RECLAMATION

Managing Water in the West

2011 Monitoring Report for Mormon Island Wetland Preserve

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

November 2011

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

2011 Monitoring Report for Mormon Island Wetland Preserve

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Background

Mormon Island Auxiliary Dam (MIAD) is a 33-m high earthfill dam that helps to impound the American River and form Folsom Lake near Sacramento, California. In the 1990's the dam foundation was modified to limit geologic deformations because of potential seismic activity in the area. Further strengthening of the dam foundation is desired, and a variety of construction activities have been considered to achieve this purpose.

As part of the Environmental Commitments/Mitigation Section of the Folsom Dam Safety and Flood Damage Reduction Final Environmental Impact Statement/ Environmental Impact Report, the Bureau of Reclamation (Reclamation) committed to developing a plan for establishing baseline conditions and monitoring the Mormon Island Wetland Preserve (MIWP; Preserve). The purpose of monitoring is to determine if construction operations associated with the project are having direct/indirect effects on wetland functions at the Preserve. Three types of monitoring are conducted in MIWP and included in this report: macroinvertebrate, herpetological, and vegetation.

Macroinvertebrate Sampling

Introduction

Extensive wetland areas exist immediately adjacent and downslope to MIAD and across Green Valley Road at MIWP (ca.within 345-m). During construction, wetlands could be directly impacted through earth moving or through relocation of roads. Dewatering of areas under construction could also change hydrological regimes to wetlands. Local resource agencies as well as Bureau of Reclamation (Reclamation) personnel are concerned that some harm to wetland aquatic macroinvertebrate assemblages may occur from planned activities. Wetland macroinvertebrates have been shown to be sensitive to a variety of disturbances that may be associated with activities at MIAD (e.g., Chipps et al. 2006, Findlay and Bourdages 2000). This paper reports on aquatic invertebrate monitoring at wetlands associated with MIAD and at other nearby wetlands that will remain unimpacted by dam construction activities.

Aquatic macroinvertebrates were sampled in February and June of 2007, 2008, 2009, and 2010 as part of a baseline monitoring effort. Sampling in 2007 was also used to test for effects of jet grouting along the dam. Examination of data suggested there were no acutely detectable impacts to wetland macroinvertebrates (Nelson and Reed 2009). Therefore, 2007 data was also included as part of the baseline monitoring to examine potential future impacts from construction. Data in the present paper provides information on baseline aquatic macroinvertebrates prior to dam construction activities. To avoid confounding dam construction impacts with natural changes in macroinvertebrate assemblages over time, reference wetlands were also sampled to control for temporal variation. Environmental variables were also collected and used to determine

important factors in structuring macroinvertebrate communities in the area. This information could be crucial in predicting whether dam modifications might impact communities.

Methods

Site Locations

The spatial relationship between the three groups of sites [Mormon Island (MI), Maximus (MX), and Willow Creek (WC)] is presented in Figure 1. Sites MI-1 and MI-2, at the MI complex (Figure 1), were closest, and MI-8, MI-9, and MI-10 furthest from the dam. MI-2, MI-3, and MI-6 were in drainage ditch environments while MI-8, MI-9, and MI-10 appeared to be artificial pools created from historic dam building borrow pits (Sutter and Francisco 1998). Other MI sites were associated with swale areas (MI-1 and MI-7) or vernal pools (MI-4, and MI-5). Sites given the MX code were found along Willow Creek East of Lake Natoma (Figure 1) and were largely located in the flood plain portion of the creek. There was direct interaction between the lotic creek environment and wetlands lateral to the creek. MX-4 differed somewhat from the other MX sites in that a drain from an industrial property entered the creek at that point, creating a slow moving slough type of environment. Willow Creek sites (Figure 1) were found at the Willow Creek State Recreational Area (Willow Creek SRA), and although they varied in surface area and depth, it appeared that all were relatively small artificial wetlands that may have been associated with historic mining/dredging activity.

Hydrology of the wetland areas differed, with flood plain wetlands at MX containing water for a large part of the year, while wetland size at MI and WC often changed from February to June, depending upon rainfall patterns.

Macroinvertebrate Monitoring

Samples were collected in February and June from 2007 to 2011. Samples were collected at 10 sites associated with MIAD that have the potential to be affected by construction activities and 10 reference sites. Reference sites were palustrine emergent wetlands selected because of gross similarities to MIAD sites in vegetation, structure, and flow, however none of the sites would be considered pristine. Instead, these reference or benchmark sites represent the “best of what’s left” (Hawkins et al., 2010). Sampling took place at the same 20 sites on each occasion (drought conditions impacted seasonal sampling in some years and resulted in a decreased number of sites) so that they were linked through time.

Aquatic invertebrates were collected with a D-frame net over a 1-minute period. Biotic samples were preserved in alcohol and shipped back to the Technical Service Center laboratory for processing. Other collected variables included dissolved oxygen (DO), conductivity, pH, and temperature as measured with a portable meter. Water samples for alkalinity and hardness were analyzed using titration methods. Estimates of detritus, percent plant cover, sampling depth, vegetation height, and vegetation type were also obtained at each site. After 2008, the diameter of each wetland was measured in February and June to provide an index of drying impacts between the two dates. Precipitation data were obtained from http://cdec.water.ca.gov/cgi-progs/queryMonthly?FLD.

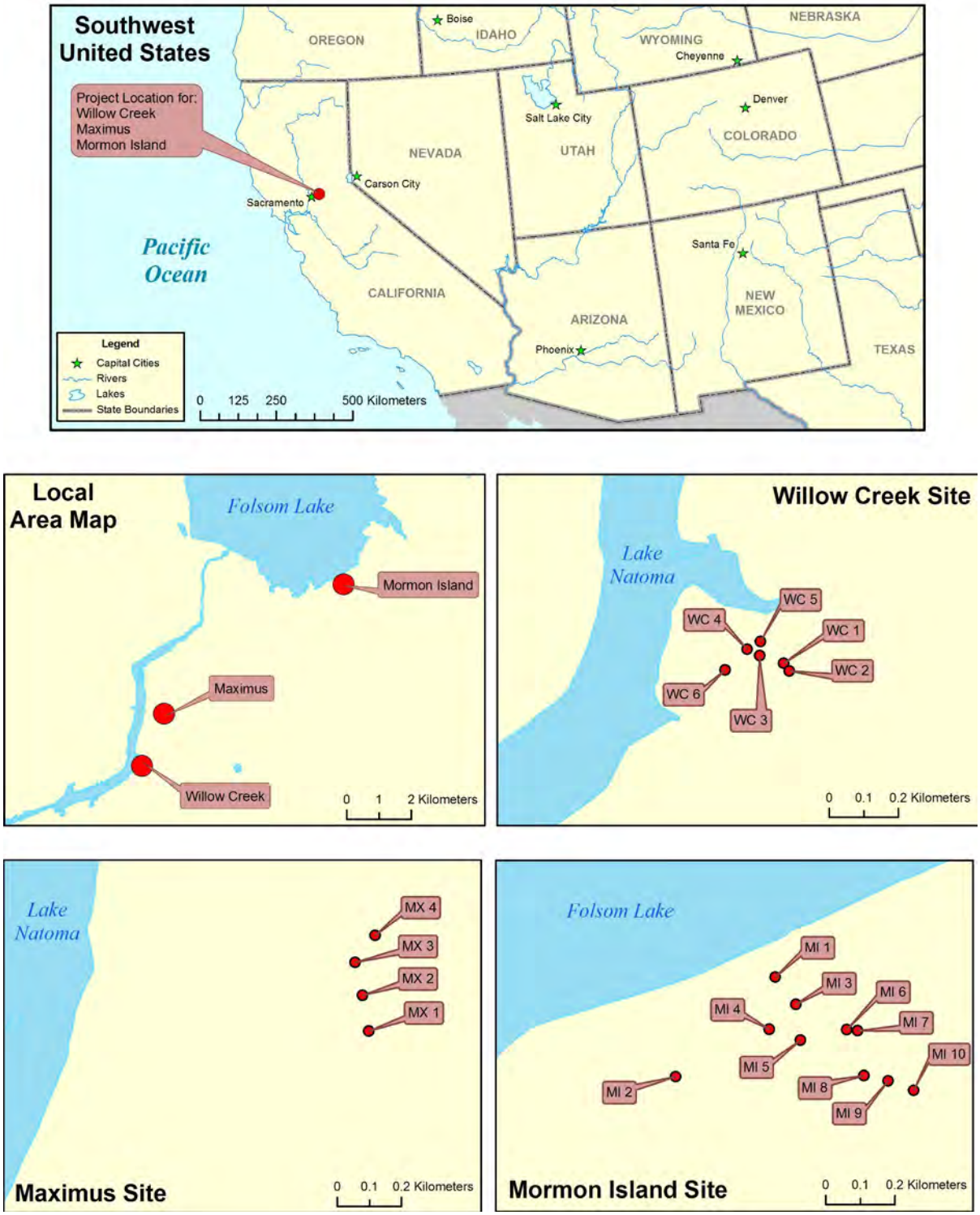


FIGURE 2.—Relative positions of the three groups of sites. MI sites may be exposed to construction impacts below the dam, while other sites (MX and WC) are considered to be reference wetlands.

Survey Limitations

The present study was conducted during a very limited temporal period on an annual basis. The purpose was not to identify or detect all aquatic macroinvertebrate taxa at the MIAD complex. Because of the limited seasonal sampling, it is possible that other, and perhaps many other, species of aquatic invertebrates use the area but were not observed during this survey. For detection of rare species that may be of conservation interest an exhaustive assessment performed throughout the year is needed.

Data Analysis for Macroinvertebrate Monitoring

Factorial analysis of variance (ANOVA) was used to test for differences in environmental variables and macroinvertebrate richness and abundance between site groups (MI, MX, and WC), months, and years.

The ‘‘quality control approach’’ of Cairns and Smith (1994) was used to track changes in comparative taxa richness values after construction initiation in 2011. This approach often uses control charts as the method for monitoring changes. Control charts are typically used to monitor a process (in this case wetland macroinvertebrate taxa richness) and depict the average value and the upper and lower control limits (the highest and lowest values from a 3 standard deviation limit) graphically. If data falls outside the control limits, it is assumed that something has changed and that further investigation is required.

The ability to detect differences caused by an impact at a site may be affected by temporal variation in communities and therefore reference sites were utilized to allow for some confidence in control chart results. It was assumed that variability resulting from local weather patterns would be similar between MIAD and reference sites, thus allowing for detection of changes at MIAD caused by construction impacts. Sites at Mormon Island (MI-1 to MI-10) were randomly paired with other reference sites in the Folsom area (MX and WC sites) and number of taxa subtracted from the number of taxa at the reference sites. It is assumed that impacted MI sites will have reduced taxa richness after initiation of construction activities and that this treatment would not impact reference sites that were spatially unassociated with the construction. Baseline data were collected from 2007 to 2010. One flaw with this experimental design for detecting impacts is that, in some cases, richness measures may be ineffective in perceiving impacts because of replacement of sensitive species by tolerant species. Therefore, ordination was also used to determine whether there were changes in macroinvertebrate assemblages that might potentially be associated with construction impacts.

Ordination techniques were used to examine patterns in the macroinvertebrate data, and to identify physical and chemical variables that were most closely associated with invertebrate distributions. Initial analysis of the macroinvertebrate data set used detrended correspondence analysis, and revealed that the data set had a gradient length > 3, suggesting that unimodal models were appropriate for analysis. Therefore, canonical correspondence analysis (CCA) was used for direct gradient analysis. Faunal data were transformed (square root transformation) before analysis. Forward selection of environmental variables and Monte Carlo permutations

were used to determine whether variables exerted a significant effect on invertebrate distributions. If environmental variables were strongly correlated (Pearson correlation, $r \geq 0.6$), only a single variable was selected for use in CCA to avoid problems with multicollinearity. Environmental variables were normalized [(ln(X+1)) or arcsin squareroot transformation for percentage data] if the Shapiro-Wilk Test indicated the necessity for this transformation. In the ordination diagram, taxa and sites are represented by geometric points and the environmental variables by arrows. The arrows roughly orient in the direction of maximum variation of the given variable, and the length of the arrow indicates how much influence a given environmental variable has on macroinvertebrate data. Perpendicular lines drawn from an arrow to macroinvertebrate taxon points determine the relative position of that taxon along the environmental axis.

