Wetland plant species composition as an indicator of California black rail *(Laterallus jamaicensis coturniculus)* presence in the Sierra Foothills

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Abstract The rate of global wetland loss is concerning as these habitats provide important ecosystem functions and habitat for flora and fauna. Further understanding of plant communities that comprise palustrine emergent wetlands is important for habitat management and conservation for wetland birds, especially since the discovery of state threatened California black rail *(Laterallus jamaicensis coturniculus)* in these wetlands near Marysville, California. No comprehensive vegetation survey of the wetlands black rails occupy has been conducted and a more detailed survey of plant species composition is likely to improve the ability to characterize habitat quality for black rails. This study aims to: 1) identify the plants of emergent wetlands in the Sierra foothills 2) determine whether plant communities differ between wetlands of different geomorphology, elevation, slope, water source and between wetlands that are grazed versus ungrazed and 3) determine whether U.S. Fish and Wildlife wetland indicator categories can be used to predict black rail presence. Contrary to our predictions, wetland plants were not homogeneous within groups with the same abiotic variables. However, plant composition did show a trend along an elevation gradient. Multivariate analysis of black rail occupancy and proportion of wetland plant indicator categories revealed no positive correlation between the two. While no significant trends were found other than elevation, only 32% of variance in the data is explained by the environmental variables looked at in this study and further examination of other factors that drive habitat quality such as soil characteristics should be explored. While wetland indicator categories do not provide a predictor for black rail occupancy, telemetry studies can provide a more detailed look at what plant communities are utilized by black rails in the Sierra Foothills.

Introduction

Wetlands are second only to tropical rainforests as the most endangered habitat in the world (Gustaitis 1989). Wetlands are invaluable ecosystems that provide ecosystem functions such as natural water pollution filtration, erosion control, flood control and support resources needed for biodiversity (Brander *et al.* 2006). But wetland resources and ecosystem functions are particularly sensitive to biological and physical alteration (Denny 1994). Their sensitivity to habitat change, as well as land use conversion, has made wetlands vulnerable to extinction. In the United States, wetland loss from the 1950s to the 1970s was at a rate of 185,000 hectares per year, compared to the current rate of 24,000 hectares lost per year (Dahl 2000). California has lost 75% of its original wetlands due to drainage and land conversion (Dahl 2000). The continual loss and degradation of wetlands throughout North America is cause for concern for the flora and fauna that inhabit and utilize these habitats. As wetlands disappear, the species found only in these ecosystems, such as wetland birds, will find it increasingly difficult to persist.

There are a wide variety of wetlands in the United States that are distinguished by differences in locality, hydrology, soil, topography and vegetation. Palustrine (inland) wetlands comprise 95% of the wetlands in the United States, and some examples include wet meadows, prairie potholes, swamps, fens, bogs and wet tundra (Mitsch and Gosselink 1993). These wetlands differ by vegetation composition, with emergent wetlands dominated by a variety of sedges, rushes, grasses or forbs. As palustrine wetlands remain under threat, further studies are needed for understanding which driving factors, such as hydrology or soil characteristics, are important for determining vegetation community composition.

There have been few comprehensive studies conducted of the vegetation composition of palustrine emergent wetlands in Northern California or of what fauna utilize the habitat. However, it is important to understand the structure of these wetlands because a metapopulation of California black rails (*Laterallus jamaicensis coturniculus* (Ridgway 1874)) was discovered in the Sierra Foothills of Northern California in 1994 (Aigner *et al.* 1995).

The black rail (*Laterallus jamaicensis* (Gmelin 1789)) is the smallest rail in North America and has a widespread distribution but is highly habitat-specific within its range. It inhabits saltwater and freshwater marshes throughout the East coast, the Mid-Atlantic States, Florida, Arizona and California (Eddleman *et al.* 1994). Black rails are reclusive and not much is known about their natural history. The black rail is of high interest for avian conservation because there is still much to be learned about their population dynamics and life history due to their sporadic distribution and secretive habits (Eddleman *et al.* 1994). The western subspecies *(L. j. coturniculus)* has scattered populations in the San Francisco Bay, Morro Bay, Baja California and at an inland location in Arizona. Once occurring in high densities in the early 1900's, their populations across the U.S. have declined drastically over the course of the 20th century and the California subspecies is listed as "threatened" by the California Department of Fish and Game (DFG 2007). Due to their short stature, they prefer shallow, standing water to be able to glean invertebrates and seeds from the muddy surface (Eddleman *et al.* 1994). These shallow-water environments are being lost and degraded due to water and flood-control projects, land-use changes, agriculture, livestock grazing and the draining of wetlands (Eddleman *et al.* 1994 and O. Richmond, unpublished data).

