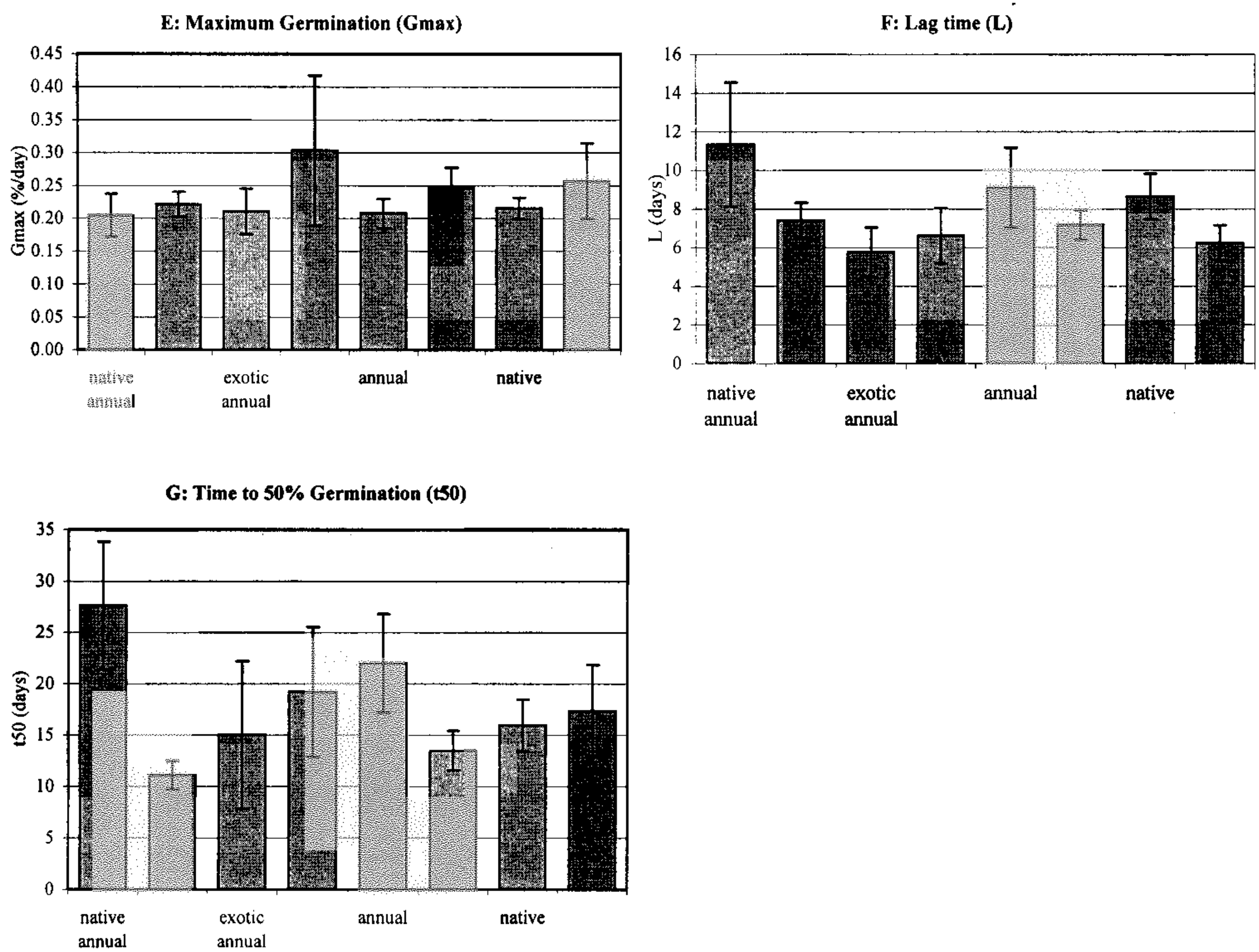


Figure 4: Germination Characteristics of 34 species



Error bars indicate standard error

Figure 4: Germination Characteristics of 34 species



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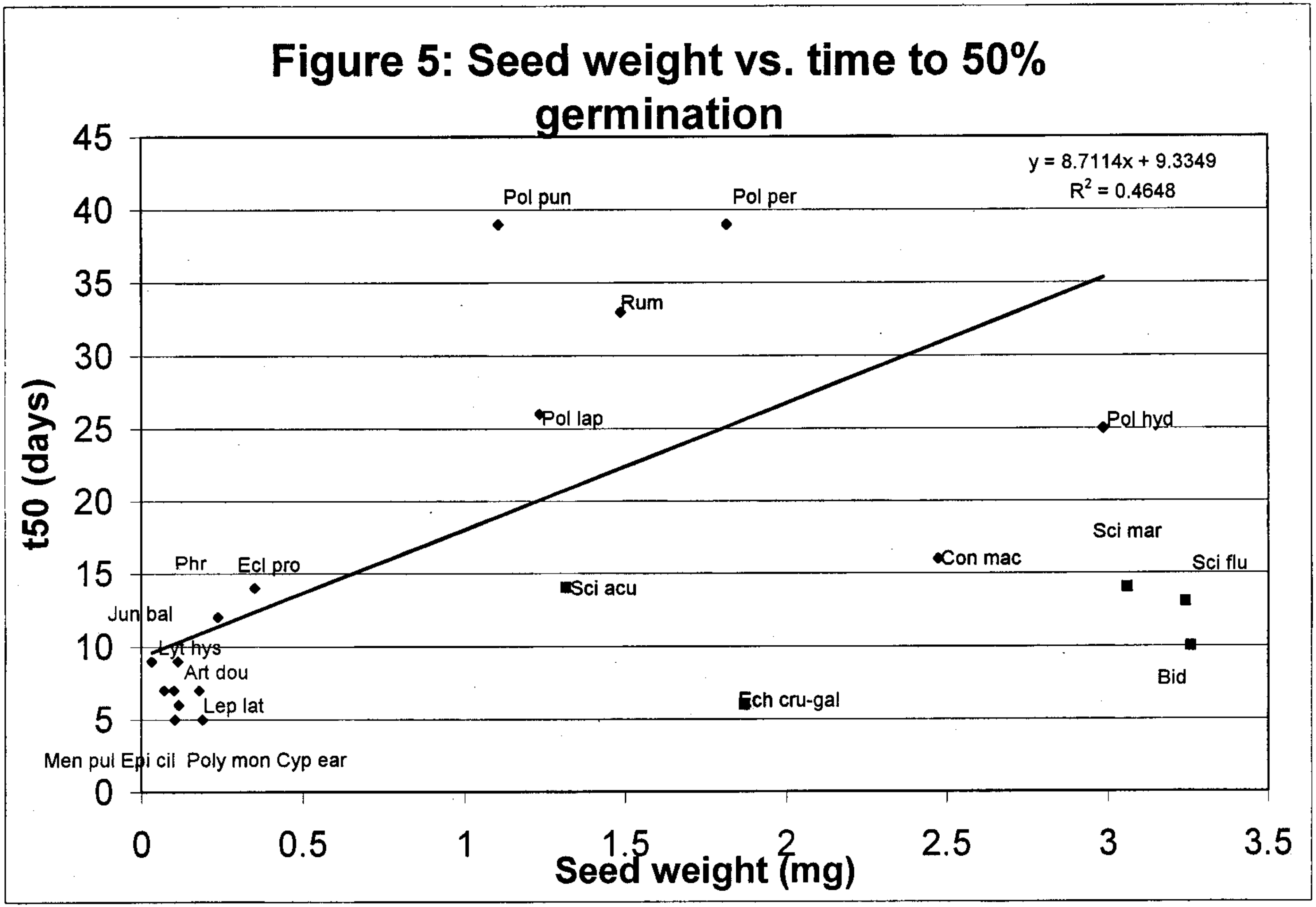
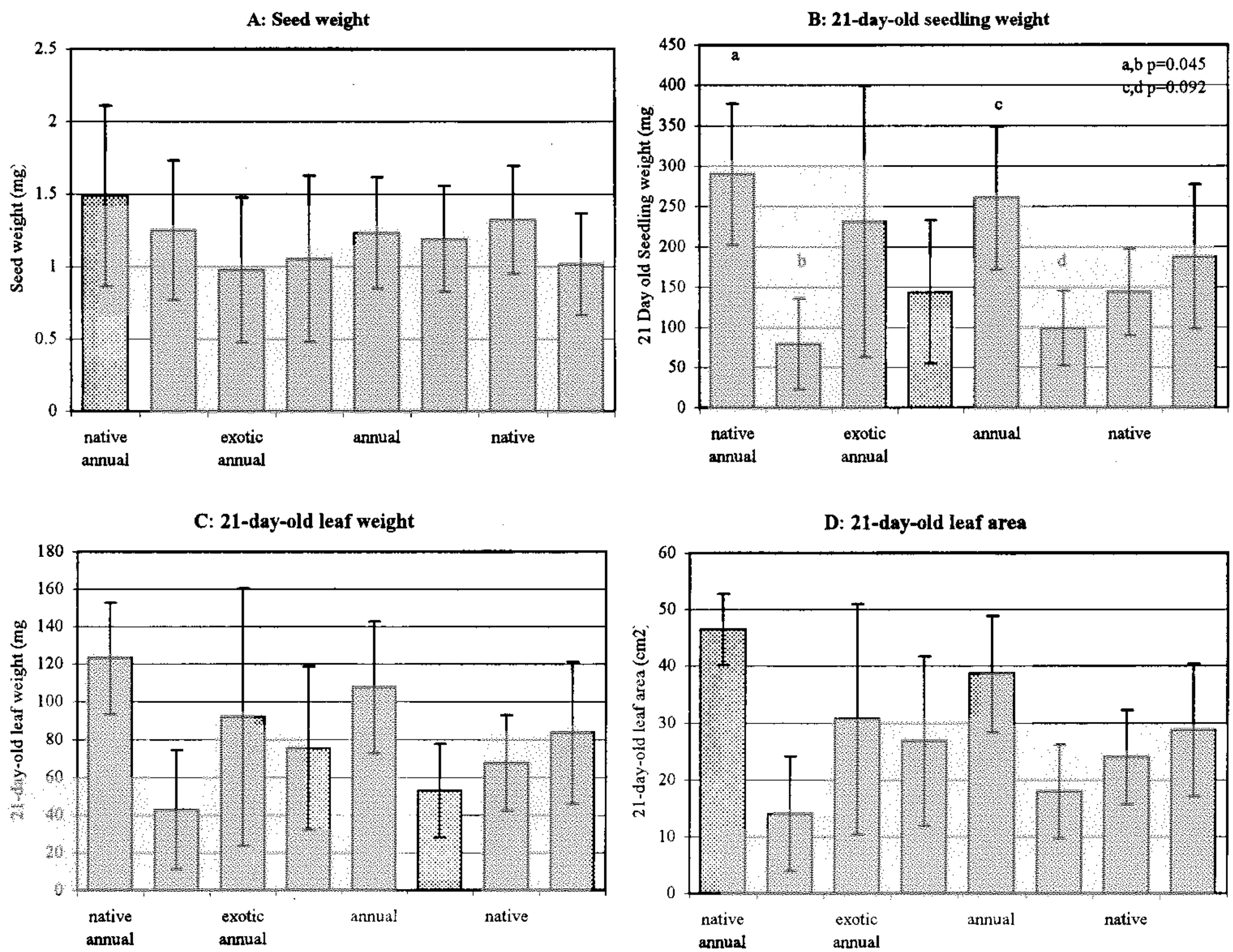


Figure 5: Seed weight vs. time to 50% germination
y = 8.7114x + 9.3349
R2 = 0.4648
t50 (days)
Seed weight (mg)
0
5
10
15
20
25
30
35
40
45
0
0.5
1
1.5
2
2.5
3
3.5
Pol pun
Pol per
Rum
Pol lap
Pol hyd
Sci mar
Con mac
Sci flu
Sci acu
Bid
Ech cru-gal
Phr
Ecl pro
Jun bal
Lyt hys
Art dou
Lep lat
Men pul Epi cil
Poly mon Cyp ear

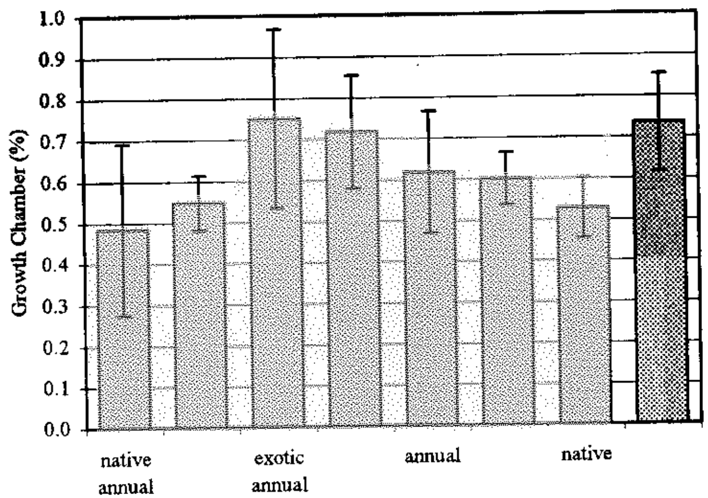
Figure 6: Germination and Growth Characteristics for 21 species



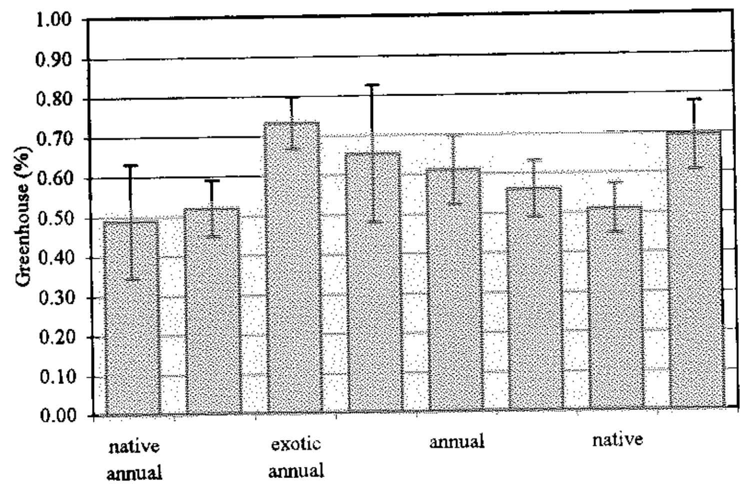
Error bars indicate standard error

Figure 6: Germination and Growth Characteristics for 21 species

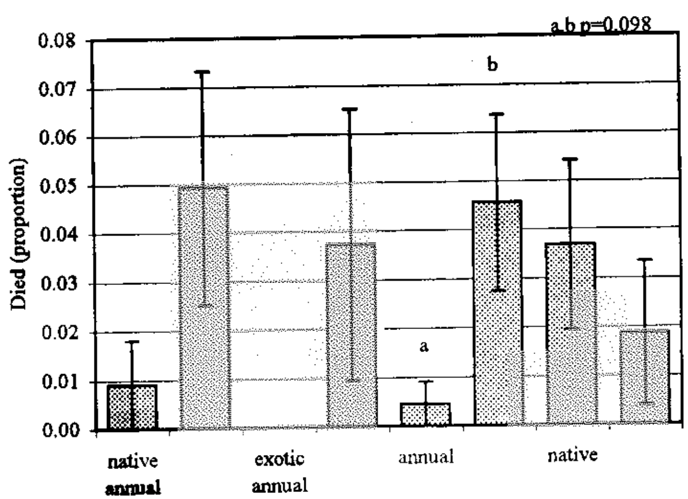
E: Growth Chamber Final Germination Proportion



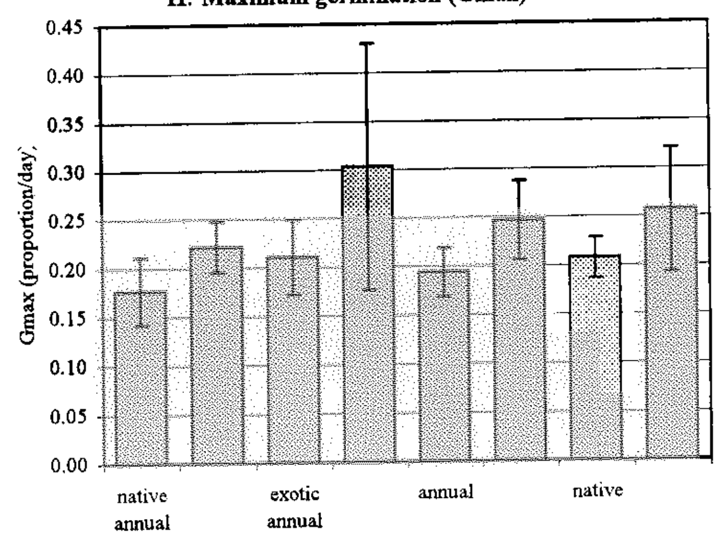
F: Greenhouse Final Germination Proportion