It is suggested that these multiple approaches used to characterize the macroinvertebrate data provide a weight-of-evidence methodology for evaluating whether significant harm is posed to the environment. It should be recognized, however, that this rather qualitative analysis introduces some subjectivity to the process, especially if life-history characteristics of certain taxa are used as evidence.

Results

Environmental variables/Macroinvertebrate metrics

Mean variables for each group of sites are presented in Table 1. Some environmental variables were significantly ($p \leq 0.05$) and highly ($r \geq 0.6$) correlated with each other. Conductivity was correlated with both alkalinity (r=0.8766, $p<0.00001$) and hardness (r=0.8731, $p<0.00001$), while surface DO was correlated with bottom DO (r=0.9631, $p<0.00001$). Therefore, alkalinity, hardness, and bottom DO were omitted from both ANOVA and ordination analyses.

Group differences

Significant differences were detected between site groups for conductivity, cover, depth, detritus, DO, pH, temperature, and vegetation height (ANOVA, $p<0.05$). Conductivity at WC sites was significantly higher than at MI and MX, while DO was significantly lower at WC. Detritus volume was significantly higher at WC compared to the other two sets of sites. Vegetation height at WC was significantly lower than at other sites. Cover was significantly higher at MX sites compared with the other two groups. Depth differed between MX sites and the other two sites, which did not differ from each other. The lotic MX sites had significantly higher pH than other sites did.

Month differences

Values for conductivity, depth, detritus volume, and vegetation cover and height did not differ significantly between February and June. Dissolved oxygen and pH were significantly lower in June, while water temperature was significantly higher.

TABLE 1.—Mean environmental variables from groups of wetland sites in the area of Folsom, CA. Data were collected in February and June from 2007-2011. Standard error is in parentheses.

Environmental variables	MI (n=86)	MX (n=39)	WC (n=57)
Alkalinity (mg/L)	81.9 (4.3)	82.4 (1.4)	157.5 (5.2)
Conductivity (µS/cm)	248 (13)	236 (4)	365 (11)
Cover (%)	54 (4)	82 (3)	42 (4)
DO-bottom (mg/L)	5.13 (0.33)	6.79 (0.42)	2.41 (0.20)
DO-surface (mg/L)	5.68 (0.34)	7.11 (0.45)	2.48 (0.20)
Depth (m)	0.43 (0.03)	0.20 (0.02)	0.33 (0.03)
Detritus (ml)	301 (31)	218 (32)	549 (65)
Hardness (mg/L)	66 (5)	90 (2)	148 (5)
pH (SU)	7.05 (0.05)	7.43 (0.06)	7.04 (0.03)
Temperature (^{o}C)	15.32 (0.58)	15.02 (0.57)	13.41 (0.64)
Vegetation height (m)	1.9 (0.3)	2.0 (0.1)	1.0 (0.1)

Year differences

We detected no significant differences between years for conductivity, DO, and vegetation cover and height. Water depth in 2007 differed significantly from depth in 2010 and 2011, but not from depths in 2008 and 2009. Detritus volume was significantly higher in 2007 compared to 2010 and 2011, though 2008-2009 did not differ significantly from other years. In 2007, pH differed significantly from pH in 2009-2011. Water temperature was significantly lower in 2011 compared to 2007, 2008 and 2010.

These data suggest that a there were important water quality and vegetation differences (cover and detritus) between landscape areas and that there were often differences between months and years.

Measurements of wetland diameter in 2008 (including sites that were dry in June) indicated a mean loss in diameter between February and June of 69% for MI sites, 28% for MX sites, and 75% for WC sites. The following year a very different rainfall pattern (e.g., Figure 2) caused large changes in seasonal wetland diameter between the years. In 2009 rainfall did not occur until after February sampling. This reversed what had been the expected pattern of wetlands, of water present in February and many wetlands dry by June. In 2009 average diameter at MI sites *increased* an average of 54% and also increased 17% at MX sites. WC sites diameter decreased by 52%. The year 2010 was the first time during the study that all of the wetlands were available for sampling in both February and June and was followed in 2011 by an almost complete sampling except for MX-3 in June (perhaps dried from beaver activity) and MI-1 which was altered (buried) by construction activity. Rainfall during the winter and spring of 2009-2010 and 2010-2011 were higher than preceeding years (Figure 2). Mean loss in diameter at MI was only 10% in 2010, while MX sites gained 10%. WC sites lost 18% of mean diameter in 2010. Values in 2011 showed a similar small amount of diameter loss, which was 8% at MI, 34% at MX (only 11% loss if MX-3 omitted), and loss at WC sites was 0.5%. Total rainfall for the study year seasons (winter-spring) was: 2007, 73 mm; 2008, 268 mm; 2009, 370 mm; 2010, 452 mm; and 2011, 629 mm.

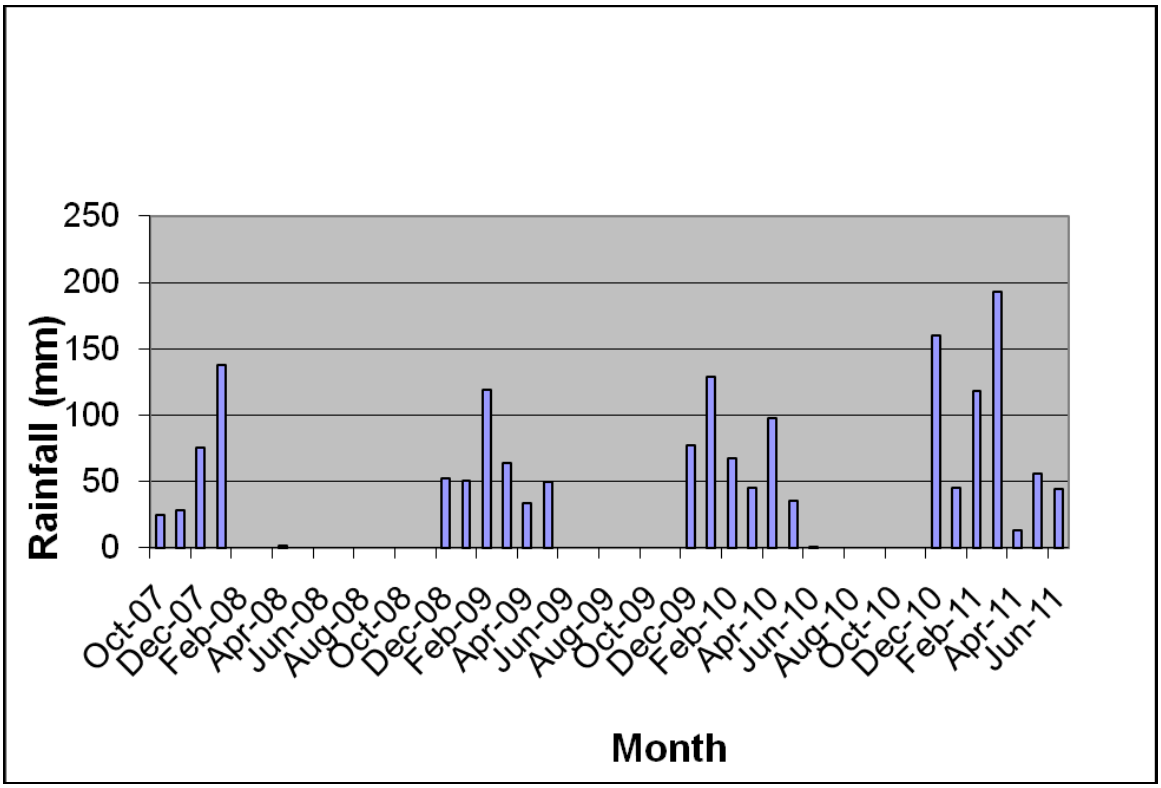


FIGURE 3.—Precipitation (rainfall) patterns recorded at Folsom Dam near studied wetland sites.

Analysis of invertebrate taxa richness data indicated that there were significant differences between site groups ($p<0.0001$) and between months ($p<0.0001$) (Figures 3 and 4). Taxa richness was lowest at WC sites and higher in June relative to February.

Abundance data indicated that significant differences ($p=0.0154$) were present between months, with abundance significantly lower in June. There were no significant differences in abundance between sites ($p>0.05$). Comparisons for yearly data indicated that abundance differed significantly ($p<0.05$) between 2008 and 2010 and 2011 but not between the other years (Figure 5).

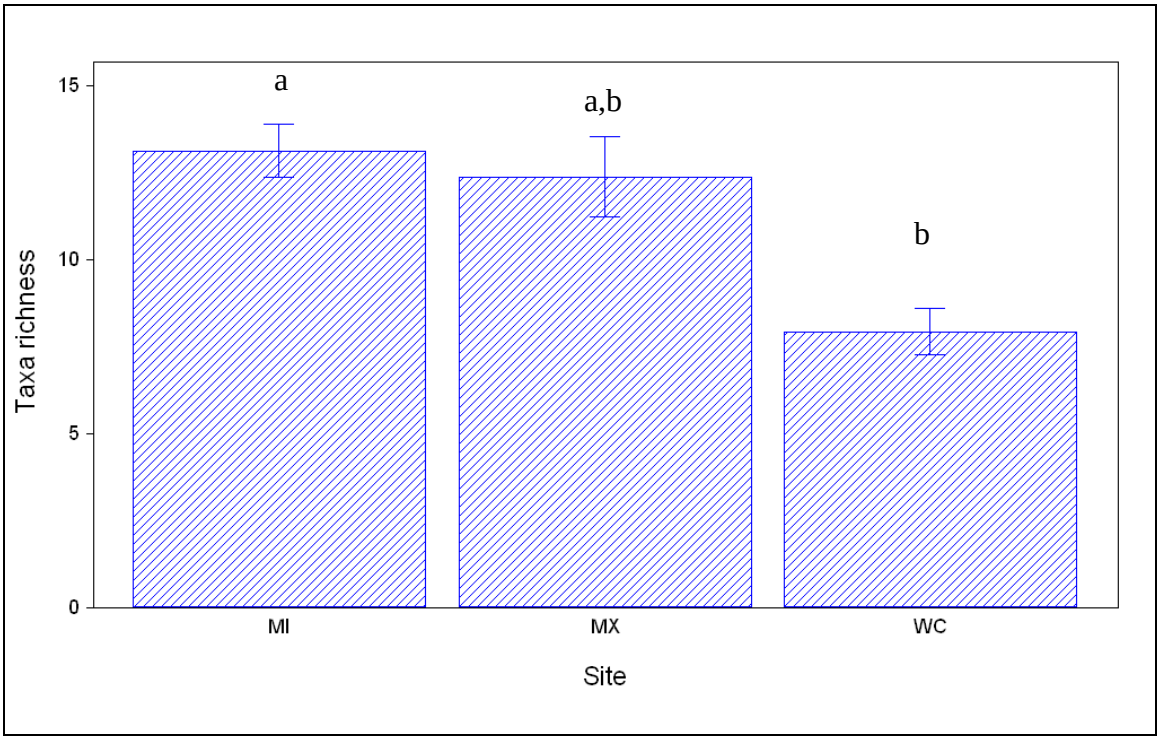


FIGURE 4.—Mean taxa richness at wetland study sites. Variance is represented by standard error bars. Bars with the same letter indicate no significant differences between values, while those with dissimilar letters indicates that there is a significant difference in mean taxa richness between sites.

