AN ABSTRACT OF THE THESIS OF

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Robert L. Jarvis

Freshwater wetlands in the Sacramento Valley provide breeding, wintering, foraging and stopover habitat for migratory and resident birds. With a loss of 95% of historic freshwater wetlands, the restoration of wetlands on private land could provide important habitat for birds. Documentation and monitoring of bird use on previously restored wetlands is needed to improve and guide wetland restoration on private lands in the Sacramento Valley.

Bird communities of two types of privately owned, restored wetlands: spring-seasonal and semi-permanent, were compared in the Sacramento Valley of California during the spring and summer of 1998 and 1999. Abundance and richness of bird communities were analyzed by species and according to two assemblage groups based on wetland dependency and general taxonomy. Non-metric Multidimensional Scaling was used to determine if different wetlands contained similar bird communities. Overlays were used to determine relationships between bird communities in ordination space and the environmental variables wetland type, wetland size, season, water depth, surrounding land use and six habitat variables.

Both spring-seasonal and semi-permanent wetlands attracted diverse bird communities, but bird community structure differed between spring-seasonal and semi-permanent wetlands. Species richness and abundance were greatest on semi-permanent wetlands. Wetland obligate species, nonwetland species, waterfowl and water birds were more abundant on semi-permanent than on spring-seasonal wetlands. Shorebirds were most abundant on spring-seasonal wetlands. The bird community changed over the season in response to migration patterns. Bird communities also differed according to water depth and wetland size. Wetland obligate and nonwetland species were more abundant on wetlands with trees. Planting trees or pole cuttings is an easy and economical way to facilitate maturation of a restored wetland. For greater biodiversity, wetland restorations in the Sacramento Valley should not promote one type of restoration over the other so long as a reliable source of water is available.

Bird Community Patterns of Spring-seasonal and Semi-permanent Wetlands in the Sacramento Valley, California

by

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P. Dawn Harris, Author

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Bird Community Patterns of Spring-seasonal and Semi-permanent Wetlands in the Sacramento Valley, California

Introduction

The restoration of converted wetlands may contribute significantly to the conservation of habitats for wetland bird communities (Brown and Smith 1998). Freshwater wetland and riparian habitat throughout the Central Valley (Valley) of California provide breeding, wintering, foraging and stopover habitat for migratory and resident birds including waterfowl, shorebirds, wading birds, raptors, and passerines. The Valley supports nearly 250 species of birds (Engilis 1995) and 60% of the waterfowl that winter in the Pacific Flyway (Wrysinski et al. 1995). Wintering waterfowl have been the primary focus of restoration efforts in the Valley. However, recent studies revealing the importance of the Valley to nesting waterfowl have prompted many wildlife agencies and private landowners to focus efforts on providing waterfowl brood rearing habitat which in turn benefits multiple non-game bird communities (de Szalay and Resh 1997, and Yarris 1995). The future development of wetlands in the Valley for breeding bird communities requires documentation and monitoring of bird use on previously restored wetlands.

Prior to European settlement the Valley contained over 1.6 million hectares of freshwater wetlands. As it was settled, federal, state and local policies encouraged the conversion of wetlands. Consequently, 95% of the wetlands were drained and filled for land conversion to agriculture, urban development, and flood control (Wrysinski et al. 1995). Of the 5% of wetland habitat remaining, federal and state wildlife refuges comprise one-third while the remaining two-thirds are owned and managed by private landowners (Smith 1995).

Heightened awareness of the benefits and values of wetlands has prompted wetland restoration throughout the nation. State and federal conservation agencies in California have responded by implementing programs that protect, restore and create wetland habitat for wildlife, primarily focusing on waterfowl. Among the programs, many are cost-share programs established to provide wildlife habitat on private lands.

Despite the multitude of management and scientific opportunities that are afforded by ecological restoration, only a small fraction of the hundreds to thousands of restorations that are performed annually benefit from the combined efforts of resource managers and scientists (Michener 1997). In this research, I highlight that relationship by evaluating two different types of freshwater wetlands.

Spring-seasonal wetlands were restored and managed under the California Department of Fish and Game's (CDFG) pilot Waterfowl Brood Pond Program. Semi-permanent wetlands were restored and protected by permanent conservation easement under the U.S. Fish and Wildlife Service's (USFWS) Partners for Fish and Wildlife Program.

Spring-seasonal wetlands in this study were artificially flooded in early spring (March 15 - April 1) and drained mid-summer (July 15 – August 15). They were restored to provide pair bonding and brood rearing habitat for locally nesting waterfowl, specifically mallard (*Anas platyrhynchos*). They are kept dry from late summer through early spring to promote the growth of annual grasses and forbs such as Italian ryegrass (*Lolium perenne*), bird's foot trefoil (*Lotus corniculatus*), curly dock (*Rumex crispus*), and rabbitfoot grass (*Polypogon monspeliensis*). Once the wetlands are flooded to a depth of 10 - 30 cm, the dense mat of annual grasses breaks down and provides habitat for invertebrates (Smith 1998), which are important foods for the growth and development of ducklings (Eldridge 1990).

Semi-permanent wetlands represent the most common wetland type in the Sacramento Valley. They are typically flooded in early fall in association with the waterfowl hunting season and drained mid-summer after the majority of waterfowl have nested. Semi-permanent wetlands are classified as Type IV by Stewart and Kantrud (1971). Like spring-seasonal wetlands, semi-permanent wetlands are highly managed and are flooded by a combination of rainfall, irrigation, runoff and snowmelt. They are drained mid-summer to promote plant species that provide a winter food source for waterfowl. They are also drained to conduct annual maintenance such as prescribed burning, mowing and/or discing, all of which reduces thick stands of vegetation, especially cattail (*Typha* sp.), to create hemi-marsh conditions (de Szalay and Resh 1997). Semi-permanent wetlands are flooded to an average depth of 30 - 60 cm and are managed to achieve a 50:50 mix of tall emergent vegetation and open water which provides maximum diversity and abundance of birds (Weller and Spatcher 1965).

Spring-seasonal wetlands are flooded on a schedule opposite that of semi-permanent wetlands in the Sacramento Valley. Spring-seasonal wetlands are more representative of the historic flooding regime of the Sacramento Valley (Smith 1998) when wetlands were inundated from December through February from rainfall and from March through June from Sierra-Nevada snowmelt. Today natural flooding does not occur from early March through July due to dams and other water conversion techniques used for irrigated agriculture and urban water supplies. Consequently, only 5-10% of the Central Valley's wetlands are flooded during the late spring and early summer.

Further support for the restoration of spring-seasonal wetlands comes from a study conducted by Resh and de Szalay (1998) in the Grasslands of California. They found many invertebrate taxa important in duckling and shorebird diets were often higher in spring-seasonal wetlands as compared to semi-permanent wetlands. Similarly, Kantrud and Stewart (1977) found that temporary wetlands in North Dakota supported greater densities of breeding dabbling ducks than any other wetland type. This condition was indicative of their fertility as reflected by the abundance and availability of invertebrate food sources. These results imply that semi-permanent wetlands provide lower invertebrate food resources for ducklings and juvenile shorebirds than spring-seasonal wetlands. However, additional wetland habitat components more prevalent on semi-permanent wetlands (e.g., emergent cover and trees) could be significant in determining breeding bird species' utilization of wetlands. Kaminski and Prince (1981) found that the interspersion of emergent vegetation and water in an equally abundant pattern was an important determinant of density and use of wetlands by breeding dabbling ducks in Manitoba.

Monitoring and analysis of habitat values of restored freshwater wetlands throughout the United States have been extremely scarce (Kusler and Kentula 1989) until recently. A study by Delphey and Dinsmore (1993) conducted in the prairie potholes was one of the first attempts to quantify the use of restored freshwater wetlands by non-waterfowl species that nest in prairie wetlands. A few studies have been conducted to either determine the bird communities of restored wetlands (Brown and Smith 1998;

Melvin and Webb 1998) or to measure the factors affecting bird communities of restored wetlands (LaGrange and Dinsmore 1989; Hemesath and Dinsmore 1993). All of these studies found that restored wetlands supported a variety of wetland birds.

The goal of this project was to evaluate and compare the bird communities of spring-seasonal and semi-permanent wetlands in the Sacramento Valley of California. I explored the influence of wetland type, wetland size, water depth, season, year, surrounding habitat, and vegetation components in shaping bird communities using 21 restored wetlands in the Sacramento Valley, California. The results are intended to provide CDFG and USFWS with useful information on the type of wetland and some of the wetland characteristics that are attractive to birds in the Sacramento Valley. Additionally the results may be used to improve and guide future wetland restoration efforts.

Study Area

The study area was the northern half of the Central Valley of California, the Sacramento Valley. The climate in the Sacramento Valley is mild Mediterranean, hot and dry during the summer and cool and wet during winter, with most of the rain occurring between November and February. The average rainfall is between 38 - 56 cm. The topography of the Sacramento Valley is characterized by flat expanses of agriculture, pasture, grasslands and remnant oak woodlands with numerous low depressional areas and a few gently rolling hills.

Research was conducted on privately owned wetlands in six counties (Figure 1) of the Sacramento Valley. In 1998, I included 6 spring-seasonal wetlands and 5 semi-permanent wetlands and in 1999, I studied 13 spring–seasonal wetlands and 8 semi-permanent wetlands. Spring-seasonal wetlands were restored between 1997-1999. The semi-permanent wetlands were restored between 1990 and 1995.

I studied all of the spring-seasonal wetlands available in 1998 and 1999. In selecting semi-permanent wetlands for the study, I tried to match semi-permanent wetlands that were in close proximity and of similar size to the spring-seasonal wetlands. Due to the lack of available semi-permanent wetlands matching the criteria, I studied fewer semi-permanent wetlands both years than spring-seasonal wetlands.

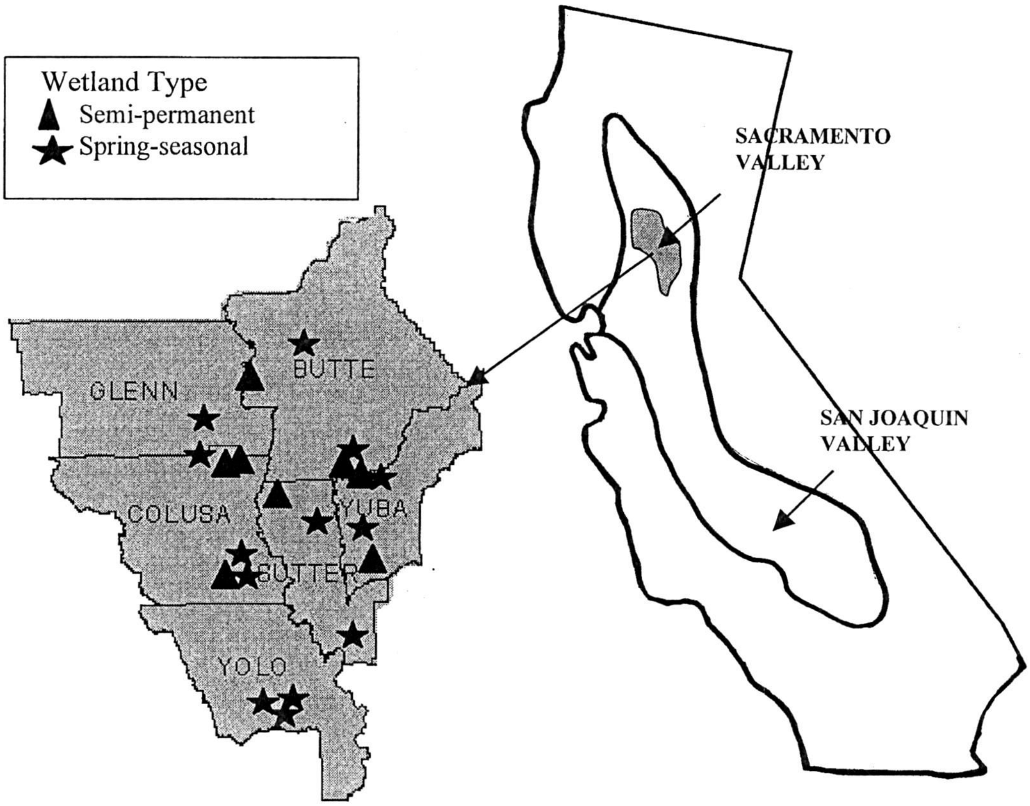

Figure 1. Location of semi-permanent and spring-seasonal wetlands throughout six counties in the Sacramento Valley, California, 1998-99.

Methods

Field Methods

I conducted bird surveys by scan sampling (Altmann 1974) biweekly from April 1 to July 15 in 1998 and 1999. The number of surveys conducted each year ranged from five to seven depending on rate of initial flood-up and availability of water throughout the field season. One person observed while the second recorded the number of each species seen or heard. Surveys were conducted throughout the day from 0600 to 1800 in 1998. Surveys were from 0500 to 1100 hours in 1999. Surveys were not conducted during heavy wind or rain because these conditions decrease the number of birds detected (Ralph et. al. 1995). Birds seen flying high overhead were not counted; those flying within the wetland including, cliff swallow (*Petrochelidon pyrrhonota*) and turkey vulture (*Cathartes aura*), were counted. A Bushnell Spacemaster 22x scope and a pair of Bausch & Lomb 8x40 Elite binoculars were used to help identify and count birds from pre-set stations along levee perimeters and access roads. Individual stations were established in areas that provided maximum concealment from the birds to minimize disturbance. The number of stations ranged from one to two stations depending on the size and shape of the wetland.

At each station, a 10-minute scan was conducted. All birds seen or heard using the wetland and the habitat type each individual utilized was recorded. A limit of ten minutes was chosen for each scan to describe community compostion (Fuller and Langslow 1984). After each scan a ten-minute rest period followed before the next 10-minute scan began. A total of five scans were conducted per survey. Scans began no later than 10 minutes after arrival at the station. If birds were disturbed upon arrival and left the wetland before the first scan was initiated, the total number of birds and species leaving was recorded and added to the first scan. Birds observed entering the wetland during a scan were counted on that survey and their landing position noted. During the ten-minute interval between scans, callback tapes were played to elicit responses from secretive species (Zimmerman 1977) which are difficult to observe: Virginia rail (*Rallus limicola*) and sora (*Porzana carolina*).

Flush counts were conducted on four wetlands where visibility was low due to the presence of extensive stands of tall emergent vegetation. The flush counts served as a truthing method to determine if the observer was missing waterfowl broods or other species of birds during scan sampling. During the flush count, birds were driven from the wetland by counters to census the total number of birds within the wetland. The abundance of bird species counted during the flush count was then compared to the abundance from the scan.

The type of vegetation available in each wetland was recorded monthly during 1998 and 1999. The dominant vegetation types were identified and categorized into six groups (Table 1). No direct measurements were made on vegetation only presence/absence data was collected. Habitat surrounding wetlands was categorized as wetland, wetland/agriculture mix, or agriculture. Both the wetland and agriculture categories refer to the wetland being surrounded 100% by the respective category. The wetland/agriculture mix refers to the wetland being surrounded by a combination of both wetland and agriculture.

Table 1. Description of cover categories for bird community study of restored wetlands in the Sacramento Valley, California, 1998-1999. Category description adapted from Fiedler (1996).