G: Proportion of seedlings mortality in greenhouse

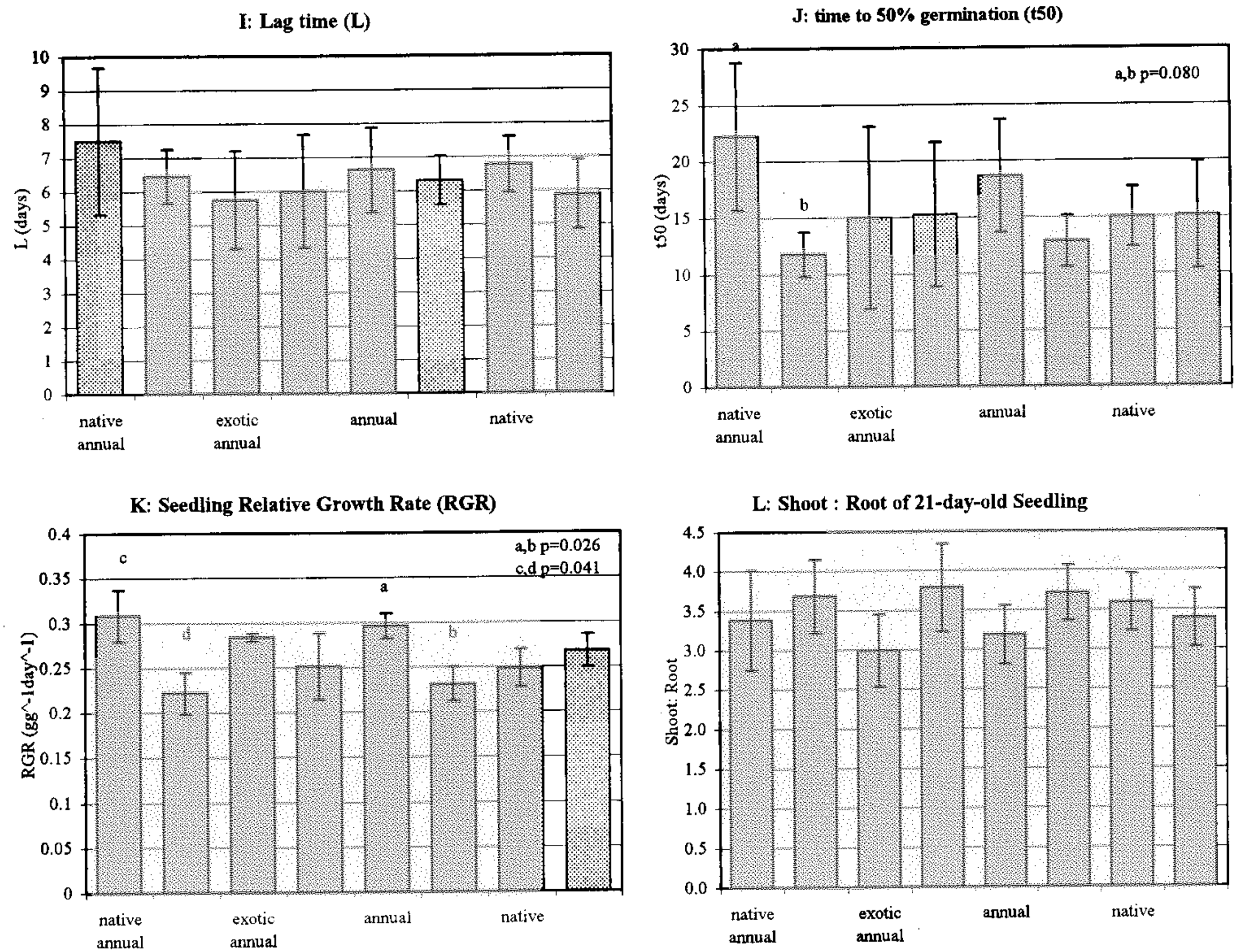


H: Maximum germination (Gmax)



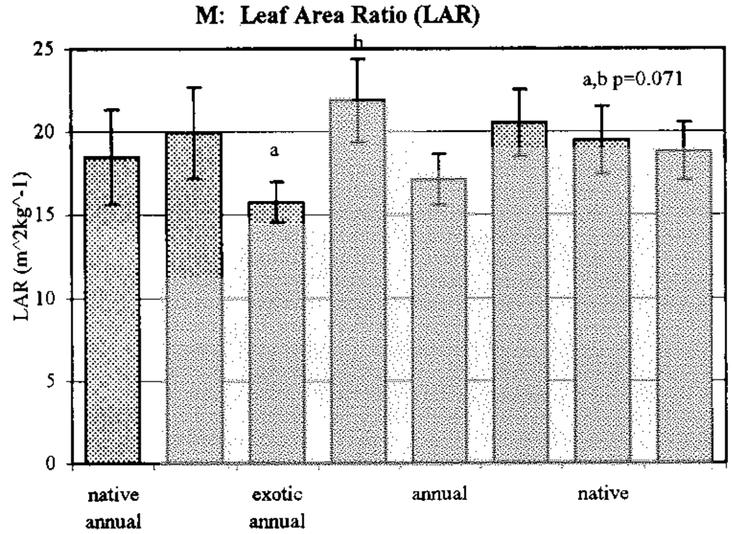
Error bars indicate standard error

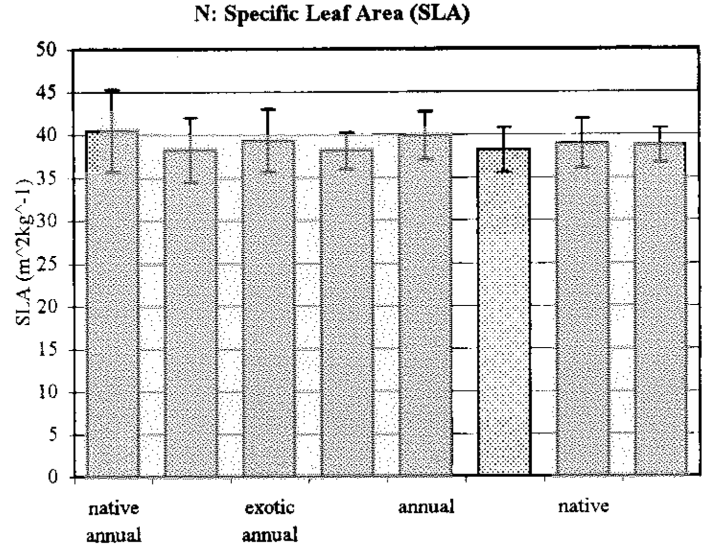
Figure 6: Germination and Growth Characteristics for 21 species

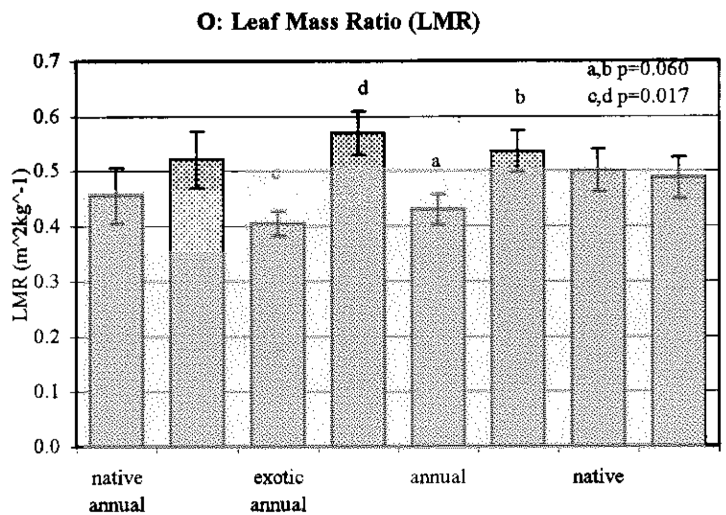


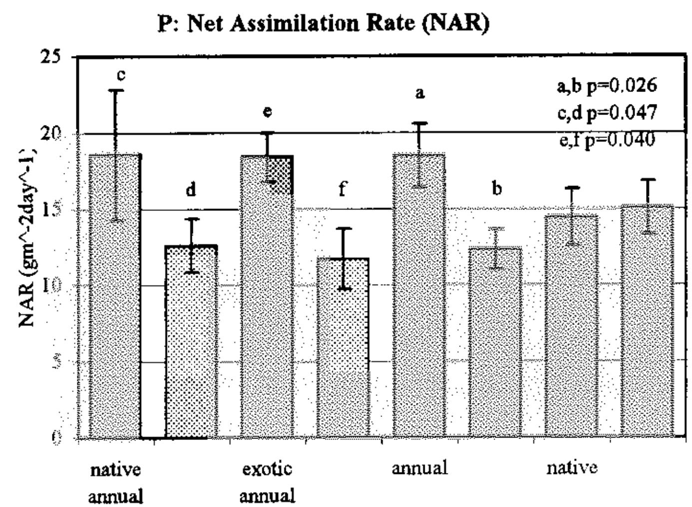
Error bars indicate standard error

Figure 6: Germination and Growth Characteristics for 21 species



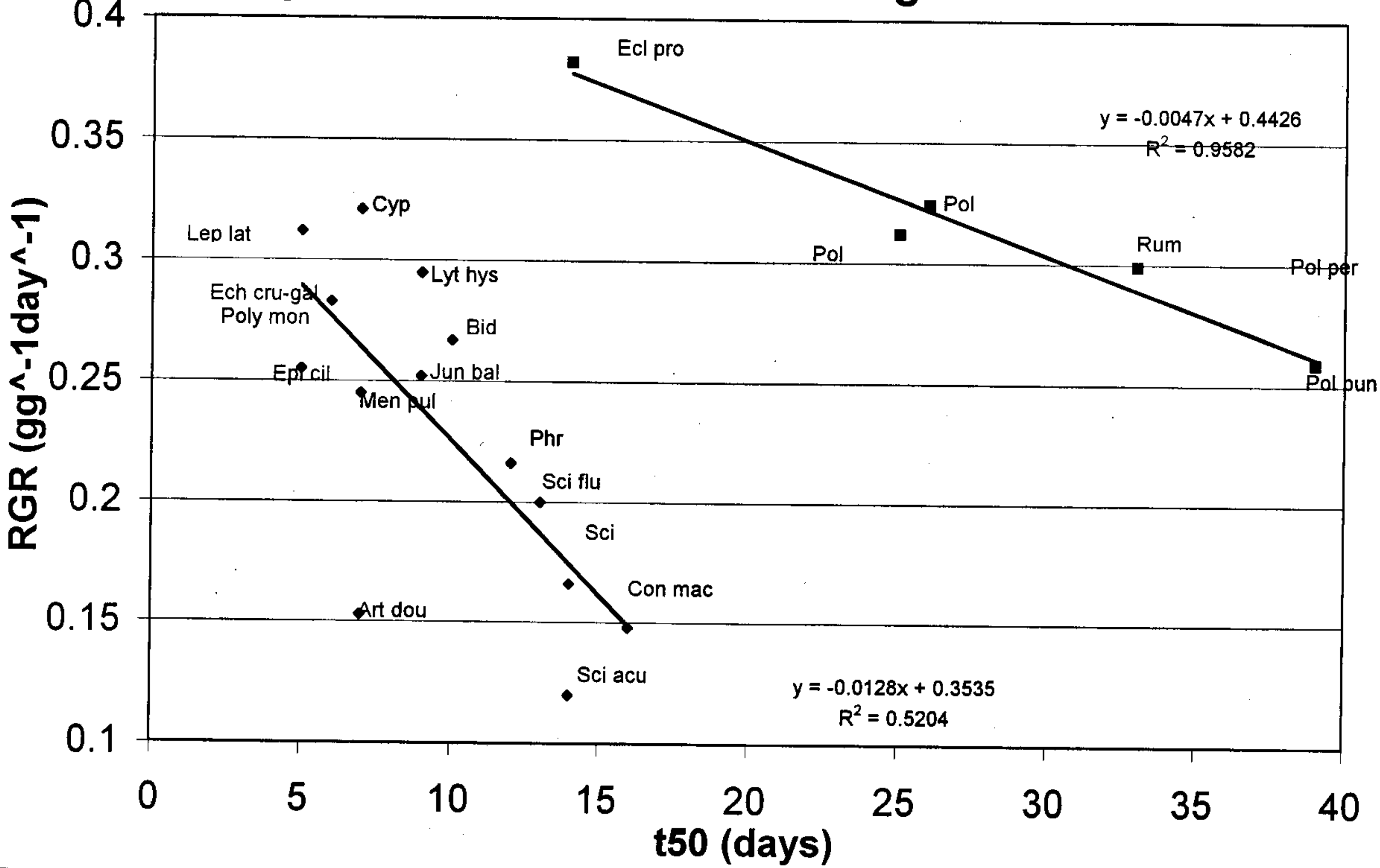






Error bars indicate standard error

Figure 7: RGR vs.time to 50% germination



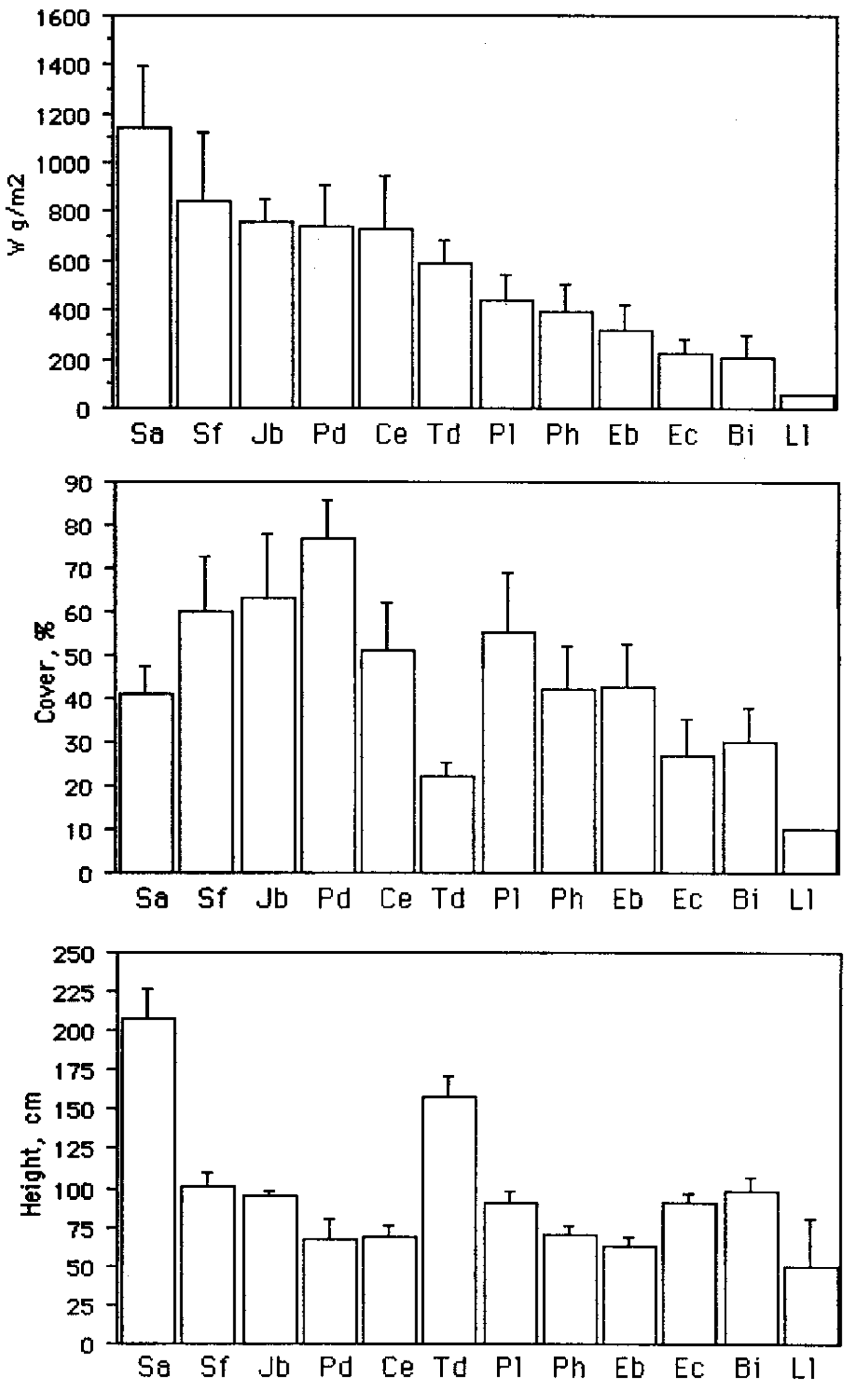


Fig. 8 The above ground biomass (W, g m^{-2}), percent cover and average height (cm) of dominant species in Central Californian wetlands. For species abbreviations see Table 2.

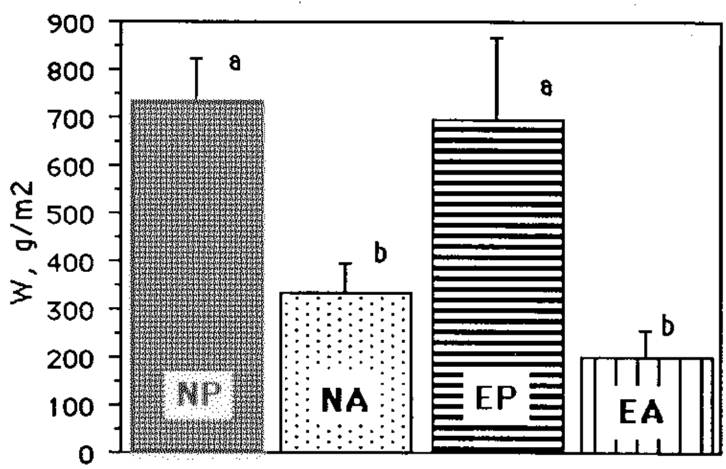


Fig. 9 Aboveground biomass (W, g m^{-2} dry weight) of native perennial (NP), native annual (NA), exotic perenial (EP) and exotic annual (EA) wetland species. Bars sharing the same letter are not significantly different .