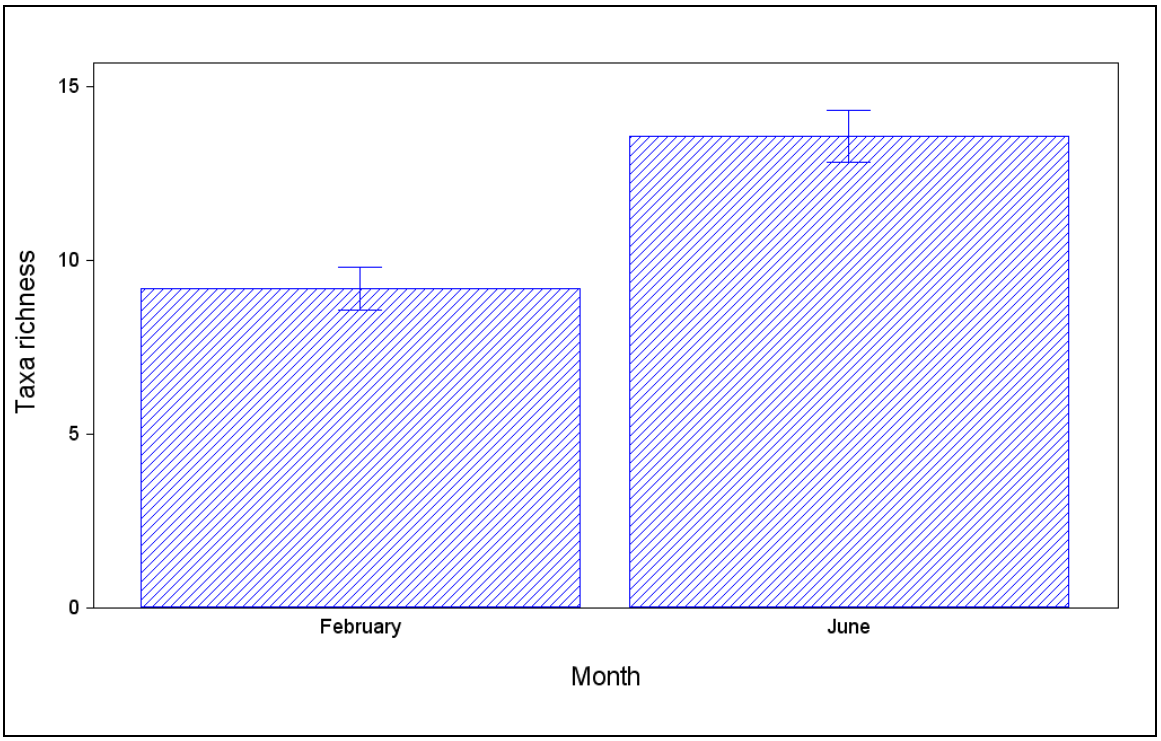


FIGURE 5.—Mean taxa richness of aquatic invertebrates at Folsom wetland sites. Richness values differed significantly (p=0.0004) between February and June sampling.

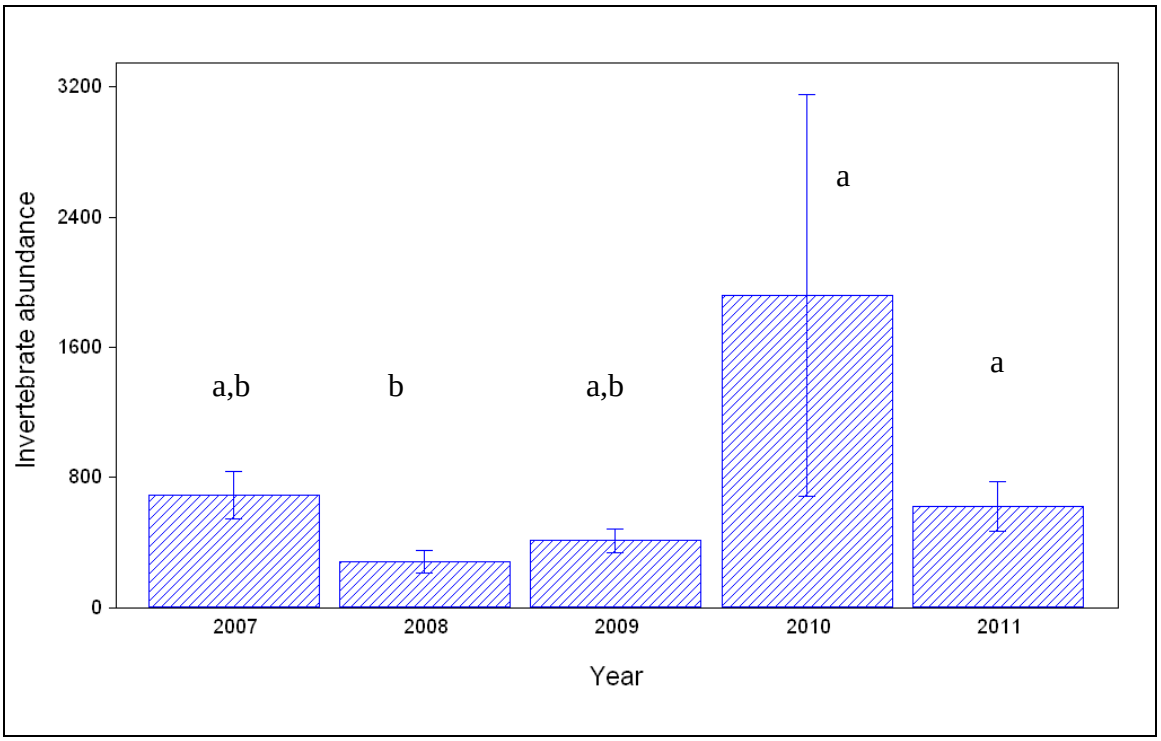


FIGURE 6.—Mean wetland invertebrate abundance by year. Variance is represented by standard error bars. Bars with the same letter indicate no significant differences between values, while those with dissimilar letters indicates that there is a significant difference in mean abundance between years.

Control Chart Data

Figure 6 presents control chart data to date. Data used were limited to richness metrics. The center line and control limits were computed using data from 2007 to 2010 (80 data points) and were collected under a variety of weather conditions and are likely representative of aquatic macroinvertebrate responses to natural variability in the Folsom area. Data collected under construction conditions demonstrates a single value falling outside the third standard deviation. This is associated with the site MI-1 which is now gone, having been buried by construction activities. Additional data collection is needed to verify more subtle changes in control chart patterns.

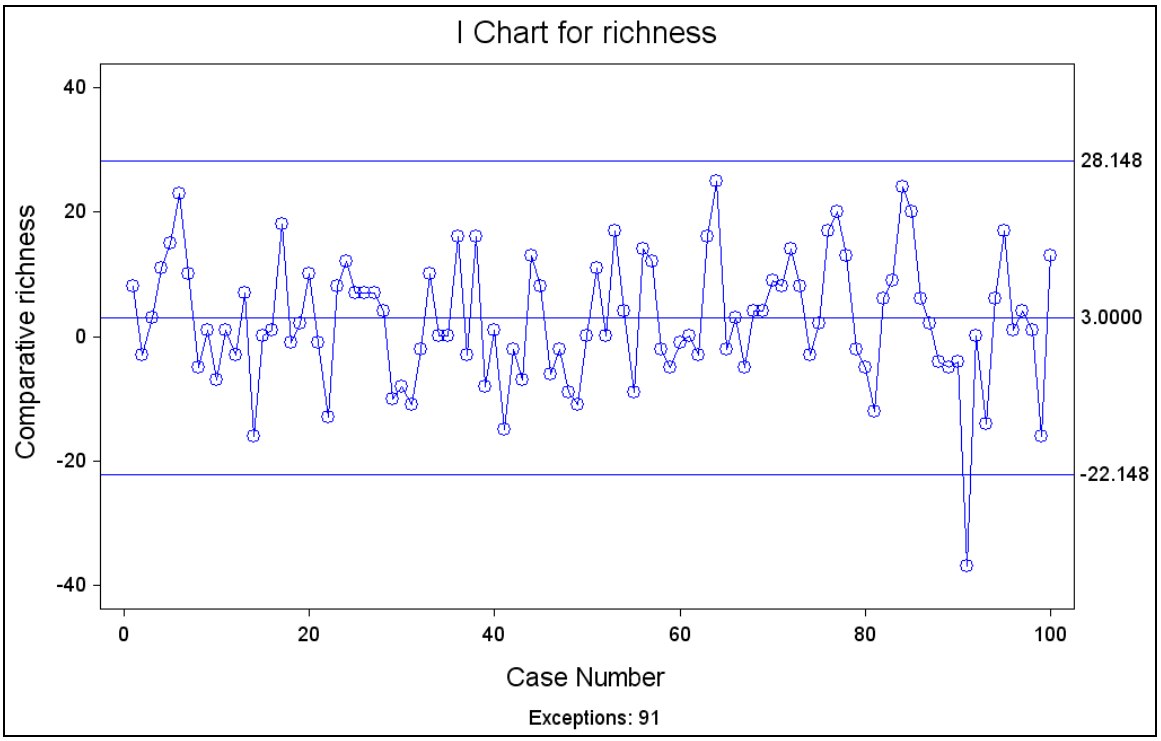


FIGURE 6.— I control chart for comparative richness values. Data from 2007-2010 were used to estimate the mean and standard deviation. The point at 28.148 represents a value that is plus three times the standard deviation and -22.148 represents a value that is minus three times the standard deviation. A single point (number 91) from 2011 is plotted below the line that is minus three times the standard deviation.

Canonical Correspondence Analysis

Results of CCA for wetland macroinvertebrates had eigenvalues of 0.275 and 0.233 for the first two axes and explained 9.1% of the species data variation and 58.6% of the species–environment relation. Analysis indicated that seven environmental variables were significant in the model in describing macroinvertebrate distributions (Figure 7). The first axis appeared to largely differentiate between June and February. Main differences along Axis I were associated with water depth and temperature. Both of these were variables likely associated with differences between February and June sampling dates, and sample sites in the positive portion of Axis I

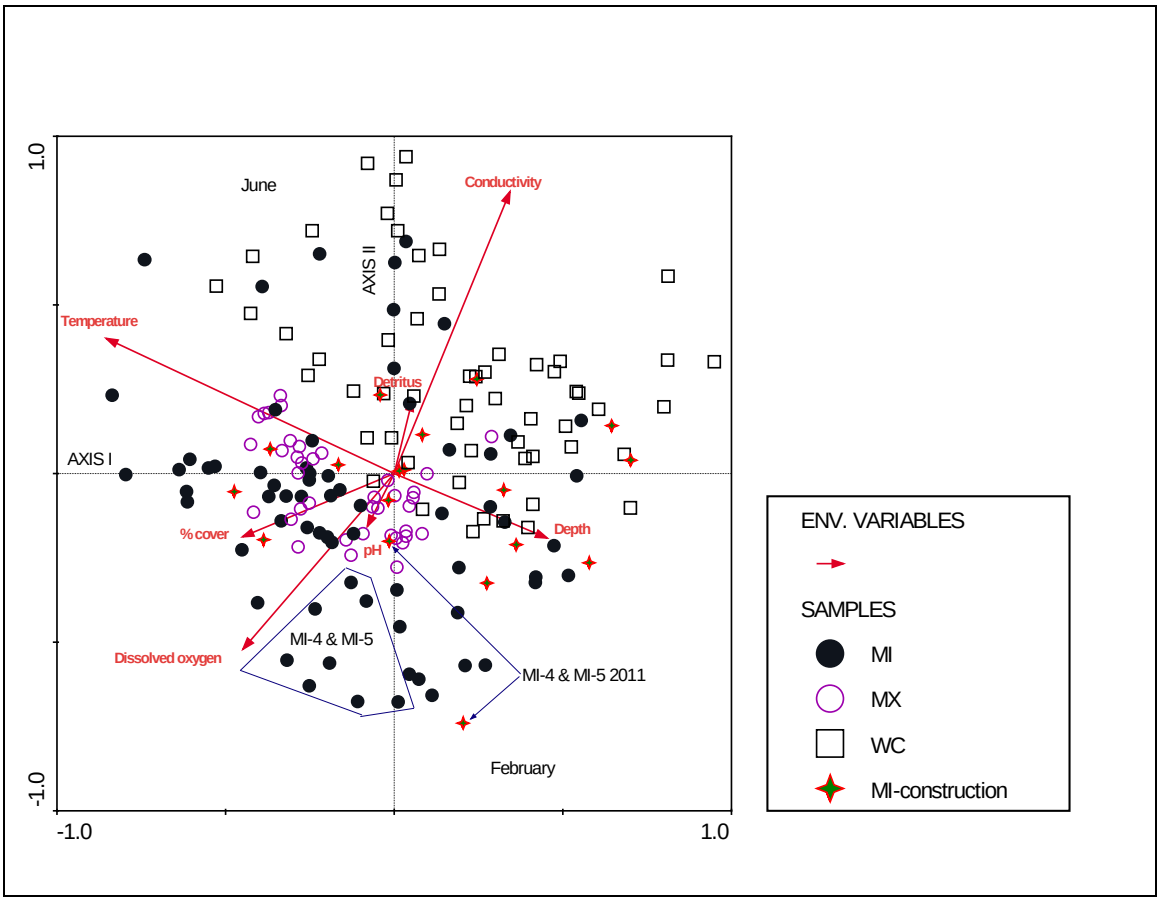


FIGURE **7.**—Canonical correspondence analysis of Folsom wetland macroinvertebrate data showing the association of sites and taxa with environmental variables. Only taxa with at least a 3% fit and weight are shown in the diagram.

were mostly those collected in February, while those in the negative portion were sites sampled in June. This seasonal gradient also extended to some degree along the negative portion of Axis II where some of the MI-4 and MI-5 sites in February were located. It appeared that CCA demonstrated patterns associated with sites and seasons. There may be a change in vernal pool samples (MI-4 & MI-5) (Figure 7) associated with 2011 data.