Black rails were known to occur throughout the San Francisco Bay since the early part of the 20th century, but a previously unknown inland population located in the foothills of the Sierra Nevada Mountains near Marysville was not discovered until 1994 (Aigner *et al.* 1995). In studies conducted by Orien Richmond and Jerry Tecklin, tape recordings of black rail were used to survey a network of wetlands in the Sierra foothills from 1996-2005. Black rails were discovered at 147 wetland sites Butte, Yuba and Nevada counties (O. Richmond, unpublished data).

California black rail habitat is characterized by dense emergent vegetation over a shallow water or muddy substrate (O. Richmond, unpublished data). Another study conducted on California black rail in the Southwestern US by Flores and Eddleman (1995) determined that vegetation composition and density along the Lower Colorado River, as well as the water depth along the surface of substrate, are important determinants of suitable habitat. Vegetation structure was found to be especially important for the inland population in Arizona along the Lower Colorado River; areas occupied by black rails had significantly higher stem densities than random points (Flores and Eddleman 1995).

In the newly discovered Sierran populations, recent studies found that black rails occupy small, perennial, shallow (<3cm deep), freshwater wetlands that are densely vegetated (O. Richmond, unpublished data). The vegetation cover is dominated mostly by rushes (*Juncus spp.*), cattails (*Typha spp.*) and sedges (family Cyperaceae). A small number of sites are dominated by grasses (family Poaceae) or forbs. The wetland sites are usually surrounded by upland plants such as dry annual grasses, oak or pine trees and other land uses such as agriculture, urban development and rangeland (O. Richmond, unpublished data).

Since habitat characteristics have been a good indicator for black rail presence in other locations, a habitat relationship study on the black rail metapopulation in the Sierra foothills was conducted by Beissinger and Richmond (2003-2006). The study examined the relationship between patch quality and rail presence. Patch quality includes factors such as hydrology, vegetation cover, geomorphic setting, and grazing. The hydrology of a site drives vegetation dynamics and invertebrate food availability while the characteristics of the plant species determine the degree of cover and the availability of seeds (O. Richmond, unpublished data). However, to date the vegetation surveys conducted at the Sierra foothills sites have been relatively crude. The surveys have categorized the dominant vegetation into groups such as grasses, forbs, rushes and sedges, but in many cases plants have not been identified to genus or species. If genus and species can be identified, specific vegetation types may serve as good indicators for black rail presence and further actions can be taken to conserve the vegetation. As individual wetland and upland plant species have different degrees of tolerance for different hydrologic regimes (e.g. flooding, depth of permanent water), particular species may be able to provide a "signature" that characterizes the past or current hydrologic regime of a site. Identifying the abundance of individual species and their tolerance of wetland conditions is likely to improve the ability to characterize habitat quality for black rails. The U.S. Fish and Wildlife has categorized plant species into Wetland Indicator Categories determined by the probability a species is found in a wetland. By categorizing individual plant species into wetland indicator categories, the plants will be grouped ecologically rather than by dominant vegetation type.

This aim of this study were to: 1) identify the plants of small, emergent wetlands in the Sierra Foothills, 2) determine whether plant communities differ between wetlands of different geomorphology, elevation, slope and water sources, and between wetlands that are grazed versus ungrazed, and 3) determine whether U.S. Fish and Wildlife wetland indicator categories can be used to predict black rail presence.

I surveyed wetlands and determined plant species abundance, wetland dependence and correlated these variables with black rail presence determined from playback surveys conducted by Orien Richmond (2002-2006) (unpublished data). Based on the vast amount of wetland plant species included in this study, I hypothesized that categorizing wetland plant species into indicator groups will be a good predictor of black rail presence because presence will be positively correlated with the proportion of plant species that occur most in wetlands and negatively correlated with the proportion of plant species that seldom occur in wetlands.

Methods

Study Sites The study sites were located in Yuba and Nevada County, California (Fig. 1). Twenty field sites were chosen ranging in size from 0.3 to 1.3 hectares. Black rail occupancy at these sites ranged from 0.2 (1 out of 5 years) to 1 (5 out of 5 years) between 2002 and 2006 (Table 1). The area extent of each site was determined by satellite imagery and previous years' visits and included all area that appeared permanently or seasonally flooded with shallow water depths and contained emergent wetland vegetation.