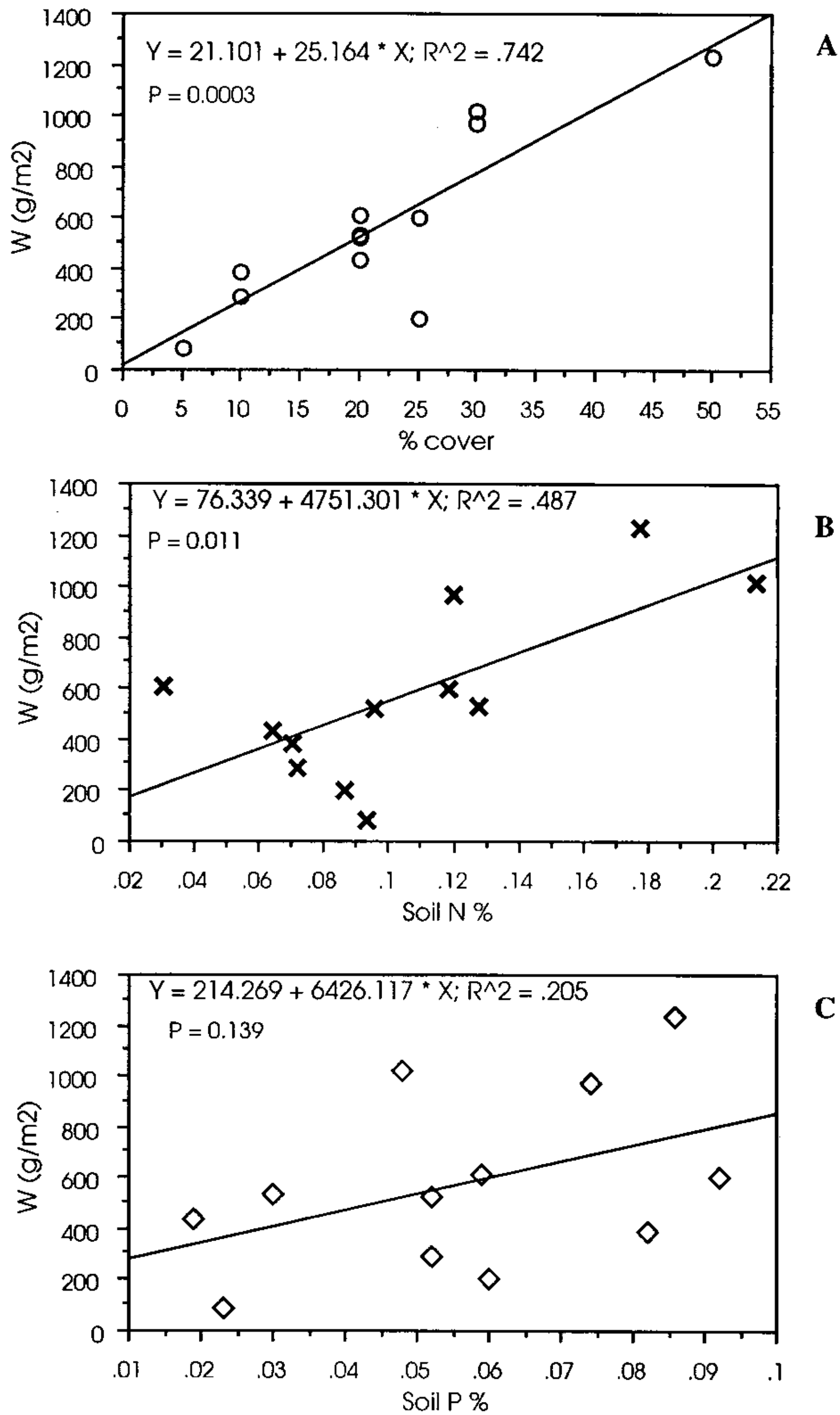


Fig. 10 Relationship between the aboveground biomass (W g m^{-2}) of ***Typha domingensis*** **and plant** cover (A), soil total nitrogen (B) and soil total phosphorus (P).

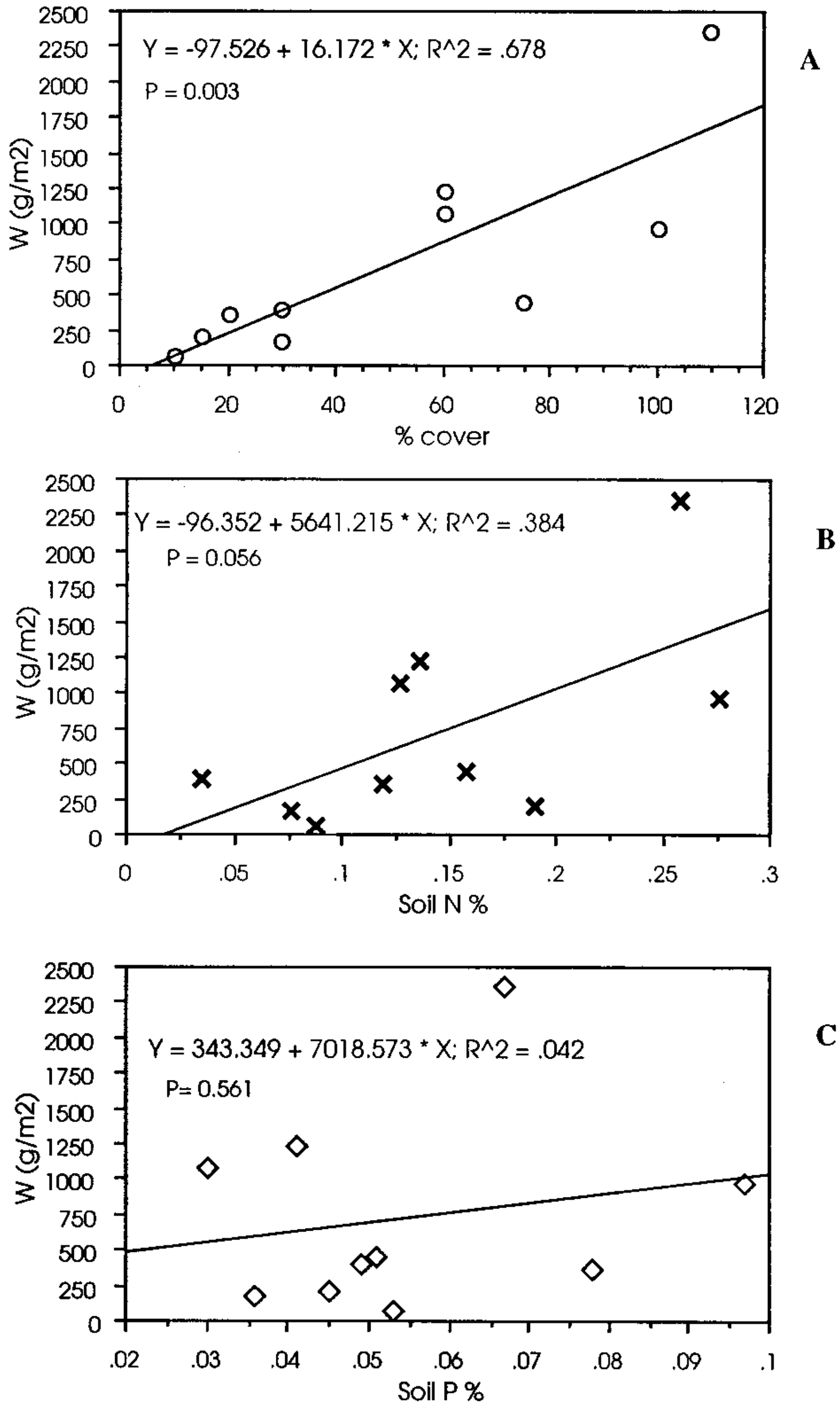


Fig. 11 Relationship between the aboveground biomass (W g m^{-2}) of *Cyperus Eragrostis* and plant cover (A), soil total nitrogen (B) and soil total phosphorus (P).

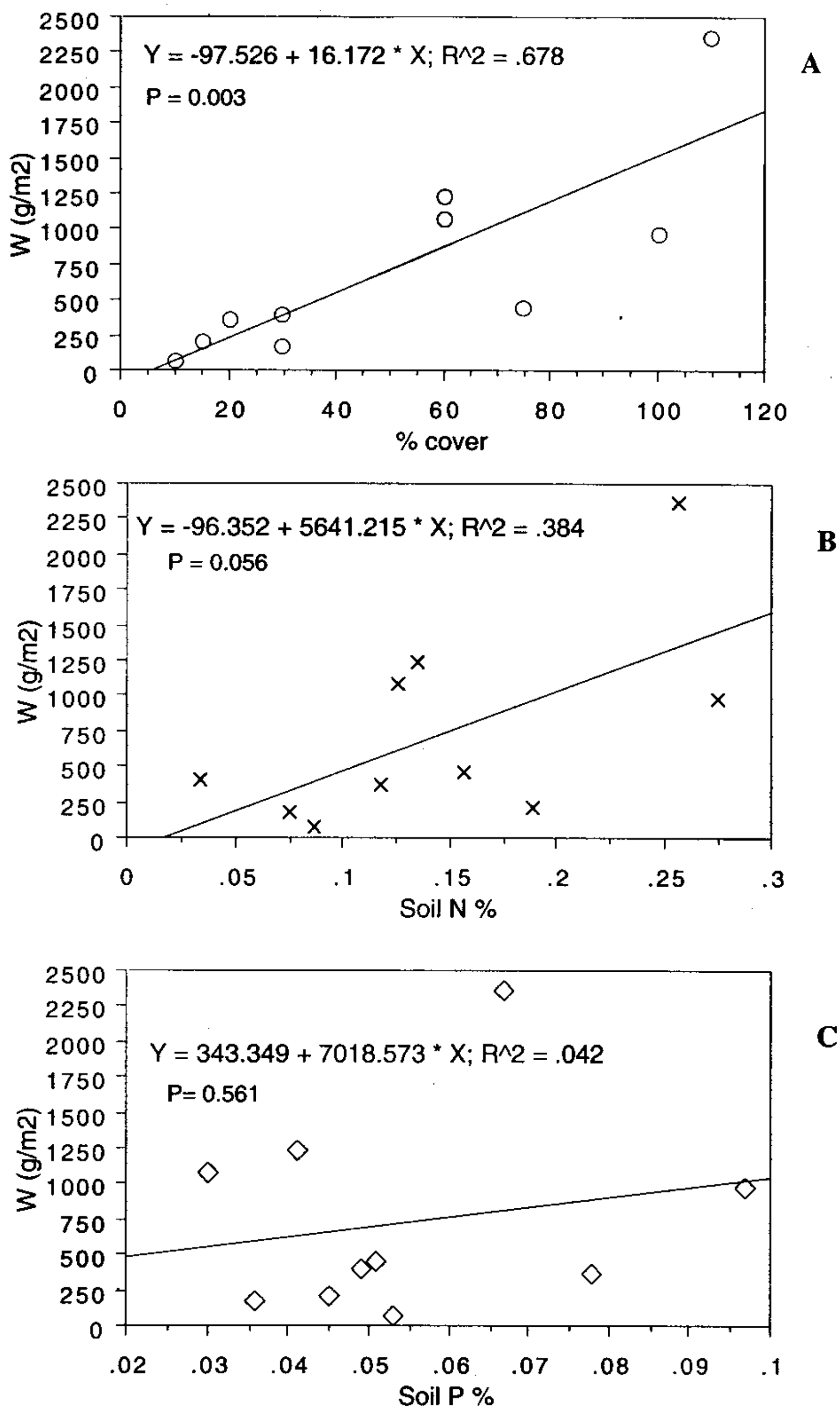


Fig12Relationship between the aboveground biomass (W g/m2) of *Cyperus Eragrostis* and plant cover (A), soil total nitrogen (B) and soil total phosphorus (P).

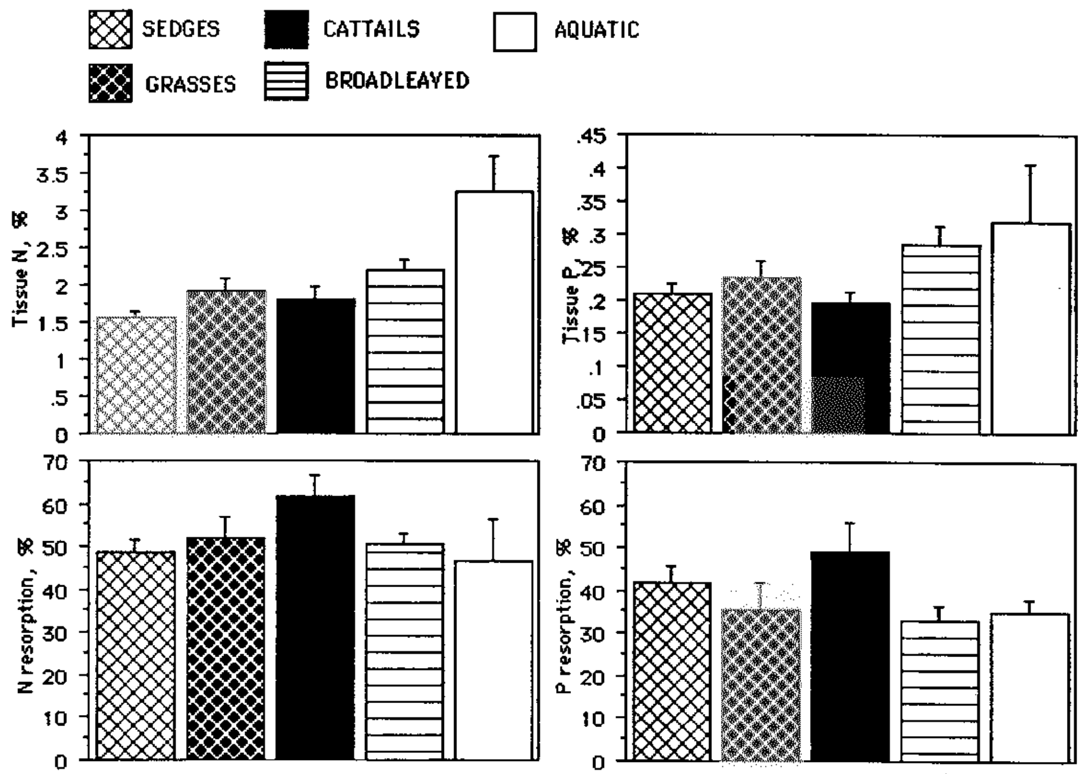


Fig. 13 Tissue nitrogen and phosphorus and nitrogen and phosphorus resorption from senescing tisues in five groups of wetland plants. Note different scale on y-axis for N and P tissue content.

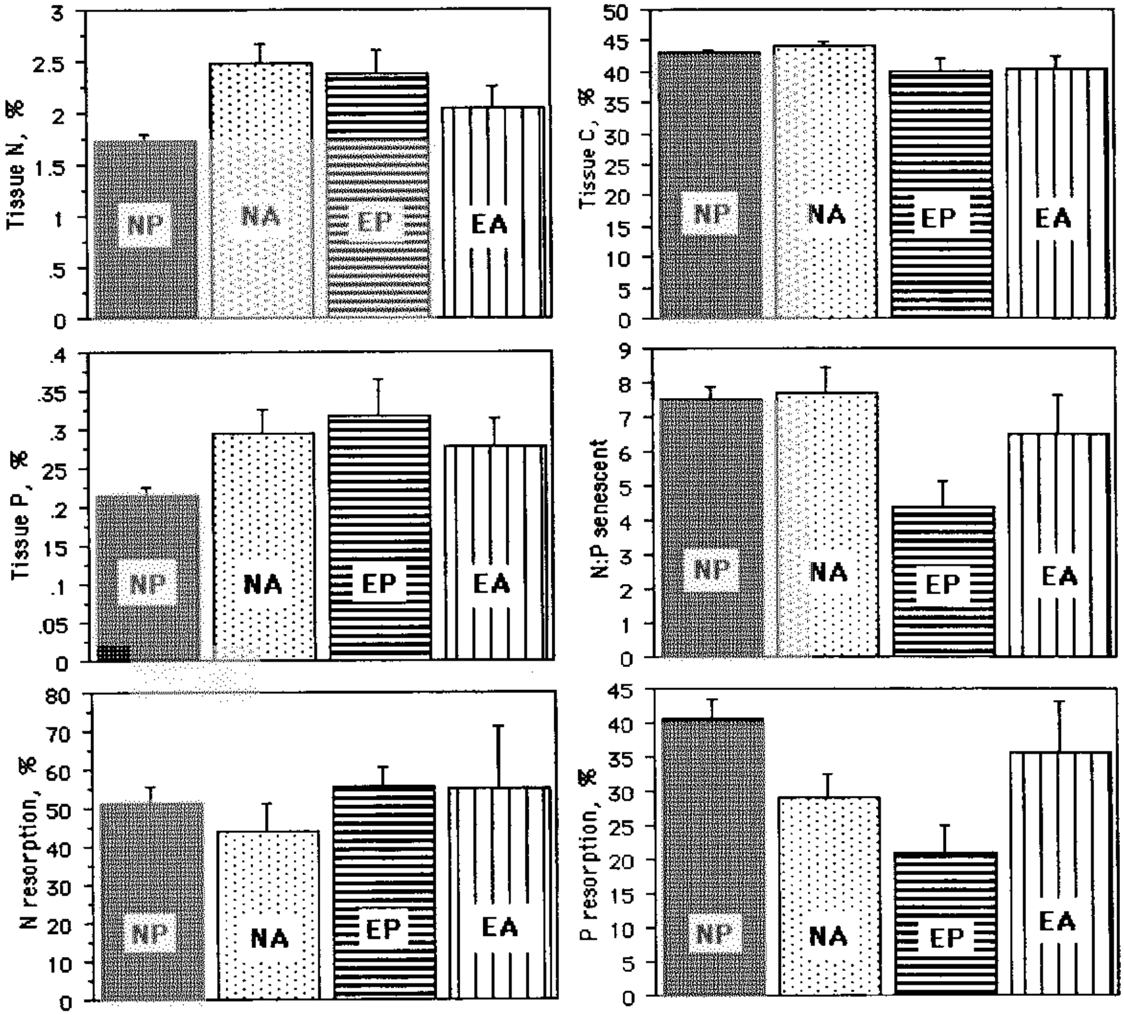


Fig. 14 Tissue nitrogen, carbon and phosphorus in live tissue; N:P ratio in senescent tissue, and N and P resorption from senenscing tissues in native perennial (NP), native annual (NA), exotic perennial (EP) and exotic annual (EA) wetland planrs.