Organisms that appeared to be associated with seasonal patterns (e.g., Figure 8) included members of the Class Ostracoda that were mostly associated with MI-4 and MI-5 locations in the negative portion of Axis II (lower part of the quadrate) that were often dried by the second sampling occasion in June. Midges such as *Psectrocladius* were also associated with this portion of the diagram along with the beetle *Agabus*. *Agabus* in the central valley of California occurs in temporary ponds where it diapauses as adults during the dry summer season (Garcia et al. 1990).

Zooplankton such as daphnids *Daphnia* and *Simocephalus* appeared to change seasonally (Figure 8) with Daphnia more abundant in February [896 $\pm$ 536 (SE) individuals/collected sample in February vs. 88 $\pm$ 34 in June] and *Simocephalus* more abundant in June [1 $\pm$0.4 (SE) individuals/collected sample in February vs. 19 $\pm$ 11 in June].

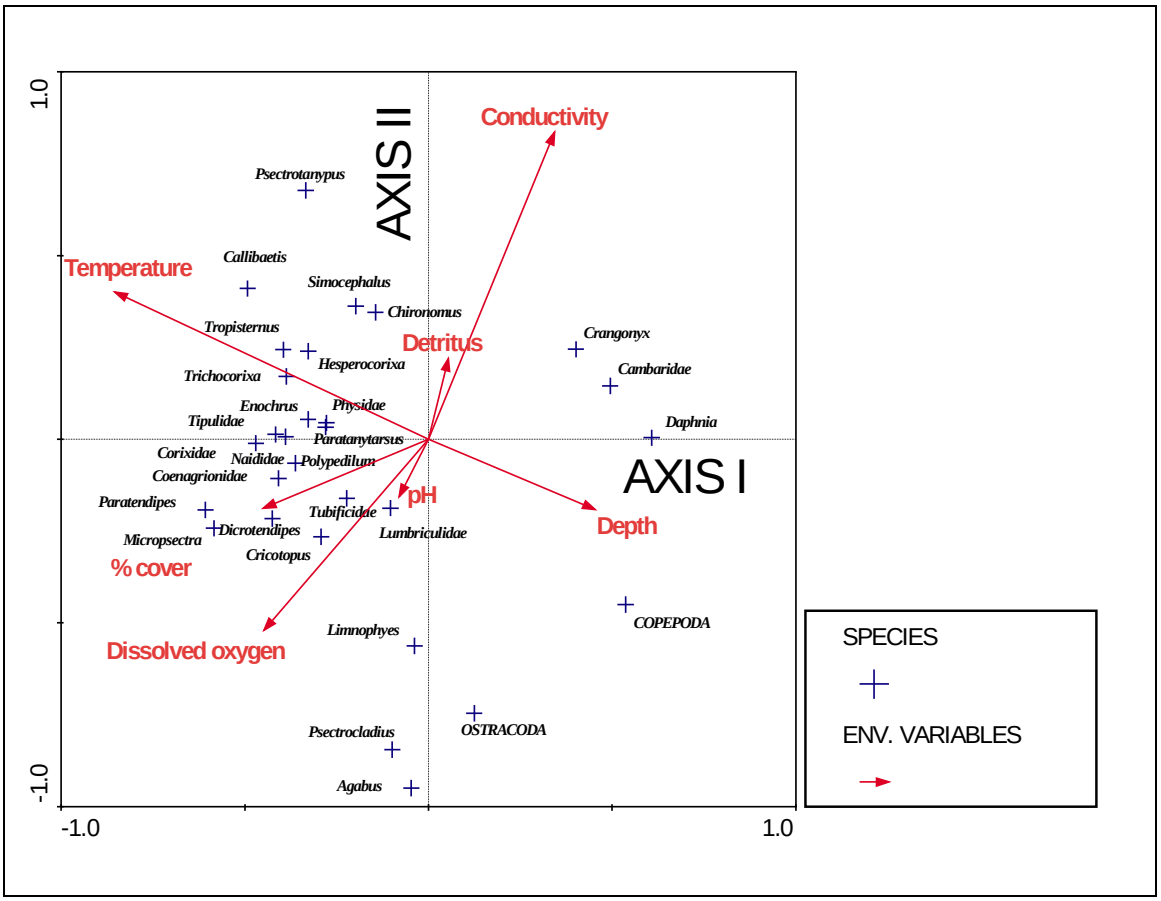


FIGURE 8.—Invertebrate taxa associated with wetlands in the Folsom, California area, as analyzed with canonical correspondence analysis.

The midge *Pscetrotanypus* was found in the highly positive part of Axis II (Figure 8) and was associated with wetlands that still retained water in June. In a study of prairie ponds, Driver (1977) found *Pscetrotanypus* to be characteristic of semi-permanent ponds, similar to those in the present study. The mayfly, *Callibaetis*, has also been found to increase in abundance in ephemeral ponds over time (Moorhead et al. 1998), and this may partially explain its presence in the positive portion of Axis II. It appeared that seasonal differences were related both to wetlands having different hydroperiods and the natural history phenology of some invertebrates.

WC sites appeared to be separated from other sites (Figure 7) and were largely associated with the more positive portions of Axis I and the positive portion of Axis II. Characteristic of these sites was higher conductivity and lower DO.

Other invertebrate species of note

Invertebrates associated with vernal pool types of wetlands (MI-4 and MI-5) included the endemic (Helm 1998) California clam shrimp (*Cyzicus californicus*) and the uncommon (Kitayama 1979) flightless haliplid beetle (*Apteraliplus parvulus*). These invertebrates are restricted to seasonal pools and were almost exclusively found at MI-4 and MI-5, which were components of the same vernal pool at the MIAD complex. *Apteraliplus parvulus* was only

detected in 2010. *Cyzicus californicus* was detected from 2007 to 2010, but not in 2011. This may have been from the decreased vernal nature of the environment that may have been caused by increased precipitation and the resulting fish populations which were noted in 2011. It appears from Figure 7 that the community composition of these sites may be changing as the ponds are become more permanent in nature.

The second CCA axis appeared, to a large degree, to separate WC sites from the other sites. Characteristic of these sites was higher conductivity and lower DO. The amphipod *Crangonyx* was in the positive portion of Axis II in association with WC and MX sites.

Conclusions

Measured variables indicate that baseline data were collected under a variety of environmental conditions. Data were collected during both dry and wet years and included life history changes in communities that occurred from February to June.

Construction activities at MIAD directly impacted a single wetland and this was detected by control chart data. Ordination indicated that vernal pool community species makeup at MIAD was also changing. Wetland burial was a direct consequence of construction activities, however, vernal pool community changes seems to be the result of weather patterns (increased preciptiation) that differentially impacted vernal pools. A shift towards longer inundation times with increased abundance of aquatic predators has been predicted to have negative impacts on branchiopods such as *Cyzicus* (e.g., Pyke 2005) in vernal pools.

Collection of environmental variables along with species information with reference sites allowed for detection of impacts from dam construction and discrimination between weather events and anthropogenic impacts. Compilation of additional data may detect more subtle changes in invertebrate communities that could be tied to anthropogenic alteration of wetland sites.

Acknowledgments

Sampling was performed under permit with the California Department of Fish and Game. Reclamation’s Dam Safety Program provided funding. Special thanks to Vicki Johanson for preparing Figure 1 and to Elle Ahlers for processing invertebrate samples.

Herpetological Monitoring

Introduction

Herpetological (herp) surveys were conducted during the past four years within MIWP to monitor populations of amphibians and reptiles, detect any special status species occurring within the Preserve and monitor any potential impacts to herp populations due to construction activities at MIAD. Baseline surveys conducted between 2008 and 2010 will be compared to data collected during and after construction (beginning in 2011). Of the six special status amphibian and reptile species considered in the Biological Monitoring Plan for the Folsom Dam Safety and Flood Damage Reduction Project, five have a possibility of occurring in the MIWP. Moderately suitable habitat exists for the western spadefoot toad (*Spea hammondii*) in the form of seasonal water and adjacent grassland. The remaining four species, California red-legged frog (CRF; *Rana aurora draytonii*), western pond turtle (*Actinemys marmorata*), California horned lizard (*Phrynosoma coronatum frontale*), and giant garter snake (*Thamnophis gigas*) have marginally suitable habitat present on the Preserve.

Methods

Initiated in 2008, herpetological surveys at MIWP were based loosely on CRF Field Survey Protocol (USFWS 2005) and consisted of both day and night surveys and included both visual search and audio survey methodology. Due to the varying periods of peak activity of the different species, surveys were conducted in the Preserve between February 15 and June 31. Three sets of surveys, each comprising two day surveys and two night surveys, were conducted; one set each during late February, mid-April and mid-June. Night surveys were conducted at least 1 hour after sunset and day surveys at least 1 hour after sunrise when air temperatures were greater than 50 ^{o}F and winds less than 5 mph. All habitat within the Preserve was surveyed during each set of day and night surveys. Due to unseasonably cold and wet weather, only one day survey was conducted during the second survey period (April) in 2010

Day and night surveys consisted of the same methodology. Prior to conducting surveys, an audio survey route of 15 points was established within MIWP which encompassed the five special status species' potentially suitable habitat (Figure 9). Audio survey points were located a minimum of 80 m apart. Upon arriving at the site and prior to entering any unsurveyed areas, the surveyor listened quietly for several minutes to document calling frogs and/or toads. Calling individuals were noted and approximate locations recorded so that, upon entering the habitat and conducting visual searches, these areas could be focused on to verify species identity. Audio surveys at each point consisted of an initial 1-minute wait to allow frogs/toads to resume calling and then a 3-minute recording period. During the recording period, the number and Wisconsin frog call index value (Table 2) of each species calling both inside and outside a 60-m radius were recorded. Often a full chorus was heard and it was impossible to count individual frogs. In these cases, estimates of abundance were made. Weather conditions were recorded at the beginning of each survey and the survey was suspended if winds exceeded 10 mph.