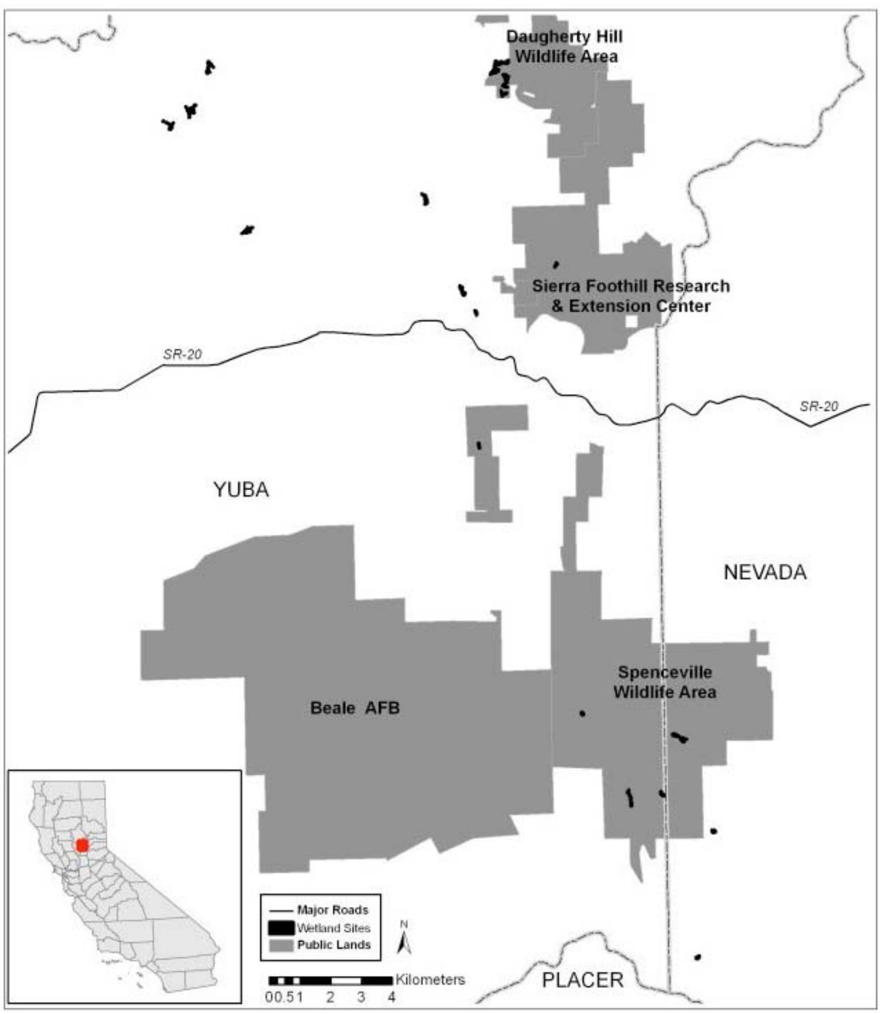

Figure 1: The black spots indicate the location of the twenty study sites in Yuba and Nevada County, California

Table 1: Area and average black rail occupancy (2002-2006) of the twenty study sites. Average occupancy was calculated by years present out of 5 years

Site	Area (Ha)	Average occupancy (2002-2006)
161	1.17	0.6
219	0.65	0.8
223	0.80	1
228	0.48	0.8
237-03	0.48	0.5
260-05	0.67	1
263a-05	0.43	0.5
272-05	1.18	1
275-05	0.96	1
Y-02	0.42	0.2
Y-04	1.10	1
Y-05	1.52	1
Y-07b	0.39	0.6
Y-26	0.63	1
Y-29	1.53	1
Y-33	0.60	1
Y-33a	1.14	1
Y-33b	0.87	1
Y-34	1.82	1
Y-34a	0.69	1

Wetland Indicator Categories To determine whether inland wetland plant species composition is a good indicator for rail presence, wetland plant species were identified to the genus and species level and categorized into appropriate Indicator categories. The U.S. Fish & Wildlife Service's National Wetlands Inventory published a national list of plant species that occur in wetlands and the plant species are categorized into five Regional Indicator categories (Cowardin et al. 1979). The Indicator categories reflect the estimated range of probabilities of a species occurring in wetland habitats versus non-wetland habitats across California. The five Indicator categories are: Obligate wetland, Facultative wetland, Facultative, Facultative upland

and Obligate upland. Obligate wetland species occur almost always under natural conditions of wetlands (estimated probability >99% of the time); Facultative wetland species usually occur in wetlands (estimated probability 66-99%), but are occasionally found in non-wetlands; Facultative species are equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%); Facultative upland species are only occasionally found in wetlands (estimated probability <33%), and Obligate upland species occur almost always in non-wetlands (estimated probability >99%). The proportion of each category was measured against average Black Rail occupancy to determine if there is a positive correlation between occupancy and Obligate and Facultative wetland species or a negative correlation with Obligate Upland species.

Data Collection Using ArcGIS and satellite imagery of the twenty sites, a set of ten random points were generated within the boundary of each wetland. In the field, a hand-held GPS unit was used to locate four of the randomly selected points at each site. At each of the four points, a random compass bearing was chosen for the direction of the transect. Each transect was 10-meters long, and at every one meter interval, plants that touched a one meter long pole were identified to species and recorded (Heady et al. 1959). Identification of plants to genus or species was done either in the field, or a sample was collected and identified in the lab.