Appendix 1 : Growth and Seedling Characteristics

Species	RGR (gg-1day-1)	Seedling wgt 7-day-old (mg)	Seedling wgt 21-day-old (mg)	Leaf area 21-day-old (cm2)	Leaf wgt 21-day-old (mg)	LAR (m2/kg)	SLA (m2/kg)	LMR (m2/kg)	NAR (g/m2day)	Shoot:Root 21-day-old	Roots 7-day-old (cm)	Roots 21-day-old (cm)	Avg. plant hgt at 56 days (cm)	Seeds present at day	Flowers present at day	Day of first tiller	Day of first clone
Alisma plantago-aquatica *																	
Artemisia douglasiana	0.1534	1.77	15.16	4.40	11.08	29.02	39.71	0.73	5.27	6.53	4.5	7-branch	45			49	
Aster subulatus *																	
Baccharis douglasii *																	
Bidens frondosa	0.2667	7.16	299.41	57.06	113.76	19.06	50.16	0.38	14.01	2.12	5-8 branch	35	60				
Carex barbarae *																	
Conium maculatum	0.1479	14.45	114.65	21.88	64.48	19.09	33.93	0.56	7.75	5.12	7 branch	13					
Crypsis schoenoides *																	
Cyperus eragrostis	0.3214	0.14	12.60	3.68	7.24	29.21	50.83	0.57	10.99	3.28	3 to 5	7-branch	49	49		35	
Echinochloa crus-galli	0.2829	2.52	132.31	21.75	45.18	16.44	48.14	0.34	17.22	1.97	3-6 branch	24	125	34		21	
Echinodorus berteroi *																	
Eclipta prostrata	0.3821	0.81	170.56	33.31	76.46	19.53	43.57	0.45	19.56	2.56	3-branch	16	day 49 (35)		42		
Epilobium ciliatum	0.2546	0.80	28.27	8.80	20.49	31.13	42.95	0.72	8.19	3.76	2	5-6 branch	53		42		
Juncus balticus	0.2515	0.17	5.75	1.16	3.16	20.17	36.71	0.55	12.49	4.26	2	3-branch	45			21	
Juncus bufonis &											3	5-branch	day 35 (15)			21	
Lepidium latifolium	0.3122	0.47	37.19	10.70	25.34	28.77	42.23	0.68	10.84	3.10	2-6 branch	7	19				
Lythrum hyssopifolium	0.2949	0.54	33.55	5.40	14.34	16.10	37.66	0.43	18.33	4.19	4	7-branch	54			21	
Mentha pulegium	0.2445	0.65	19.93	4.42	10.70	22.18	41.31	0.54	11.05	2.67	4	8-11 branch	25				
Paspalum dilatatum *													day 42 (35)			21	
Paspalum distichum *											4.5 branch	17	day 35 (75)			21	
Phragmites australis	0.2161	0.77	15.86	2.68	7.66	16.90	34.99	0.48	12.78	3.73	1.5 to 4	6-branch	57			28	
Polygonum hydropiperoides	0.3116	6.78	531.50	94.61	293.13	17.80	32.28	0.55	17.53	2.95	1-branch	17	day 49 (19)				
Polygonum lapathifolium	0.3242	5.70	533.42	57.47	209.10	10.77	27.48	0.39	30.07	3.98	2-branch	10.5	day 49 (24)		36		
Polygonum persicaria	0.2833	13.83	730.15	90.49	295.76	12.39	30.60	0.41	22.83	2.77	5-branch	12	day 28 (22)				
Polygonum punctatum	0.2589	4.13	155.10	38.07	93.45	24.55	40.74	0.60	10.55	4.85	4.5-branch	9 to 14	day 35 (6)				
Polypogon monspeliensis	0.2748	0.60	28.11	5.10	12.52	18.14	40.73	0.45	15.16	3.04	3-branch	6.5-	32				
Rumex crispus	0.2993	6.10	402.96	70.09	200.74	17.39	34.92	0.50	17.19	4.26	6-branch	11	day 49 (17)				
Sagittaria latifolia *																	
Sagittaria sanfordii !																	
Scirpus acutus	0.1197	1.54	8.23	1.32	2.28	16.04	57.89	0.28	7.48	1.40	2-branch	3	22				21
Scirpus californicus *													50				49
Scirpus maritimus (ID as *fluviatilis*)	0.2000	3.94	64.83	6.98	31.06	10.77	22.47	0.48	18.58	2.84	3-branch	5	65	54			21
Scirpus maritimus	0.1660	2.84	29.04	2.40	9.25	8.26	25.95	0.32	20.09	4.39	2-branch	4	day 49 (53)				42
Typha domingensis *													day 49 (66)				45

* = less than 10% final germination proportion for both growth chamber and greenhouse

& = less than 10% final growth chamber germination proportion

! = less than 10% final greenhouse germination proportion

Appendix 2: Nutrient enrichment mesocosm experiment

					ABOVE-GROUND					BELOW-GROUND				
tub	Nitrogen	Phosphorus	water	species	% P above	% N above	% C above	N:P	biomass wgt (g)	% P below	% N below	% C below	N:P	biomass wgt (g)
1	low	low	flood	*Bidens frondosa*	0.168	1.244	44.517	7.40	0.57	0.095	0.838	36.165	8.82	0.17
3	low	low	drwdn	*Bidens frondosa*	0.228	1.222	45.004	5.36	0.84	0.103	1.085	34.017	10.49	0.37
4	high	low	flood	*Bidens frondosa*	0.067	1.609	46.154	23.83	2.58	0.061	1.664	27.926	27.39	0.82
2	high	low	drwdn	*Bidens frondosa*	0.098	2.315	45.925	23.74	2.09	0.044	1.533	36.322	34.59	0.99
5	low	high	flood	*Bidens frondosa*	0.297	1.186	45.128	4.00	0.69	0.168	0.853	39.518	5.08	0.18
7	low	high	drwdn	*Bidens frondosa*	0.322	1.236	44.948	3.84	0.86	0.175	0.867	33.208	4.97	0.28
8	high	high	flood	*Bidens frondosa*	0.190	2.075	45.947	10.95	7.71	0.065	1.555	38.405	24.00	1.19
6	high	high	drwdn	*Bidens frondosa*	0.209	2.619	46.071	12.56	3.98	0.160	1.145	32.404	7.17	1.15
1	low	low	flood	*Cyperus eragrostis*	0.290	1.771	41.533	6.11	1.06	0.117	0.649	30.505	5.56	1.03
3	low	low	drwdn	*Cyperus eragrostis*	0.461	1.823	41.026	3.95	0.88	0.098	0.515	26.500	5.26	1.12
4	high	low	flood	*Cyperus eragrostis*	0.073	2.874	43.956	39.62	4.90	0.058	1.128	32.062	19.28	3.13
2	high	low	drwdn	*Cyperus eragrostis*	0.085	3.178	44.056	37.26	6.00	0.040	1.065	34.894	26.55	3.32
5	low	high	flood	*Cyperus eragrostis*	0.444	1.787	40.931	4.02	0.77	0.098	0.896	41.235	9.15	0.94
7	low	high	drwdn	*Cyperus eragrostis*	0.515	1.967	39.579	3.82	1.19	0.115	0.737	36.487	6.41	1.73
8	high	high	flood	*Cyperus eragrostis*	0.192	2.248	42.182	11.72	16.88	0.084	0.842	41.431	10.05	5.82
6	high	high	drwdn	*Cyperus eragrostis*	0.251	2.811	41.568	11.20	15.68	0.128	1.093	40.738	8.56	6.61
1	low	low	flood	*Echinochloa crus-galli*	0.111	0.640	41.217	5.78	1.98	0.038	0.734	40.984	19.21	1.23
3	low	low	drwdn	*Echinochloa crus-galli*	0.210	0.712	40.990	3.38	2.78	0.049	0.447	25.296	9.13	1.63
4	high	low	flood	*Echinochloa crus-galli*	0.033	1.734	42.114	51.88	5.04	0.031	1.016	42.598	32.57	3.66
2	high	low	drwdn	*Echinochloa crus-galli*	0.046	1.617	42.353	34.83	5.26	0.024	0.532	23.353	22.14	3.77
5	low	high	flood	*Echinochloa crus-galli*	0.285	0.703	39.509	2.47	2.22	0.129	0.452	28.555	3.50	1.16
7	low	high	drwdn	*Echinochloa crus-galli*	0.276	0.533	41.552	1.93	3.65	0.117	0.494	29.011	4.24	1.83
8	high	high	flood	*Echinochloa crus-galli*	0.099	1.562	41.795	15.80	23.58	0.056	0.478	22.927	8.58	6.06
6	high	high	drwdn	*Echinochloa crus-galli*	0.153	1.744	40.603	11.38	20.05	0.065	1.011	38.380	15.56	3.18
1	low	low	flood	*Lepidium latifolium*	0.333	1.664	39.349	4.99	0.20	0.325	1.138	42.239	3.50	0.16
3	low	low	drwdn	*Lepidium latifolium*	0.484	1.848	40.168	3.82	0.22	0.480	1.119	39.522	2.33	0.17
4	high	low	flood	*Lepidium latifolium*	0.104	3.016	43.097	28.87	1.32	0.107	1.850	28.420	17.30	0.53
2	high	low	drwdn	*Lepidium latifolium*	0.103	3.321	40.367	32.13	1.72	0.065	1.962	31.939	30.06	0.56
5	low	high	flood	*Lepidium latifolium*	0.487	1.746	39.623	3.59	0.19	0.469	1.237	38.146	2.64	0.09
7	low	high	drwdn	*Lepidium latifolium*	0.607	1.915	39.657	3.16	0.20	0.536	1.337	42.387	2.50	0.12
8	high	high	flood	*Lepidium latifolium*	0.205	2.207	41.736	10.79	3.72	0.246	1.356	23.561	5.52	1.90
6	high	high	drwdn	*Lepidium latifolium*	0.181	2.614	41.582	14.47	4.63	0.153	1.577	39.160	10.33	1.51
1	low	low	flood	*Phragmites australis*	0.264	1.901	44.081	7.21	0.35	0.225	0.762	41.046	3.39	0.47
3	low	low	drwdn	*Phragmites australis*	0.205	1.915	44.569	9.32	0.67	0.200	0.652	43.933	3.26	0.94
4	high	low	flood	*Phragmites australis*	0.223	3.058	43.885	13.69	0.53	0.252	1.952	40.639	7.76	0.44
2	high	low	drwdn	*Phragmites australis*	0.127	2.729	44.251	21.48	1.77	0.068	1.388	45.040	20.41	1.17
5	low	high	flood	*Phragmites australis*	0.290	1.851	44.760	6.40	0.56	0.232	0.626	43.711	2.70	0.48
7	low	high	drwdn	*Phragmites australis*	0.222	1.712	45.600	7.72	1.00	0.210	0.565	43.244	2.69	0.69
8	high	high	flood	*Phragmites australis*	0.256	2.621	45.763	10.23	1.91	0.284	1.443	39.222	5.08	1.13
6	high	high	drwdn	*Phragmites australis*	0.419	2.595	41.582	6.19	0.26	0.556	1.428	39.112	2.57	0.10

Bidens frondosa L.

Devil's Beggartick, Sticktight, Bur Marigold

Family: Asteraceae
Native

General Description:
This annual plant is distinguished by having each flowerhead surrounded by 5-9 narrow, leaflike bracts; center of flower head is orange. They are weedy plants with 2 pronged barbed fruits that cling to clothing.

Stems:
Stems are erect, square, glabrous or sparsely pilose, and 0.5 to 1.3 m tall.

Leaves:
Opposite leaves are pinnately compound with 3-5 petioled leaflets; leaflets are 2-8 cm long, lanceolate and irregularly serrate; terminal leaflet is close to being sessile; segments are irregularly lanceolate, coarsely and irregularly toothed or lobed; outer phyllaries are 5-8 cm long and foliaceous; inner phyllaries are much smaller, 8 to 10 mm, and more ovate.

Inflorescence:
Radiate or discoid heads are on 2-10 cm long peduncles; involucre is about 1 cm. in diameter and hemispheric; outer phyllaries are 5-8,1-5 cm long, approximately linear, and ciliate; inner phyllaries are 5-7 mm long and ovate; chaff scales are 5-7 mm long and brownish.

Flower:
Many flowers are crowded together into a head. Flowers are tubular and form a disk. They are without ray flowers present and each head is subtended by 5-8 leafy, ciliate bracts; stamens and 5 and ovary inferior.

Fruit:
Achene is blackish , 6-10 mm long, and has two awns that are 3-4.5 mm long with retrorse barbs. The achene is glabrous to stiffly hairy.

Germinability:
Germination from air-dried seeds stored at room temperature is about 60%.

Life History:
Ruderal- It germinates marginally well and has a low seedling establishment. It has a medium-high seedling Relative Growth Rate. (0.267 $gg^{-1}day^{-1}$) A 21-day-old seedling has a mass of about 300 mg dry weight. The biomass of mature plants ranges from 300 to 1600 gm^{-2} dry weight.

Habitat:
This species is found in brackish and freshwater marshes; found on sites that are occasionally flooded and especially on disturbed sites. It is found in littoral zones, low woods, wet meadows, swamps, roadside ditches, and along streams, fields.

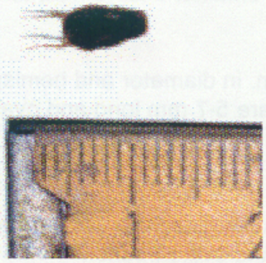
Range in California:
This species is generally found below 1600 m in North Coast Ranges, the Great Central Valley, southwestern California and in Modoc, Shasta, Mono and parts of Lassen counties.

Potential for use in restored wetlands:
This species is recommended for drier sites. This species readily germinates from air-dried seeds.

Potential for use in created wetlands for wastewater treatment:
Not recommended. This species generally prefers drier sites that are only occasionally flooded.

K.J. Tekel 2000

Top left: Achene
Top right: Flowers
Middle and Bottom right: Mature plant
Middle left: Mature flower with fruit
Bottom left: Two-week old seedling



K.J. Tekel 2000

Artemisia douglasiana Besser

Mugwort

Family: Asteraceae
Native

General Description:
This perennial species sprouts from horizontal rootstocks and is aromatic and bitter.

Stems:
Stems are many, erect, brown to gray-green, stout, and 50-250 cm tall.

Leaves:
Leaves are alternate, evenly spaced, 1-15 cm long, narrowly elliptic to widely oblanceolate, entire or coarsely 3-5 lobed near tip, sparsely tomentose above, and densely white-tomentose below.

Inflorescence:
Inflorescence is 10-30 cm long and 3-9 cm wide and leafy. Branches are widely spreading. Heads are 2-4 mm in diameter, bell-shaped and generally nodding. Phyllaries are obovate and gray-tomentose The margins are wide and transparent.

Flower:
There are 6-9 pistillate flowers. There are 9-25 disk flowers that are staminate. Central flowers are all fertile.

Fruit:
Fruit is less than 1 mm long and glabrous.

Germinability:
Germination from air-dried seeds stored at room temperature is about 90%.

Life History:
Competitive-ruderal. This species germinates well and has a high seedling establishment. It has a low seedling Relative Growth Rate. (0.153 $gg^{-1}day^{-1}$) A 21-day-old seedling's mass is about 15 mg dry weight and the first new shoot will emerge in about 7 weeks. The biomass of mature plants ranges from 700 to 1000 gm^{-2} dry weight.

Habitat:
This species is commonly found along stream banks, open to shady areas and in drainages.

Range in California:
This species is common in less than 2200 m altitudes throughout California except for desert and Modoc, Mono and parts of Lassen counties.

Potential for use in restored wetlands:
This species is recommended. It has a high rate of germination and but is not invasive.

Potential for use in constructed wetlands for wastewater treatment:
This species has a potential for being used in species mixtures because it propagates quickly by seeds. Its nutrient uptake capacity needs to be invesigated.

K.J. Tekel 2000

Top left: Two-week old seedling
Top right: Fruit
Middle left: Inflorescence
Middle right: Immature plants
Middle bottom: Mature plant

Alisma plantago-aquatica L.

Water Plantain, Mad-Dog Weed

Family: Alismataceae
Native

General Description:
This perennial species is distinguished by its large, plaintain-like leaves in a basal rosette and by its small, white flowers in clusters on a stout flowering stem.

Stems:
Stem is erect, smooth, and 10-120 cm long.

Leaves:
Leaves normally have a distinct blade and petiole and are all basal. Leaves (including petioles) are 7-45 cm long and blades are 5.5-15 cm long and 1.5-10 cm wide. Blades are lanceolate to ovate, pointed at the tip, rounded or sometimes subcordate at the base.

Inflorescence:
Inflorescence is generally much greater than leaves. Pedicels are ascending to erect.

Flowers:
White flowers are whorled, up to 5 mm across, and 3-sided. Sepals are 3, green, ovate, and plane or somewhate gibbous. Petals are 3, white or sometimes rose to pink, 3-6 mm long, rhombic in outline and have margins that are entire or minutely erose. Stamens are 6 and have glabrous filaments. Pistils are numerous in a single, often obscurely 3-sided whorl. Styles are 1-1.5 mm long and ovaries superior.

Fruit:
Achene is borne in circular heads that are up to 5 mm in diameter, is often 3-ribbed on back, and is 2-3 mm long.

Germinability:
This species does not germinate from air-dried seed stored at room temperature.

Habitat:
This species is found along streams, around margins of ponds, lakes, marshes, in shallow water or on wet mud and requires temporarily flooded conditions.

Range in California:
This species is found in elevations less than 1600 m throughout California except for desert, Modoc, Mono, and parts of Lassen counties. Specifically, it is found on shores of brackish and freshwater marshes from Ventura County north; especially abundant in the Sacramento-San Joaquin delta region and north in Sacramento Valley.

Potential for use in restored wetlands:
An efficient way of propagation by seeds needs to be designed (probably including scarification and stratification) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species has not been tested. It has a potential for small-scale wastewater treatment operation, especially after the methods for the necessary seed scarification and stratification are worked out.

K.J. Tekel, 2000

Aster subulatus Michaux var. *ligulatus* Shinn.

Small Aster, Annual Salt-Marsh Aster

Family: Asteraceae
Native

General Description:
This annual aster is distinguished by its 1.3 cm wide flower heads and very short purplish rays. Leaves are narrowly lanceolate shaped, 5-25 cm long, and 30-90 cm tall.

Stems:
Stems are erect, 20-80 cm long, and glabrous.

Leaves:
Leaves are basal, alternate, cauline, sessile, generally 3-6 cm long, linear to oblanceolate, acute, and glabrous.

Inflorescence:
Heads are in an open cyme; phyllaries are linear to lanceolate, acute to long-tapered, green and sometimes pale-margined.

Flowers:
Ray flowers are many; corollas are generally less than 7 mm long, pink to violet, and barely greater than corollas.

Fruit:
Fruit can be hairy, somewhat ribbed on angles, and the pappus is very fine.

Germinability:
Germination from air-dried seed stored at room temperature is very low, about 1%.

Habitat:
This species is found in wet places, often alkaline, marshes, floodplains and rice fields.

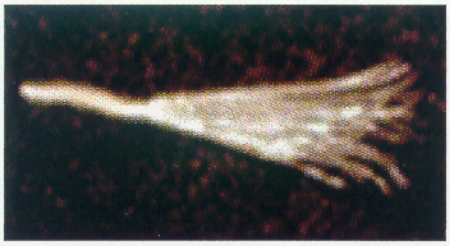
Range in California:
This species is common in elevations less than 200 m in Great Central Valley and central western to southwestern California.