Habitat Classification	Description
Tall emergents	Tall emergent plants are commonly found in shallow and some deepwater marshes throughout the Sacramento Valley. Species seen on study wetlands include: broad-leaved cattail (*Typha latifolia*) and hard-stem bulrush (*Scirpus acutus*).
Open water	Areas of open water where no vegetation is growing or is growing but has not emerged from the water column.
Upland grass and forbs	Annual and perennial grasses and forbs found in close proximity to or within wetlands throughout the Sacramento Valley. Species seen on study wetlands include: Italian ryegrass (*Lolium perenne*), wild oat (*Avena fatua*), broadleaf peppergrass (*Lepidium latifolium*), bird's-foot trefoil (*Lotus corniculatus*), Mediterranean barley (*Hordeum marinum*), rabbitfoot grass (*Polypogon monspeliensis*), and Curly Dock (*Rumex crispus*).
Short emergents (moist soil emergents)	Short emergent plants are commonly found in many wet habitats throughout the Sacramento Valley, particularly seasonally inundated and saturated wetlands. Species seen on study wetlands include: swamp timothy (*Crypsis schoenoides*), jointgrass (*Paspalum distichum*), nutsedge (*Cyperus eragrostis*), Ammania (*Ammania Coccinea*), Water-hyssop (*Bacopa* sp.), water primrose (*Ludwigia peploides*), cocklebur (*Xanthium strumarium*), baltic rush (*Juncus balticus*), and creeping spikerush (*Eleocharis macrostachya*).
Mudflat	Areas of moist open land within a wetland that is devoid of vegetation. Mudflats are exposed when water within the wetland recedes exposing the moist ground underneath to the air.
Trees	A woody perennial plant having a single, elongate main stem or multiple stems with a single canopy of leaves. Species seen on study wetlands include: Fremont cottonwood (*Populus fremontii*), sandbar willow (*Salix exigua*), red willow (*Salix laevigata*), arroyo willow (*Salix lasiolepsis*), box elder (*Acer negundo*) and Valley oak (*Quercus lobata*).

After initial flooding, water depth was measured at 25 meter intervals along transects oriented diagonally through the wetland. Water depth for the entire season was monitored using a permanent water gauge installed at a fixed location, usually in a deep area, within each wetland. To estimate the average water depth during each visit, the net change in depth was subtracted from the average depth along transects measured after flood-up.

Species Assemblages and Analysis

I compared species abundance, assemblage abundance and species richness, between spring-seasonal and semi-permanent wetlands. These measures were considered comparable for a specific species between wetlands under the assumption that the species does not differ appreciably in its ability to be detected from wetland to wetland. But interspecific comparisons within and between wetlands were limited since species do differ markedly in their conspicuousness (Beals 1960). I used the maximum number of individuals of a given species detected during a given scan during one survey (1998-1999) as a measure of species abundance. A sample unit for this project is defined as the number and species of birds recorded on a specific date for a specific wetland. Mean number of individual species was determined by averaging the species abundance for all scans over both years for a given species.

I investigated the degree to which bird communities differed between years by running a preliminary analysis. Year was not significantly correlated on the ordination nor did it account for significant differences in assemblages according to Multi-response Permutation Procedure (Mielke 1984). As a result species abundance was pooled for both years for each species. Assemblage abundance was determined by combining all of the maximum species abundance for each a priori assemblage over the entire sampling period. Species richness was defined as the total number of species recorded over the duration of the study for both spring-seasonal and semi-permanent wetlands.

Species richness is a type of alpha diversity defined by Whittaker (1972) as the number of species in individual sample units. I used species richness as the measure of alpha diversity of the bird community because it is a straightforward parameter that is easy to communicate. Other diversity measurements, although widely used in ecology, have serious statistical shortcomings (Wiens 1992; Colinvaux 1986). Species richness is a direct expression of diversity of the sample that is easy to interpret and attractive to many ecologists since it is the most observable and manageable form of biological diversity across a landscape (Magurran 1988). The primary limitation of species richness is its sensitivity to sample unit size and the skill of the observer.

Wetland bird communities are typically large and contain a heterogeneous mix of species. It is advantageous, therefore, to consider more homogeneous subsets of species within these communities. Specifying an assemblage of specific species provides a way to explore community features that are not revealed by a consideration of individual species numbers and abundance alone without getting overwhelmed by a mass of species-specific detail that could obscure interesting community patterns (Wiens 1992). For this reason, all species were placed into two assemblages and analyzed accordingly. The first assemblage was based on wetland dependency and the second was based on general taxonomy. The wetland dependency assemblage followed classification similar to Brown and Smith (1998) where each species was placed into one of three groups: wetland obligate, wetland associated, and nonwetland. Wetland obligate birds were classified following a list of wetland dependent birds developed by Crowley et al. (1996). Wetland associated birds and nonwetland birds were classified according to habitat associations in Ehrlich et al. (1998) and from personal experience. The second assemblage, taxonomic, categorized bird species according to taxonomy. Each species was assigned to one of the following seven bird groups: waterfowl (ducks and geese), wading birds (herons, egrets, ibis, pelicans and terns), water birds (coots, rails and grebes), shorebirds (plovers and sandpipers), raptors, passerines and other species (kingfishers, woodpeckers, pheasants). Mourning dove (*Zenaida macroura*) and rock dove (*Columba livia*) were placed in the passerine group because of their similarities in feeding and behavior to many passerines. After placing each species into their respective assemblage group the assemblage abundance was calculated by summing the species abundance for that assemblage group. For example, the assemblage abundance for the waterfowl group was calculated by summing the species abundances for all of the individual species assigned to the waterfowl group. The end result is one number representing waterfowl abundance for one of the 21 project wetlands.

My community data are multivariate because each sample unit is composed of the abundances for many different species. Multivariate analysis allows simultaneous evaluation of numerous explanatory variables with the goal of treating the data set as a whole, reducing the information to reveal the underlying structure (Gauch 1982, Tabachnick and Fidell 1996, and McCune and Mefford 1999). All multivariate analyses were conducted using PC-ORD version 4.07 (McCune and Mefford 1999). I generated summary statistics and boxplots on the abundance data to assess the need for monotonic transformations. The abundance for each sample unit was log transformed (x + 1) to reduce the average skew and the coefficient of variation, thus improving normality. Rare species and species that did not occur on 5% or more of the sample units were deleted. This resulted in the deletion of 28 species bringing the total species count down to 71 species. These 71 species were used in the first ordination analyzing individual species abundance.

Ordination is a multivariate method that arranges sample units along axes on the basis of species composition data as a way of graphically summarizing complex relationships into one or a few dominant patterns. Ordination is most often used in community ecology to seek and describe patterns of species composition (McCune and Mefford 1999). One complaint of ordination is that it groups sampling units in community types that are typically arbitrary. However, the designation of distinct community types in wetlands, which attract both wetland and nonwetland species, is desirable for managers who target specific groups of species.

Non-metric Multidimensional Scaling (NMS) is an ordination method based on ranked distance that is suited to data that do not have multivariate normality or are on arbitrary or discontinuous scales (Kruskal 1964). NMS calculates the stress in the data set where stress is a measure of departure from monotonicity in the relationship between the dissimilarity in the original space and distance in the reduced ordination space. In other words, sample units close in the ordination space are more similar than sample units distant in the ordination space and will subsequently have lower stress. Ordinations using a normal analysis (i.e. sample units in species space) were constructed for this study using NMS with the quantitative version of the Sorensen distance measure to determine similarities. For the initial ordination runs, I requested a 6-dimensional (D) solution stepping down to a 1-D solution, an instability criterion of 0.0005, 20 runs with the real and randomized data, and 200 iterations. After running these ordinations I reviewed a Scree Plot or a plot of the final stress versus the number of dimensions. Scree plots are used to determine the appropriate number of dimensions (axes) for the final solution. Selection of the appropriate number of dimensions is critical in NMS. As dimensions are added to a solution the pattern on other dimensions changes, so for a given number of dimensions the solution for a specific axis is unique (McCune and Mefford 1999). In addition, as axes are added to the solution the variance explained increases and the final stress decreases. Using too many dimensions, however, makes interpretation of the results almost impossible since the variation is spread over a large number of axes. It is advantageous then to express the variation in as few dimensions as needed to express the covariation in as many attributes as possible (McCune and Mefford 1999). Reviewing the Scree Plot and selecting the number of axes beyond which reductions in stress were small determined the final solution. I checked the stability of the final solution, called the stability criterion, by examining a plot of stress versus iteration number. An illustration of a stable solution in the plot shows stress dropping quickly and stabilizing in a smooth curve where stress is low and even. Overfitting the data, selecting a dimensionality that is too high for the number of sample units, results in a curve that fluctuates erratically. After determining the number of dimensions for my ordination I ran NMS a second time requesting the specified dimensions with no step down in dimensionality and 10 runs with the real data.

To determine if measured environmental variables (Table 2) indicated a pattern on the ordination axes I used overlays. Overlays are simply a graphic way of seeing if a variable is patterned on an ordination. Joint plots were used to relate quantitative variables to ordination axes. Variables included specific species abundance, water depth, and wetland size. Vector angles and length in the joint plots illustrate the strength and direction of the variables. The coefficient of determination, r, was used to explain the cumulative proportion of variance explained by each axis by examining the r^2 between distance in ordination space and distance in original space. Environmental variables that had biologically meaningful correlations were defined by an $r^2 \geq 0.1$ for quantitative variables and $r^2 \geq 0.2$ for assemblage variables. Hereafter these biologically meaningful results will be referred to as significant correlations, despite the absence of a p-value.

Table 2. Description of quantitative (Q) and categorical (C) environmental variables used in the environmental matrix.

Environmental Variable		**Description**
Water depth	Q	Mean water depth (cm)
Wetland type	C	Spring-seasonal or Semi-permanent
Season	C	Spring (April – May) / Summer (June – July)
Year	C	1998 or 1999
Size	Q	Wetland size (ha)
Surrounding habitat	C	wetland, agriculture, mix
Trees	C	present or absent
Tall emergent	C	present or absent
Short emergent	C	present or absent
Open water	C	present or absent
Mudflat	C	present or absent

MRPP is a non-parametric method for testing multivariate differences among two or more groups. MRPP tests the hypothesis of no difference between groups. It has the advantage of not requiring assumptions of multivariate normality and equality of variance that are often not met in ecological data (Mielke 1984). Multi-response permutation procedure (MRPP) was used to determine if differences in overall bird communities with respect to specific environmental variables were significant. An environmental matrix (second matrix) was structured with the 11 environmental variables (Table 2) as columns and wetland plot as the sample unit represented by rows.

MRPP provides a test statistic (T), a measure of the "effect size" (A), and a p-value. MRPP requires that groups of entities be defined from a variable in the species abundance matrix or from an environmental variable in a second matrix. The T-statistic describes the separation between the groups. It is defined as the difference between the observed and expected deltas divided by the square root of the variance in the delta (Mielke 1984). The observed delta is the average within-group distance and is compared to the expected delta that is calculated to represent the mean delta for all possible partitions of the data. The chance corrected within group agreement (A), is a description of the "effect size" and is independent of the sample size. If all sample units within groups are identical $A = 1$, and $A = 0$ when heterogeneity within groups equals expectation by chance. In community ecology, values for A are commonly below 0.1 and an $A \geq 0.3$ is fairly high. Statistical significance ($p < .05$) may result even with a small A if the sample size is large. For example, an A of 0.1 may be statistically significant with $N = 200$. When this happens it is important to consider the ecological significance of the result in lieu of the statistical significance (McCune pers. com.).

Indicator Species analysis (Dufrene and Legendre 1997) was used to examine the association between species assemblages and the presence/absence of specific habitat components: open water, short emergents, tall emergents, trees, and mudflat. To do this, Indicator Values (IV) were calculated using Indicator Species Analysis to detect and describe the value of different species for indicating environmental conditions for community data. The maximum indicator value for each species assemblage was tested for significance using a Monte Carlo randomization procedure. Assemblages were defined by each of the habitat components in six different analyses.

Results

During the spring and summer of 1998 and 1999 a total of 99 bird species were found within 21 restored wetlands in the Sacramento Valley of California (Table 3). A total of 24,703 individuals were recorded for all of the 21 restored wetlands. The total number of individuals detected was greater on spring-seasonal wetlands than on semi-permanent wetlands (Table 4). Species richness, however, was greatest on semi-permanent wetlands during both years of the study (Table 5). A total of 91 species were identified on the 8 semi-permanent wetlands and 87 species were identified on the 13 spring-seasonal wetlands. Eight species were observed only on spring-seasonal wetlands (Table 3): American kestrel (*Falco sparverius*), golden eagle (*Aquila chrysaetos*), whimbrel (*Numenius phaeopus*), Wilson's phalarope (*Phalaropus tricolor*), downy woodpecker (*Picoides pubescens*), golden-crowned sparrow (*Zonotrichia atricapilla*), loggerhead shrike (*Lanuis ludovicianus*), and rock dove. Twelve species were unique to semi-permanent wetlands (Table 3): Forster's tern (*Sterna forsteri*), semi-palmated plover (*Charadrius semipalmatus*), American white pelican (*Pelecanus erythrorhynchos*), black-headed grosbeak (*Pheucticus melanocephalus*), bushtit (*Psaltriparus minimus*), house sparrow (*Passer domesticus*), lesser goldfinch (*Carduelis psaltria*), western wood-peewee (*Contopus sordidulus*), willow flycatcher (*Empidonax traillii*), Wilson's warbler (*Wilsonia pusilla*), yellow warbler (*Dendroica petechia*), and yellow-rumped warbler (*Dendroica coronota*).

The most abundant species using both spring-seasonal and semi-permanent wetlands were red-winged blackbird (*Agelaius phoeniceus*), American coot (*Fulica americana*), mallard (*Anas platyrhynchos*) and cliff swallow (*Petrochelidon pyrrhonota*).

Table 3. List of all species seen during scan sampling on spring-seasonal and semi-permanent wetlands in the Sacramento Valley, CA, 1998-1999. The occurrence of a species on a particular wetland type is listed as Presence (P) and Absence (A). Also shown is the assignment of each species to a specific assemblage: wetland dependency or taxonomic.

	Species	**Semi-permanent**	**Spring-seasonal**	**Wetland dependency**	**Taxonomic assemblage**
1	American wigeon *(Anas americana)*	P	P	obligate	waterfowl
2	Blue-winged teal *(Anas discors)*	P	P	obligate	waterfowl
3	Canada goose *(Branta canadensis)*	P	P	obligate	waterfowl
4	Cinnamon teal *(Anas cyanoptera)*	P	P	obligate	waterfowl
5	Gadwall *(Anas strepera)*	P	P	obligate	waterfowl
6	Green-winged teal *(Anas crecca)*	P	P	obligate	waterfowl
7	Mallard *(Anas platyrhynchos)*	P	P	obligate	waterfowl
8	Northern Pintail *(Anas acuta)*	P	P	obligate	waterfowl
9	Northern shoveler *(Anas clypeata)*	P	P	obligate	waterfowl
10	Redhead *(Aythya americana)*	P	P	obligate	waterfowl
11	Ring-necked duck *(Aythya collaris)*	P	P	obligate	waterfowl
12	Ruddy duck *(Oxyura jamaicensis)*	P	P	obligate	waterfowl
13	Wood duck *(Aix sponsa)*	P	P	obligate	waterfowl
14	American kestrel *(Falco sparverius)*	A	P	nonwetland	raptors
15	Golden eagle *(Aquila chrysaetos)*	A	P	nonwetland	raptors
16	Northern harrier *(Circus cyaneus)*	P	P	associated	raptors
17	Red-tailed hawk *(Buteo jamaicensis)*	P	P	nonwetland	raptors
18	Swainson's hawk *(Buteo swainsoni)*	P	P	nonwetland	raptors
19	Turkey Vulture *(Cathartes aura)*	P	P	nonwetland	raptors
20	White-tailed kite *(Elanus leucurus)*	P	P	nonwetland	raptors
21	American Coot *(Fulica americana)*	P	P	obligate	water birds
22	Common moorhen *(Gallinula chloropus)*	P	P	obligate	water birds
23	Pied-billed grebe *(Podilymbus podiceps)*	P	P	obligate	water birds