Plant species were identified using resources such as *Selected Plants of Northern California and Adjacent Nevada* (Oswald 2002), calflora.org, and the staff of the California State University at Chico Herbarium. After the plants were identified to species, they were categorized into three Indicator categories: Obligate wetland, Facultative, and Upland (USDA 2007). Due to the small sample size of plant species, Facultative wetland and Facultative species were combined into one group “Facultative”. Facultative upland and Obligate upland species were grouped into “Upland”.

Abiotic variable data such as site area, elevation, slope, geomorphology, water source and grazing were obtained from Richmond and Beissinger (O. Richmond, unpublished data).

Black rail occupancy at each wetland was determined by playback surveys. A wetland was considered “occupied” if there was a vocal response from at least one black rail, or “unoccupied” if after the entire wetland was surveyed there was no response. Each wetland was surveyed by walking every 50 meters and broadcasting black rail vocalization. Occupancy data for each of the twenty sites from playback surveys conducted from 2002-2006 was obtained from Richmond and Beissinger (O. Richmond, unpublished data).

Technique of analysis To determine if the sites had similar plant communities, the statistical program PC ORD (4.17/MjM Software/Oregon) was used. The proportion of each plant species was calculated for each site. To see if there were any homogeneous plant compositions, a Detrended Correspondence Analysis (DCA) was used. To analyze plant communities with abiotic variables (area, elevation, slope, water source), a Canonical Correspondence Analysis was used (CCA), and to test the difference between grazed and ungrazed sites, a Multi-Response Premutation Procedure (MRPP) was used to test species composition homogeneity within each group and whether an observed difference between the two groups was due to chance.

Black rail occupancy at each site, either zero (absent) or one (present), from 2002-2006 was averaged to obtain an occupancy fraction. The proportion of each wetland indicator category at each site was calculated by summing the number of plants that occurred in each category and dividing by the total number of points surveyed.

To analyze the relationship between plant species composition and rail occupancy, the statistical program JMP (5.1.2/SAS Institute/North Carolina) was used. To evaluate the relationship between the three variables and rail occupancy, a multivariate method was used. The proportions of plant species within the different Wetland Indicator Categories were used as explanatory variables in a series of multivariate models with the average occupancy of black rails as the response variable. Because the data are non-parametric, Spearman's rank correlation coefficient was used to measure the correlation between plant category and occupancy.

Results

A total of 74 transects were sampled resulting in 740 points over twenty sites. There were 46 different plant species identified. Site 263a-05 was removed from the following analyses because of sampling error.

Plant Species Composition Wetland plant species that occurred across all sites were identified and tabulated for a total of 740 sample points. Over 35% of the plants identified consisted of two species, *Juncus effusus* and *Typha* sp. Four species, *Paspalum dilatatum, Eleocharis macrostachya, Epilobium ciliatum* and *Leersia oryzoides,* each occurred at between 5% and 10% of the points sampled, while all other species occurred less than 5% of the time (Table 2).

Table 2: Plant species of twenty emergent inland wetlands of the Sierra Foothills, their % occurrence and categorized by the U.S. Fish and Wildlife Wetland Indicator Categories

Family	**Plant Species**	**% Occurrence**	**Indicator Category**
Juncaceae	*Juncus effusus*	18.62	Obligate
Typhaceae	*Typha*	16.48	Obligate
Poaceae	*Paspalum dilatatum*	7.92	Facultative
Cyperaceae	*Eleocharis macrostachya*	5.84	Obligate
Onagraceae	*Epilobium ciliatum*	5.78	Facultative
Poaceae	*Leersia oryzoides*	5.06	Obligate
Polygonaceae	*Polygonum punctatum*	4.54	Obligate
Cyperaceae	*Eleocharis montevidensis*	4.15	Facultative
Juncaceae	*Juncus balticus*	3.83	Obligate
Cyperaceae	*Cyperus niger*	3.57	Facultative
Poaceae	*Holcus lanatus*	2.4	Facultative
Polygonaceae	*Polygonum hydropiperoides*	2.4	Obligate
Brassicaceae	*Rorippa nasturtium-aquaticum*	2.34	Obligate
Rosaceae	*Rubus discolor*	2.08	Facultative
Cyperaceae	*Carex lanuginosa*	1.62	Obligate
Cyperaceae	*Cyperus eragrostis*	1.62	Facultative
Cyperaceae	*Cyperus strigosus*	1.17	Facultative
Cyperaceae	*Scirpus acutus*	0.91	Obligate
Verbenaceae	*Verbena bonariensis*	0.78	Facultative
Aristolochiaceae	*Aristolochia californica*	0.65	Upland
Portulacaceae	*Claytonia perfoliata*	0.65	Facultative
Lamiaceae	*Mentha pulegium*	0.58	Obligate
Poaceae	*Polypogon monspeliensis*	0.58	Facultative
Asteraceae	*Helenium puberulum*	0.52	Facultative
Lamiaceae	*Stachys stricta*	0.52	Facultative
Vitaceae	*Vitis californica*	0.52	Facultative
Cyperaceae	*Carex barbarae*	0.45	Facultative
Polygonaceae	*Rumex crispus*	0.45	Facultative