Potential for use in restored wetlands:
An efficient way of propagation by seeds needs to be designed (probably including scarification and stratification) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species has not been tested. It has a potential for small-scale wastewater treatment operation, especially after the methods for the necessary seed scarification and stratification are worked out.

K.J. Tekel 2000

Top left: Fruit
Middle left: Flowers
Middle right: Mature plant
Bottom left: Close-up of mature plant
Bottom right: Close-up of mature flower with fruits



K.J. Tekel 2000

Carex barbarae Dewey

Santa Barbara Sedge

Family: Cyperaceae
Native

General Description:
This is a monecious species that has extensive rhizomes. The leaf blades are triangular shaped. It is a very important species for traditional basket making.

Stems:
Stems are erect 30 to100 cm tall, and have extensive horizontal rhizome systems (up to 180 cm in length).

Leaves:
Leaf blades are light green and triangular shaped, 3.5-9 cm wide, and have a lower sheath, They are strongly keeled towards the base. Sheath front is purple and lower is shredding to network or fringe of veins.

Inflorescence:
Lateral spikelets are 2.5-8 cm long, 5-8 mm wide, brown, and have tips that sometimes staminate; pistillate flower bract is awned. The awn or tip is hairy; staminate spikes are 1 to 2; pistillate spikes are 2 to 3.

Fruit:
Perignyia are 50-200 per spikelet, spreading 1.9-2.5 mm wide, oval-orbicular to obovate, 3-4.5 mm long, marginally 2-ribbed, straw colored or brownish, red-dotted, abruptely short-beaked, tough and thick walled, and have teeth that are minutely hairy.

Germinability:
Germination from air-dried seeds stored at room temperature is low, about 3%.

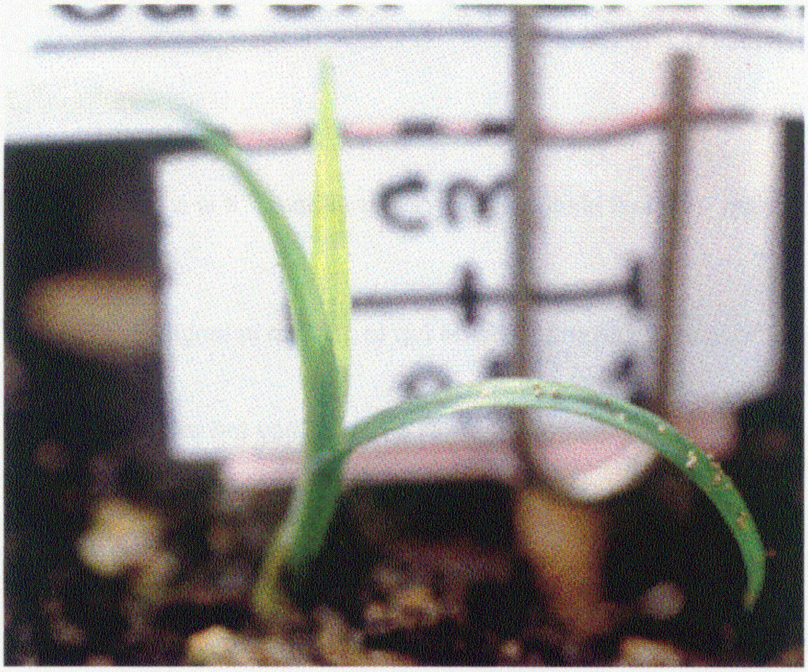
Habitat:
This species is found in seasonally wet places, along streams or on slopes and occasionally bordering marshes. It can withstand a wide range of water depths, surviving both floods and droughts but perfers moist soil. It grows on dry slopes and also seasonally inundated areas.

Range in California:
This species is found in elevations less than 900 m in Klamath Ranges, North Coast Ranges, Cascade Range foothills, Sierra Nevada foothills, the Great Central Valley and the south coast.

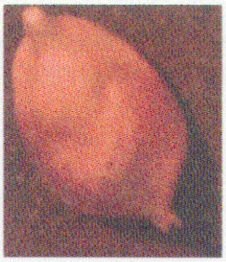
Potential for use in restored wetlands:
This species is recommended if cuttings from rhizomes are used for propagation.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended if cuttings from rhizomes are used for propagation. Information on its nutrient capacity needs to be invesigated.

K.J. Tekel 2000



Top left: Two-week old seedling
Top right: Perigynia
Bottom left: Immature plant



Crypsis schoenoides (L.) Lam.

Swamp Grass

Family: Poaceae
Exotic

General Description:
This annual grass is pink to purple and generally mat-like.

Stems:
Stem is decumbant, 5-75 cm tall, and has few branches.

Leaves:
Blade is 2-10 cm long, sheath is wide, and is glabrous.

Inflorescence:
Inflorescence is 3-75 mm long, 5-15 mm wide, ovoid to cylindric, and enclosed by subtending sheath; spikelet is about 3 mm long; glume margin is glabrous, lower glume is less than upper glume; lemma is generally greater than glume.

Fruit:
Fruit is 1 mm long, ovoid in shape, and has points at the ends.

Germinability:
This species does not germinate from air-dried seed stored at room temperature.

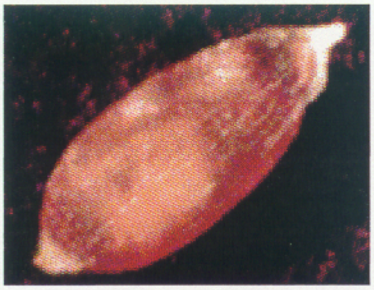
Habitat:
This species is found in wet places, vernal pools, and overflow lands.

Range in California:
This species is found in elevations less than 500 m throughout California except for the desert and Modoc, Mono, and parts of Lassen counties.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000



Top left: Fruit
Middle left: Mature plant
Middle right: Close-up of inflorescence

Cyperus eragrostis Lam.

Tall Flatsedge

Family: Cyperaceae
Native

General Description:
It is a perennial sedge with trigonous stems that are slightly swollen at the base. It is characterized by short, thick rhizomes and coarse fibrous roots.

Stems:
Stems are 10-90 cm tall, has trigonous stems, and are slightly swollen at the base.

Leaves:
Leaves are basal, almost as long as stem, scabrellate on margin and occasionally on midrib.

Infloresence:
Inflorescence is a compact globose compound umbel,with 4-8 bracts; bracts are scabrellate on the margins and midrib, of unequal length, and are 3-50 cm long; flower bracts are 6-12 per spikelet, 2.0-2.3 mm long, ovate-lanceolate, beige, and have a tip acute.

Flowers:
Flowers are bisexual with one stamen.

Fruit:
Fruit is 1.2-1.4 mm long, black or dark brown, finely reticulate, stalked, and has beaked tip. Fruit has triangular cross-section and encloses one seed.

Germinability:
Germination from air-dried seed stored at room temperature is about 77%.

Life History:
Competitive-ruderal. It germinates well and has a high seedling establishment. It has a medium seedling Relative Growth Rate. (0.273 $gg^{-1}day^{-1}$) A 21-day-old seedling has a mass of about 10 mg dry weight. A new shoot is formed in about 5 weeks. The plant matures in about 7 weeks when fruit are present. The biomass of mature plants ranges from 500 to 2100 gm^{-2} dry weight.

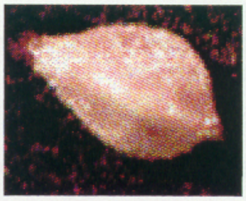
Habitat:
This species is found on moist sediment to shallow flooded zones, in low marsh area of freshwater tidal sloughs, marshes, vernal pools, in ditches, and on streambanks.

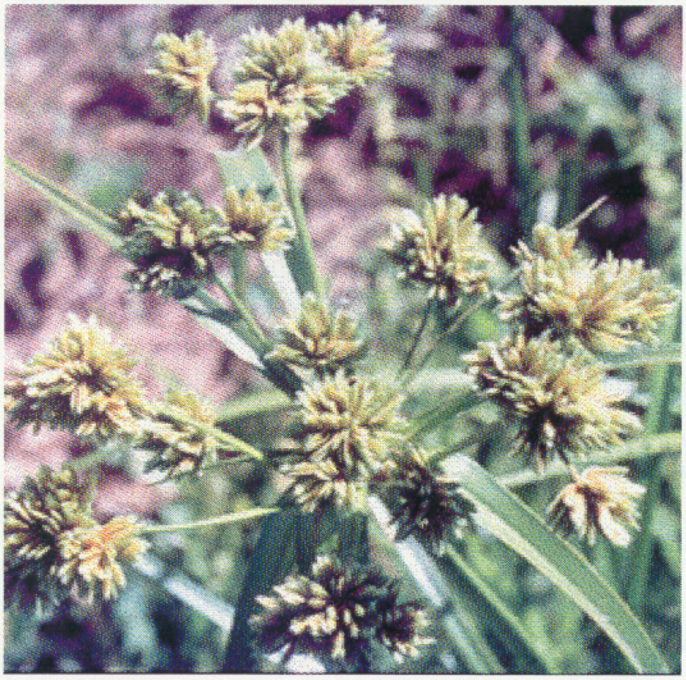
Range in California:
This species is found in areas less than 700 m in elevation throughout California except for the desert and Modoc, Mono, and parts of Lassen counties.

Potential for use in restored wetlands:
This species is recommended. It is a native species that germinates well and produces large quantities of fruit.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended. It is a native species that germinates well. It's nutrient uptake potential needs to be investigated.

K.J. Tekel 2000





Top left and right: Mature plant
Middle right: Fruit
Bottom left: Close-up of rays with spikelets

K.J. Tekel 2000

Echinochloa crus-galli (L.) P. Beauv.

Barnyard Grass, Wild Millet

Family: Poaceae
Exotic

General Description:
This tufted annual grass is 60-160 cm tall. Culms can be spongy, especially at bases and between nodes. It is usually flattened at bases with erect tips (decumbent), looking as though it had been trampled.

Stems:
Culms are erect or nodding, often branching at the base and up to 1.5 m tall.

Leaves:
Sheaths are glabrous and 3-7 cm. long; blades are elongate, 0.5-30 cm long, and 5-15 mm wide; slightly rough to touch.

Inflorescence:
Ligules are reduced; panicle is erect or nodding, 8-30 cm long, 2-10 cm wide, and purple tinged; racemes are spreading, ascending, or appressed, and the lower racemes are somewhat distant.

Spikelets:
Spikelets are 3-5 mm long excluding awns and crowded; there are 1 to several hispid hairs and are 2-4 mm long at base of spikelets; awns are variable, mostly 5-10 mm long on at least some of the spikelets, and sometimes as much as 5 cm. long; sterile lemma body is 3-4 mm long, unawned or has an awn that is 1-10 mm long; fertile lemma and palea are 2.8-4.5 mm long.

Germinability:
Germination from air-dried seed stored at room temperature is about 97%.

Life History:
Ruderal. It germinates very well and has a high seedling establishment. It has a high seedling Relative Growth Rate. (0.302 $gg^{-1}day^{-1}$) A new tiller is formed in about 3 weeks and a 21-day old seedling has a mass of about 130 mg dry weight. The plant matures in about 5 weeks when spikelets are present. The biomass of mature plants ranges from 250-1600 gm^{-2} dry weight.

Habitat:
This species is found in low salinity tidal marshes and freshwater marshes. It is often found on levees intermixed with other herbs and shrubs; moist or wet soil in cultivated or waste places, fields, roadsides. It is a troublesome weed in rice fields.

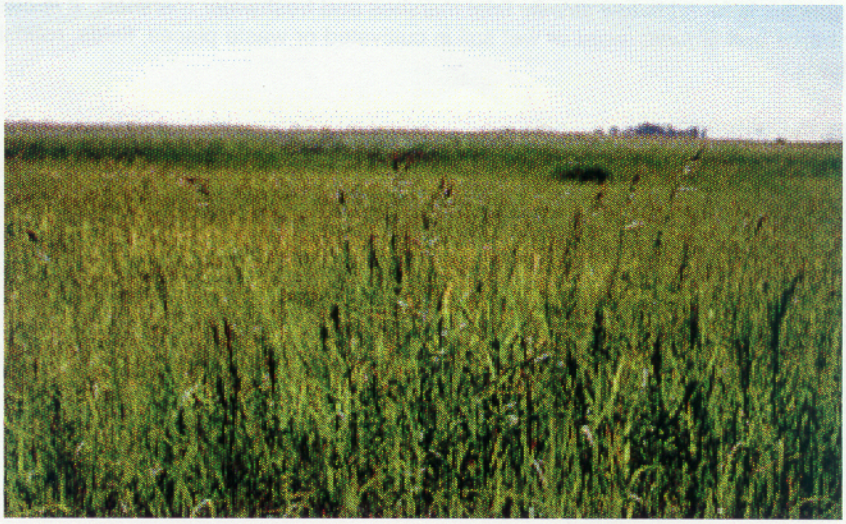
Range in California:
This species is found throughout California in elevations less than 1500 m.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000

Top left: Immature plant
Top right: Inflorescence
Bottom left: Spikelet
Bottom right: Habitat of Mature plants



K.J. Tekel

Echinodorus berteroi (Sprengel) Fassett

Burhead

Family: Alismataceae
Native

General Description:
This species is generally an annual species in California. The leaves are petiole angled and the blade is linear to cordate. The fruit is cluster bur-like. The biomass of mature plants ranges from 470-1000 gm^{-2} dry weight.

Stems:
No real stem.

Leaves:
Leaves are petiole angled; blade is linear to cordate, with transparent lines, and coarsely veined; submerged blades are linear and wavy; floating and emergent blades are 6-14 cm long and 3-15 cm wide.

Inflorescence:
Inflorescence is generally larger than the leaves and the peduncle is angled; pedicels are less than 20 mm long and generally ascending.

Flowers:
Petals are 6-9 mm long; stamens are about 12.

Fruit:
Body of the fruit is 1.5-3 mm long, ribs are generally 5; beak is less than 2 mm.

Germinability:
Germination from air-dried seeds stored at room temperature is very low, about 1%

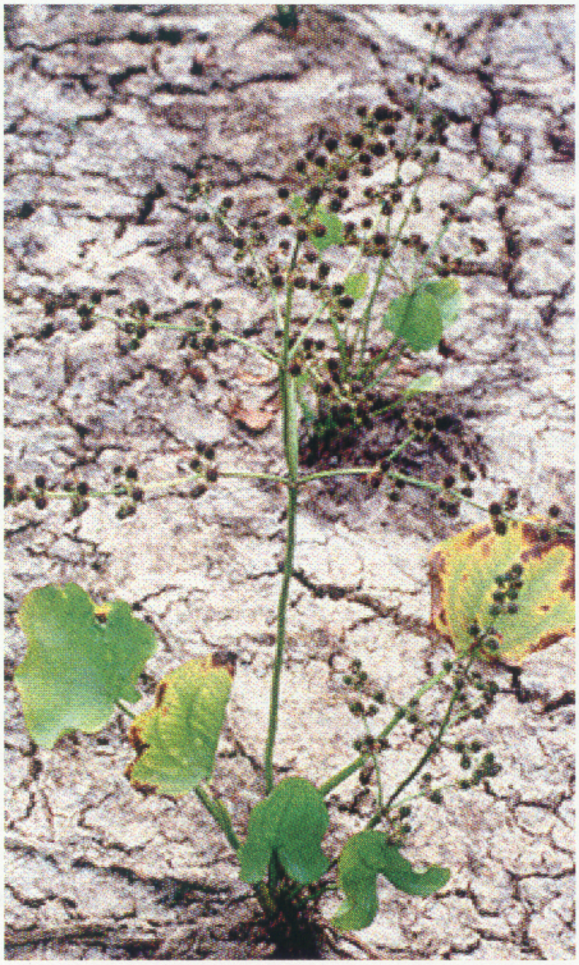
Habitat:
This species is found in wet ditches, ponds, and marshes.

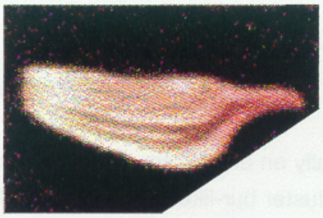
Range in California:
This species is found at elevations less than 300 m in the Inner North Coast Ranges, Great Central Valley, and central western to southwestern California.

Potential for use in restored wetlands:
An efficient way of propagation by seeds needs to be designed (probably including scarification and stratification) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species has not been tested. It has a potential for small-scale wastewater treatment operation, especially after the methods for the necessary seed scarification and stratification are worked out.

K.J. Tekel 2000





Top and middle left: Mature plant
Top right: Fruit
Middle right: Close-up of flower and inflorescence
Bottom: Habitat of adult plants

K.J. Tekel 2000

Epilobium ciliatum Raf

Willow Herb, Fireweed

Family: Onograceae
Native

General Description:
This perennial species is less than 190 cm tall, loosely clumped, has basal rosettes or fleshy bulbets, and is generally strigose in lines or spreading-hairy.

Stems:
Stems are less than 190 cm tall. The main stem branching in upper half especially in flower clusters.

Leaves:
Leaves are 1-15 cm long and narrowly lanceolate to ovate. The veins are conspicuous. The petiole is less than 8 mm long.

Inflorescence:
Infloresence is densely strigose, can be spreading, and generally glandular.

Flowers:
Hypanthium is 0.5-2.6 mm long; sepals are 2-7.5 mm long; petals are 2-14 mm long and white to purple-rose; stamens are less than or equal to pistil; stigma is club- or head-like.

Fruit:
Fruit is 15-100 mm long and hairy; pedicels are less than 30 mm long; seed is 0.8-1.9 mm long and ridged.

Germinability:
Germination from air-dried seed stored at room temperature is about 70%.

Life History:
Competitive-ruderal. It germinates marginally well and quickly. It has a high seedling establishment. It has a medium seedling Relative Growth Rates. (0.255 $gg^{-1}day^{-1}$) A 21-day-old seedling has a mass of about 30 mg dry weight. It flowers in about 6 weeks.

Habitat:
This species is abundant in disturbed areas, moist meadows, streambanks, and along roadsides.

Range in California:
This species is found in elevations less than 4100 m throughout California.

Potential for use in restored wetlands:
This species is recommended. It is a native species that germinates reasonably well and is not weedy.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended but its nutrient uptake potential needs to investigated.