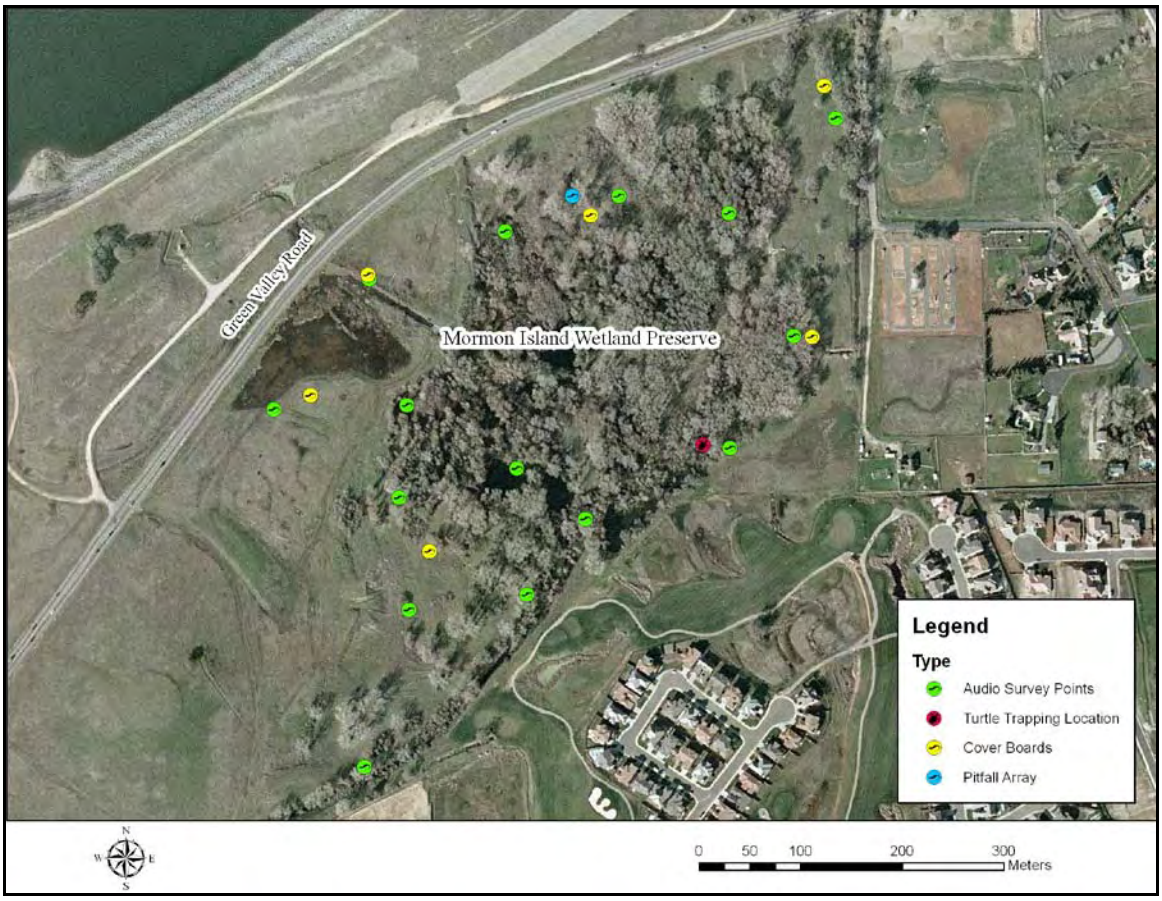


FIGURE 9.—Herpetological survey methodologies and locations in MIWP.

TABLE 2.—Wisconsin frog call index (Paloski et al. 2006).

Index Value	Criteria
1	Individuals can be counted; there is space between calls (no overlapping).
2	Calls of individuals can be distinguished but there is some overlapping of calls.
3	Full chorus. Calls are constant, continuous, and overlapping; individual calls cannot be distinguished.

The visual search portion, conducted concurrently with the audio survey, consisted of walking between audio survey points and searching the ground and vegetation for reptiles and amphibians. Logs, rocks and other debris were also overturned to document fossorial species such as snakes and lizards. In the wet portions of the Preserve, the perimeter of open water areas and adjacent banks and upland habitat were focused upon. Species, location, and activity were recorded for all amphibians and reptiles observed.

In addition to visual and audio surveys and in order to gain additional insight into the herp community present within the Preserve, pitfall trapping and turtle trapping using hoop nets was conducted within the Preserve beginning in 2009. Based on USGS protocol (Fisher et al. 2008), pitfall trap arrays consist of a 30.5-m-long drift fence with the bottom 10 cm buried in the ground. At each end, a 5-gallon bucket is buried centered under the drift fence, and in the middle of the drift fence a funnel trap is placed on either side (Figures 10 and 11). Initially, three arrays were planned for installation in different habitats within the Preserve. Unfortunately, the coarse, rocky nature of the soil in the Preserve prevented installation at all but one site (Figure 9). This array was installed during the second survey and was placed in an open meadow that contains standing water during wet weather. Vegetation consists of grasses, sedges (*Carex* spp.) and rushes (*Juncus* spp.) with an overstory of Fremont cottonwood (*Populus fremontii*), arroyo willow (*Salix lasiolepis*), black willow (*Salix gooddingii*), narrow-leaved willow (*Salix exigua*) and poison oak (*Toxicodendron diversilobium*). This one array was opened for 3 days (approx. 72 hours) during each of the final two herp survey periods in 2009 and was closed by attaching lids to the pitfall traps and removing the funnel traps. Due to the difficulty of installation, standing water conditions (which prevent running of traps) and the small amount of data it provided, pitfall trapping was discontinued in 2010. In lieu of pitfall traps, cover boards (6 – each 32” x 48”) were installed during 2011 within a variety of habitats throughout the preserve in a continued effort to monitor more secretive species. Collection of these data will begin during 2012 surveys.

Turtle trapping was conducted within ponded water on the east side of the Preserve (Figures 10 and 12). Five three-hoop, knotted-nylon turtle traps were located within suitable turtle habitat and baited with canned sardines. Trapping was conducted for

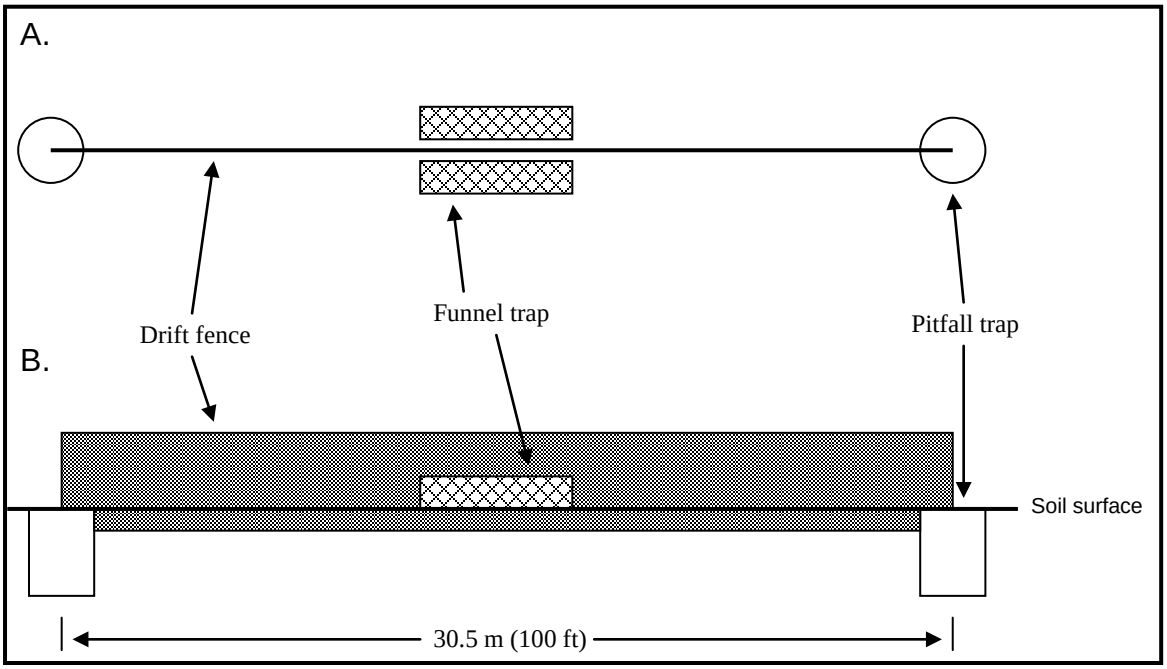


FIGURE 10.—Overhead view (A) and side view (B) of pitfall trap array.

FIGURE 11.—Photo showing habitat at pitfall trap array installed in MIWP during 2009. Funnel traps were not in place at the time of this photo.

FIGURE 12.—Photo of typical turtle trapping habitat within MIWP. Note the three traps in the center of the picture.

3 days (72 hours) during each of the last two survey periods. Traps were checked daily and captured individuals were identified to species and sex, weighed, measured, and individually marked by notching marginal scutes.

Results

Audio Survey

During 2008 audio surveys four species of frogs and toads were documented (Table 3). By far the most abundant, the Pacific treefrog (*Hyla regilla*) was heard exclusively at night calling from wet areas and surrounding vegetation. It was documented within a 60-m radius at 38% (23) of points and at 83% (50) of points outside a 60-m radius during night surveys within the first two survey periods (February 26–27 and April 22–23). Often a full chorus (Wisconsin index 3) was heard. The species was not documented during the third survey period (June 23–24). The second most abundant species was the bullfrog (*Rana catesbeiana*). It was heard only during the third survey period (June 23–25) and was documented outside the 60-m radius at eight points during night surveys and once during the day. Between one and three individuals were heard at these points and it appeared that many times these calls were coming from the adjacent golf course or wet areas on the eastern side of the Preserve. Two toad species were also documented—the western spadefoot and red-spotted toad (*Bufo punctatus*). One western spadefoot was heard calling at night on February 27. One red-spotted toad was heard calling at night on June 23.

During 2009 audio surveys only two species of frogs were documented. Similar to 2008, the Pacific treefrog was by far the most abundant, accounting for 97% of all vocalizations and 100% of vocalizations documented within the 60-m radius. This species was heard almost exclusively at night and only documented during the first two survey periods (March 1–3 and April 26–27). It was documented at 37% of points within the 60-m radius and 90% of points outside the 60-m radius during night surveys within the first two survey periods. The other species documented during call surveys was the bullfrog. Similar to 2008, it was heard only during the third survey period (June 16–17) and was documented at seven points outside the 60-m radius. These detections were always Wisconsin index 1 and were heard on the east side of the Preserve where there is a more permanent water source.

Survey data from 2010 are similar to previous years' data with the exception that only one day and no night surveys were conducted during the second survey period (April) due to weather restrictions. The Pacific treefrog was again the most abundant species documented. It comprised 97% of all calling individuals both within and outside the 60-m radius and, often, a full chorus (Wisconsin index 3) was heard. The species was only heard during the first survey period and rarely during the day. During first period night surveys, it was heard within 60-m at 70% of points and outside 60-m at all points. Two other species were heard during audio surveys in 2010. The bullfrog was heard only during the third survey period and comprised 3% of calling individuals both inside and outside the 60-m radius. Two striped chorus frogs (*Pseudacris triseriata*), a species whose native range does not include California (Stebbins 1985), were heard at different points during the February 24 night survey.

TABLE **3.**—Amphibian and reptile detections at Mormon Island Wetland Preserve – 2008 to 2011.

Species	Status	Method of Detection and Relative Abundance*							
		2008		2009		2010		2011	
		Visual	Audio	Visual	Audio	Visual	Audio	Visual	Audio
Pacific treefrog (adults)	None	Rare	Abundant	Rare	Abundant	Rare	Abundant	Rare	Abundant
Pacific treefrog (larvae)	None	Abundant		Abundant		Abundant		Common	
Striped chorus frog (adults)	None						Rare		
Bullfrog (adults)	None	Rare	Rare	Rare	Rare	Rare	Rare	Rare	Rare
Bullfrog (larvae)	None			Rare				Rare	
Western spadefoot toad (adults)	California Species of Special Concern		Rare						
Red-spotted toad (adults)	None		Rare						
Western toad (adults)	None			Rare					
Western toad (larvae)	None			Uncommon					
Western pond turtle	California Species of Special Concern	Rare		Rare		Rare		Rare	
Common garter snake	None					Rare			
Sharp-tailed snake	None	Rare							
California kingsnake	None							Rare	
Western rattlesnake	None			Rare		Rare		Rare	
Northern alligator lizard	None							Rare	
Western fence lizard	None	Uncommon		Rare		Uncommon		Uncommon	

* Abundant species compose > 75% of detections, common species 25 to 74%, uncommon species 10–24%, and rare species < 10%.