Table 2 (continued)

Family	**Plant Species**	**% Occurrence**	**Indicator Category**
Polygonaceae	*Rumex crispus*	0.45	Facultative
Gentianaceae	*Centaurium muehlenbergii*	0.39	Facultative
Lamiaceae	*Lycopus americanus*	0.32	Obligate
Apocynaceae	*Vinca major*	0.26	Upland
Asteraceae	*Cirsium vulgare*	0.26	Facultative
Clusiaceae	*Hypericum perforatum*	0.26	Upland
Lythraceae	*Lythrum californicum*	0.26	Obligate
Clusiaceae	*Hypericum anagalloides*	0.19	Obligate
Cyperaceae	*Carex praegracilis*	0.19	Facultative
Cyperaceae	*Cyperus flavescens*	0.19	Obligate
Asclepiadaceae	*Asclepias fascicularis*	0.13	Facultative
Juncaceae	*Juncus acuminatus*	0.13	Obligate
Cyperaceae	*Eleocharis pachycarpa*	0.06	Obligate
Onagraceae	*Epilobium densiflorum*	0.06	Obligate
Onagraceae	*Epilobium pallidum*	0.06	Facultative
Plantaginaceae	*Plantago lanceolata*	0.06	Facultative
Poaceae	*Lolium multiflorum*	0.06	Facultative
Poaceae	*Taeniatherum caput-medusae*	0.06	Upland

The Detrended Correspondence Analysis shows the distribution of sites based on plant species composition (Fig 2). If sites had homogeneous plant species composition, they would be grouped together. The groupings would indicate that certain sites had distinct plant communities that differed from other sites. There was however, no obvious grouping of sites, except for sites Y-33, Y-33a and Y-33b. These three sites were geographically close - less than 50 meters away from each other, and therefore their plant composition were similar. Sites Y-26 and 223 were “outliers” because both sites had rare species that were only found at those two sites. The plant species driving both axes were rare species that occurred less than 2% of the time.