K.J. Tekel 2000

Top left: Two-week old seedling
Top right: Fruit
Middle right: Close-up of flower
Bottom and Middle left: Mature plant
Bottom right: Mature leaves and flower

K.J. Tekel 2000

Juncus balticus Willd.

Baltic Rush

Family: Juncaceae
Native

General Description:
This perennial species has scaly rhizomes, is generally unbranched, and is slender to stout in form.

Stems:
Stems are 35-110 cm tall, 1-6 mm wide, generally cylindric, and often in small clusters.

Leaves:
Leaves are basal and the blades are absent; sheaths are variable and 2-15 cm long.

Infloresence:
Infloresence appears lateral and open; lowest bract is cylindric, resembling stem, and generally much greater than infloresence; flowers are 5-50 or more; bractlets are 2 and membranous.

Flowers:
Perianth segments are 3-6 mm long; sepals are equal to petals and scarious; margins of petals are wider than those of sepals; stamens are 6; filaments are much less than anthers; ovary superior, pistil is 1 and 3- or sometimes 1-celled; stigmas are 3.

Fruit:
Fruit is a loculicidally 3-valved capsule; beak is small but obvious; seed is 0.4-0.8 mm long; appendages are absent.

Germinability:
Germination from air-dried seed stored at room temperature is about 50%.

Life History:
Competitor- It germinates marginally and relatively slow. It has a marginal seedling establishment. It has a relatively high seedling Relative Growth Rate. (0.252 $gg^{-1}day^{-1}$) A 21-day-old seedling has a mass of about 6 mg dry weight. The first clone appears in about 3 weeks. The biomass of mature plants ranges from 900-1500 gm^{-2} dry weight

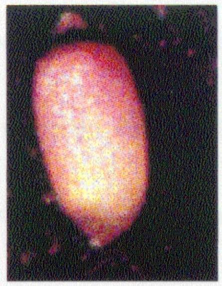
Habitat:
This species is common and widespread on moist to rather dry ground.

Range in California:
This species is found in elevations less than 2200 m throughout California.

Potential for use in restored wetlands:
This species is recommended. This native rush, once established by seed or transplants, will form a reasonably tall and dense stand with extensive lateral spread. It also can be used to stablize ground.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended. This native rush, once established by seed or transplants, will form a reasonably tall and dense stand with extensive lateral spread. It's nutrient uptake capacity needs to be investigated.

K.J. Tekel 2000



Top left: Close-up of inflorescence
Top right: Fruit
Middle left: Habitat of mature plants

Lepidium latifolium L.

Peppergrass, Pepperwort

Family: Brassicaceae
Exotic

General Description:
This species is an erect, invasive, perennial that is 40-100 cm tall, grayish, and rhizomed with small white flowers.

Stems:
No real stem

Leaves:
Basal leaves are less than 30 cm long, 6-8 cm wide, and petioled; cauline leaves are reduced but many, and 1-4 cm wide.

Inflorescence:
Hairs are sparse or none on the panicle.

Flowers:
Sepals are less than 1 mm long, margins are wide and white; petals are white; stamens are 6.

Fruit:
Fruit is about 2 mm long, approximately round, and has sparse hairs; pedicel is much greater than the fruit, slender, cylindric, and has sparse hairs; there is no style.

Germinability:
Germination from air-dried seed stored at room temperature is about 100%.

Life History:
Ruderal. It germinates very well and fast. It has a high seedling establishment. It has a high seedling Relative Growth Rate. (0.312 $gg^{-1}day^{-1}$) A 21-day-old seedling has a mass of about 40 mg dry weight. The biomass of mature plants ranges from 450-600 gm^{-2} dry weight.

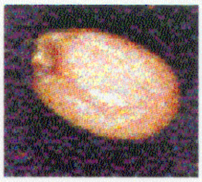
Habitat:
This species is invasive and is found in tidal shores, salt marshes, freshwater marshes, disturbed areas, and roadsides.

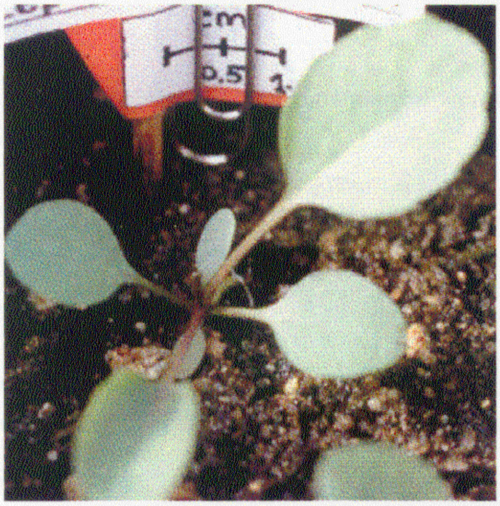
Range in California:
This species is found in elevations less than 1900 m throughout California except for desert and Klamath Ranges.

Potential for use in restored wetlands:
Not recommended. An exotic.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic.

K.J. Tekel 2000





Top left: Close-up of flowers
Top right: Fruit
Bottom left: Two-week old seedling
Bottom: Habitat of mature plants

K.J. Tekel 2000

Ludwigia peploides (Kunth) Raven

False Loosestrife, Water Primrose

Family: Onagraceae
Native

General Description:
This perennial species is found floating, matted or creeping along banks. It has yellow flowers and the leaves are egg- or oval- shaped.

Stems:
Stems are 10-300 cm long, prostrate to erect, and simple or branched. It can root at nodes.

Leaves:
Leaves are less than 10 cm long, alternate and can be clustered; blade is oblong to round, subentire, and glabrous to spreading hairy-above.

Flowers:
Sepals are 5 or can be 6 and 3-12 mm long; petals are 5 or 6 and 7-24 mm long; stamens are 10 or can be 12 in 2 unequal sets; anthers are 0.5-2.2 mm long

Fruit:
Fruit is reflexed; pedicel is 6-90 mm long; body is cylindric, approximately 5 angled, hard, and subglabrous to spreading hairy; seed is 1-1.5 mm long and embedded in inner fruit wall.

Germinability:
Unknown

Habitat:
This species is found in ditches, streambanks, and lakeshores.

Range in California:
This species is found in elevations less than 900 m in Sierra Nevada foothills, Great Central Valley, along the coast, San Francisco Bay, Western Transverse Ranges, and Mojave Desert.

Potential for use restored wetlands:
This species is recommended. It is a native species and cuttings can be used for propagation.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended. It is a native species and cuttings can be used for propagation. It grows very well in waters enriched with nitrogen.

Top left: Mature plant with flowers
Top right: Close-up of flower
Bottom left: Fruit

K.J. Tekel 2000

Conium maculatum L.

Poison Hemlock

Family: Apiaceae
Exotic

General Description:
This biennial speices is often found on waste sites and has a smooth and purple-spotted stems. It is deadly poisonous if eaten.

Stems:
Stem is 50-300 cm tall, branching, purple-spotted, and has a musty odor.

Leaves:
Leaves are widely ovate, pinnately dissected and 2-pinnate into small segments; base of leaves are enlarged and sheathing the stem; blade is widely ovate and 15-30 cm long; lower leaves are dilated, have sheathing petioles, and are 30-60 cm or more long, including petiole; upper leaves are sessile.

Inflorescence:
Inflorescences are much branched; peduncles are 2-8 cm long; bracts beneath the umbel are entire; umbels are large, compound, and 3-8 cm wide; rays are 10-15 and 2-4 cm long; pedicels are slender and 4-6 mm long; involucle are 5-6, small, ovate, and have 4-6 acuminate bracts; bractlets are 1.5-2 mm long.

Flowers:
Flowers are white; sepals are obsolete; carpels have prominent undulate ribs.

Fruit:
Fruit is 2-3 mm long, glabrous, broadly ovate, slightly flattened, and have ribs that are generally wavy.

Germinability:
Germination from air-dried seed stored at room temperature is about 60%.

Life History:
Competitive-ruderal. This species germinates marginally well but has a low seedling establishment. It has a low seedling Relative Growth Rate (0.148 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 110 mg dry weight.

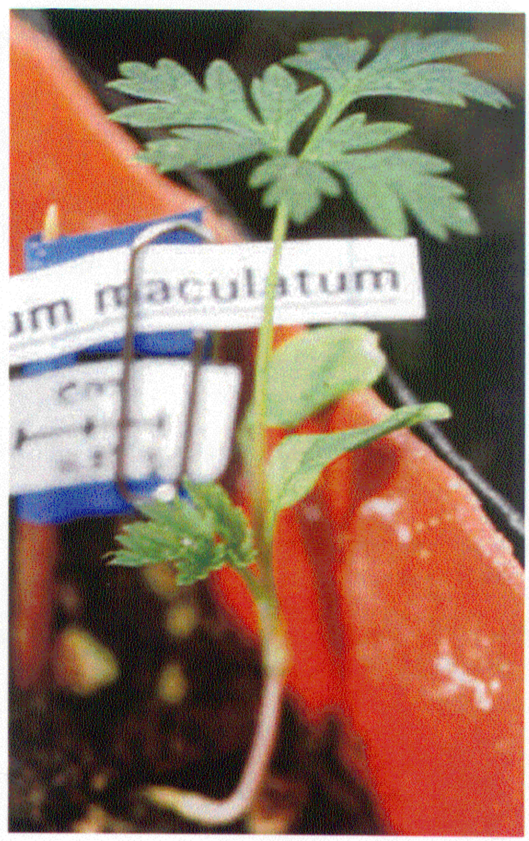
Habitat:
This species is found in moist areas, waste sites, abundantly established in shady or low, and wet ground.

Range in California:
This species is found in elevations less than 1000 m throughout California except for the desert and Modoc, Mono, and parts of Lassen counties.

Potential for use in restored wetlands:
Not recommeded. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommeded. An exotic species.

Top left: Mature plant
Top right: Achene
Bottom left: Flowers
Bottom right: Two-week old seedling



K.J. Tekel 2000

Eclipta prostrata (L.) L.

Family: Asteraceae
Native

General Description:
This annual species is a low herb with decumbant or ascending stems. It has herbage that is rough-hairy with the hairs appressed.

Stems:
Stems are 10-100 cm tall, decumbent or ascending, and rooting from lowest nodes.

Leaves:
Leaves are opposite, simple, sessile, lanceolate or narrowly elliptic, entire or short-toothed, and have acute tips.

Inflorescence:
Peduncle is less than 15 mm long; involucre is 4-10 mm in diameter; phyllaries are 4-5 mm long and acute.

Flowers:
Ray flowers have a corolla that is 1.5-3 mm long; disk flowers have corollas that are 1.5-2 mm long.

Fruit:
Fruit is 1.7-2.2 mm long, obovate, smooth and can be warty; pappus is less than or equal to 0.2 mm in length.

Germinability:
Germination from air-dried seeds stored at room temperature is about 100%.

Life History:
Competitive-ruderal. It germinates extremely well and moderately fast. It has a high seedling establishment. It has a high seedling Relative Growth Rate (0.382 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 170 mg dry weight It flowers in about 6 weeks.

Habitat:
This species is found in damp places, streams, ditches and in moist waste sites.

Range in California:
This species is found in elevations less than 300 m in the Great Central Valley, southern Coast Ranges, southwest, and the Sonaran Desert.

Potential for use in restored wetlands:
This species is recommended. It is a low lying native herb that germinates quickly and grows rapidly.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended but its nutrient uptake potential needs to investigated.

K.J. Tekel 2000

Top left: Two-week old seedling
Top right: Fruit

Lythrum hyssopifolium L.

Loosestrife

Family: Lythraceae
Exotic

General Description:
This species is an annual or biennial. It is a pale waxy green plant that is usually found in drier locations. Their flowers are smaller than purple loosestrife flowers, and not as deep red or purple; they are sometimes white.

Stems:
Stems are 10-60 cm long and branching; lower branches are prostrate to erect and generally glabrous.

Leaves:
Lowermost leaves are opposite; Upper leaves are generally alternate, sessile, linear to oblong or lanceolate, 5-30 mm long.

Inflorescence:
Spike is terminal; bracts are linear, flowers are sessile.

Flowers:
Hypanthium is 4-6 mm long and cylindric; sepals are deltate and shorter than appendages: appendages are approximately 1 mm long and awn-like; petals are 2-5 mm long and pink to rose; stamens are 4-6 inclusive; style can be exserted.

Fruit:
Capsule is ellipsoidal to cylidric; seeds are shiny, brown, striate, and hollow on one side.

Germinability:
Germination for air-dried seed stored at room temperature is about 100%.

Life History:
Stress-tolerating ruderal. It germinates well and moderately quickly. It has a high seedling establishment. It has a relatively high seedling Relative Growth Rate (0.295 $gg^{-1}day^{-1}$). A new shoot will form in around 3 weeks. A 21-day-old seedling has a mass of about 35 mg dry weight.

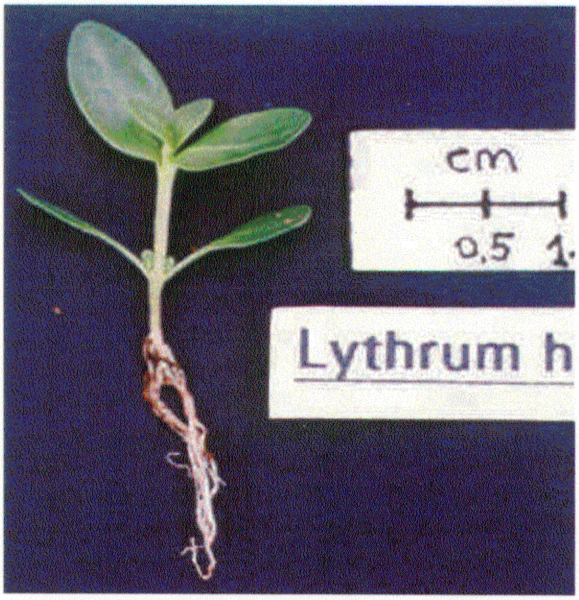
Habitat:
This species is found in marshes, drying pond margins, wet soil, vernal pools, margins of streams and pools, and is often a garden weed.

Range in California:
This species is found in elevations less than 1600 m throughout California except for the desert and Modoc, Mono and parts of Lassen counties.

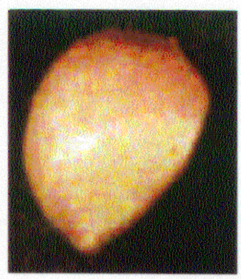
Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K. J. Tekel 2000



Top left: Two-week old seedling
Top right: Close-up of flower
Middle left: Mature plant
Middle right: Achene
Bottom: Mature plants



K. J. Tekel 2000

Mentha pulegium L.

Pennyroyal mint

Family: Lamiaceae
Exotic

General Description:
This species is a perennial aromatic forb that has greenish-gray hairy square stems. It has powdery blue to lavender flowers that are clustered in leaf axils. It is a very variable species in leaf shape and pubescence. The oil is toxic.

Stems:
Stems are decumbent to ascending, 10-60 cm long, square, and are short-hairy.

Leaves:
Leaves are generally 1.5-2.5 cm long and reduced upward; lower leaves are short-petioled, cauline, and generally subsessile; blade is narrowly ovate to elliptic, base is tapered to obtuse; tip is generally rounded, entire to finely serrate, and the lower surface is short hairy.

Infloresence:
Each axillary is head-like and subtended by reflexed leaves or leaf-like bracts. Flowers are in dense whorls bunched at intervals from midway along plant to tops of stems.

Flowers:
Calyx is 2.5-4 mm long and short-hairy; corolla is 5-8 mm long and violet to lavender; stamens are greater than corolla lobes.

Fruit:
Nutlets are small, ovoid, and finely reticulate.

Geminability:
Germination from air-dried seed stored at room temperature is about 65%.

Life History:
Competitive-ruderal. It has marginal germination and seedling establishment. It has a medium seedling Relative Growth Rate (0.245 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 20 mg dry weight.

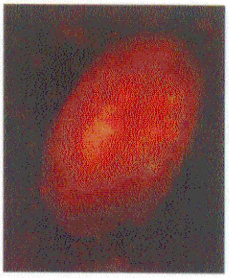
Habitat:
This species is found in low marshy ground of wet meadows, prairies, fields, pastures, riverbanks and pond edges. It is common in disturbed areas such as impoundments, borrow-pits and ditches.

Range in California:
This species is found in elevations less than 1000 m in northwest, San Joaquin Valley, central western California, and Southern Coast Ranges.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000



Top left: Two-week old seedling
Top right: Nutlet
Bottom left: Inflorescence of mature plant
Bottom right: Mature plant

K.J. Tekel 2000

Paspalum dilatatum Poiret

Dallis Grass

Family: Poaceae
Exotic

General Description:
This weedy species is a perennial grass that sprouts from short rhizomes and is 50-150 cm tall.

Stems:
Stems are decumbent to erect, 25-140 cm tall, and have 2-6 nodes.

Leaves:
The sheath is 6-30 cm long and glabrous to hairy; ligule is 2-8 mm long; blade is 9-35 cm long and 4-10 mm wide, has a glabrour upper surface, and is sometimes sparsely hairy at base.

Inflorescence:
Main axis is 3-20 cm long; 3-6 primary branches each being 4-12.5 cm long; Spikelets are many, have 2 per node and has a stalk that is 1-1.5 mm long.

Spikelets:
Spikelet is 3-4 mm long and 2-2.5 mm wide, elliptic, green to purple, and has no lower glume; lower floret lemma has 5-9 veins, has a tip that is acute to rounded; upper floret is 0.7-0.9 times the lower floret length.

Germinability:
Germination from air-dried seed stored at room temperature is low, about 7%.

Habitat:
This species is found in moist places, ditches, roadsides, salt marshes, and tidal flats.

Range in California:
This species is found in elevations less than 400 m throughout California except for Modoc county, parts of Lassen and Shasta counties, and the Sonaran desert.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000

Top left: Inflorescence
Middle left: Spikelet
Right: Mature plant

K.J. Tekel 2000

Paspalam distichum L.

Family: Poaceae
Native

General Description:
This species is a perennial grass that sprouts from stolons and rhizomes. The biomass of mature plants ranges from 400-1400 gm^{-2} dry weight.

Stems:
Stems are decumbent to erect, 8-60 cm tall, and have 5-15 nodes.