Audio surveys conducted during 2011 only documented two species of frog – Pacific treefrog and bullfrog. Similar to previous years, Pacific treefrog was by far the most abundant, comprising 97 and 99 percent of detections within and outside of 60 meters, respectively. This species was documented at 23 percent of all survey points and 87 percent of survey points during night surveys of the first two survey periods. Bullfrog, a non-native species, was only heard during night surveys in June, presumably due to its inactivity during cooler times of the year.

Comparisons of relative abundance between construction and pre-construction data are difficult due to the irregularity and small sample sizes of most species documented during audio surveys. Mann-Whitney W tests were conducted comparing detections of the most commonly heard species, the pacific treefrog, both inside 60 m and for all detections. Neither test, either detections inside 60 m ($W = 46{,}088.0$, $P = 0.27$) or all detections ($W = 46{,}483.0$, $P = 0.28$), showed a significant difference between preconstruction and construction period data ($\alpha = 0.05$)

Visual Search

Ten species of herpetofauna (three amphibians and seven reptiles) have been recorded during visual searches of the MIWP between 2008 and 2011 (Table 3). Pacific treefrog larvae are typically abundant during all three survey periods in various waterbodies within the Preserve. Numerically they dominate the visual herp observations. Adults are visually observed much more infrequently due to their cryptic, secretive nature (during surveys, any frog/toad encountered out of the water, regardless of stage of metamorphosis, was considered an adult). Bullfrog was the second most regularly observed species of frog/toad. Juvenile bullfrogs were often observed along the ditch on the east side of the preserve adjacent to the golf course. Several larval bullfrogs were observed during April 2009 and 2011 surveys in the same ditch. The western toad (*Bufo boreas*) was the last species of frog/toad observed during visual surveys. Numerous larval and adult toads were observed in June of 2009 in or adjacent to one of the Preserve ponds.

Reptiles, with the exception of the western fence lizard (*Sceloporus occidentalis*), were observed less frequently within the Preserve during the past four years. A population of western pond turtles (a California Species of Special Concern) has been visually confirmed in ponds on the eastern edge of the Preserve during each year of the study. Several individuals were trapped and individually marked during the past three years (see below). The western fence lizard is ubiquitous throughout the Preserve and is observed regularly due to its relatively conspicuous nature. The northern alligator lizard (*Elgaria multicarinata*), a highly secretive species, was observed for the first time during 2011 surveys. Lastly, four species of snake – common garter snake (*Thamnophis sirtalis*), sharp-tailed snake (*Contia tenuis*), California kingsnake (*Lampropeltis getula*) and western rattlesnake (*Crotalus viridis*) – were visually documented within the Preserve, although infrequently.

Pitfall Trap Array

As stated above, due to difficulty of installation and a high water table, only one array was installed in 2009 and its operation was discontinued in 2010. It was opened for a

total of 6 days (approximately 138 hours) during the second and third herp survey periods in 2009. Two adult western toads and two western fence lizards were captured during the June survey period.

Turtle Trapping

Turtle trapping began during the 2009 field season and was conducted during the second two survey periods in 2009, 2010 and 2011. During 2009, trapping was conducted for a total of 29 trap-days (5 traps for 5.8 days). A total of 11 western pond turtles were captured (0.38 per trap day), weighed, measured and individually marked. Eight males and three females were captured and, based on carapace length, all appeared to be adults. During 2010, presumably due to a much colder spring, only four turtles were captured during 28.3 trap-days (0.14 per trap day). One, a 170 millimeter female, was a recapture from 2009. The other three were new adults; two males and a female. No turtles were captured during the April survey period. Weather during 2011 was similar to 2010 – cooler and wet during all herp survey periods – and only two western pond turtles were captured during 26.2 trap days (0.08 per trap day). One immature turtle – the first captured within the Preserve during this study – measured 116 mm carapace length. The other turtle was a 180 mm male. Both were individually marked and released.

Discussion

In total, 13 species of reptiles and amphibians have been documented at MIWP. By far, the species occurring in greatest abundance is the Pacific treefrog. During the first two survey periods, an almost deafening chorus is heard during night surveys and larvae have been documented annually within several Preserve ponds. From year to year, overall abundance fluctuated slightly. This species is highly adaptable and, contrary to its name, is often found on the ground. It occupies springs, ponds, streams, and swamps in a variety of habitats including grassland, woodland, forest, and farmland and will even live in wet recessions among rocks and logs in otherwise dry habitats (Wright 1995, Stebbins 1985). The bullfrog is also regularly documented during surveys in the Preserve, although it is not nearly as abundant as the Pacific treefrog. Adult frogs are seen or heard on a regular basis and larval bullfrogs were documented during 2009 and 2011. This species is not native to California but, in many locations throughout the western U.S., has adversely impacted populations of native species. It is highly aquatic, usually found in or near permanent water. This fact may limit its abundance at MIWP, as many of the wet areas in the Preserve dry out on an annual basis. The last frog species documented is the striped chorus frog. At least one individual was heard during a night audio survey in February 2010. This species is not native west of the Rocky Mountains and was likely a captive release.

Three toad species were documented during surveys, although none have been located since 2009. All life-stages of the western toad were documented during 2009, and this species appears to be the most abundant toad within the Preserve. This species occupies a wide range of habitat types from mountain meadows to lower elevation grasslands and woodlands and is typically found near water (Stebbins 1985). The other two toad species documented were much less abundant. One red-spotted toad was heard calling from a

distance during the third survey period in 2008. It is unclear if this individual was in the Preserve or on the adjacent golf course. This species frequents grassland, scrubland, oak woodlands, and rocky, desert regions near permanent water sources (Stebbins 1985, Behler and King 1979). Its range extends from central Oklahoma and Texas to southeastern California, and it is not typically found north of Inyo County. Thus, it is unknown if this individual represents a range expansion or captive release. One western spadefoot toad, a California Species of Special Concern, was heard calling at night on February 27, 2008. This species tolerates a wide variety of arid conditions and typically prefers shortgrass plains and sandy, gravelly areas favorable for burrowing. Moderately suitable habitat is present within the Preserve. Breeding is highly dependent on rainfall and occurs in slow moving water or temporary pools. Metamorphosis from egg to larvae to adult is rapid (Stebbins 1985, Behler and King 1979). Presumably, this species is not present in great numbers in the Preserve and it is unknown if reproduction is occurring.

Seven reptile species were also documented during surveys. A substantial population of western pond turtles was documented in the ponds on the eastern edge of the Preserve. Also a California Species of Special Concern, this species frequents ponds, lakes, rivers, and quiet waters with significant aquatic vegetation (Stebbins 1985, Behler and King 1979). In our area, it is typically active during the warmer months of the year (approximately February to November). This species is highly aquatic and drying of water bodies in the Preserve may limit its abundance. It is also unclear if reproduction is occurring within the Preserve, as no nesting or young of the year turtles and only one juvenile turtle have been observed, or where these turtles go when the Preserve ponds dry during drier years. The western fence lizard is one of the most common species of lizards in the Western United States. It occurs in a variety of habitats including grassland, chaparral, sagebrush, woodlands, coniferous forests and farmland. Subspecies of the common garter snake occur throughout North America. This species is quite a generalist and occupies a wide array of habitats, although they are most often found in proximity to a water source. The sharp-tailed snake frequents grasslands, woodlands and chaparral and can often be found in oak woodlands near water courses. It is a secretive snake usually found under logs, rocks or other debris. The California kingsnake, a subspecies of the common kingsnake, is a constrictor that inhabits primarily open areas including grasslands and weedy areas but also uses woods, shrublands and riparian areas. It feeds on a variety of prey including amphibians, lizards, small mammals and other snakes, including rattlesnakes to whose venom they are immune. Lastly, subspecies of the western rattlesnake are widespread throughout the Western United States. The subspecies occurring in our study area, the northern Pacific rattlesnake (*C. v. oreganus*), ranges from central California through Oregon and Washington and into southern British Columbia. It inhabits a wide array of habitats including grasslands and oak woodlands. Individuals observed in the Preserve were seen in tall grass adjacent to apparent burrows and may be overwintering nearby.

Two California Species of Special Concern have been documented in the Preserve since herp surveys began in 2008. One of these, the western pond turtle, apparently maintains a viable population within ponds on the Preserve although, as stated above, capture rates decreased greatly from 2009 to 2010 and 2011. This is likely due to reduced activity caused by cooler, wetter weather (Figure 13) as opposed to a reduction in population

within the Preserve. Any decrease in water supply to the Preserve could impact the persistence of this population and monitoring will potentially detect any impacts. The other documented Species of Special Concern, the western spadefoot toad, was heard calling during one night audio survey in 2008. As of yet a population has not been documented within the Preserve and it seems unlikely that one will be discovered in the future.

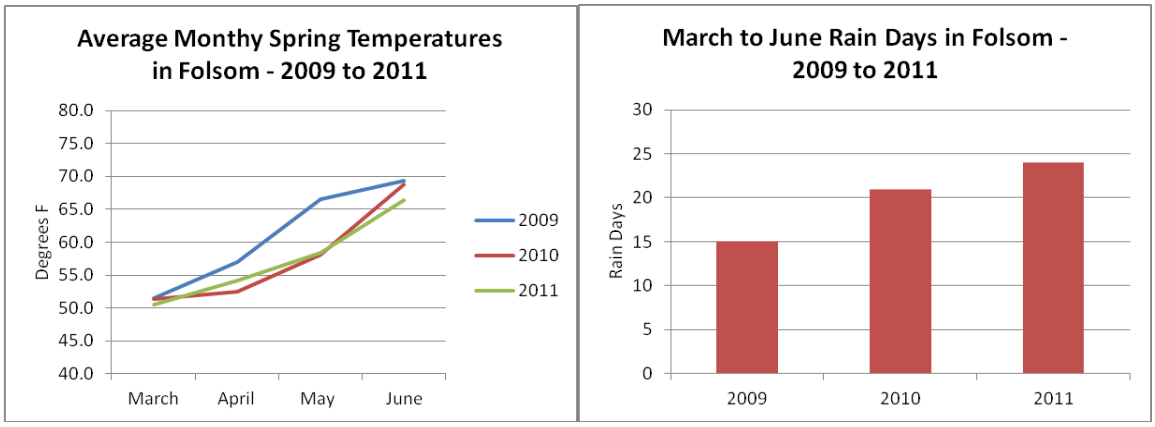


FIGURE **13.**—Average monthly temperature and number of rain days during turtle trapping at Folsom, California.

Conclusions

Data collected within the Preserve between 2008 and 2010 provided a baseline of herpetological species richness and relative abundance. These data are then compared to subsequent years in order to assess any impacts to the herp community due to construction activities at MIAD. After one year of construction period sampling, determination of construction impacts is difficult based on the irregularity of detections of many species and the small sample sizes collected. Currently, it appears that the herp community within the Preserve has not been significantly impacted. Future surveys, in conjunction with the other studies conducted concurrently within the Preserve, will either bolster or refute these assertions.

During surveys a variety of species have been documented and, while common species are regularly heard and/or seen, other species have been located sporadically during certain years. Abundance of even common species has varied between years, most likely based on environmental conditions including ambient temperatures, cloud cover and presence and amount of water present during individual surveys. It is assumed that the variety of sampling methodologies conducted will document a majority of species occurring within the Preserve and give at least an index of abundance of common species. Audio and visual surveys compiled a partial list of species occurring on the Preserve and audio surveys will provide an index of relative abundance against which future frog audio surveys can be compared. Turtle trapping confirmed the presence of a population of western pond turtles. These data, in conjunction with future monitoring efforts including the cover boards installed in 2011, will continue to assess any impacts from construction activities at MIAD.