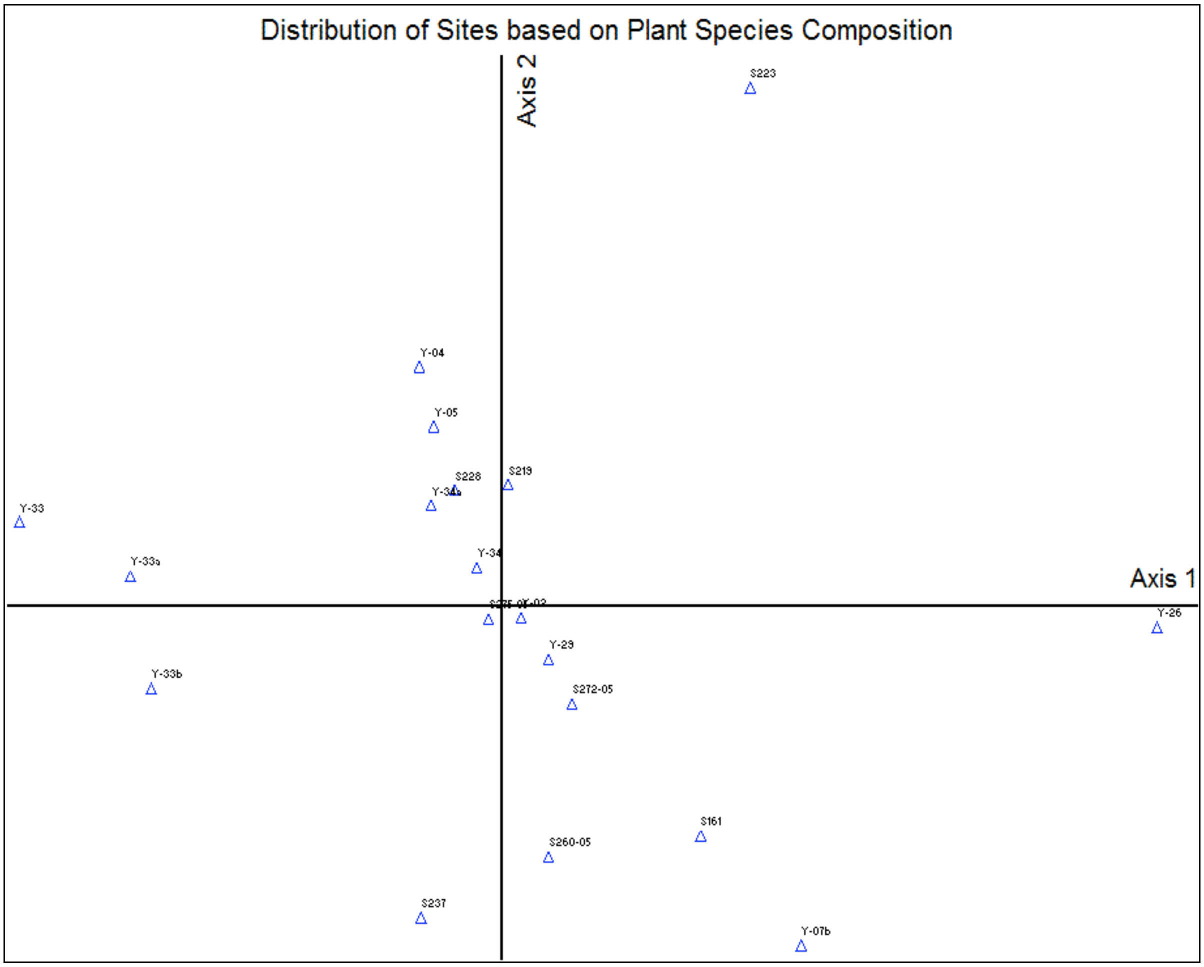

Figure 2: Detrended Correspondence Analysis of plant species at each site. Axis 1 is driven by *Carex Lanuginosa*, *Lycopus americanus*, *Juncus Balticus* and *Cirsium vulgare*, with positive values towards the right and negative values to the left. Axis 2 is driven by *Asclepias fascicularis*, *Carex praegracilis*, *Carex barbarae* and *Scirpus acutus.* All plant species driving the axes are uncommon, occurring less than 2%.

Grazed vs. Ungrazed The twenty sites were grouped either as grazed or ungrazed (10 of each) and a Multi-response Permutation Procedure (MRPP) was used. The test statistic T, describes the separation between the two groups. The T value for grazed and ungrazed sites was 0.62, which is not negative and indicates that the groups are not strongly separated. The p-value of 0.44 indicated no significant difference between the two groups. The agreement statistic A describes within-group homogeneity, compared to the random expectation. If heterogeneity within groups equals expectation by chance, then $A = 0$ or if $A < 0$, there is less heterogeneity within groups than expected by chance (McCune and Grace, 2002). The A value of -0.0007 indicates that there is heterogeneity within each group i.e. there was no significant difference between grazed and ungrazed sites relative to plant composition.

Abiotic Variables All sites (except 236a-05) were run in the analysis but when site Y-26 was removed, the pattern along the elevation gradient became apparent (Fig 3). Plant species composition fell along the elevational axis, from low elevation to high. Elevation drove axis 1 and water source "irrigation leak" drove axis 2.