Leaves:
Sheath is 3-20 cm long and glabrous; ligule is less than 1.5 mm; blade is 2-22 cm long and 2-7 mm wide and has a glabrous upper surface.

Inflorescence:
Main axis is less than 1.5 cm and has 2-3 primary branches that are 1.5-5.5 cm long; spikelets are many, 1-2 per node and the stalk is less than 0.5 mm long.

Spikelets:
Spikelets are 2.5-3.5 mm long, about 1.5 mm wide, and obovate to elliptic; lower glume is less than 2.5 mm and 1-veined; lower floret lemma is 3-5 veined and has an acute tip; upper floret is slightly smaller than lower floret.

Germinability:
Germination from air-dried seed stored at room temperature is very low, about 4%.

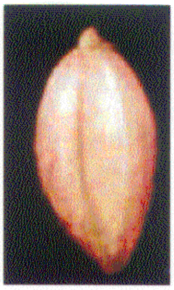
Habitat:
This species is found in moist places, marshes, ditches, around ponds, and along streams.

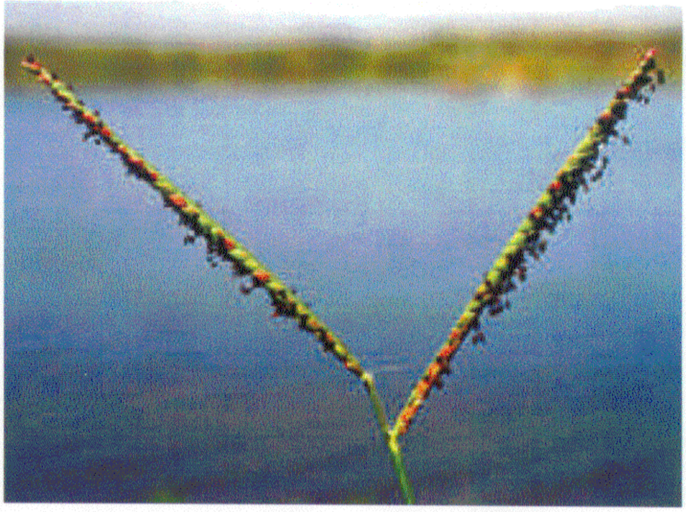
Range in California:
This species is found in elevations less than 1650 m throughout California except in the Sonaran desert.

Potential for use in restored wetlands:
An efficient way of propagation by seeds needs to be designed (probably including stratification and scarification) before this species could be recommended for use in restored wetlands.

Potentital for use in constructed wetlands from wastewater treatment:
Nutrient uptake capacity by this species has not been studied. It has a potential for small-scale wasteater tretment operation, especially after the methods for the necessary seed scarfication and stratification are worked out.

K.J. Tekel 2000





Top left: Spikelet
Top right: Close-up of inflorescence
Bottom: Habitat of mature plants

K.J. Tekel 2000

Phragmites australis (Cav.) Steudel

Common Reed

Family: Poaceae
Native

General Description:
This grass is distinguished by its large stature, up to 4 m tall, and it's large panicle of spikelets. It is a perennial robust reed with thick rhizomes or stolons that can form dense stands.

Stems:
Stems are erect and 2-4 m tall.

Leaves:
Leaves are blade-like, 20-45 cm long and 1-5 cm wide; margins are scabrous and generally break at the collar.

Inflorescence:
Inflorescence is feather-like, generally of a purple color, and 15-50 cm long, and oblong to ovoid.

Spikelets:
Spikelet is 10-16 mm long; lower glume is 3-7 mm long; upper glume is 5-10 mm long; florets are 2-10 cm long.

Germinability:
Germination from air-dried seed stored at room temperature is about 60%.

Life History:
Competitor. It germinates marginally well and relatively quickly. It has a good seedling establishment. It has a medium seedling Relative Growth Rate (0.216 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 15 mg dry weight. A new tiller is formed in about 4 weeks.

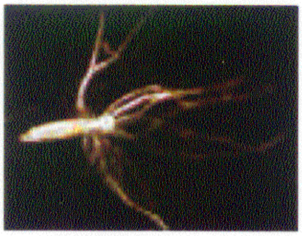
Habitat:
This species is found in freshwater marshes on banks of streams, in irrigation ditches, along rivers and canal bank and is most successful in mineral soils. It is also found on reclaimed stripmine areas. It is found in saturated sediments to >100cm water depth.

Range in California:
It is found in elevations less than 1600 m throughout California.

Potential for use in restored wetlands:
This species is recommended with caution. This species is found to be highly invasive on the east coast of the United States.

Potential for use in constructed wetlands for wastewater treatment:
This species is recommended with caution. This species is found to be highly invasive on the east coast of the United States.

K.J. Tekel 2000



Top left: Spikelet
Middle right: Close-up of culm and leaves
Middle left: Immature plant
Bottom: Mature plants with infloresences

K.J. Tekel 2000

Polygonum hydropiperoides Michaux

Waterpepper

Family: Polygonaceae
Native

General Description:
This *Polygonum* differs from all others by its bristly sheaths, nearly smooth stems, leaves that are less than 2 cm wide, and non-dotted sepals. It is perennial herb with rhizomes that often forms mats.

Stems:
Stems are ascending to erect and less than 1 m tall.

Leaves:
Leaves are alternate, lance shaped, shortly stalked, wavy, more or less acute, glandular below, 10 cm long, and fringed with hairs.

Inflorescence:
Branches are spike-like, generally 6-10 cm long and 2-5 mm wide; bract margin is bristly.

Flowers:
Flowers are white, magenta-tinged basally, and are in long, slender, sparse racemes that mostly droop at their tips; stamens are 6-8 where two are functionless; styles are 2-3 to the pistil and ovary superior.

Fruit:
The achene is black, is as long as the perianth, three-sided and nut-like.

Germinability:
Germination from air-dried seed stored at room temperature subject to 0.525% household bleach scarification for 2 days is about 40%.

Life History:
Competitive-Stress-tolerator. It does not germinate very well and it germinates slowly. It has a relatively high seedling establishment. It has a high seedling Relative Growth Rate (0.312 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 530 mg dry weight. The biomass of mature plants ranges from 500-1200 gm^{-2} dry weight.

Habitat:
This species is found in fresh water marshes, swamps, along streams, around ponds and lakes, and in ditches. It is found abundantly in places that are under water during the winter

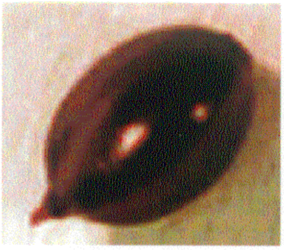
Range in California:
It is found in elevations less than 1500 m throughout California except for the desert and Modoc, Mono, and parts of Lassen counties.

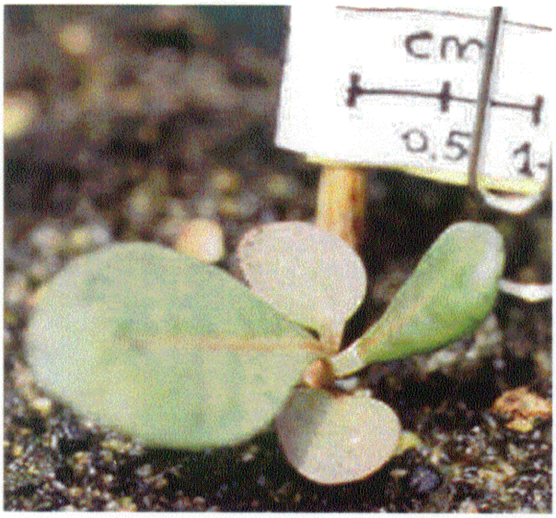
Potential for use in restored wetlands:
A more efficient means of propogation needs to be designed (either more research into necessary seed scarification and stratification or by cuttings or rhizomes) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species needs to be investigated. It has a potential for small-scale wastewater treatment operation, especially after the methods for the improved propagation are worked out.

K.J. Tekel 2000

Top left: Achene
Middle left: Two-week old seedling
Middle right: Mature plants
Bottom left: Close-up of inflorescence
Bottom right: Habitat of mature plants





Polygonum lapathifolium L.

Willow-Weed

Family: Polygonaceae
Native

General Description:
This annual species has racemes of flowers that are usually drooping. The sheaths on the stem of the plant are without bristles. The flowers are higly variable in color but are usually not bright pink.

Stems:
Stem is upright, sometimes rather stout, up to 1.2 m tall, and smooth. The sheaths are not bearing bristles at the tip.

Leaves:
Leaves are alternate, simple, narrowly to broadly lanceolate, up to 20 cm long and 4 cm wide, pointed at the tip, tapering to the base, usually smooth, and often with glabrous dots on the lower surface.

Inflorescence:
Branches are spike-like, 3-8 cm long and 5 mm wide, generally drooping, and dense.

Flowers:
Flowers are many in few to several drooping racemes. The racemes are up to 7.6 cm long and 0.6 cm wide. Their stalks are sometimes with stalked glands. Sepals are 6, partly united, white, greenish, or pale-pink, petal-like, and 3-veined; Stamens are usually nine; ovary superior, styles are 2 and free to the base.

Fruits:
Achenes are lenticular, shiny, and 0.32-0.42 cm long.

Germinability:
Germination from air-dried seeds stored at room temperature and subject to 0.525% household bleach scarfication is about 40%.

Life History:
Competitive-Stress-tolerator. It does not germinate very well and it germinates slowly. It has a relatively high seedling establishment. It has a high seedling Relative Growth Rate (0.324 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 530 mg dry weight. It flowers in about 5 weeks. The biomass of mature plants ranges from 500-1400 gm^{-2} dry weight.

Habitat:
It it found in moist soil, wet meadows, roadside ditches, and often in disturbed areas.

Range in California:
It is found in elevations less than 1500 m in throughout California.

Potential for use in restored wetlands:
A more efficient means of propogation needs to be designed (either more research into necessary seed scarification and stratification or by cuttings or rhizomes) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species needs to be investigated. It has a potential for small-scale wastewater treatment operation, especially after the methods for the improved propagation are worked out.

K.J. Tekel 2000

Top left: Close-up of racemes and flowers
Bottom left: Two-week old seedlings
Bottom right: Achene

K.J. Tekel 2000

Polygonum persicaria L.

Lady's Thumb

Family: Polygonaceae
Exotic

General Description:
This species differs from similar smartweeds by its bristly sheaths, dense, erect spikes of pinkish flowers, and its annual habit. It also has taproot. Hybrids with *P. lapthifolium* have narrower inflorescences and flat brown fruit.

Stems:
Stems are upright or ascending, branched, up to 90 cm tall, and usually smooth; sheaths are bristly at the tip.

Leaves:
Leaves are alternate, simple, lanceolate to linear-lanceolate, up to 13 cm long and 2 cm wide, pointed at the tip, tapering to nearly sessile base. and usually smooth. Leaves usually have a dark central spot and can be gland-dotted below.

Inflorescence:
Inflorescence is spike-like, dense, less than 3 cm long, and generally interrupted below; peduncles are glabrous; bracts may be strigose-bristly.

Flowers:
Many flowers are crowded in dense racemes; racemes are erect and up to 4 cm long on smooth stalks; sepals are usually 5, united below, usually pinkish, and up to 0.4 cm long; stamens are 6-9; ovary superior, styles are usually 2.

Fruits:
Achenes are triangular or sometimes flattened, 0.32-0.42 cm brown to black, long, smooth, and shiny.

Germinability:
Germination from air-dried seed stored at room temperature and subject to 0.525% household bleach scarification is about 60%.

Life History:
Competitive-Stress-tolerator. It germinates marginally well but germinates very slowly. It has a high seedling establishment. It has a relatively high seedling Relative Growth Rate (0.283 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 730 mg dry weight.

Habitat:
It is found in moist and disturbed areas.

Range in California:
It is found in elevations less than 1500 m throughout California.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000

Above: Two-week old seedling
Below: Achene

K.J. Tekel 2000

Polygonum punctatum Elliott

Dotted Smartweed

Family: Polygonaceae
Native

General Description:
This species is easily distinguished by the black dots on the white sepals and the bristly sheaths on the stem. Erect perennial, but with the lower branches sometimes rooting at the nodes, usually bearing rhizomes and stolons.

Stems:
Stems are upright, usually rather slim. up to 90 cm tall, but usually shorter, and rather smooth. The sheath bears bristles at the top.

Leaves:
Leaves are alternate, simple, elliptic to lanceolate, up to 10 cm long and 2 cm wide, pointed at the tip, tapering to the base, and usually smooth or occasionally strigose on the lower surface.

Inflorescence:
Inflorescence has branches that are generally 5-8 cm long, slender, and interrupted below.

Flowers:
Flowers are many in arching or erect, interrupted racemes; racemes are up to 10 cm long and about 0.6 cm wide; sepals are 6, partly united, white to greenish white, petal-like, and the surface is covered with black dots; stamens are usually nine; ovary superior, styles are 2 or 3.

Fruits:
Achenes are black. shiny, and 2-3-angled.

Germinability:
Germination from air-dried seeds stored at room temperature and subject to 0.525% household bleach scarfication is about 20%.

Life History:
Competitive-Stress-tolerator. It does not germinate very well and it germinates slowly. It has a relatively high seedling establishment. It has a medium seedling Relative Growth Rate (0.259 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 150 mg dry weight.

Habitat:
It is found in wet soil, wet meadows, marshes, roadside ditches, around lakes and ponds.

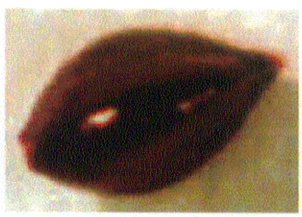
Range in California:
It is found in elevations less than 1500 m throughout California.

Potential for use in restored wetlands:
A more efficient means of propogation needs to be designed (either more research into necessary seed scarification and stratification or by cuttings or rhizomes) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species needs to be investigated. It has a potential for small-scale wastewater treatment operation, especially after the methods for the improved propagation are worked out.

K.J. Tekel 2000

Top left: Two-week old seedling
Below: Achene



Polypogon monspeliensis (L.) Desf.

Rabbit-Foot Grass, Annual Beard Grass

Family: Poaceae
Exotic

General Description:
This annual grass is distinguished by its soft bristly spike-like panicles and its one-flowered spikelets with both the glumes and lemmas awned.

Stems:
Stems are solitary or several in clumps, upright, up to 20-100 cm tall, and hollow.

Leaves:
Leaves are elongated, narrow, up to 20 cm long and 0.8 cm wide, rough along the edges, otherwise smooth, and conspicuously ridged on the upper surface; ligule is up to 0.6 cm long.

Inflorescence:
Inflorescence is 1-17 cm long, plume-like and densely flowered; spikelets are arranged in a dense panicule that resembles a spike.

Spikelet:
One-flowered, glumes are about 1-2.5 mm long, awned from the notched tip; awn is up to 2-10 mm long; lemma is about 0.5-1.5 mm long with an awn that is about 0.5-4.5 mm long; stamens are 3; ovary superior.

Germinability:
Germination from air-dried seed stored at room temperature is about 85%.

Life History:
Ruderal. It germinates well and quickly. It has a high seedling establishment. It has a relatively high seedling Relative Growth Rate (0.275 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 30 mg dry weight.

Habitat:
It is found in wet soil in ditches, vernal pools, marshes along streams and rivers, around lakes and ponds.

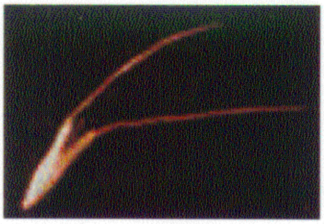
Range in California:
It is found in elevations less than 2100 m throughout California.

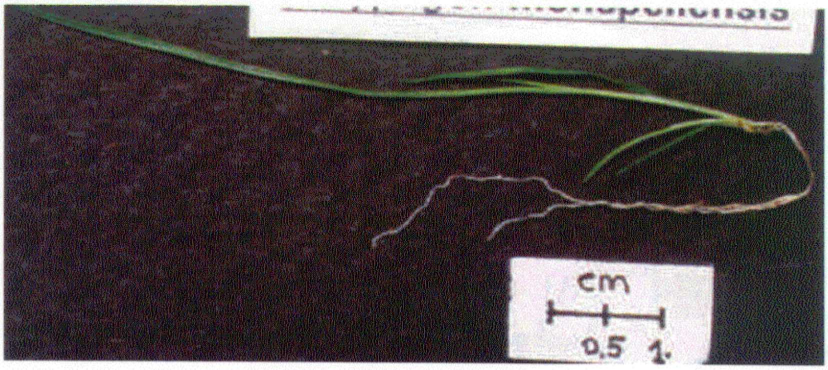
Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000

Top left: Habitat of mature plants
Top right: Mature plant
Middle left: Close-up of inflorescence
Middle right: Immature plants
Bottom left: Spikelet
Bottom right: Two-week old seedling





K.J. Tekel 2000

Ranunculus sceleratus L.

Cursed Buttercup

Family: Ranunculaceae
Native

General Description:
This succulant annual species is said to have very acrid juice which raises blisters on the skin. The leaves resemble those of celery. It can usually be distinguished by its small pale yellow flowers and smooth, nearly succulent stems and leaves and its elongating fruit clusters.

Stems:
Stems are erect, hollow, somewhat fistulose, simple to branched, hairs are none to sparse, and up to 50 cm tall.

Leaves:
Leaves are alternate, basal and lower cauline petioles are 3-9 (12) cm long; blades are 1.5 to 3 cm long, cordate to reniform, and deeply lobed to 1-ternate; lobes or leaflets are toothed to deeply lobed.

Flowers:
Receptacle are generally puberulents and 5 free from each other; sepals are 2-3 mm long; petals are 5, yellow, 2-5 mm long and 1-2 mm wide; stamens and pistils are numerous, each with superior ovary.

Fruit:
Fruit are many and cluster to ovoid to subcylindric; body is 1-2 mm long. Sides are greater than 1 mm wide, generally smooth or transversely ridged, and back faintly keeled; beak is less than 1 mm long, and generally straight.

Germinability:
Unknown

Habitat:
It is found in waste sites, overgrazed pastures, shrubland, muddy shallow pools, lake margins, streambanks and often found in brackish and alkaline sites.