	Species	Semi-permanent	Spring-seasonal	Wetland dependency	Taxonomic assemblage
24	Sora *(Porzana carolina)*	P	P	obligate	water birds
25	Virginia rail *(Rallus limicola)*	P	P	obligate	water birds
26	American bittern *(Botaurus lentiginosus)*	P	P	obligate	wading birds
27	Black-crowned night heron *(Nycticorax nycticorax)*	P	P	obligate	wading birds
28	Black tern *(Chlidonias niger)*	P	P	obligate	wading birds
29	Caspian tern *(Sterna caspia)*	P	P	associated	wading birds
30	Double-crested cormorant *(Phalacrocorax auritus)*	P	P	obligate	wading birds
31	Forster's tern *(Sterna forsteri)*	P	A	obligate	wading birds
32	Great blue heron *(Ardea herodias)*	P	P	associated	wading birds
33	Great Egret *(Casmerodius albus)*	P	P	obligate	wading birds
34	Green heron *(Butorides striatus)*	P	P	obligate	wading birds
35	Snowy egret *(Egretta thula)*	P	P	obligate	wading birds
36	White-faced Ibis *(Plegadis chihi)*	P	P	obligate	wading birds
37	American White Pelican *(Pelecanus erythrorhynchos)*	P	A	obligate	wading birds
38	American avocet *(Recurvirostra americana)*	P	P	obligate	shorebirds
39	Black-bellied plover *(Pluvialis squatarola)*	P	P	associated	shorebirds
40	Black-necked stilt *(Himantopus mexicanus)*	P	P	obligate	shorebirds
41	Common snipe *(Gallinago gallinago)*	P	P	obligate	shorebirds
42	Dunlin *(Calidris alpina)*	P	P	obligate	shorebirds
43	Greater yellowlegs *(Tringa melanoleuca)*	P	P	obligate	shorebirds
44	Killdeer *(Charadrius vociferus)*	P	P	associated	shorebirds
45	Least sandpiper *(Calidris minutilla)*	P	P	obligate	shorebirds
46	Long-billed curlew *(Numenius tahitiensis)*	P	P	obligate	shorebirds
47	Long-billed dowitcher *(Limnodromus scolopaceus)*	P	P	obligate	shorebirds
48	Semi-palmated plover *(Charadrius semipalmatus)*	P	A	obligate	shorebirds
49	Western sandpiper *(Calidris mauri)*	P	P	obligate	shorebirds

	Species	Semi-permanent	Spring-seasonal	Wetland dependency	Taxonomic assemblage
50	Whimbrel *(Numenius phaeopus)*	A	P	obligate	shorebirds
51	Wilson's phalarope *(Phalaropus tricolor)*	A	P	obligate	shorebirds
52	Belted kingfisher *(Megaceryle alcyon)*	P	P	obligate	others
53	Downy woodpecker *(Picoides pubescens)*	A	P	nonwetland	others
54	Northern Flicker *(Colaptes auratus)*	P	P	nonwetland	others
55	Nuttall's woodpecker *(Picoides nuttallii)*	P	P	nonwetland	others
56	Ring-necked pheasant *(Phasianus colchicus)*	P	P	nonwetland	others
57	American crow *(Corvus brachyrhynchos)*	P	P	nonwetland	passerines
58	American Goldfinch *(Carduelis tristis)*	P	P	nonwetland	passerines
59	American pipit *(Anthus rubescens)*	P	P	nonwetland	passerines
60	American Robin *(Turdus migratorius)*	P	P	nonwetland	passerines
61	Ash-throated flycatcher *(Myiarchus cinerascens)*	P	P	nonwetland	passerines
62	Barn swallow *(Hirundo rustica)*	P	P	associated	passerines
63	Black phoebe *(Sayornis nigricans)*	P	P	associated	passerines
64	Black-headed grosbeak *(Pheuticus melanocephalus)*	P	A	nonwetland	passerines
65	Blue grosbeak *(Guiraca caerulea)*	P	P	nonwetland	passerines
66	Brewer's blackbird *(Euphagus cyanocephalus)*	P	P	nonwetland	passerines
67	Brown-headed cowbird *(Molothrus ater)*	P	P	nonwetland	passerines
68	Bullock's oriole *(Icterus spurius)*	P	P	nonwetland	passerines
69	Bushtit *(Psaltriparus minimus)*	P	A	nonwetland	passerines
70	Cliff swallow *(Hirundo pyrrhonota)*	P	P	associated	passerines
71	Common yellowthroat *(Geothlypis trichas)*	P	P	obligate	passerines
72	European starling *(Sturnus vulgaris)*	P	P	nonwetland	passerines
73	Golden-crowned sparrow *(Zonotrichia atricapilla)*	A	P	nonwetland	passerines
74	House finch *(Carpodacus mexicanus)*	P	P	nonwetland	passerines
75	House sparrow *(Passer domesticus)*	P	A	nonwetland	passerines

	Species	Semi-permanent	Spring-seasonal	Wetland dependency	Taxonomic assemblage
76	Lesser goldfinch *(Carduelis psaltria)*	P	A	nonwetland	passerines
77	Loggerhead shrike *(Lanuis ludovicianus)*	A	P	nonwetland	passerines
78	Marsh Wren *(Clistothorus palustris)*	P	P	obligate	passerines
79	Mourning dove *(Zenaida macroura)*	P	P	nonwetland	passerines
80	Northern mockingbird *(Mimus polyglottos)*	P	P	nonwetland	passerines
81	Oak titmouse *(Baeolophus inornatus)*	P	P	nonwetland	passerines
82	Red-winged blackbird *(Agelaius phoeniceus)*	P	P	associated	passerines
83	Rock dove *(Columba livia)*	A	P	nonwetland	passerines
84	Ruby-crowned kinglet *(Regulus calendula)*	P	P	nonwetland	passerines
85	Savannah sparrow *(Passerculus sandwichensis)*	P	P	nonwetland	passerines
86	Song sparrow *(Melospiza melodia)*	P	P	nonwetland	passerines
87	Tree swallow *(Tachycineta bicolor)*	P	P	associated	passerines
88	Tri-colored blackbird *(Agelaius tricolor)*	P	P	obligate	passerines
89	Western kingbird *(Tyrannus verticalis)*	P	P	nonwetland	passerines
90	Western meadowlark *(Sturnella neglecta)*	P	P	nonwetland	passerines
91	Western Scrub-Jay *(Aphelocoma californica)*	P	P	nonwetland	passerines
92	Western wood-peewee *(Contopus sordidulus)*	P	A	nonwetland	passerines
93	White-crowned sparrow *(Zonotrichia leucophrys)*	P	P	nonwetland	passerines
94	Willow flycatcher *(Empidonax traillii)*	P	A	associated	passerines
95	Wilson's warbler *(Wilsonia pusilla)*	P	A	nonwetland	passerines
96	Yellow warbler *(Dendroica petechia)*	P	A	nonwetland	passerines
97	Yellow-billed magpie *(Pica nuttali)*	P	P	nonwetland	passerines
98	Yellow-headed blackbird *(Xanthocephalus xanthocephalus)*	P	P	obligate	passerines
99	Yellow-rumped warbler *(Dendroica coronota)*	P	A	nonwetland	passerines

Table 4. Total number (n) of individual birds, mean number of birds and the standard error of the mean (SE) observed from the wetland dependency assemblage and the taxonomic assemblage for semi-permanent and spring-seasonal wetlands during 1998-1999 in the Sacramento Valley, California.

Bird Groupings	**Semi-permanent**		**Spring-seasonal**	
	N	**mean ± SE**	**N**	**mean ± SE**
Wetland dependency assemblage				
Wetland Obligate	8,244	93.7 ± 9.4	7,659	58.9 ± 6.1
Wetland Associated	2,204	25.1 ± 3.6	5,014	38.6 ± 2.7
Non-wetland	711	8.1 ± 0.6	871	6.7 ± 0.5
Total	11,159		13,544	
Taxonomic assemblage				
Waterfowl	3,547	40.0 ± 5.8	2,928	22.3 ± 2.5
Raptors	75	0.9 ± 0.1	93	0.7 ± 0.1
Water Birds	3,281	37.3 ± 5.7	2,505	19.1 ± 3.6
Wading Birds	381	4.3 ± 0.8	486	3.7 ± 0.8
Shorebirds	612	7.0 ± 2.1	1,407	10.8 ± 2.3
Passerines	3,163	35.6 ± 3.6	5,956	45.8 ± 2.7
Others	100	1.1 ± 0.1	169	1.3 ± 0.1
Total	11,159		13,544	

Table 5. Name, location (County), size, year surveyed, type of wetland, and species richness for wetlands studied in the Sacramento Valley, California, 1998-1999.

Wetland Name	Location	Size (ha)	Year(s) Surveyed	Wetland Type	Species richness
Beeman	Yolo	13.4	1998 , 1999	spring-seasonal	48
Folsom	Yuba	7.5	1998 , 1999	spring-seasonal	51
VBS	Colusa	6.9	1998 , 1999	spring-seasonal	48
Conaway I	Yolo	6.9	1998 , 1999	spring-seasonal	47
Kalfsbeek SS	Colusa	7.3	1998 , 1999	spring-seasonal	47
Conaway II	Yolo	4.0	1999	spring-seasonal	39
Struckmeyer	Sutter	6.1	1999	spring-seasonal	39
Knowles	Glenn	2.4	1999	spring-seasonal	38
Saddleback	Yuba	5.9	1999	spring-seasonal	31
Stolp	Butte	0.8	1999	spring-seasonal	30
Wallace	Sutter	2.0	1998 , 1999	spring-seasonal	30
Cinco 5	Colusa	1.2	1999	spring-seasonal	27
Turkey Tract	Butte	13.4	1999	spring-seasonal	24
Victor Ranch	Yuba	3.2	1998 , 1999	semi-permanent	62
Sydenstricker	Sutter	10.9	1998 , 1999	semi-permanent	52
Laughing Mallard	Colusa	5.3	1998 , 1999	semi-permanent	51
Rancho Rio	Yuba	6.0	1999	semi-permanent	47
Holmestead II	Butte	5.7	1998 , 1999	semi-permanent	42
Kalfsbeek SP	Colusa	6.1	1998 , 1999	semi-permanent	40
Delluchi	Colusa	5.9	1999	semi-permanent	36
Llano Seco	Butte	7.3	1999	semi-permanent	36

The most common species occurred on more than 95% of the study wetlands and included the four ubiquitous species listed above along with American bittern (*Ixobrychus exilis*), cinnamon teal (*Anas cyanoptera*), killdeer (*Charadrius vociferus*), ring-necked pheasant (*Phasianus colchicus*) and tree swallow (*Tachycineta bicolor).*

Conducting flush counts did not result in a large enough difference between the flush count and scan sampling (Table 6) to continue implementing them part as part of the survey.

Semi-permanent wetlands averaged 6.3 ha in size ranging from 3.2 ha to 10.9 ha (Table 5). Spring-seasonal wetlands were comparable in mean size, 6.0 ha, to semi-permanent wetlands. Spring-seasonal wetlands ranged in size from 0.8 ha to 13.5 ha (Table 5).

Mean water depth for each wetland was calculated for 1998-99. Mean water depth for spring-seasonal wetlands was 18.8 cm and ranged from 2.9 cm to 33.5 cm. Mean water depth for semi-permanent wetlands was 24.3 cm, ranging from 11.0 cm to 52.6 cm.

Under the wetland dependency assemblage (Table 4), wetland obligate species were more abundant on semi-permanent wetlands ($\bar{x} = 93.7$, SE $\pm$ 9.4) than on spring-seasonal wetlands ($\bar{x} = 58.9$, SE $\pm$ 6.1). Nonwetland species were also most abundant on semi-permanent wetlands ($\bar{x} = 8.1$, SE $\pm$ 0.1). Wetland associated species were more abundant on spring-seasonal wetlands ($\bar{x} = 38.6$, SE $\pm$ 2.7) than on semi-permanent wetlands ($\bar{x} = 25.1$, SE $\pm$ 3.6).

Under the taxonomic assemblage scheme (Table 4), waterfowl were more abundant on semi-permanent wetlands ($\bar{x} = 40.0$, SE $\pm$ 5.8) than on spring-seasonal

Table 6. Comparison of five flush counts to five scan sample counts conducted on four wetlands in 1998 and 1999.

		Mallard	Gadwall	Cinnamon teal	Wood duck	Virginia rail
April 98	Scan	14	0	0	0	0
	Flush	8	0	0	0	0
May 98	Scan	6	2	0	1	0
	Flush	6	0	0	2	0
June 98	Scan	31	2	4	0	0
	Flush	12	2	4	0	1
June 98	Scan	22	0	2	0	0
	Flush	30	0	0	0	0
April 99	Scan	28	0	0	0	0
	Flush	14	0	0	0	0

wetlands ($\bar{x}$ = 22.3, SE ± 2.5). Water birds were most abundant on semi-permanent wetlands ($\bar{x}$ = 37.3, SE ± 5.7), as were wading birds ($\bar{x}$ = 4.3, SE ± 0.8). Shorebirds were more abundant on spring-seasonal wetlands ($\bar{x}$ = 10.8, SE ± 2.3) than on semi-permanent wetlands ($\bar{x}$ = 7.0, SE ± 2.1). Passerines were most abundant on spring-seasonal wetlands ($\bar{x}$ = 45.8, SE ± 2.7). For raptors, the mean number of individuals using semi-permanent ($\bar{x}$ = 0.9, SE ± 0.1) wetlands was almost identical to the mean number using spring-seasonal ($\bar{x}$ = 0.7, SE ± 0.1) wetlands. The same was true for other using semi-permanent ($\bar{x}$ = 1.1, SE ± 0.1) and spring-seasonal ($\bar{x}$ = 1.3, SE ± 0.1) wetlands.

Non-metric multidimensional scaling was used to explore the spatial pattern of bird communities. Three ordinations were explored 1) species abundance 2) wetland dependency assemblage and 3) taxonomic assemblage. From all three ordinations explored, the environmental variables that had significant correlations ($r^2 \geq 0.1$ for quantitative environmental variables and $r^2 \geq 0.2$ for assemblage variables) with the ordination or illustrated patterning were wetland type, wetland size, water depth, season, and surrounding habitat.

I determined a 3-dimensional solution was most appropriate for the species abundance data after examining a Scree Plot and the stability criterion. Final stress for the solution was 19.3 and instability was 0.00009. The three axes explained 74% of the cumulative variation present in the data: Axis 1 = 31%, Axis 2 = 24%, and Axis 3 = 19%. Wetlands that were closer together had similar bird communities as compared to wetlands that were farther apart in ordination space. Axis 1 had significantly strong negative correlations (Table 7) with three species, American coot (r = -0.80), gadwall (*Anas strepera*) (r = -0.51), and mallard (r = -0.56) (Figure 2). Axis 2 had significantly strong

Table 7. Results of Nonmetric Multidimensional Scaling on species abundance data. Species' correlation's (Pearson's *r*) are given for each axis. Significant correlations were defined by an $r^2 \geq 0.2$.

	Axis 1		**Axis 2**		**Axis 3**	
	r	**r^2**	**r**	**r^2**	**r**	**r^2**
American coot	-0.80	0.64	-0.16	0.02	-0.45	0.20
Black-necked stilt	-0.11	0.01	0.43	0.19	-0.46	0.21
Cinnamon teal	-0.17	0.03	-0.03	0.00	-0.48	0.23
Cliff swallow	0.17	0.03	-0.24	0.06	-0.52	0.27
Gadwall	-0.51	0.26	-0.16	0.03	-0.26	0.07
Killdeer	-0.04	0.00	0.49	0.24	-0.49	0.24
Mallard	-0.56	0.32	-0.08	0.01	-0.17	0.03
Marsh wren	-0.09	0.01	-0.67	0.45	0.03	0.00
Pied-billed grebe	-0.21	0.05	-0.58	0.33	-0.29	0.09
Red-winged blackbird	0.37	0.14	0.47	0.22	0.28	0.08

negative correlations (Table 7) with marsh wren (*Cistothorus palustris*) (r = -0.67) and pied-billed grebe (*Podilymbus podiceps*) (r = -0.58) and strong positive correlations with killdeer (r = 0.49) and red-winged blackbird (r = 0.47) (Figures 2 and 3). Axis 3 had significantly strong negative correlations (Table 7) with American coot (r = -0.45), black-necked stilt (*Himantopus mexicanus*) (r = -0.46), cinnamon teal (r = -0.48), cliff swallow (r = -0.52), and killdeer (*Egretta thula*) (r = -0.49) (Figure 3). Overlays of the 12 environmental variables showed distinct patterns for wetland type, season and surrounding habitat. The temporal variation for the ordination was patterned on Axis 1 where wetlands separated out on a seasonal gradient moving from spring to summer (Figure 4). Wetland type was patterned on Axis 2 (Figure 5). Spring-seasonal and semi-permanent wetlands showed distinct separation for the majority of sample units in the ordination but indicated overlap for some of the wetlands. Water depth (r^2 = 0.15) was correlated with Axis 2 (Figure 6). Surrounding habitat showed a grouping of the wetland and wetland/agriculture mix near the midpoint of axis 1 and 2 while the agriculture only group was separated along the same axis but nearer to the top of the gradient in between the two axes (Figure 7). The remaining environmental variables did not demonstrate a pattern on the species abundance ordination. Species abundance differed according to wetland type (A = 0.066, p = .0000), wetland size (A = 0.198, p = .0000), water depth (A = 0.087, p = .0002), season (A = 0.072, p = .0000), and surrounding habitat (A = 0.099, p = .0000).