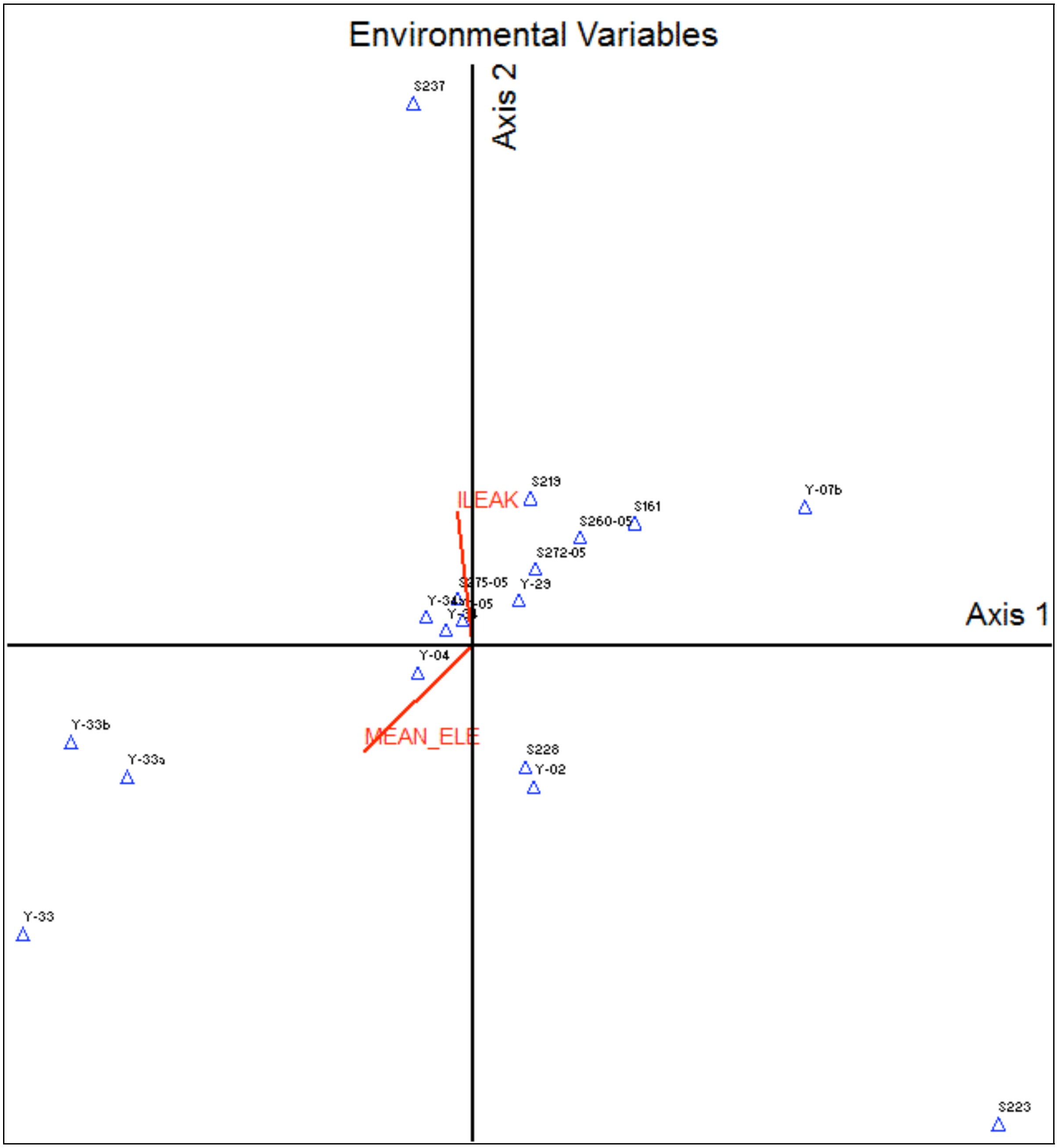

Figure 3: A Canonical Correspondence Analysis of plant species and abiotic factors. Axis 1 is driven by pond margins in the positive direction and negatively associated with springs. Axis 2 is driven by pond margin in the positive direction and springs in the negative direction

Indicator Categories The proportion of obligate wetland plants were between 40-95%, facultative wetland plants 0-60% and upland plants 0-37% across all sites (Table 3).

Table 3: Proportion of Wetland Indicator Categories and Average Black Rail Occupancy (2002-2006) for all wetland sites

Site	Obligate	Facultative	Upland	Occupancy 02-06
Y-04	0.94	0	0.06	1
Y-26	0.89	0.08	0.03	1
Y-05	0.82	0.07	0.11	1
Y-29	0.71	0.24	0.06	1
Y-34a	0.71	0.25	0.04	1
275-05	0.69	0.31	0	1
Y-34	0.68	0.21	0.11	1
272-05	0.59	0.28	0.13	1
Y-33	0.58	0.38	0.05	1
260-05	0.56	0.07	0.37	1
Y-33a	0.55	0.32	0.13	1
Y-33b	0.52	0.13	0.35	1
223	0.38	0.59	0.03	1
219	0.69	0.29	0.02	0.8
228	0.59	0.33	0.07	0.8
161	0.44	0.28	0.28	0.6
263a-05	0.98	0	0.02	0.5
237	0.73	0.23	0.04	0.5
Y-2	0.57	0.19	0.24	0.2

Spearman's Rho indicated no significant correlation between black rail occupancy and any of the three wetland indicator categories (Table 4).

Table 4: Significance of wetland indicator categories and black rail occupancy

Category	Spearman's Rho (correlation coefficient)	P-value
Obligate	0.03	0.90
Facultative	0.09	0.70
Upland	-0.06	0.81

Discussion

What are the plants of small emergent wetlands in the Sierra Foothills? Small, emergent wetlands in the Sierra Foothills are dominated by rushes such as *Juncus effuses* and *J. balticus,* cattails (*Typha spp.*), perennial grasses *Paspalum dilatatum, Leersia oryzoides* and sedges (*Cyperus niger, Eleocharis macrostachya, E. montevidensis*). All species identified in the Poaceae family are non-native and invasive except for *Leersia oryzoides.* This does not come as a surprise given that California's grasslands are dominated by non-native, invasive species. A few unexpected species such as *Vinca major* and *Vitis californica* were present. *V. major* is invasive garden plant and *V. californica* is a wild grape. *Rubus discolor* or Himalayan Blackberry is non-native and invasive and has been observed in the Sierra Foothills to overtake wetlands if not controlled. Although *R. discolor* is non-native, black rails have been heard vocalizing from under Blackberry bushes in wetlands that were heavily grazed.