Range in California:
It is found at elevations less than 2000 m throughout Cascade Ranges, Great Central Valley and Modoc Plateau.

Potential for use in restored wetlands:
If an efficient means of propagation is found then this species could be recommended.

Potential for use in constructed wetlands for wastewater treatment:
If an efficient means of propagation is found and the nutrient capactiy is evalueated then this species could be recommended.

K.J. Tekel 2000

Top: Closeup view of fruit, flowers, and leaves
Bottom left: Mature plants

K.J. Tekel 2000

Rumex crispus L.

Curly Dock

Family: Polygonaceae
Exotic

General Description:
This species is a biennial or perennial forb that is 50-150 cm tall. It has yellow-greenish leaves and stems. The lower leaves are lance-shaped and are often heart-shaped with strongly curled margins. The wings of the fruit are heart-shaped and entire or obscurely toothed. It is a common weed of fields and waste places.

Stems:
Stems are less than 150 cm, stout and have a reddish or purplish tint.

Leaves:
Leaves are alternate, basal and cauline, and less than 50 cm; blade is lanceolate; margin is strongly curled, especially near base, and has a reddish or purplish tint.

Inflorescence:
Inflorescence is dense, narrow, and may be leafy. Panicles are usually strict, of wand-like branches with few leaves; glomerules are usually dense; pedicels are 1.5-2 times as long as the mature perianth and are articulate below the middle.

Flowers:
Flowers are perfect; inner perianth lobe is approximately 5 mm long, ovate to round, base cordate, and has 3 tubercles. It is unequal, much smaller than 1/3 width of lobe; stamens are 6 and ovary superior with 3 styles. Sepals have prominent bump; flowers become dried, pappery, dark reddish to chocolate brown as fruit matures.

Fruit:
Fruits are 3-winged; each wing broadly ovate, up to 2 mm long, smooth, rounded at the tip, and usually bearing a wart-like tubercle.

Germinability:
Germination from air-dried seed stored at room temperature is about 100%.

Life History:
Ruderal. It germinates very well but rather slowly. It has a high seedling establishment. It has a high seedling Relative Growth Rate (0.299 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 400 mg dry weight. The biomass of mature plants ranges from 840-1000 gm^{-2} dry weight.

Habitat:
It is found in disturbed areas, waste grounds, and floodplains.

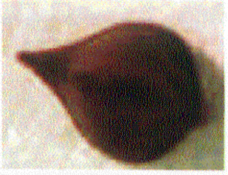
Range in California:
It is found in elevations less than 2500 m throughout California.

Potential for use in restored wetlands:
Not recommended. An exotic species.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. An exotic species.

K.J. Tekel 2000

Top left: Habitat of mature plants
Top right: Close-up of dried flowers with mature fruit
Middle right: Achene
Bottom left: Mature plant
Bottom right: Close-up of flowers



K.J. Tekel 2000

Sagittaria latifolia Willd.

Broad-leaf arrow-head

Family: Alismataceae
Native

General Desription:
The leaves are usually very broad and arrowhead-shaped. This perennial species differs from other broad-leaved species of arrowheads by its achene with a horizontal beak and the boat-shaped bracts that are either pointed or round-tipped, but not tapering to a long point.

Stems:
The only stems are the rhizomes that are below the surface of the ground in terrestrial forms.

Leaves:
Leaves are variable, but most of them arrow-head shaped, and up to 46 cm long. The basal triangular lobes are either longer or shorter than the terminal lobe and smooth; leaf stalks are angular and not round.

Flowers:
Male and female flowers are usually borne separately but on the same plant. The uppermost flowers are usually male and the lowermost flowers are usually female. Each flower is subtended by boat-shaped, pointed or round-tipped bracts up to 2 cm long. Sepals are 3, free from each other, green, up to 0.6 cm long, and eventually pointing downward. Petals are 3, free from each other, white, and up to 2.5 cm long. There are numerous stamens and ovaries are superior and overcrowded

Fruits:
Many achenes are crowded into a round head. Head is up to 4 cm long. Achenes are obovoid, up to 5 cm long, winged, with a horizontal beak.

Germinability:
This species did not germinate from air dried seeds stored at room temperature. It is known that *Sagittaria* seeds must be sown quickly otherwise they will die.

Habitat:
It is found in wet ditches, slow streams, edges of lakes and ponds, often in shallow water.

Range in California:
It is found in elevations less than 1500 m everywhere throughout California except in the desert.

Potential for use in restored wetlands:
A more efficient way of propagation by seeds needs to designed (probably including scarification and stratification to prolong the lives of the seeds) before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Nutrient uptake capacity by this species needs to be investigated. It has potential for small-scale wastewater treatment operation, especially after the methods for the necessary seed treatment are worked out.

K.J. Tekel 2000

Top left: Leaf and flowers
Top right: Achene
Bottom left: Close-up of flowers
Bottom right: Habitat of mature plants

K.J. Tekel 2000

Scirpus acutus Bigelow var. occidentalis (S. Watson) Beetle

Tule, Great Bulrush

Family: Cyperaceae
Native

General Description:
This perennial species has a cylindric culm throughout and a panicle-like inflorescence with spikelets in clusters of 1-7. This species if often confused with *S californicus* but can be distinguished by its darker green-blue color (*S californicus* has a lighter green color), its cylindric stem, and less-open formed umbellate inflorescence. It may hybridize with *S californicus*, *S. tabernaemontani*, and possibly others. The above-ground biomass dies off at the end of the growing season while *S. californicus* does not.

Stems:
Stems are erect, 2-4 m tall, 4-12 mm wide in middle, and cylindric.

Leaves:
Leaves are often basal; sheaths are prominent; blades are 1-2, much smaller than sheaths length, flat, and glabrous.

Inflorescence:
Inflorescence is panicle-like; spikelets are 3-many, generally in clusters of 1-7 at branch tips, 7-10 mm long and 3-4.5 mm wide; longest bract is 1-4 cm long, generally erect, and leaf-like; flower bract is about 4 mm long, glabrous, brown, midrib is pale, and the tip is acuminate to short-pointed.

Flower:
Perianth bristles are 6, generally less than 2.5 mm long, contoured to straight, teeth are above middle dense, and reflexed; stamens are 2-3 and ovary superior with 2-cleft styles.

Fruit:
Fruit is 2.0-2.5 mm long, 2-angled, grey-brown, smooth and has a beak that is 0.1-.3 mm long.

Germinability:
Germination from air-dried seed stored at room temperature and subject to 3.5% bleach scarification for 2 days is about 50%.

Life History:
Competitor. This species germinates better and faster when subjected to scarification but overall has low seed germination. It has a moderate seedling establishment. It has a low seedling Relative Growth Rate (0.120 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 8 mg dry weight. The first clone emerges in about 3 weeks. The biomass of mature plants ranges from 1000-4000 gm^{-2} dry weight.

Habitat:
It is commonly found in meadows, marshes, and streambanks.

Range in California:
It is very abundant in elevations less than 2500 m throughout California except for the desert regions.

Potential for use in restored wetlands:
This species is readlily propagated through cuttings of rhizomes. Once established, it is a very robust and tall species forming long-lived dense stands.

Potential for use in constructed wetlands for wastewater treatment:
This species is readlily propagated through cuttings of rhizomes. Once established, it is a very robust and tall species forming long-lived dense stands.

K.J. Tekel 2000

Top left: Close-up of inflorescence
Top right: Fruit
Middle: Mature plant with *S. californicus* in background
Bottom: Habitat of mature plants

K.J. Tekel 2000

Scirpus californicus (C. Meyer) Steudal

California Bulrush

Family: Cyperaceae
Native

General Description:
This perennial species has a 3-angled stem that is more conspicuous towards top. This species is often confused with *S. acutus* but can be distinguished by its lighter green color (*S. acutus* has a darker green-blue color), its 3-angled stem, and a more open, loosely formed umbellate inflorescence at maturity. The above-ground biomass does not die back at the end of the growing season like *S. acutus* does.

Stems:
Stems are erect, 2-4 m tall, less than 10 mm wide in middle, and 3-angled throughout or cylindric below.

Leaves:
Leaves are often basal; sheaths are less than 1/6 the stem length; blades are none or 1-2, much smaller than sheaths, flat, and glabrous

Inflorescence:
Inflorescence is panicle-like; spikelets are 20-many, clustered at branch tips, 5-11 mm long, and approximately 3 mm wide; branches are flexible and arched; main bract is 3-8 cm long, erect and stiff; flower bract is 2.5-3 mm long, glabrous, and orange-brown. The midrib is thick. The margin is woolly and the tip notch is short; awn is less than 0.5 mm long and generally bent.

Flower:
Perianth bristles are generally 2-4, often equal to fruit height, flat, thick, and fringed; stigmas are 2.

Fruit:
Fruit is generally 2 mm long, 2-angled, smooth, and dark brown.

Germinability:
Germination from air-dried seed stored at room temperature and subject to 3.5% bleach scarification for 2 days is very low, about 3%.

Habitat:
It is found in mostly coastal marshes and inland marshes.

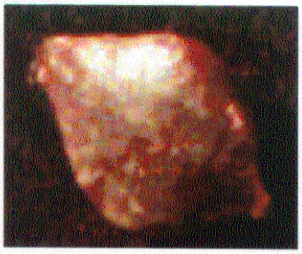
Range in California:
It is common in elevations less than 200 m along most of the California coast; also found in the Central Valley and in the eastern Mojave Desert.

Potential for use in restored wetlands:
This species is readlily propagated through cuttings of rhizomes. Once established, it is a very robust and tall species forming long-lived dense stands.

Potential for use in constructed wetlands for wastewater treatment:
This species is readlily propagated through cuttings of rhizomes. Once established, it is a very robust and tall species forming long-lived dense stands.

K.J. Tekel 2000

Top left: Inflorescence
Top right: Fruit
Bottom: Habitat of mature plants



K.J. Tekel 2000

Scirpus fluviatilis (Torrey) A. Gray

River Bulrush

Family: Cyperaceae
Native

General Description:
This perennial species has a loose-umbellate inflorescence with two or more bracts that subtend the infloresence and acute spikelet. The leaves are involucral, usually longer than the inflorescence, and 8-16 mm wide. The horizontal rhizomes form tubors. The biomass of mature plants ranges from 750-2000 gm^{-2} dry weight.

Stems:
Stems are erect, up to 2 m tall, 5-15 mm wide, 3-angled, and smooth or angles are finely scabrous above.

Leaves:
Leaves are cauline; sheaths are clearly veined at top; blades are much larger than sheaths, generally 6-20 mm wide when dried and flat, glabrous, and has a midrib and margins that are finely scabrous.

Inflorescence:
Inflorescence is panicle-like (sometimes head-like); spikelets are 8-50, 15-28 mm long and 6-10 mm wide, and most generally in clusters of 1-4 (sometimes 8) at branch tips; bracts are 2-3, much taller than the inflorescence, spreading, leaf-like, and the longest is generally 4-15 mm. wide when dry; flower bract is 7-10 mm long, not strongly appressed, scabrous, light brown, and the tip notch is less than 1 mm long; awn is 2-3 mm long and may be bent.

Flower:
One flower per scale, with many scales per spikelet; spikelets are up to 5 cm long, forming terminal clusters subtended by many leaf-like bracts. Perianth bristles are generally 6 and half to greater than length of fruit; stigmas are 3, pistils are 1; styles are 3; ovary superior.

Fruit:
Generally 3.5-4.5 mm long, strongly 3-angled, smooth, pale brown, tip rounded, and has a beak that is 0.3-0.8 mm long.

Germinability:
Unknown.

Habitat:
It is found in marshes in interior valleys.

Range in California:
It is found in elevations less than 1300 m in the Sacramento Valley, Lassen and Modoc counties, occasionally in the northern coastal ranges of Lake and San Mateo counties, and in the northern high Sierra Nevadas.

Potential for use in restored wetlands:
This species is readlily propagated through cuttings of rhizomes.

Potential for use in constructed wetlands for wastewater treatment:
This species is readlily propagated through cuttings of rhizomes.

K.J. Tekel 2000

Top left: Close-up of inflorescence
Top right: Mature plants
Bottom: Habitat of mature plants

K.J. Tekel 2000

Scirpus maritimus L.

Saltmarsh Bulrush

Family: Cyperaceae
Native

General Description:
This bulrush is distinguished by it stout growth form and its large spikelets densely crowded in an unusually sessile cluster at the tip of the stem.

Stems:
Stems are upright, triangular, usually unbranched, up to 1.5 m tall, and without hairs.

Leaves:
Leaves are alternate, elongated, flat, up to 0.6 cm wide, and without hairs,

Inflorescence:
Several inflorescences are crowded into spikelets, 10-30 mm long and 7-8 mm wide, usually sessile; spikelets are densely clustered at the tip of the stem, rounded at the tip, up to 2.5 cm long and 0.6 cm thick, and subtended by 2-4 leaf-like bracts of different lengths; scales are usually pale brown, minutely hairy, and notched at the tip with a short awn arising from the notch.

Flowers:
Perianth bristles are generally 6 and deciduous; stamens are 3, ovary superior, styles are 2.

Fruit:
Achenes are lenticular, up to 0.4 cm long, and have a minute point at the tip with a few short bristles at the base.

Germinability:
Germination from air-dried seeds stored at room temperature is about 50% after a 3.5% bleach scarfication treatment for 2 days.

Life History:
Competitor. This species germinates better and faster when subjected to scarification but overall it has moderate seed germination. It has a low seedling establishment. It has a low seedling Relative Growth Rate (0.166 $gg^{-1}day^{-1}$). A 21-day-old seedling has a mass of about 30 mg dry weight. The first clone emerges in about 3 weeks.

Habitat:
It is found in wet meadows, marshes, around pools, particular in alkaline or in brackish habitats.

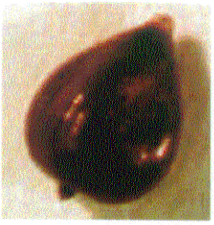
Range in California:
It is found in elevations less than 2500 m from the northwestern to southwestern California, the Great Central Valley, Modoc Plateau, and the Desert Province.

Potential for use in restored wetlands:
This species is readlily propagated through cuttings of rhizomes.

Potential for use in constructed wetlands for wastewater treatment:
This species is readlily propagated through cuttings of rhizomes.

K.J. Tekel 2000

Top left: Two-week old seedling
Top right: Fruit
Middle right: Inflorescence
Bottom: Habitat of mature plants



K.J. Tekel 2000

Typha domingensis Pers.

Southern Cattail

Family: Typhaceae
Native

General Description:
This rhizomanous perennial species is distinguished by its tall pistillate spike, usually 6-10 times as long as thick, and located below the staminate part. The pistillate and staminate sections of the spike are separated by a distance as great as the diameter of the pistillate spike or greater.

Stems:
Stems are erect, sterile, 1.5-4 m tall, with 6-9 leaves and have a white pith.

Leaves:
Leaves are 6-12 mm wide, light-yellowish green, convex on the back; sheaths are tapering at throat to the blade, scarious-margined above. Leaves are gland-dotted on the inside near the base of the plant.

Flowers:
Staminate flowers have a single pollen grain; pistillate flowers have linear stigmas and sterile ovaries, are rounded to truncate, generally less than pedicel hairs, pale-brownish, and have hair tips that are straw colored to orange brown.

Inflorescence:
Inflorescence has a naxed axis between the staminate and pistillate flowers and is 1-8 cm. long; staminate bractlets are irregularly branched, and are straw-colored to cinammon-brown; pistillate stalk is about 0.5 mm. long, and peg-like; spike is less than 35 cm long and 15-25 mm wide in front, and bright-yellow to orange-brown; bractlet is greater than pedicel hairs and the tip is acute to acuminate.

Germinability:
Germination from air-dried (presumably sterile) seeds stored at room temperature was very low, about 3%.

Life History:
Competitor. It forms tall stands that have a thick leaf canopy and often can often dominate a wetland system. The biomass of mature plants ranges from 1700-3000 gm^{-2}dry weight

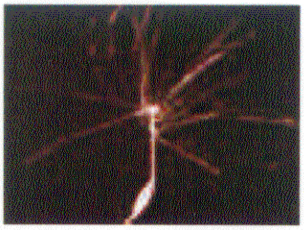
Habitat:
It is found in coastal and valley marshes at low altitudes.

Range in California:
It is found at elevations less than 1500 m throughout California.

Potential for use in restored wetlands:
This species forms dense and tall monoculture stands outcompeting other native wetland emergent species.

Potential for use in constructed wetlands for wastewater treatment:
This species forms dense and tall monoculture stands outcompeting other native wetland emergent species. With good managment strategies, this species can then be used.

K.J. Tekel 2000



Top left: Seed
Middle left: Pedicel
Middle right: Mature plants
Bottom: Habitat of mature plants

K.J. Tekel 2000

Xanthium strumarium L.

Cocklebur

Family: Asteraceae
Native

General Description:
This is a coarse annual species of open spaces with rough stems and triangular leaves. It is primarily distinguished by its barrel-shaped fruit covered in hooked prickles. It is a highly variable species and populations have shown founder effects.

Stems:
Stems are less than 150 cm tall, thick and may be fleshy, generally red or black spotted, and unarmed.

Leaves:
Leaves are alternate and long-petioled; blades are less than 15 cm long, widely triangular or heart-shaped at base, generally 3-lobed, coarsely toothed, green below and above, and scabrous; base is generally 3-veined.

Inflorescence:
Pistillate heads are clustered below staminate heads.

Flowers:
Male and female flowers are found separately in small heads; each male head is subtended by a series of small green bracts; each female head is subtended by hooked prickles; stamens are 5 and ovary inferior

Seeds:
Bur is cylindric to barrel-shaped, up to 2.5 cm long; spines are generally stout.

Germinability:
Unknown.

Habitat:
It is found in disturbed areas, fallow fields, along streams, in sloughs, and wet prairies.

Range in California:
It is found in elevations less than 500 m throughout California except for Modoc, Mono, and parts of Lassen counties.

Potential for use in restored wetlands:
An efficient way of propagation needs to be investigated before this species could be recommended for use in restored wetlands.

Potential for use in constructed wetlands for wastewater treatment:
Not recommended. This species prefers drying locations.

K.J. Tekel 2000

Top left: Habitat of mature plants
Top right: Mature plants
Bottom: Close-up of leaves and bur

K.J. Tekel 2000