I selected a 2-D solution with a final stress of 18.7 and instability of 0.0001 for the wetland dependency assemblage. My reason for selecting this solution was based on review of the Scree Plot and the stability criterion. The two axes produced by the

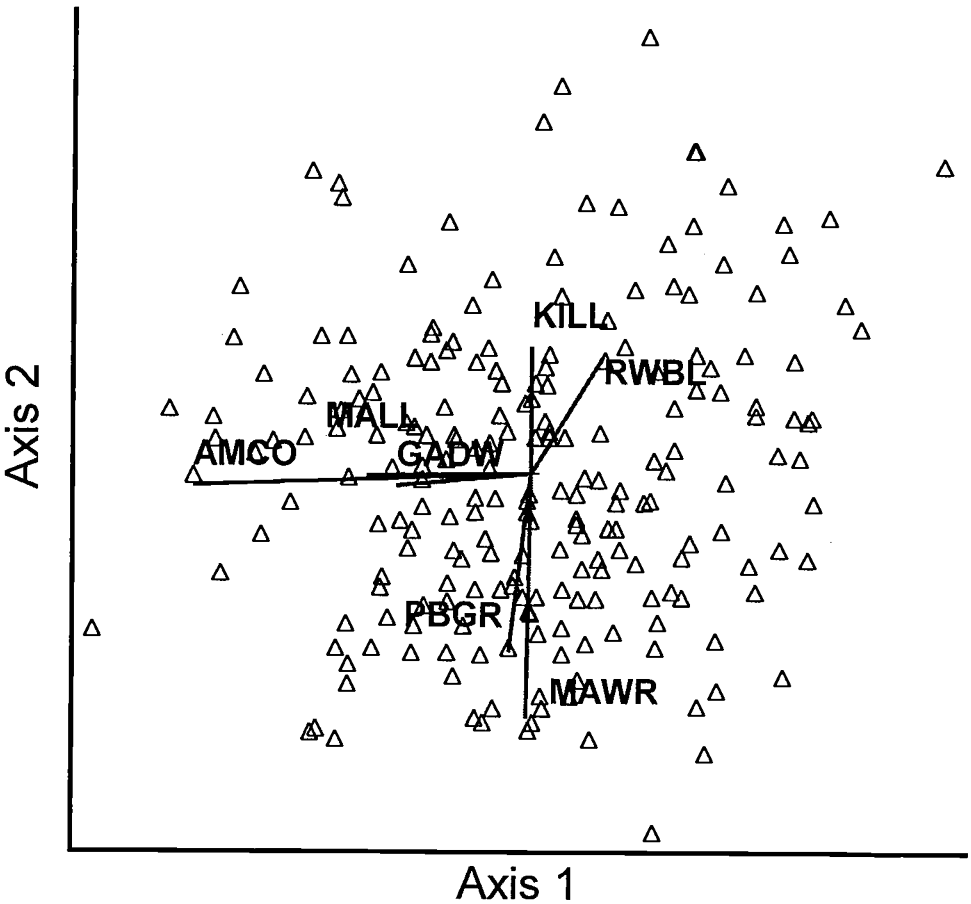

Figure 2. Three-dimensional Nonmetric Multidimesional Scaling ordination for species abundance data projected onto Axes 1 and 2. The joint plot shows species vectors that have significant correlations ($r^2 \geq 0.2$) with species abundance. The two axes explain 55% of the cumulative variation present in the data, Axis 1= 31% and Axis 2 = 24%. Kill = killdeer, RWBL = red-winged blackbird, MALL = mallard, GADW = gadwall, AMCO = American coot, PBGR = pied-billed grebe, MAWR = marsh wren.

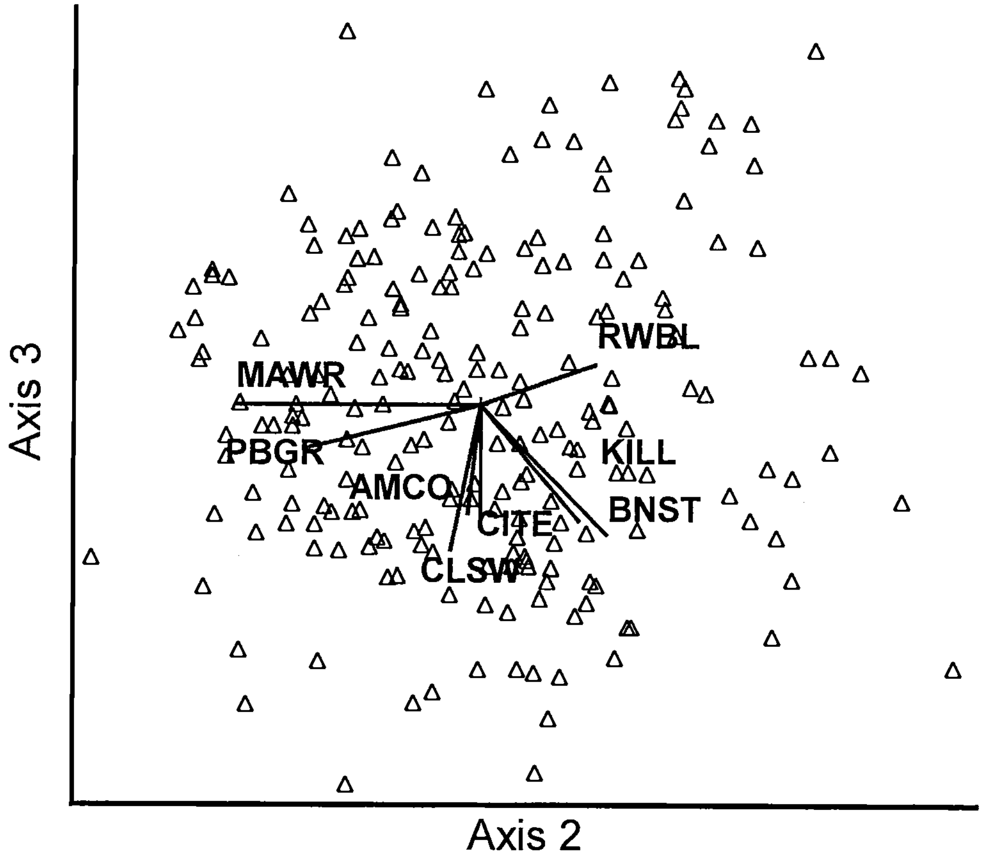

Figure 3. Three-dimensional Nonmetric Multidimesional Scaling ordination for species abundance data projected onto Axes 2 and 3. The joint plot shows vectors that have significant correlations ($r^2 \geq 0.2$) with species abundance. The two axes explain 43% of the cumulative variation present in the data, Axis 2= 24% and Axis 3 = 19%. RWBL = red-winged blackbird, MAWR = marsh wren, PBGR = pied-billed grebe, AMCO = American coot, CITE = cinnamon teal, KILL = killdeer, BNST = black-necked stilt, CLSW = cliff swallow.

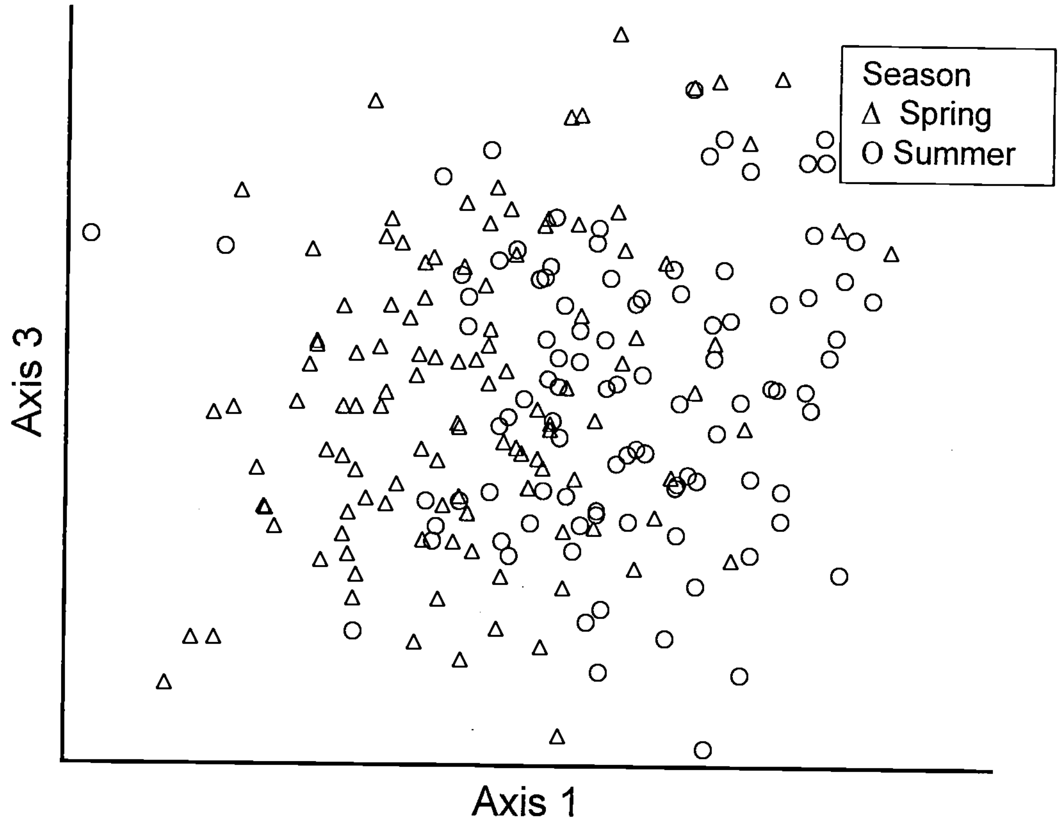

Figure 4. Three-dimensional Nonmetric Multidimesional Scaling ordination with season as an overlay. Ordination is based on species abundance data projected onto Axes 1 and 3. The two axes explain 50% of the cumulative variation present in the data, Axis 1 = 31% and Axis 3 = 19%.

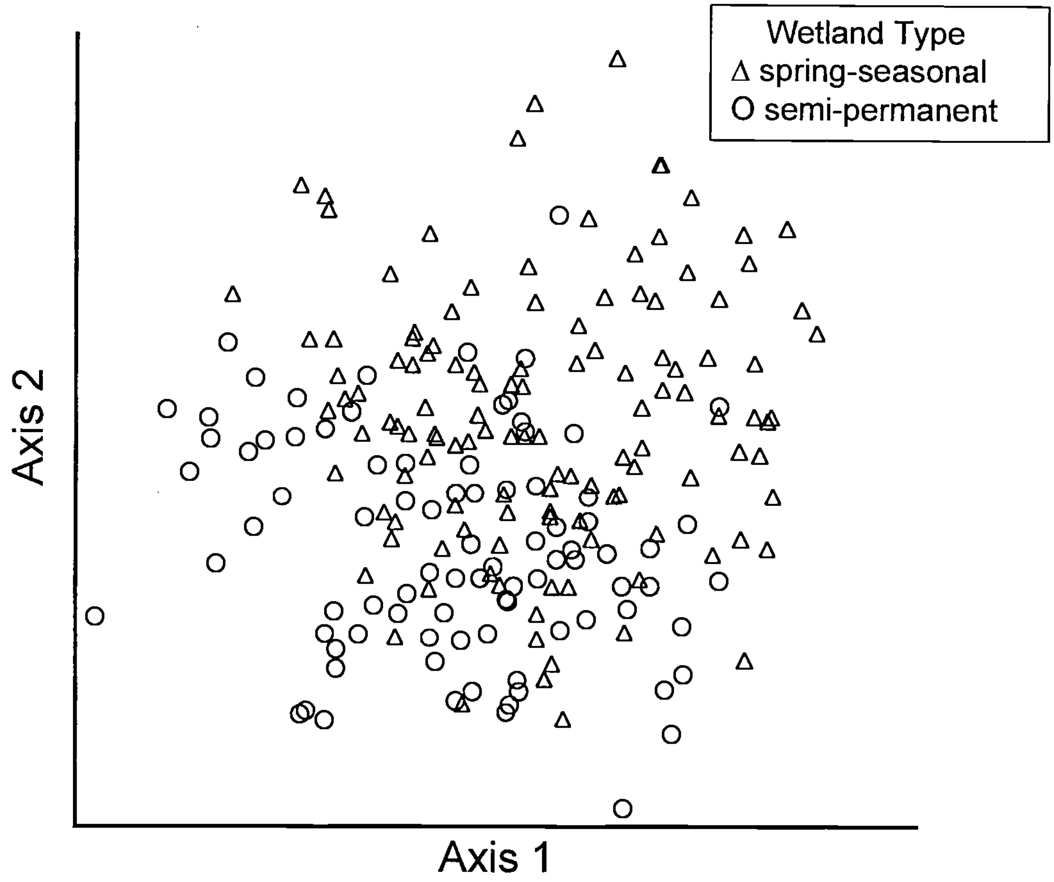

Figure 5. Three-dimensional Nonmetric Multidimesional Scaling ordination with wetland type as an overlay. Ordination is based on species abundance data projected onto Axes 1 and 2. The two axes explain 55% of the cumulative variation present in the data, Axis 1 = 31% and Axis 2 = 24%.

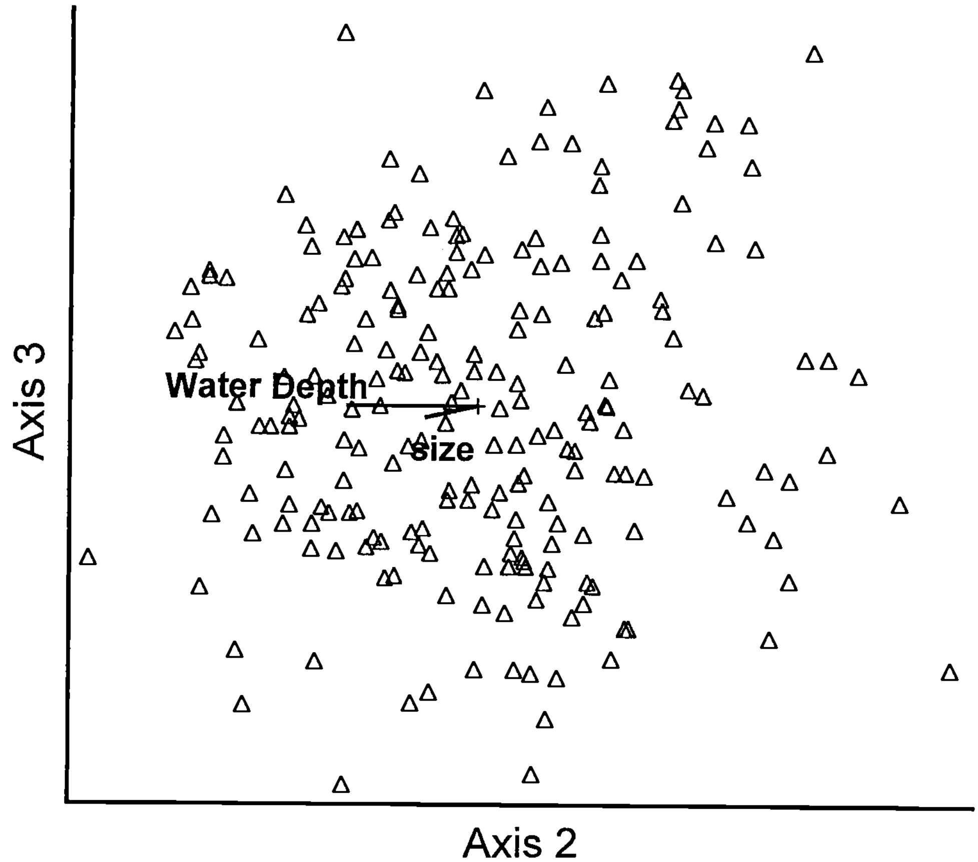

Figure 6. Three-dimensional Nonmetric Multidimesional Scaling ordination for species abundance data projected onto Axes 2 and 3. The joint plot shows vectors that have significant correlations ($r^2 \geq 0.1$) with species abundance. The two axes explain 43% of the cumulative variation present in the data, Axis 2 = 24% and Axis 3 = 19%.