The plant species of small, emergent, inland wetlands of the Sierra Foothills have not been thoroughly described and understanding these communities is essential for further assessment of habitat usage by black rails and other habitat-specific animals. The knowledge of specific plant species can give land managers a better sense of what type of ecological community occurs at these small, emergent wetlands and also an idea of different hydrologic regimes as particular species may have a higher tolerance for permanent water while other species may indicate seasonal drying of wetlands.

Do plant communities differ between grazed and ungrazed sites? The plant composition was not homogeneous within grazed and ungrazed sites. The two groups also did not show any differences between grazed and ungrazed sites more than what would be expected by chance and therefore the null hypothesis cannot be rejected. Ungrazed sites were expected to have increased species variability, as a previous study by Allen-Diaz and Jackson (2006) showed that grazing removal in spring-fed wetlands increased species diversity. My findings do not support the hypothesis that there is a difference in plant communities between grazed and ungrazed sites. This unexpected result could be due to small sample size (20 sites) and the sites were not picked for equal distribution of grazed and ungrazed sites at different geomorphologies.

Do plant communities differ between sites with different water sources, geomorphology, elevation or slope? The only pattern detected was plant composition differing from low to high elevation. Plant composition in low elevation sites was more similar than plant composition in higher elevation sites. When the outlier Y-26 was removed from the analysis, the elevation trend showed. This was due to the high occurrence of *Carex lanuginosa* (90%) at site Y-26. *C. lanuginosa* was not common, occurring less than 2% of the time out of the twenty sites. *C. lanuginosa* also occurs at higher elevations (200-10,750 ft.), but site Y-26 was at a lower elevation (111 ft.).

The variables cumulatively only explained 32% of the variance in species composition. However, the study design was not focused on looking at these variables and the sites are not evenly distributed in these categories. The small sample size may also have prevented any other significant results from being observed.

Does classifying wetland plant species into indicator categories (obligate, facultative, upland) provide a good predictor of black rail presence? A positive correlation was expected between sites with a higher proportion of obligate and facultative plant species and black rail occupancy, and a negative correlation was expected for sites with a higher proportion of upland plant species. There was no significant correlation between occupancy and any of the three indicator categories, and the indicator categories therefore were not a good predicator of black rail presence.

The study by Flores and Eddleman (1995) grouped plants into categories such as inland saltgrass, mixed shrub, Giant bulrush, Three-square bulrush and Southern cattail and found by telemetry that black rails did not use vegetation types in proportion to their availability. They found that habitat structure such as vegetation density was more effective than plant composition to predict black rail use of habitat. Grouping the plants into five categories seemed crude and grouping plant species into indicator categories seemed to be a better way of characterizing the ecological community.

Occupancy data was skewed towards higher occupancy averages, with no sites sampled with no occupancy in the last four years. This was a shortcoming when designing the study, as sites were originally chosen based on 2007 occupancy. The summer of 2007 was an unusual year as there was about 33% occupancy of all the wetlands when the average is usually about 60% occupancy. The occupancy in 2007 of the sampled sites were more evenly distributed, however this did not accurately reflect the range of average occupancy values for the 2004-2007 period.

Radio telemetry will be used on black rails in the Sierra Foothills beginning in the summer of 2008, and knowledge of where black rails spend most of their time in the wetlands will be helpful for determining what plant communities are important. Grouping plants into indicator categories may be too broad to be used as a predictor of black rail presence.

While there were no clear groupings of distinct plant communities between the sites, further time could be spent designing an improved study to look at differences in plant communities at these wetlands, using this study as a pilot. Since the environmental variables we tested only explained 32% of the variance, there may be other variables that the study did not account for which may be important drivers of plant community composition. Further studies into soil types could be helpful in explaining plant communities, such as nitrogen capacity. The lack of predictive value of the indicator categories shows that the habitat of black rails needs to be studied further. The lack of knowledge of their natural history, especially of the metapopulation in the Sierra Foothills, prompts further investigation of their behavior and habitat usage. Since the indicator categories cannot be a predictor for black rail presence, wetland management must look into more detailed assessment of habitat quality for the conservation of these fragmented habitats.

As wetlands are continually lost, conservation and protection of these habitats is essential for the conservation of biodiversity. Habitat analysis of the California black rail is essential for conservation implementation because managing their populations is difficult due to their reclusive nature. Vegetation cover has shown to be an important factor for rail presence, as rail occurrence is correlated with how high and dense the vegetation is in the habitat. Occupancy is positively associated with vegetation and percent cover (O. Richmond, unpublished data). A more in-depth study of what drives wetland quality is important for management of California's inland wetlands. Identifying the major components of the characteristics that drive habitat quality is essential for management of wetlands, especially for those that do not have those components. Identifying suitable wetlands can serve to protect black rail habitat and also serve to restore wetlands that do not possess quality characteristics. Habitat restoration and management of wetlands that carry out the suitable habitat characteristics can serve to conserve the threatened California black rail.

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