Vegetation Monitoring

Introduction

Construction activities in the watershed above and adjacent to MIWP could have potential impacts to the vegetative communities by altering the hydrology. Three years of baseline data were collected within the project area prior to major construction impacts. In 2011, modifications to MIAD began and this was the first year monitoring was conducted while construction activities occurred. Vegetation monitoring will continue during construction and as required in the environmental commitments section of the EIS post-construction to determine if the operations have had an impact (positive or negative) on the vegetative communities at MIWP.

Methods

A description and overall map of the vegetation communities on site were developed using digital aerial photography and ground-truthed as necessary. The standard for vegetation classification was Sawyer and Keeler-Wolf (1995). Data were collected in May from 2008 through 2011.

Vegetative cover was measured along 15 permanent transects located in representative community types (Figure 14). Two transects (B1 and B2) were located in an emergent wetland. The remaining 13 transects were located in a cottonwood/willow riparian woodland.

For understory measurements, the point-intercept method was used along each of the 50 m transects. This entailed dropping a pin at every 0.5 m along the tape and recording the first "hit" for herbaceous plant species and for woody species under 1 m tall (Figure 15). Bare soil, water, or litter was recorded if a plant was not intercepted by the pin. This method provided an estimate of percent cover by species for the herbaceous layer.

The overstory mid-canopy shrub/tree layer was measured along each transect using the line-intercept method. The point along the transect where overstory canopy above the tape began and the point at which it ended for each woody species over a meter and under 12.2 m (40 ft) tall was noted. The length of each transect covered by each species was then totaled and used to calculate percent cover per species. Because species overlapped in some cases, the sum of the cover for all species did not necessarily reflect the actual percentage of overstory cover along the tape. The percentage of the tape covered by overstory was also calculated for each transect.

Canopy cover was also estimated using a densiometer by taking four readings – two at each direction parallel to the transect and two at each direction perpendicular to the transect- at each end of the transect and at the 25 m point. The 4 readings at each point

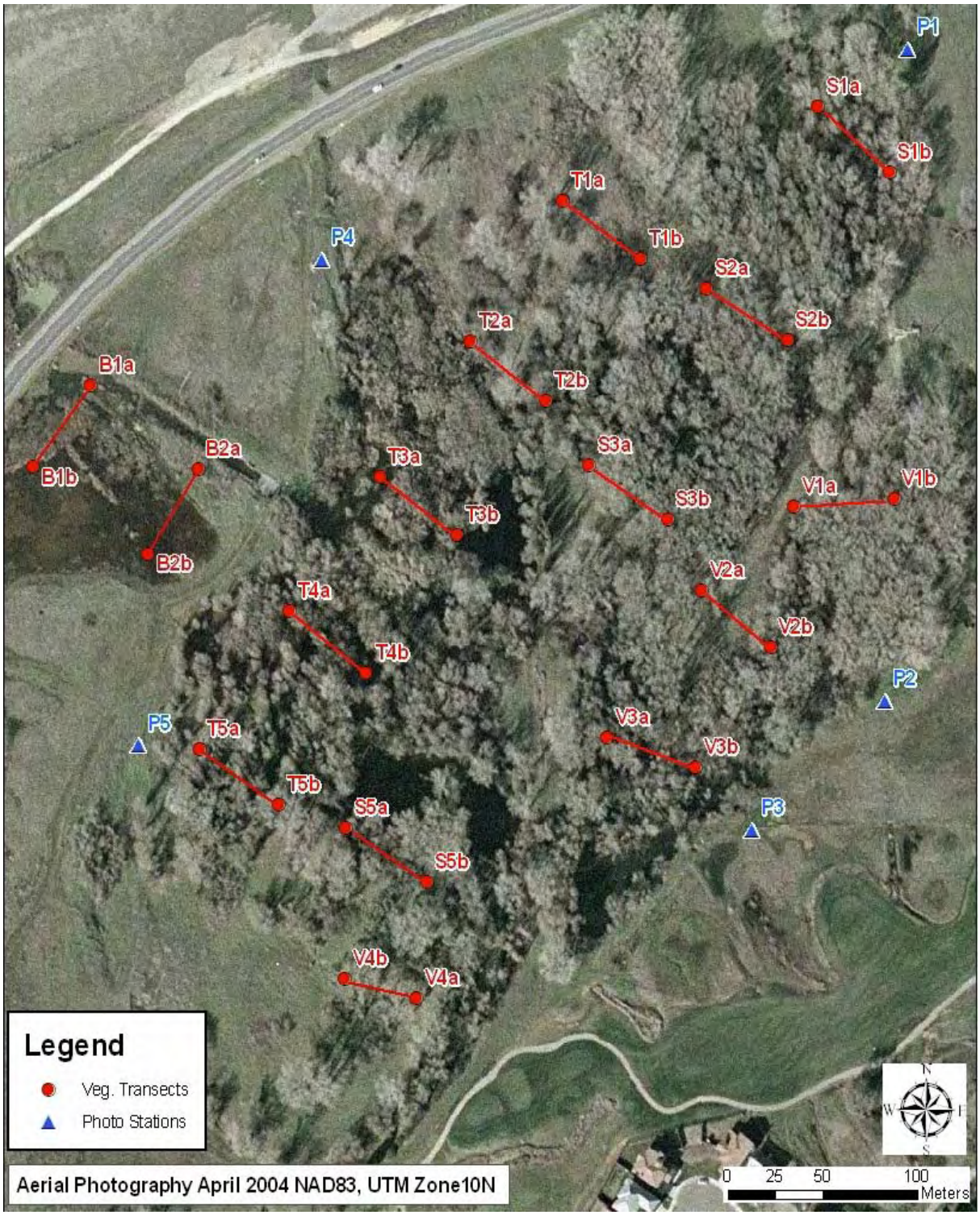


FIGURE 14.—Vegetation transects and photo stations at MIWP.

FIGURE 15.—Measuring understory vegetation by dropping a pin every 0.5 m along the transect tape and recording the plant species, litter, bare soil, or water that was intercepted; MIWP.

were averaged to get one value per point, or 3 values per transect, which were averaged to get an estimate of the mean percent canopy cover for each transect.

Prism plots were established at each end of forested transects to measure the density and size class of trees (Figure 16). BAF (basal area factor) 5 or 10 sized prisms were used depending on the size of trees within the plot, and DBH (diameter at breast height) was measured for each tree determined to be in the plot. For trees that forked below breast height level, each fork was measured at breast height (i.e. 4.5 ft) above the fork (not above the ground).

Cover and density data from the cottonwood/willow riparian area were compared between sampling periods to evaluate any statistically significant changes in vegetation over time. Data from 2008 through 2010 were baseline (*i.e.* pre-project) as compared to data from 2011, which were collected during the first year of the project. ANOVA and the paired t-test were used to statistically compare normally distributed data, and the Kruskall-Wallace and the signed rank nonparametric tests were used to compare data that were not normally distributed. An alpha of 0.05 was used to determine statistical significance. There were not enough samples (n=2) within the emergent wetland to provide a valid sample size for statistical analysis.

Permanent photo points were also established at both ends of each transect and throughout the study area to visually document vegetation height, density, species composition and overall site development. See Figure 14 for photo point locations.

FIGURE 16.—Estimating tree density using optical prisms at each end of transects; MIWP.

Results

The vegetation map of the site is shown in Figure 17. Seven dominant vegetation cover types were delineated and classified as Cattail emergent, Narrowleaf willow, Goodding's willow, Cottonwood/Arroyo Willow, Cottonwood/Goodding's willow, Cottonwood/ Goodding's willow/Narrowleaf willow/Arroyo willow, and Upland. For discussion and analyses purposes, two vegetation communities were evaluated. The cattail emergent cover type was treated as one community, referred to here as "Emergent wetland" and data from five cover types were grouped into the "Cottonwood/willow riparian woodland" community. No transects were located within the Upland cover type. The number of transects within each cover type is shown in Table 4.

Fifty-seven annual and perennial plant species were detected in all methods of understory and overstory measurements while monitoring the 15 transects over 4 years (Table 5).

Emergent Wetland

The percentage of total and relative plant cover by lifeform in the herbaceous (*i.e.* understory) layer for the emergent wetland are shown in Table 6. The total percent cover of all variables was similar from 2008 to 2010; however in 2011 there were considerable

FIGURE 17.—Dominant vegetation cover types; MIWP.

TABLE 4.—The number of transects within each vegetation cover type; MIWP.

Cover type	Number of transects
Cattail emergent	2
Narrowleaf willow	2
Goodding's willow	2
Cottonwood/Arroyo willow	4
Cottonwood/Goodding's willow	2
Cottonwood/Goodding's willow/Narrowleaf willow/Arroyo willow	3
Upland	0

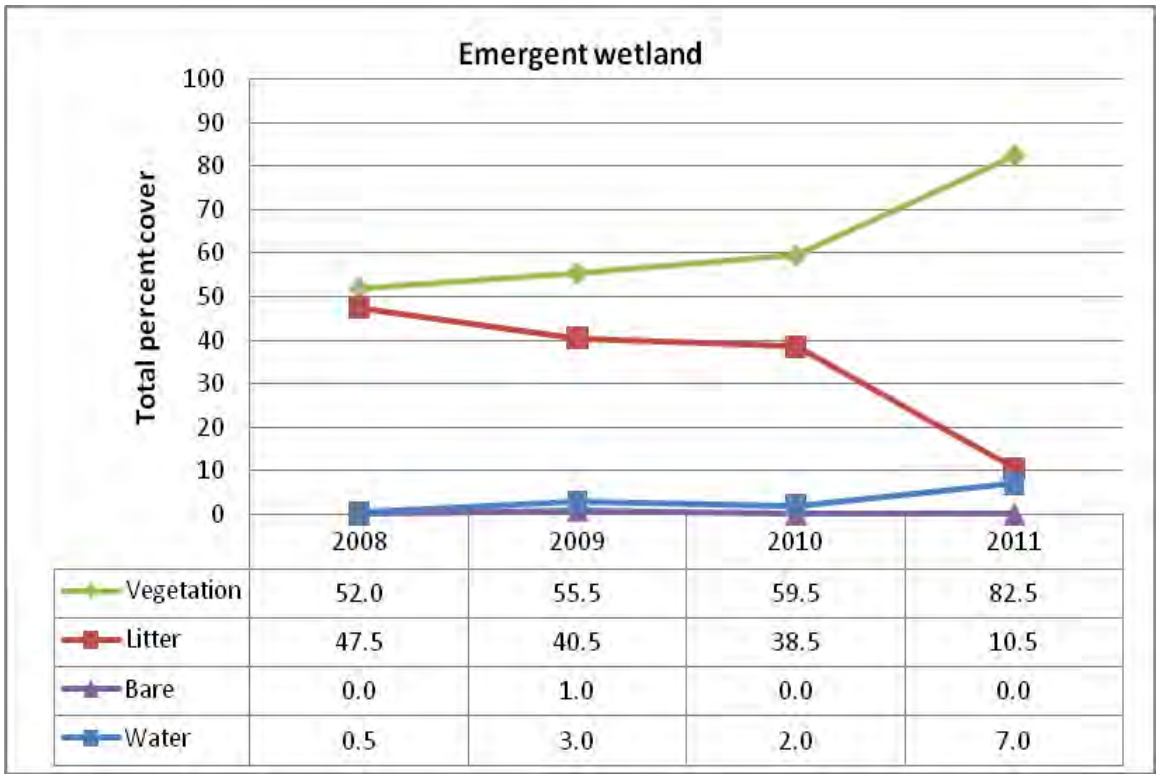
TABLE 5.—Plant list including species code, scientific and common names, and introduced or native status for all species detected; MIWP.