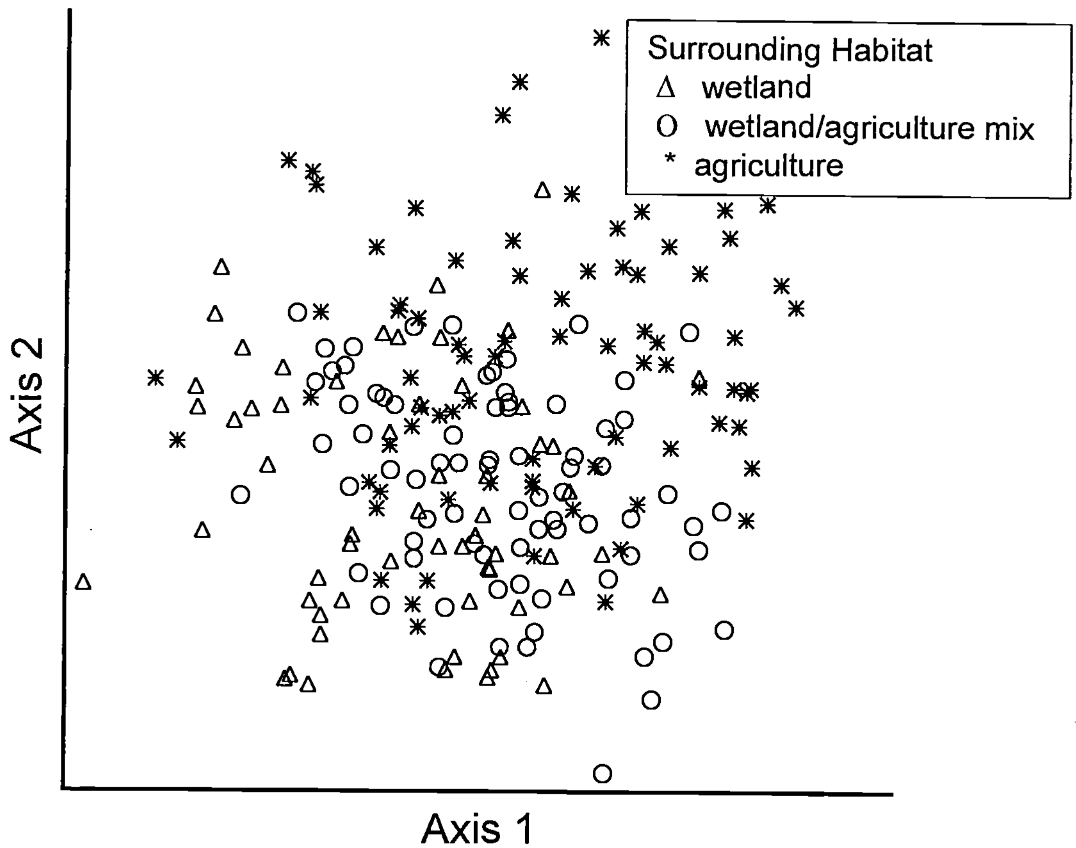

Figure 7. Three-dimensional Nonmetric Multidimesional Scaling ordination with surrounding habitat as an overlay. Ordination is based on species abundance data projected onto Axes 1 and 2. The two axes explain 55% of the cumulative variation present in the data, Axis 1 = 31% and Axis 2 = 24%.

ordination described 84% of the cumulative variation present in the data: Axis 1 = 43.5% and Axis 2 = 40.5%. Wetland obligate birds had strong negative correlations with both axes 1 and 2 (Table 8). Axis 1 illustrated (Figure 8) a significantly strong negative association with wetland obligate birds (r = -0.63) and a strong positive association with wetland associated birds (r = 0.78). Axis 2 (Figure 8) had a significantly strong negative association with wetland obligate birds (r = -0.79) and a strong positive association with nonwetland birds (r = 0.55). Overlays with environmental variables illustrated that Axis 1 is patterned with wetland type (Figure 9). Axis 2 (Figure 8) was correlated with water depth (r^2 = 0.05) but the correlation was not biologically significant. Season was patterned on both axes 1 and 2 on a diagonal plane (Figure 10). None of the other 9 environmental variables demonstrated strong patterning on the ordination. Similarly, MRPP revealed that groups within the wetland dependency assemblage differed for wetland type (A = 0.051, p = .0000), season (A = 0.045, p = .0000), and water depth (A = 0.060, p = .0600) but also indicated that the groups differed according to wetland size (A = 0.094, p = .0000).

For the taxonomic assemblage, I selected a 3-dimensional ordination plot after a thorough examination of a Scree Plot and stability criterion. Final stress for the solution was 15.5 and instability was 0.00009. The three axes explained 85.5% of the cumulative variation present in the data: Axis 1 = 23%, Axis 2 = 40%, and Axis 3 = 22.5%. Axis 1 (Figures 11 and 12) had a significant strong negative correlation (Table 9) with shorebirds (r = -0.90). Axis 2 (Figure 11) had significantly strong positive associations with waterfowl (r = 0.66), wading birds (r = 0.72) and water birds (r = 0.65). Axis 3 (Figure 12) had significantly strong negative correlations with both waterfowl (r = -0.60)

Table 8. Results of Nonmetric Multidimensional Scaling on abundance data for the wetland dependency assemblage. Correlation's (Pearson's *r*) are given for each axis. Significant correlations were defined by an $r^2 \geq 0.2$.

	Axis 1		**Axis 2**	
	r	**r^2**	**r**	**r^2**
Wetland Obligate Birds	-0.63	0.39	-0.79	0.63
Wetland Associated Birds	0.78	0.61	-0.21	0.04
Nonwetland Birds	0.12	0.01	0.55	0.30

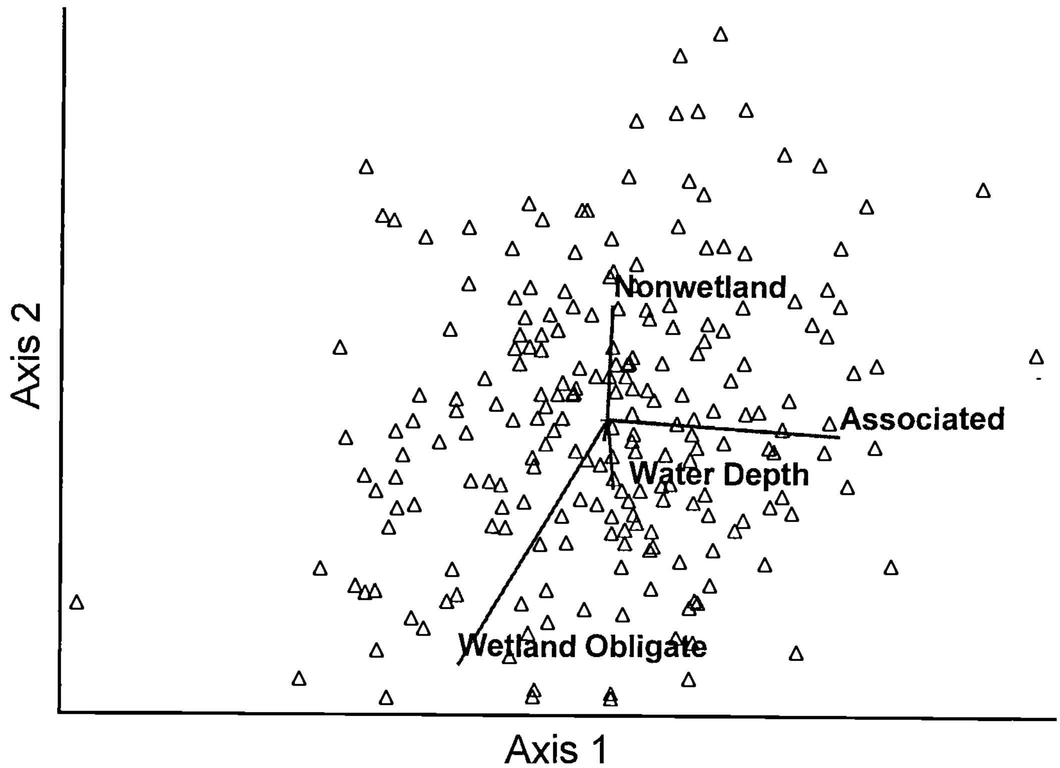

Figure 8. Two dimensional Nonmetric Multidimesional Scaling ordination for the wetland dependency assemblage data projected onto Axes 1 and 2. The joint plot shows vectors that have significant correlations ($r^2 \geq 0.1$ for quantitative environmental variables and $r^2 \geq 0.2$ for assemblage variables) with the wetland dependency assemblage. The two axes explain 84% of the cumulative variation present in the data, Axis 1 = 43.5% and Axis 2 = 40.5%.

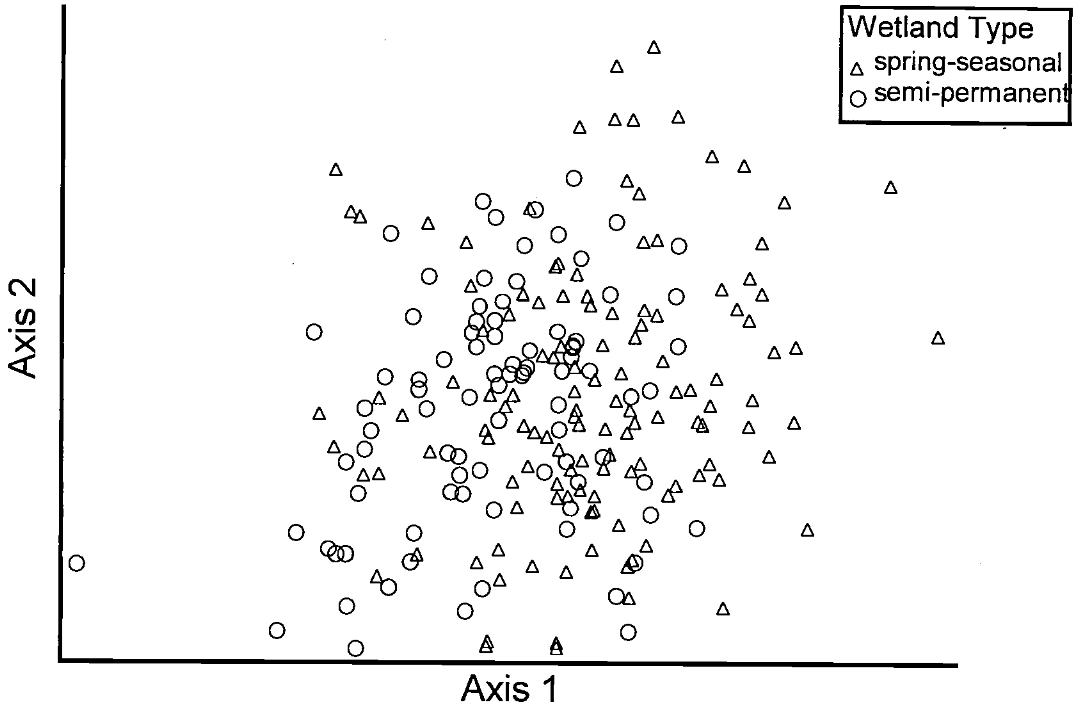

Figure 9. Two-dimensional Nonmetric Multidimesional Scaling ordination with wetland type as an overlay. Ordination is based on abundance data for the wetland dependency assemblage projected onto Axes 1 and 2. The two axes explain 84% of the cumulative variation present in the data, Axis 1 = 43.5% and Axis 2 = 40.5%.

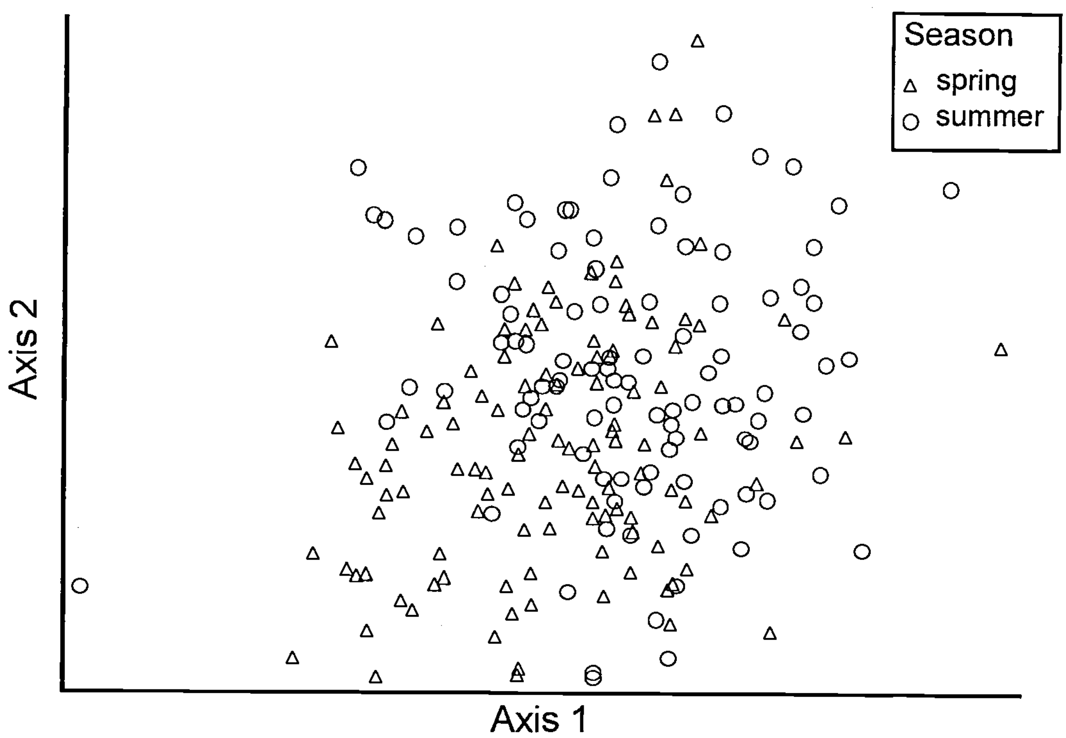

Figure 10. Two-dimensional Nonmetric Multidimesional Scaling ordination with season as an overlay. Ordination is based on abundance data for the wetland dependency assemblage projected onto Axes 1 and 2. The two axes explain 84% of the cumulative variation present in the data, Axis 1 = 43.5% and Axis 2 = 40.5%.

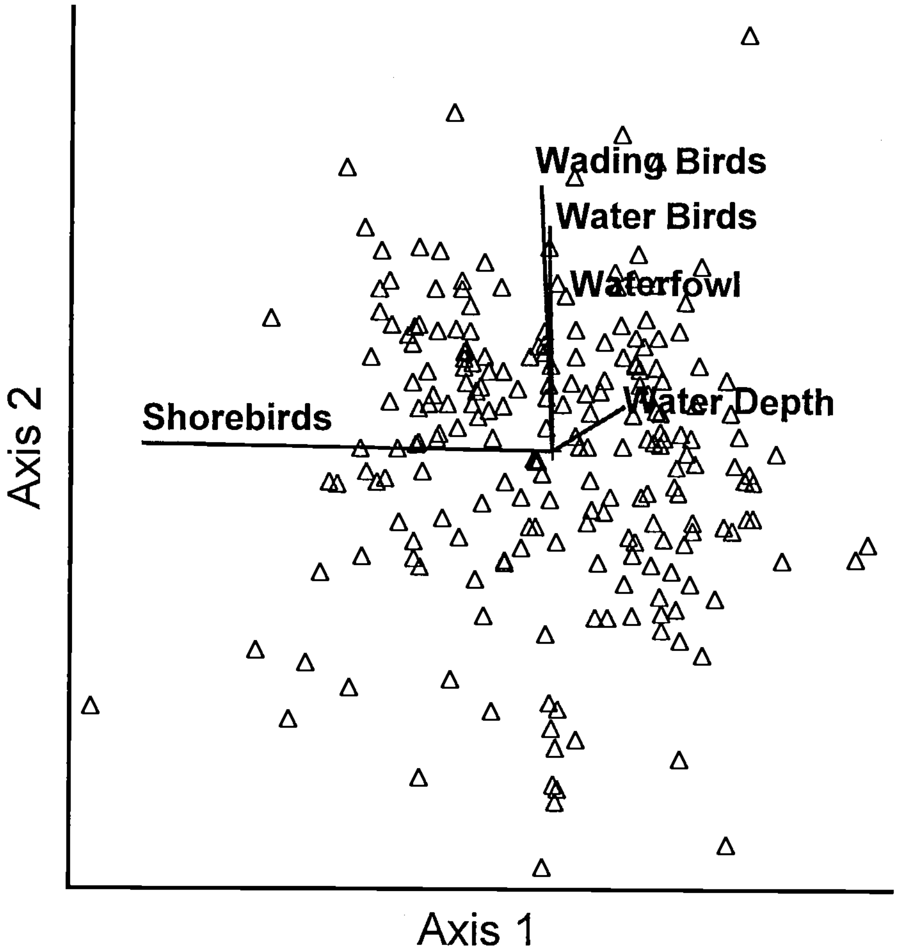

Figure 11. Three-dimensional Nonmetric Multidimesional Scaling ordination for the taxonomic assemblage data projected onto Axes 1 and 2. The joint plot shows vectors that have significant correlations ($r^2 \geq 0.1$ for quantitative environmental variables and $r^2 \geq 0.2$ for assemblage variables) with the taxonomic assemblage. The two axes explain 63% of the cumulative variation present in the data, Axis 1 = 23% and Axis 2 = 40%.

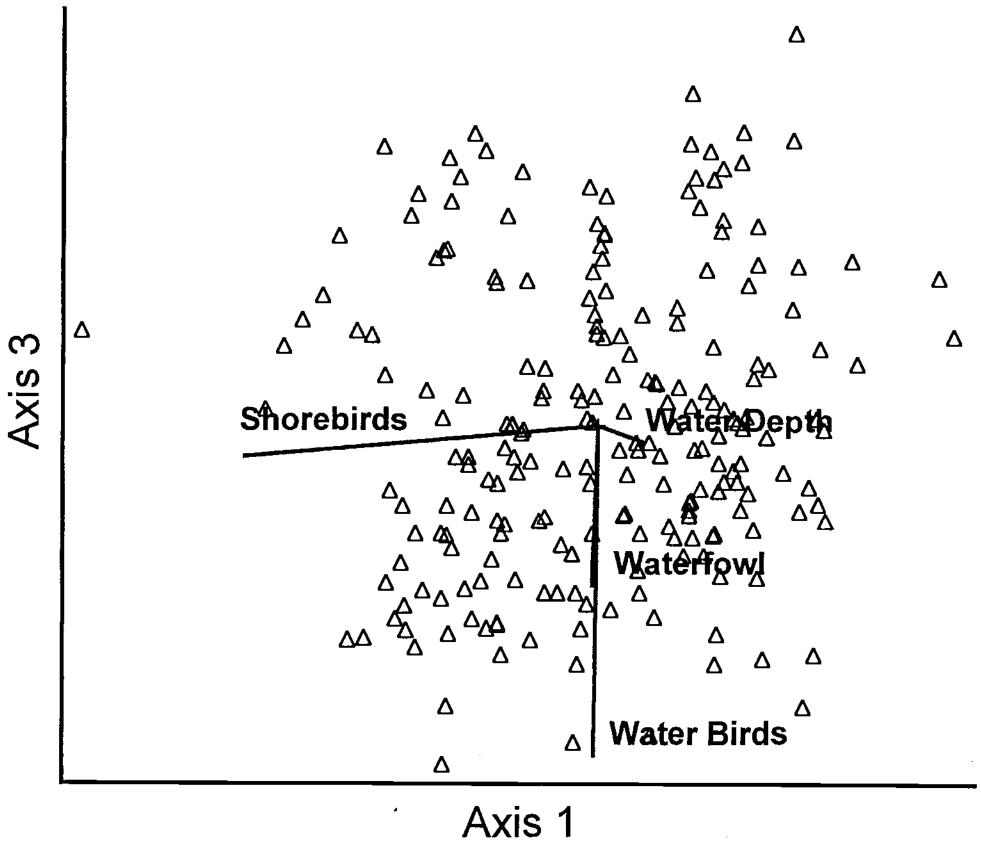

Figure 12. Three-dimensional Nonmetric Multidimesional Scaling ordination for the taxonomic assemblage data projected onto Axes 1 and 3. The joint plot shows vectors that have significant correlations ($r^2 \geq 0.1$ for quantitative environmental variables and $r^2 \geq 0.2$ for assemblage variables) with the taxonomic assemblage. The two axes explain 45.5% of the cumulative variation present in the data, Axis 1 = 23% and Axis 3 = 22.5%.

Table 9. Results of Nonmetric Multidimensional Scaling on the taxonomic assemblage data. Correlation's (Pearson's *r*) are given for each axis. Significant correlations are defined by an $r^2 \geq 0.2$.

	Axis 1		Axis 2		Axis 3	
	r	$\mathbf{r^2}$	**r**	$\mathbf{r^2}$	**r**	$\mathbf{r^2}$
Waterfowl	-0.11	0.01	0.66	0.44	-0.60	0.37
Wading birds	-0.16	0.03	0.72	0.51	0.12	0.02
Water birds	-0.10	0.01	0.65	0.42	-0.86	0.75
Shorebirds	-0.90	0.81	0.13	0.02	-0.27	0.07
Raptors	-0.05	0.00	-0.02	0.00	-0.09	0.01
Passerines	-0.02	0.00	-0.24	0.06	0.23	0.06
Others	-0.04	0.00	-0.19	0.04	0.08	0.01

and water birds (r = -0.86). Raptors, passerines and other bird groups did not have strong correlations with any of the axes (Table 9). Overlays of the 12 environmental variables manifested patterns with wetland type, season and surrounding habitat. The taxonomic assemblage had a significant correlation with water depth ($r^2 = 0.11$) on Axis 1 (Figures 11 and 12). Surrounding habitat was illustrated on Axis 2 (Figure 13). Patterning was distinct for the agricultural surroundings but was weaker for the wetland and wetland/agricultural mix (Figure 13). Axis 3 was patterned with wetland type (Figure 14) and season (Figure 15). MRPP confirmed that the bird communities under the taxonomic assemblage differed for wetland type (A = 0.043, p = .0000), wetland size (A = 0.109, p = .0000), water depth (A = 0.068, p = .0024), season (A = 0.067, p = .0000), and surrounding habitat (A = 0.079, p = .0000).

According to the MRPP for the wetland dependency and taxonomic assemblages, there was a difference in the average within group rank of distances for three habitat components: trees, open water, and short emergent vegetation, on the 21 restored wetlands (Table 10). The remaining habitat components, tall emergents and mudflats, were not significant variables (Table 10) in dictating differences between bird communities for the two species assemblages on restored wetlands in the Sacramento Valley.

Indicator species analysis (Table 11) revealed that wetland obligate (IV = 52.3) and nonwetland (IV = 57.6) birds were significantly more abundant on wetlands where trees were present than on wetlands with no trees. Indicator Species Analysis did not reveal any significant relationships between trees and the taxonomic assemblage (Table 12).

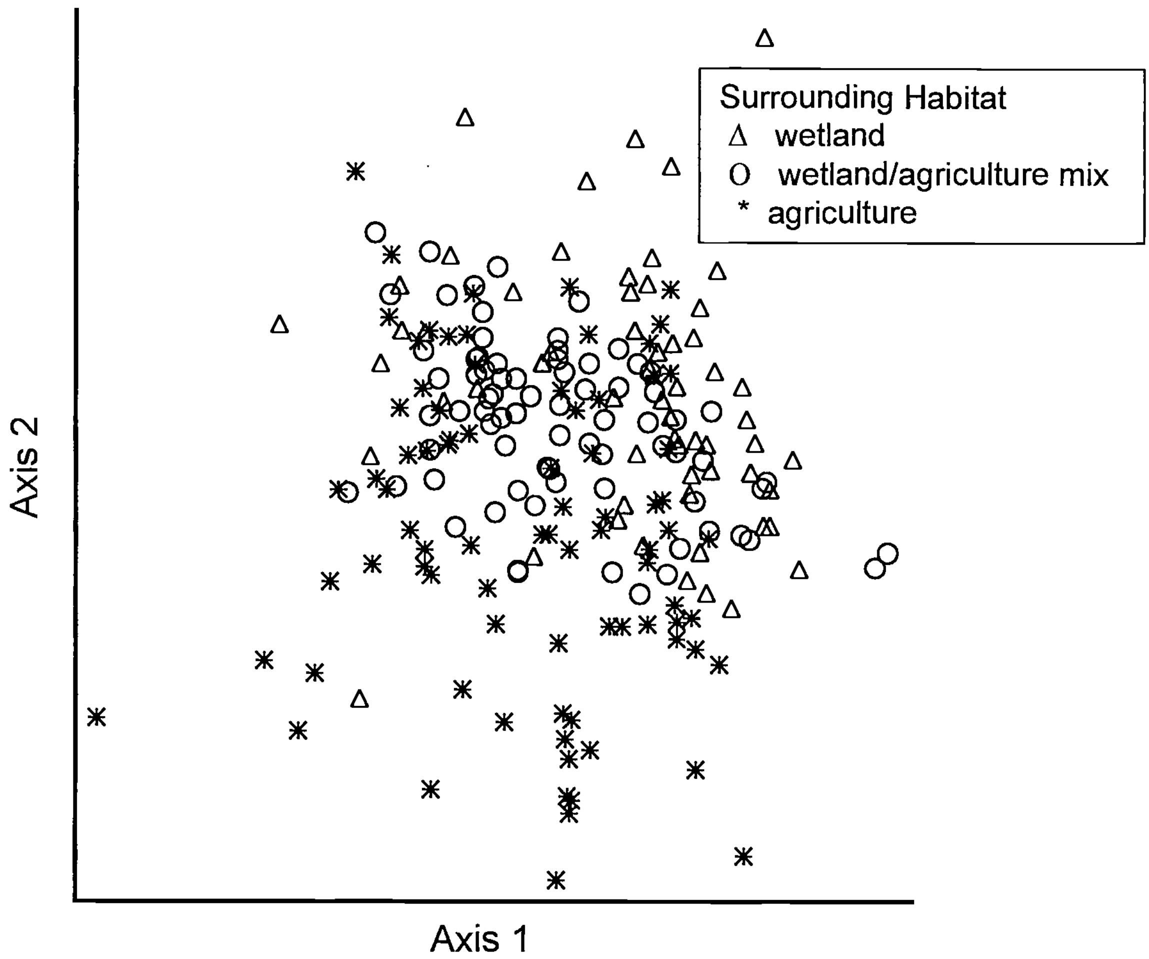

Figure 13. Three-dimensional Nonmetric Multidimesional Scaling ordination with surrounding habitat as an overlay. Ordination is based on abundance data for the taxonomic assemblage projected onto Axes 1 and 2. The two axes explain 63% of the cumulative variation present in the data, Axis 1 = 23% and Axis 2 = 40%.

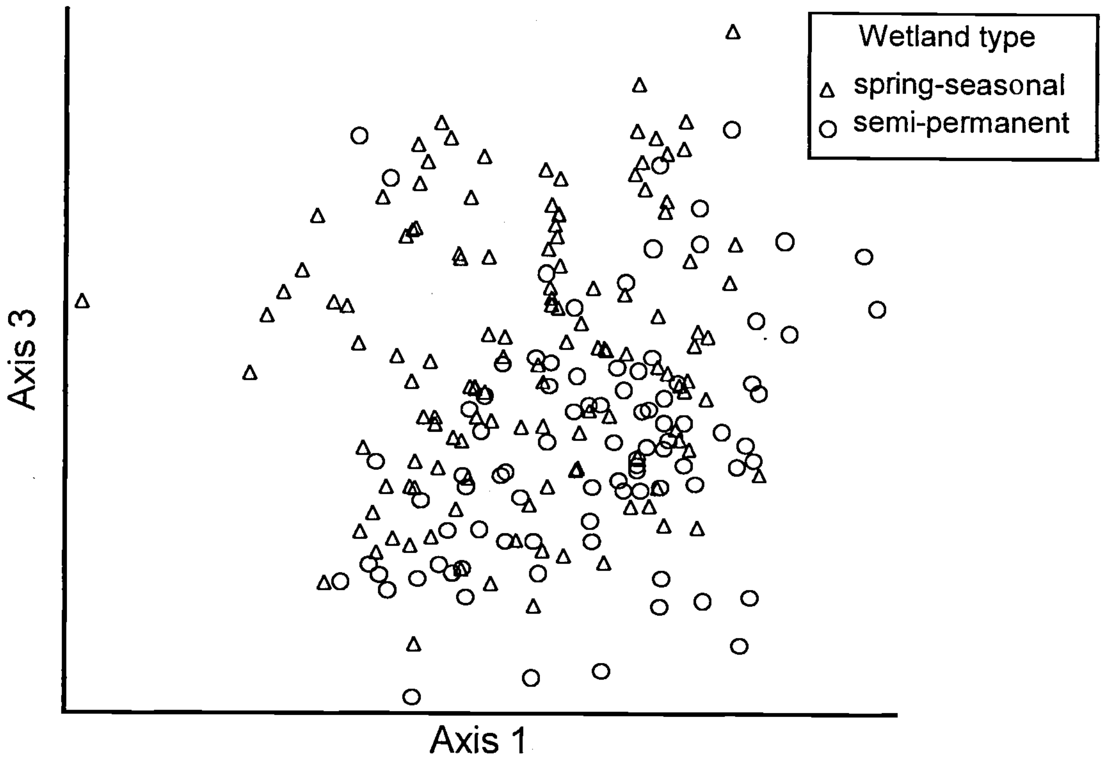

Figure 14. Three-dimensional Nonmetric Multidimesional Scaling ordination with wetland type as an overlay. Ordination is based on abundance data for the taxonomic assemblage projected onto Axes 1 and 3. The two axes explain 45.5% of the cumulative variation present in the data, Axis 1 = 23% and Axis 3 = 22.5%.

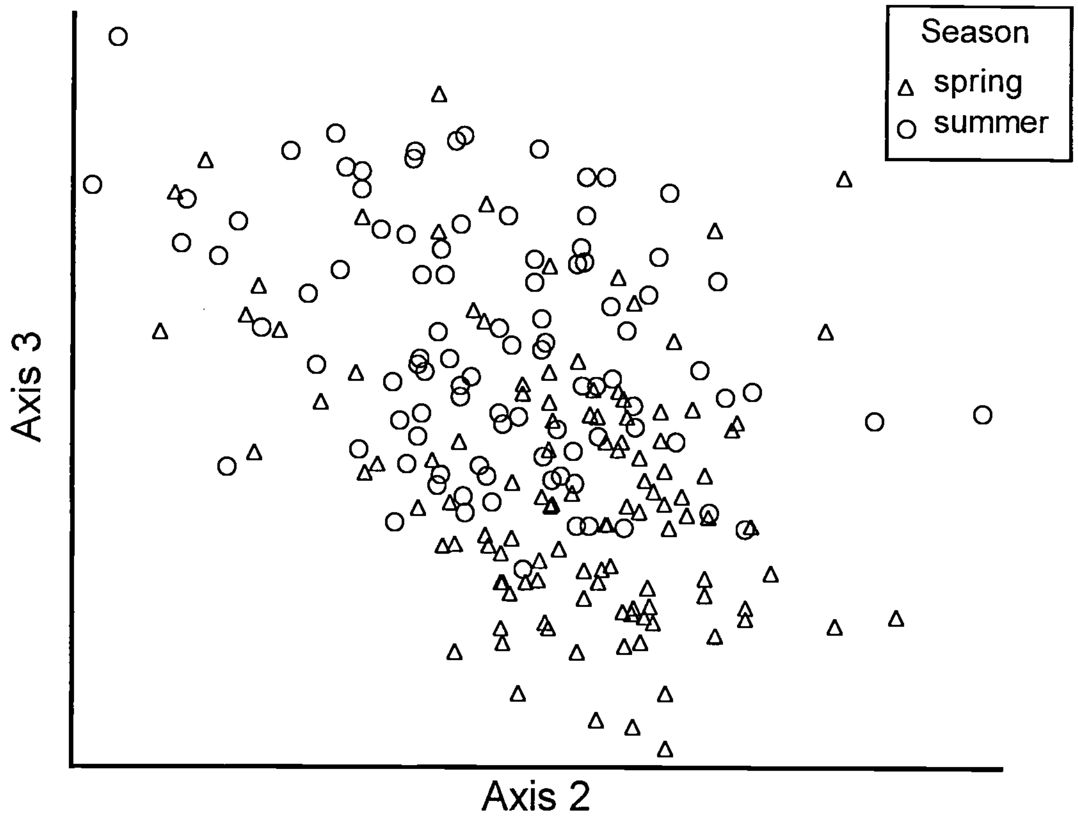

Figure 15. Three-dimensional Nonmetric Multidimesional Scaling ordination with season as an overlay. Ordination is based on abundance data for the taxonomic assemblage projected onto Axes 2 and 3. The two axes explain 62.5% of the cumulative variation present in the data, Axis 2 = 40% and Axis 3 = 22.5%.

Table 10. Multi-response permutation procedure (MRPP) results for the wetland dependency and taxonomic assemblages in the Sacramento Valley, California, 1998-1999 for measured environmental variables. The chance corrected within group agreement (A) is a description of the effect size independent of the sample size. If all sample units within groups are identical A = 1, and A = 0 when heterogeneity within groups equals expectation by chance. In community ecology values for A are commonly below 0.1.

Wetland Dependency Assemblage

Environmental variables	A	p-value
Trees	0.06	0.00
Mudflat	0.01	0.10
Open water	0.04	0.00
Tall emergent	0.02	0.14
Short emergent	0.04	0.01

Taxonomic Assemblage

Environmental variables	A	p-value
Trees	0.04	0.00
Mudflat	0.01	0.13
Open water	0.05	0.01
Tall emergent	0.01	0.60
Short emergent	0.04	0.00

Table 11. Indicator Value Scores from Indicator Species Analysis for the wetland dependency assemblage using the three significant habitat components as determined by MRPP. Monte Carlo test of significance of observed maximum indicator value for species with 10,000 permutations give the significance of the indicator value.

	Open Water	**Short Emergent**	**Trees**
Wetland Obligate	56.8 (p = .0001)	56.0 (p = .0001)	52.3 (p = .0125)
Wetland Associated	50.6 (p = .4743)	50.9 (p = .3498)	50.9 (p = .2632)
Nonwetland	53.9 (p = .0057)	53.6 (p = .0128)	57.6 (p = .0001)

Table 12. Indicator Value Scores from Indicator Species Analysis for the taxonomic assemblage using the three significant habitat components as determined by MRPP. Monte Carlo test of significance of observed maximum indicator value for species with 10,000 permutations give the significance of the indicator value.

	Open Water	**Short Emergent**	**Trees**
Waterfowl	57.0 (p = .0001)	55.8 (p = .0002)	49.8 (p = .7325)
Water Birds	57.8 (p = .0001)	58.2 (p = .0001)	50.5 (p = .1310)
Wading Birds	45.5 (p = .0950)	44.5 (p = .1827)	42.6 (p = .2365)
Shorebirds	43.6 (p = .0275)	41.4 (p = .0950)	33.8 (p = .7941)
Raptors	26.5 (p = .3739)	25.1 (p = .5825)	28.0 (p = .1498)
Passerines	51.3 (p = .0921)	51.3 (p = .1101)	50.9 (p = .1582)
Others	42.8 (p = .0469)	41.1 (p = .1095)	38.8 (p = .1428)

Indicator species analysis (Table 11) indicated that wetland obligate birds were most abundant in wetlands that maintained open water (IV = 56.8) and nonwetland birds were associated with wetlands that did not maintain large areas of open water (IV = 53.9). Indicator Species Analysis (Table 12) revealed that waterfowl (IV = 57.0), water birds (IV = 57.8) and shorebirds (IV = 43.6) were also associated with open water areas. Passerines, raptors and others were not associated with open water.

Wetland obligate species (IV = 56.0) (Table 11) were associated with the absence of short emergent vegetation. Nonwetland birds (IV = 53.6) were associated with the presence of short emergent vegetation. Indicator species analysis (Table 12) indicated that both waterfowl (IV = 55.8) and water birds (IV = 58.2) were observed more frequently in wetlands that were not dominated by short emergent vegetation.

Mallards are the target species for CDFG's Brood Pond Program. Indeed, mallard was among the most common and abundant species using both spring-seasonal and semi-permanent wetlands. The mean number of mallards seen using semi-permanent wetlands ($\bar{x}$ = 322.4, SE ± 14.1) was much greater than the mean number seen using spring-seasonal wetlands ($\bar{x}$ = 163.3, SE ± 6.2).

Discussion

Birds are popular targets with ecologists investigating natural communities because birds generally are diurnal, conspicuous and their distribution and natural history are fairly well known (Wiens 1992). Studying birds helps when measuring the quality of the environment (Garrett 1996). For these reasons, bird communities were studied as a basis to compare the similarities and differences between spring-seasonal and semi-permanent wetlands.

Spring-seasonal and semi-permanent wetlands in the Sacramento Valley attract diverse bird communities. This is evidenced by the large number of species I observed in both types of wetlands. Bird communities were affected by wetland type, wetland size, water depth, season, and surrounding habitat. Trees, open water and short emergent vegetation played subtle but important roles in attracting a variety of species to restored wetlands, ultimately affecting the community composition of those wetlands.

Species richness was greater on semi-permanent wetlands than on spring-seasonal wetlands even though five additional spring-seasonal wetlands were surveyed. Overall richness was high for both spring-seasonal and semi-permanent wetlands. Several species were found only on spring-seasonal or only on semi-permanent wetlands. For some of these species only one individual was detected during the field season, whereas, a few of the species unique to one wetland type were seen regularly. Wilson's phalarope, golden eagle, willow flycatcher and lesser goldfinch were species seen only once during a field season. These species are either not typically found in wetland habitats (i.e. golden eagle) or only use Sacramento Valley wetlands as migration routes (i.e. willow flycatcher and Wilson's phalarope). The occurrence of these species in my study wetlands was unusual and served only to increase the species richness of a specific wetland. Black-headed grosbeak, bushtit, and western wood-peewee were species seen only on semi-permanent wetlands but on numerous occasions. These species are typically associated with hardwood forests and/or riparian areas and were potentially attracted to specific semi-permanent wetlands that maintained a variety of tree species or were associated with a larger wetland complex.

Even with high species richness for both wetland types a few species represented the majority of the birds observed. The distribution of occurrences was skewed toward four species: mallard, red-winged blackbird, American coot and cliff swallow. The mallard is the most common waterfowl species in the Sacramento Valley and can be found exploiting a variety of habitats that include marshes, lakes, ponds and irrigation ditches (Engilis 1995). Cliff swallows are colony nesters that have found human made structures provide suitable nest sites to the exclusion, in some areas, of natural nesting sites. Human made structures that provide a substrate for nesting, such as water culverts and bridges, in close proximity to restored wetlands serve as catalysts by attracting large numbers of cliff swallows to forage in the wetlands. American coots are gregarious members of the rail family that are adapted to feeding in wetlands and sometimes grazing in meadows and fields. Restored wetlands that are associated with bird-friendly crops, such as rice, sorghum, and corn, will attract American coots and other species that can exploit a range of habitat types. Red-winged blackbirds are a polygamous species believed by some ornithologists to be the most numerous native land bird in North America. They live in marshes, sloughs, ponds, lakes, streams, upland fields, and orchards (Terres 1996) so it is no surprise to see them in such high abundance on spring-seasonal and semi-permanent wetlands. Each of these species is considered a generalist; possessing habits that are varied or unspecialized, allowing them to exploit a great variety of food sources and habitats. Some of the study wetlands were newly restored, providing marginal cover and food resources but were still exploited in some degree by all four of these species. Five additional species seen on 95% of the study wetlands were American bittern, cinnamon teal, killdeer, ring-necked pheasant and tree swallow. These species are commonly found breeding throughout Sacramento Valley wetlands in late spring and early summer. Their presence on spring-seasonal and semi-permanent wetlands, therefore, was expected.

The total number of birds was greater on spring-seasonal wetlands than on semi-permanent wetlands, however, if red-winged blackbird counts are removed from the data the difference in the total number of birds seen on both types of wetlands is negligible. The total count of red-winged blackbirds on spring-seasonal wetlands was more than three times greater than the total count on semi-permanent wetlands. Four spring-seasonal wetlands had very high densities of red-winged blackbirds. Each of these wetlands was characterized by shallow water depths and two years growth of cattails and Baltic rush making them particularly attractive to red-winged blackbirds. Red-winged blackbirds form huge flocks that migrate by day, foraging for grain and seeds in fields with other species of blackbirds, and roost at night in dense cover in wetland habitats. They have been known to cause damage to crops such as corn, sunflowers, and rice, as they switch from a spring diet of mostly insects to a diet of seeds in the summer. Two semi-permanent wetlands had greater densities of red-winged blackbirds than the other six semi-permanent wetlands. These two wetlands had extensive stands of cattail and maintained shallow water depths, whereas, the other six wetlands contained small patches of managed cattail and deeper water.

A number of measured environmental variables were associated with bird communities through NMS ordination and confirmed with MRPP. Wetland type, wetland size, water depth, season and surrounding habitat all illustrated strong patterning in one or more of the ordinations for species abundance data, the wetland dependency assemblage and the taxonomic assemblage.

Overlays on the ordination for species abundance showed patterning for wetland type, season and surrounding habitat. Wetland size was not significantly correlated with the ordination; however, through MRPP I found that species abundances differed significantly according to size. Axis 1 manifested a seasonal gradient moving from spring into summer. American coot, gadwall, and mallard were all associated with spring. These species are winter residents of Sacramento Valley wetlands with the majority of the population moving to more northern latitudes to breed in late spring so it was expected that abundance of these species would be greater in spring than in late summer.

Wetland type was patterned on Axis 2 and water depth was significantly correlated with Axis 2. Shallow water depths were associated with spring-seasonal wetlands on the ordination and were positively correlated with two species of birds: killdeer and red-winged blackbird. Marsh wren and pied-pilled grebe were both negatively correlated with Axis 2. Their patterning on the ordination was associated with semi-permanent wetlands, deep water and large wetland size. Pied-billed grebes eat aquatic insects and small fish. They are adapted to water where they dive and swim for their prey so it is imperative that wetlands provide water deep enough to sustain these diving birds. Managers of spring-seasonal wetlands were required to maintain water depths between 10 and 30 cm. Water depths averaged > 30 cm for three of the spring-seasonal wetlands. The remaining wetlands fell within the required depth except for Turkey Tract, which was below the required depth. Water depths below 15 cm proved ideal for attracting shorebirds such as killdeer and a few species of songbirds such as red-winged blackbird that are affiliated with wetlands.

Surrounding habitat displayed a gradual transitioning pattern near the midpoint of Axes 1 and 2. Agriculture was almost completely separate from wetland on the NMS ordination while the wetland/agriculture mix fell directly in between the two extremes. The abundance of marsh wren and pied-billed grebe were correlated with wetland as the surrounding habitat. These species are entirely dependent on wetlands for breeding and feeding and do not have documented associations with agricultural areas. In Iowa, Brown and Dinsmore (1986) found that species richness of marsh dwelling birds was greater in wetland complexes than in larger isolated marshes. This is the likely explanation for why the abundance of pied-billed grebe and marsh wren was correlated with restored wetlands that were surrounded by other wetlands. Red-winged blackbird and killdeer were associated with agriculture as the surrounding habitat. These species are affiliated with both wetland and upland habitats, especially some types of agriculture. Their opportunistic use of specific restored wetlands was probably in conjunction with the agriculture surrounding the wetland.

Axis 3 did not show distinct patterning with any of the environmental variables. Negative correlations with American coot, black-necked stilt, cinnamon teal, cliff swallow, and killdeer suggests that Axis 3 might be correlated with some type of food source or behavior that was not measured as part of this study.

The environmental variables that were patterned on the wetland dependency assemblage ordination included wetland type and season. Axis 1 was patterned with wetland type. Wetland obligate birds were associated with semi-permanent wetlands and wetland associated birds were associated with spring-seasonal wetlands. Semi-permanent wetlands supported a greater number of wetland obligate and nonwetland species than spring-seasonal wetlands. Wetland obligate species included all species of waterfowl, rails, and most species of shorebirds and wading birds. Any number of factors from wetland size, water depth, cover, and invertebrate density could play important roles in why the abundance of wetland obligate birds was greater on semi-permanent than on spring-seasonal wetlands. Since semi-permanent wetlands are much older than spring-seasonal wetlands, site fidelity might also contribute as a factor. Most species of waterfowl (Anderson et al. 1992) and many other species of birds exhibit site fidelity to breeding areas.

Spring-seasonal wetlands supported a greater number of wetland associated species than semi-permanent wetlands. Red-winged blackbirds had an effect over this group of birds. Spring-seasonal wetlands had large densities of red-winged blackbirds assuring that its shear numbers would influence any assemblage containing this species. Shallow water depth and the presence of mudflats, requirements for foraging shorebirds, on spring-seasonal wetlands attracted killdeer and black-bellied plover in greater numbers than did semi-permanent wetlands.

Water depth was correlated with Axis 2 but the correlation was not significant. MRPP, however, revealed that groups within the wetland dependency assemblage did differ significantly according to water depth and wetland size. In the wetland dependency assemblage ordination, wetland obligate birds were associated with deeper water depths, larger wetland size and open water areas. Semi-permanent wetlands are required to maintain water depths from 30 to 60 cm, but most maintained water depths of 10 – 30 cm, similar to water depths of spring-seasonal wetlands. These water depths along with an abundance of short emergents and submerged vegetation made the semi-permanent wetlands very attractive to birds in the wetland obligate group such as American coots, common moorhen and a number of species of breeding waterfowl that included mallard, gadwall, cinnamon teal and wood duck (*Aix sponsa*). During the breeding season, waterfowl favor water depths under 25 cm, due to the small size and buoyancy of downy ducklings, which restricts them to a narrow feeding zone close to the water surface (Sugden 1973). Kantrud and Stewart (1977) found the most important ecological factor in the distribution and density of waterfowl among different types of wetlands was water permanence or the length of time water was maintained in the wetland, and water depth. Most species in the wetland obligate group prefer and/or require open water for foraging. Wetlands with dense, monotypic stands of cattail and/or bulrush will have a decrease in use by wetland obligate species (Weller and Spatcher 1965; Weller and Fredrickson 1973). Although spring-seasonal wetlands are dry from September through March, the brief flood-up for the breeding season produces rapid growth of many wetland plants, especially cattail, which do very well in shallow water.

Within a few weeks wetlands can be completely filled with stands of cattails leaving no pockets of open water for foraging waterfowl and other wetland obligate species.

The wetland obligate group consists of birds that nest in the Sacramento Valley and birds that winter in the Sacramento Valley but move north in spring to breed in more northerly latitudes. A seasonal gradient, on a diagonal plane, was patterned on both Axis 1 and 2. Wetland obligate birds were associated with spring and nonwetland birds were associated with summer. The nonwetland bird group was comprised of mostly neotropical migratory songbirds such as western kingbird (*Tyrannus verticalis*), American goldfinch (*Carduelis tristis*), and blue grosbeak (*Guiraca caerulea*) that were associated with summer. These neotropical migrants arrive in late-April to breed in the Sacramento Valley while wintering birds are migrating north to breed. This shift in the composition of bird communities using semi-permanent and spring-seasonal wetlands from spring to summer can be attributed to migration. Winter residents migrated north to breed and were replaced by species that nest in the Valley.

Trees were one of the most important factors affecting bird communities in the wetland dependency assemblage. Wetland obligate and nonwetland birds were more abundant on wetlands that contained trees within or around the perimeter of the wetland. Most species in the nonwetland group were passerines and raptors, many of which depended on trees for a place to roost, nest, and feed. Trees also provided thermal cover important during periods of inclement weather and seclusion for breeding pairs of birds (Fredrickson and Laubhan 1996). Trees were present on 88% of the semi-permanent wetlands in this study but only present on 45% of the spring-seasonal wetlands. Not surprisingly, the mean number of nonwetland species observed on semi-permanent wetlands was greater than the mean number observed on spring-seasonal wetlands. In addition, species richness of nonwetland species was greater on semi-permanent wetlands. Although a causal relationship cannot be drawn from the data it is apparent that without the presence of trees, spring-seasonal wetlands would not attract a great diversity of nonwetland species. Some of the nonwetland species seen on the study wetlands that require trees include Nuttall's woodpecker (*Picoides nuttallii*), Northern flicker (*Colaptes auratus*), black-headed grosbeak, Bullock's oriole (*Icterus spurious*), oak titmouse (*Baeolophus inornatus*), willow flycatcher , yellow-rumped warbler and Western-wood peewee.

The solution for the taxonomic assemblage illustrated patterns with wetland type, season, and surrounding habitat. Although wetland size was not significantly correlated with any axis, groups within the taxonomic assemblage differed according wetland size. Axis 1 was significantly correlated with water depth and had a strong negative correlation with shorebirds. Spring-seasonal wetlands were very successful in attracting large numbers of migrating shorebirds including long-billed dowitcher, least sandpiper and western sandpiper. Two shorebirds seen exclusively on spring-seasonal wetlands were whimbrel and Wilson's phalarope. Both of these species are attracted to mudflats and shallow waters where they probe for invertebrates. Fredrickson and Reid (1986) assert that very few waterbird species (i.e. waterfowl, shorebirds, grebes, wading birds) exclusively use water deeper than 25 cm but many species utilize habitats flooded to depths less than 10 cm. Semi-permanent wetlands supported a greater mean number of waterfowl, water bird and wading bird species than spring-seasonal wetlands.

Wetland size was not a significant factor in shaping bird communities. Size showed very weak patterning and no significant correlation on the ordination. Surrounding habitat has a strong pattern on the ordination. Positive correlations for waterfowl, wading birds, and water birds were also significant. Brown and Dinsmore (1986) found that size of a wetland is an important consideration in managing marsh birds. They found species richness of marsh birds decreasing as wetland size increased. Both semi-permanent and spring-seasonal wetlands in the Sacramento Valley were of average size compared to this and another study (Brown and Smith 1998) investigating size, which allowed for a greater diversity of habitats than if the wetlands were very small. The importance of small wetlands, however, cannot be overlooked as their presence may be critical for the persistence of specific bird species by providing specialized requirements (Gibbs 1993).

The habitat directly adjacent to each wetland was categorized as wetlands, a mix of wetlands and agriculture, or strictly agriculture. Waterfowl, waders and water birds were correlated with surrounding habitat of wetland and to a lesser degree with wetland/agriculture mix. Waterfowl populations, especially ducks, are influenced by wetland characteristics such as quality, total area of the wetland complex, size and configuration of wetland complexes (Fredrickson and Reid 1988). All of the species of ducks that were recorded as breeding during this study are upland nesters.

Wetland type and season were patterned on the ordination. The strong negative correlations for waterfowl and water birds on were affiliated with semi-permanent wetlands and spring. The pattern of use for these two groups of birds changed over the field season with the majority of the species occurring in highest abundance in early spring and tapering off in late summer. A large portion of waterfowl in the Pacific Flyway winter in the Sacramento Valley. Those that winter further south use the Sacramento Valley wetlands as stopovers on their northward migration to breeding grounds. Although a strong pattern did not emerge in ordination for the five remaining taxonomic groups, the composition of bird communities for both spring-seasonal wetlands and semi-permanent wetlands changed from spring to summer. Spring-seasonal wetlands attracted a greater mean number of shorebirds and passerines than did semi-permanent wetlands. In early spring, an abundance of shorebirds and waterfowl, consisting of many different species were seen on both wetland types. In late spring, 9 of the 13 waterfowl species and all but 3 of the shorebirds (black-necked stilt, killdeer, and American avocet) migrated out of the area. These migratory species were rarely seen on any of the study wetlands. This demonstrates that both spring-seasonal and semi-permanent wetlands provide habitat for migratory species. The species richness and abundance of passerines also differed over the spring and summer season. Passerines were abundant on both wetland types during both spring and summer but the species that made up the community were different. During spring, warblers, sparrows, and other species that nest further north were seen briefly using the study wetlands during migration. In summer, species that nest in the Sacramento Valley arrived from their southern wintering grounds and replaced the early migrants that nest further north. Some of these species included western kingbird, cliff swallow, tree swallow, and blue grosbeak.

Waterfowl and water birds were associated with the presence of short emergent vegetation. The most common species of short emergent vegetation observed on the restored wetlands were baltic rush (*Juncus balticus*), creeping spikerush (*Eleocharis macrostachya*), curly dock (Rumex crispus), nutsedge (*Cyperus eragrostis*), and water primrose (*Ludwigia peploides*). These plant species supplied the bird communities with cover and forage in the form of a seed head or as a substrate for invertebrates. Waterfowl, water birds and shorebirds were associated with open water.

Mallards warrant individual mention because it is the target species for CDFG's Waterfowl Brood Pond Program. Research by Yarris (1995) on survival and habitat use of mallard ducklings in the rice-growing region of the Sacramento Valley prompted CDFG to fund the Brood Pond Program. It was found that ricefields provided exceptional mallard brood-rearing habitat when the rice plants were tall enough to conceal the birds. However, lack of available wetlands before and just after rice flooding was detrimental to early nesting mallards. Yarris's (1995) recommendation was to encourage programs that promote spring wetlands, hence the beginning of spring-seasonal wetlands. I found mallards were twice as abundant on semi-permanent wetlands than on spring-seasonal wetlands. One reason why mallards were more abundant on semi-permanent wetlands could be attributed to age of the wetland. All of the semi-permanent wetlands studied were, at a minimum, three years old. Whereas, the spring-seasonal wetlands were less than 2 years old. VanRees-Siewart and Dinsmore (1996) found the mean number of breeding birds of all species combined was significantly greater in older restored wetlands in Iowa, but, the number of breeding waterfowl species did not differ with age of the wetlands. The composition of waterfowl species, however, did change with wetland age. Many of the species that initially used restored wetlands did not use older restored wetlands. Availability of upland nesting habitat could easily be a factor contributing to lower numbers of mallards using spring-seasonal wetlands. Spring-seasonal wetlands are traditionally located among agricultural complexes in contrast to semi-permanent wetlands that were mostly located within wetland complexes. Emergent cover (Weller and Fredrickson 1973), ratio of emergent cover to open water (Weller and Spatcher 1965), water depth (Kantrud and Stewart 1977) and disturbance (Klein et al. 1995, Korschgen and Dahlgren 1992) could also be factors affecting mallard use.

The primary limitation to the sampling effort of this project was visibility. In early April visibility was nearly 100% on almost all of the wetlands. During summer, short emergent vegetation, cattails and bulrush became increasingly dense. This abundance of plant growth decreased the amount of open water but provided cover for waterfowl and water birds making it difficult for the observer to detect their presence. However, it is unlikely that the differences in bird communities on spring-seasonal and semi-permanent wetlands resulted from differences in the detectibilities of birds. The most common birds were conspicuous species and were not likely to be missed during surveys on any of the wetlands. Furthermore, secretive species such as ducks, rails, grebes and bitterns should have been more difficult to detect in the mature vegetation of semi-permanent wetlands but were sighted in greater abundance on these wetlands than on the spring-seasonal wetlands. Finally, flush counts conducted on four of the wetlands with low visibility did not yield significant differences in the number of birds flushed versus the number seen during the scans.

Management Implications

To optimize bird use of restored wetland habitat, resource managers and program leaders need reliable scientific information regarding the bird species using restored wetlands under their jurisdiction. They need to know what species occur in the wetlands and how management decisions impact those species. Long term monitoring and inventory of wildlife habitats is an essential component of natural resource management. Monitoring serves as a feedback mechanism to promote integration of conservation and development (Brenner 2000).

For exceptional monitoring of wetlands, Fredrickson and Laubhan (1996) recommend keeping records for each individual wetland not the entire complex as a whole. Specific information on manipulations within each wetland unit should also be recorded. Water depth, duration and date of flooding, drawdown dates and rates, vegetation conditions, season, temperature and weather are all important factors which help to understand the response of bird communities to habitat manipulations. The frequency and timing of counts are critical to obtain useful assessments of manipulations (Fredrickson and Laubhan 1996). Keep counts confined to early morning between the hours of 0600 and 1030 and conduct more than one count during the breeding season to incorporate early and late nesting species. I collected baseline data on bird communities using 21 restored wetlands in the Sacramento Valley and it was the first study of its kind in this area. This was an important first step in understanding if restoration programs on private lands aimed at providing habitat for breeding birds and migrating shorebirds and songbirds are achieving their goals.

Once the basic question of what bird communities are occurring on restored wetlands the question of why can be addressed. Wildlife use of wetlands is largely determined by the type, quality and distribution of foods and cover (Weller and Spatcher 1965; Weller and Fredrickson 1974; Kaminski and Prince 1981, deSzalay and Resh 1997). Following this fluctuations in water depth influence the distribution, composition and productivity of vegetation that becomes established in a wetland (Fredrickson and Laubhan 1996).

Water depth, water permanence and timing of flooding are paramount to consider when attracting waterfowl, shorebirds, wading birds and other water birds. Foods and cover in wetlands that are not flooded, or flooded to deeply are largely unavailable to the majority of these species (Fredrickson and Laubhan 1996). When possible, flooded wetlands should be sustained at shallow depths providing habitat diversity ranging from open water to mudflat. Both water permanence and water depth had direct bearings on species composition in this study. I suggest water be maintained at depths of 5 – 30 cm from April through August on semi-permanent wetlands to attract waterfowl broods as well as shorebirds, wading birds, and water birds.

Prior to enrolling a landowner into a restoration program, government agencies should ensure that participating landowners have rights to water in the spring and summer. Depending on the management of water, restored wetlands may either be detrimental or beneficial to bird communities, especially breeding birds (Brown and Dinsmore 1986). In four instances spring-seasonal wetlands had to be drained to prevent leakage into adjacent fields. In addition, water was not available for the wetland due to priority rights for agricultural crops. Bird use was nonexistent during these brief periods when wetlands went dry and was reduced dramatically for weeks after the wetland was re-flooded. Landowner commitment should be considered when selecting future wetlands for program enrollment. Absentee landowners with no onsite staff may be of particular concern.

Both spring-seasonal and semi-permanent wetlands attracted bird communities. Spring-seasonal wetlands attracted a greater diversity and abundance of shorebirds while semi-permanent wetlands attracted a greater diversity of nonwetland and wetland obligate species. An appropriate mix of wetland habitats on a landscape level is required to influence the overall composition of bird communities during the breeding season (Creighton et al. 1997) so it is important that both wetland types are available. Management of waterfowl and other wetland dependent species is complicated because each species has unique requirements that are associated with different wetland types (Fredrickson and Reid 1988). Likewise, the requirements for a single species are best met from a variety of wetland types. Not all wetlands are meant to be breeding habitat. Migratory stopover and wintering areas provide essential resources for many species of birds especially shorebirds. Agencies and managers should avoid modifying such areas to create breeding habitat if doing so would impair other seasonal uses (Ringleman 1992). Many agricultural crops are exploited by a number of birds because the crops are widespread, accessible and provide high levels of carbohydrates. Bird friendly crops planted adjacent to restored wetlands can provide invertebrate food resources to shorebirds and waterfowl wintering in the Sacramento Valley (Harrell et al.1995). Bird friendly crops identified in the Sacramento Valley include corn, wheat, rice, barley, oats, peas, sorghum, rye, millet, and soybeans.

Although semi-permanent wetlands had greater species diversity, that should not be the exclusive wetland type restored. This follows a suggestion from Brown and Dinsmore (1986) that the best strategy in attaining greater species richness to be acquisition of wetlands adjacent to existing marsh complexes.

The topography of spring-seasonal and semi-permanent wetlands is very different. Restorations completed under PFW required deleveling, which provided relief within the wetland. Deleveling is beneficial to a variety of different bird species. Shallow areas of a wetland can provide foraging opportunities for shorebirds and wading birds while the deeper areas attract diving birds such as cormorants, grebes, and pelicans that forage for fish and invertebrates. Microhabitats are more numerous in semi-permanent wetlands because of the varying water depths that attract a greater variety of bird species. Spring-seasonal wetlands are flooded on such a temporary basis that deleveling is not required. Spring-seasonal wetlands are usually selected for the Brood Pond Program if they have relatively flat topography and seasonal water rights. Although the microhabitats in these wetlands are not as diverse as in semi-permanent wetlands, the abundance of a primary food resource (i.e. invertebrates) for many breeding birds is notably higher than in semi-permanent wetlands (Resh and de Szalay 1998).

Maintenance is necessary on both spring-seasonal and semi-permanent wetlands to keep the habitat in good condition to better attract bird communities. Specifically, consistent maintenance to control cattails and/or any other species that becomes monotypic within a wetland is necessary to preserve open water. Two active and widely used methods in the Sacramento Valley to control cattails and hard-stem bulrush and encourage desirable plant species are prescribed burning and mowing. De Szalay and

Resh (1997) conducted a study in California's Central Valley determining the effects of mowing and burning on plants and invertebrates important in waterfowl diets. They found that both prescribed burning and mowing are successful in increasing densities of invertebrates and some plant species. They stressed the importance that some areas of the wetland remain unmanipulated to compensate for potential negative effects to some invertebrate or plant taxa that do not respond positively to burning or mowing. Program leaders should require private landowners to maintain areas of open water through some type of maintenance activity preferably burning, mowing or discing.

Overall the absence of diverse habitat types, especially trees, on spring-seasonal wetlands appeared to be the limiting factor in attracting a greater number of nonwetland dependent bird species. A similar study comparing breeding bird communities of restored and natural prairie potholes found that full recovery of breeding bird communities at restored wetlands will not likely occur until development of all the vegetation zones are complete (Delphey and Dinsmore 1993). Restored wetlands cannot be considered equal to natural wetlands during their first three years of development (Brown and Smith 1998). This can be assumed for any type of restored wetland. It will take time for spring-seasonal wetlands to fully recover a diversity of vegetation zones, as time can compensate for the lack of vegetation on newly restored marshes (Hemesath and Dinsmore 1993). One small but significant initial step could be taken to expedite the recovery. Planting trees or pole cuttings from native willows and cottonwood is an easy and economical way to promote maturation of the wetland.

Conservation of natural areas, especially wetlands, is complicated by habitat fragmentation, invasion of non-native species, development near area boundaries, recreational use, and agricultural use. In addition to the habitat components mentioned and physiographic features of the wetlands; predation, availability of nest sites, and disturbance are all factors that may be important in influencing local bird communities on both spring-seasonal and semi-permanent wetlands. The extent of use a wetland receives by wildlife is also influenced by the condition of adjacent habitats. A study determining the impact of such activities and the habitat surrounding restored wetlands would provide insight as to whether these wetlands are functioning as sources and not sinks.

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