	Code	Scientific Name	Common Name	Intro/Nat
Trees/Shrubs	BAPI	*Baccharis piluaris*	Coyote bush	N
	FICA	*Ficus carica*	Common fig	I
	PINI	*Pinus nigra*	Austrian pine	I
	PISA	*Pinus sabiniana*	Gray pine	N
	POFR	*Populus fremontii*	Fremont's cottonwood	N
	PYAN	*Pyracantha angustifolia*	Firethorn	I
	QUDO	*Quercus douglasii*	Blue oak	N
	QUWI	*Quercus wislizenii*	Interior live oak	N
	SAEX	*Salix exigua*	Narrow-leaved willow	N
	SAGO	*Salix gooddingii*	Goodding's black willow	N
	SALA	*Salix lasiolepis*	Arroyo willow	N
	TODI	*Toxicodendron diversilobium*	Poison oak	N
Grasses/ Grass-like	AGAV	*Agrostis avenaceae*	Pacific bentgrass	I
	BRDI	*Bromus diandrus*	Ripgut brome	I
	BRIN	*Bromus inermis*	Smooth brome	I
	BRMA	*Bromus madritensis*	Foxtail chess	I
	BRSE	*Bromus secalinus*	Rye brome	I
	CAPR	*Carex praegracilis*	Clustered field sedge	N
	CATU	*Carex tumulicola*	Foothill sedge	N
	ELAC	*Eleocharis acicularis*	Needle spikerush	N
	ELMA	*Eleocharis macrostachya*	Pale spikerush	N
	ELGL	*Elymus glaucus*	Blue wildrye	N
	LOMU	*Lolium multiflorum*	Italian ryegrass	I
	JUBA	*Juncus balticus*	Baltic rush	N
	MUSP	*Muhlenbergia* sp	Muhly	
	NALE	*Nasella lepida*	Foothill needlegrass	N
	POMA	*Polypogon maritimus*	Beardgrass	I
	POMO	*Polypogon monspeliensis*	Rabbitsfoot grass	I
	POPR	*Poa pratensis*	Kentucky bluegrass	N
	SCAC	*Scirpus acutus*	Common tule	N
	SCCE	*Scirpus cernuus*	Annual tule	N
	TACA	*Taeniatherum caput-medusae*	Medusahead	I
	TYLA	*Typha latifolia*	Broad-leaf cattail	N
	VUMY	*Vulpia myuros*	Rat-tail fescue	I
Forbs	ANCA	*Anthriscus caucalis*	Bur-chervil	I
	ASSP	*Asclepias* sp.	Milkweed	N
	AZFI	*Azolla filiculoides*	Pacific mosquitofern	N
	CIAR	*Circium arvense*	Canada thistle	I
	GAAP	*Galium aparine*	Goose grass	N
	GEDI	*Geranium dissectum*	Cutleaf geranium	I
	EPCI	*Epilobium cilatum*	Willow herb	N
	HISP	*Hieracium* sp.	Hawkweed	
	HOSP	*Horkelia* sp.	Horkelia	N
	HYMU	*Hypericum mutilum*	Dwarf St. John's wort	N
	LACE	*Lactuca serriola*	Prickly lettuce	I
	LEMI	*Lemna minor*	Common duckweed	N
	LUPE	*Ludwigia peploides*	Water primrose	N
	MEAR	*Mentha arvensis*	Wild mint	N
	POLA	*Polygonum lapathifolium*	Pale smartweed	N
	RUCO	*Rumex conglomeratus*	Clustered dock	I
	RUDI	*Rubus discolor*	Himalayan blackberry	I
	SIMA	*Silybum marianum*	Milk thistle	I
	SOOL	*Sonchus oleraceus*	Common sowthistle	I
	TRSP	*Trifolium pratense*	Red clover	I
	VICA	*Vitis californica*	California wild grape	N
	VIVI	*Vicia villosa*	Hairy vetch	I
	XAST	*Xanthium strumarium*	Cocklebur	N

TABLE 6.—Total and relative percent cover of individual plant species detected in the herbaceous layer of transects in the emergent wetland; MIWP.

Emergent wetland	2008		2009		2010		2011	
	Total percent cover	Relative percent cover	Total percent cover	Relative percent cover	Total percent cover	Relative percent cover	Total percent cover	Relative percent cover
Narrow-leaved willow	0.5	1.0	0.5	0.9	0.0	0.0	1.0	1.2
Total native shrubs	0.5	1.0	0.5	0.9	0.0	0.0	1.0	1.2
Foothill sedge	1.0	1.9	0.0	0.0	0.5	0.8	0.5	0.6
Pale spikerush	3.5	6.7	4.0	7.2	7.0	11.9	10.5	12.8
Blue wildrye	0.5	1.0	1.5	2.7	0.0	0.0	0.5	0.6
Baltic rush	20.0	38.5	16.5	29.8	16.0	27.0	35.5	43.0
Broadleaf cattail	7.5	14.4	5.0	9.0	11.0	18.6	6.5	7.9
Muhlenbergia	0.0	0.0	0.0	0.0	0.5	0.8	0.0	0.0
Total native grasses	32.5	62.5	27.0	48.7	35.0	59.1	53.5	64.9
Pacific bentgrass	3.0	5.8	4.0	7.2	1.5	2.5	1.5	1.8
Ripgut brome	3.5	6.7	0.0	0.0	0.0	0.0	4.5	5.5
Foxtail chess	0.0	0.0	3.0	5.4	1.5	2.5	1.0	1.2
Rye brome	0.0	0.0	2.0	3.6	0.5	0.8	0.0	0.0
Italian ryegrass	1.5	2.9	0.0	0.0	0.5	0.8	0.0	0.0
Beardgrass	1.0	1.9	0.5	0.9	1.5	2.5	0.0	0.0
Medusa head	1.0	1.9	0.0	0.0	0.0	0.0	1.5	1.8
Rat-tail fescue	1.5	2.9	8.0	14.4	14.0	23.5	5.5	6.7
Smooth brome	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6
Total introduced grasses	11.5	22.1	17.5	31.5	19.5	32.6	14.5	17.6
Willow herb	0.5	1.0	1.0	1.8	1.5	2.5	1.0	1.2
Hawkweed	0.5	1.0	3.5	6.3	0.0	0.0	0.0	0.0
Horkelia	0.0	0.0	0.0	0.0	0.5	0.8	0.0	0.0
Common duckweed	0.0	0.0	1.5	2.7	0.0	0.0	1.0	1.2
Water primrose	1.5	2.8	0.0	0.0	0.0	0.0	5.5	6.7
Pale smartweed	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.2
Pacific mosquitofern	0.0	0.0	0.0	0.0	0.0	0.0	3.5	4.2
Total native forbs	2.5	4.8	6.0	10.8	2.0	3.3	12.0	14.5
Cutleaf geranium	0.0	0.0	0.5	0.9	0.0	0.0	0.0	0.0
Prickly lettuce	0.0	0.0	1.5	2.7	0.0	0.0	0.0	0.0
Clustered dock	0.0	0.0	1.0	1.8	0.0	0.0	0.0	0.0
Common sowthistle	0.5	1.0	0.5	0.9	0.0	0.0	0.0	0.0
Red clover	0.0	0.0	0.5	0.9	0.0	0.0	1.0	1.2
Hairy vetch	4.5	8.6	0.5	0.9	0.0	0.0	0.0	0.0
Canada thistle	0.0	0.0	0.0	0.0	3.0	5.0	0.5	0.6
Total introduced forbs	5.0	9.6	4.5	8.1	3.0	5.0	1.5	1.8
Total vegetation	52.0	100.0	55.5	100.0	59.5	100.0	82.5	100.0
Total litter	47.5		40.5		38.5		10.5	
Total bare/rock	0.0		1.0		0.0		0.0	
Total water/algae	0.5		3.0		2.0		7.0	
TOTAL COVER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

increases in vegetation cover while litter cover decreased (Figure 18). Total cover of vegetation increased slightly from 52.0 percent in 2008 to 59.5 percent in 2010. In 2011, total vegetation cover increased to 82.5 percent. Total cover of litter slightly decreased from 47.5 percent in 2008 to 38.5 percent in 2010. In 2011, the total cover of litter fell to 10.5 percent. Total cover of bare ground remained at 0.0 percent from 2008 to 2011 and total percent cover of water increased negligibly from 0.5 in 2008 to 2.0 in 2010 but had a greater increase to 7.0 percent in 2011.

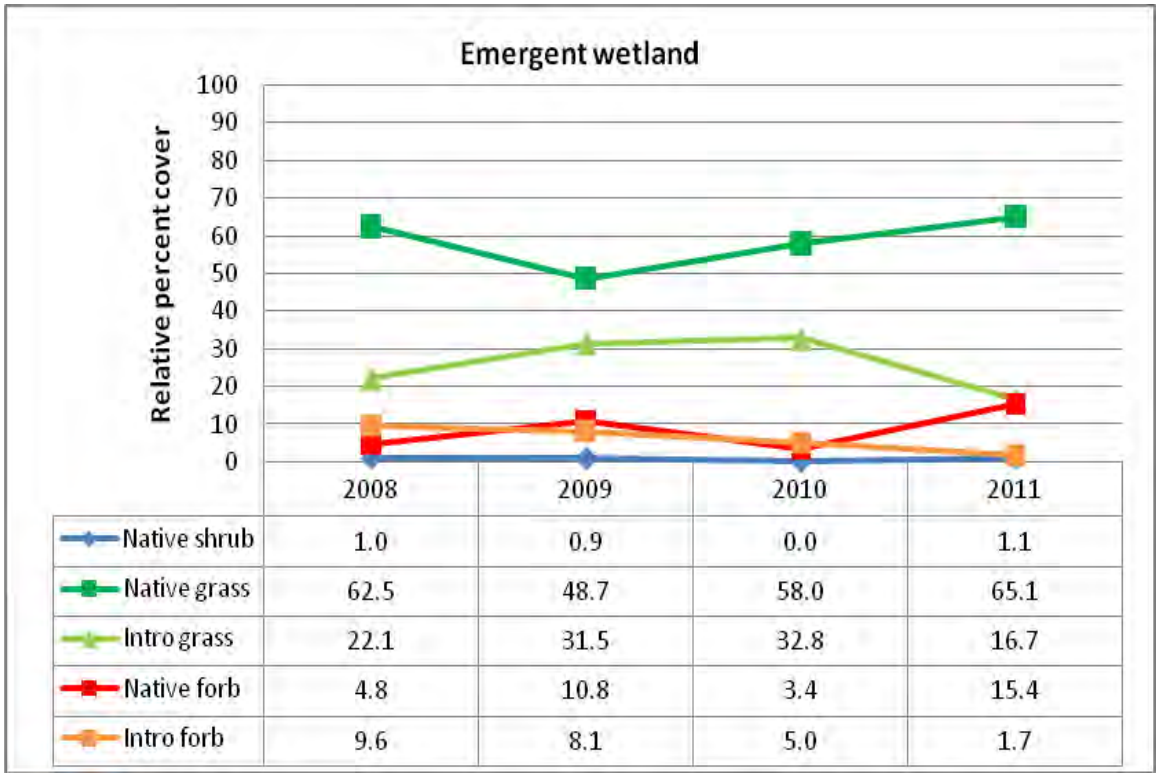


	2008	2009	2010	2011
Vegetation	52.0	55.5	59.5	82.5
Litter	47.5	40.5	38.5	10.5
Bare	0.0	1.0	0.0	0.0
Water	0.5	3.0	2.0	7.0

FIGURE 18.— Total percent cover of herbaceous vegetation, litter, bare ground, and water in the emergent wetland from 2008 to 2011; MIWP.

Narrow-leaved willow was the only tree/shrub detected in the herbaceous layer of this vegetation community with low cover in all years. The most common grasses or grass-like species based on percent cover were Baltic rush and broadleaf cattail in 2008, Baltic rush and rat-tail fescue in both 2009 and 2010, and Baltic rush and pale spikerush in 2011. The most common forb species were hairy vetch and water primrose in 2008, hawkweed, common duckweed, and prickly lettuce in 2009, Canada thistle and willow herb in 2010, and water primrose and Pacific mosquitofern in 2011.

The most common plant types relative to other lifeforms in the emergent wetland were native and introduced grasses in all years (Figure 19). Relative cover of native grasses decreased from 62.5 percent in 2008 to 48.7 percent in 2009, but increased to 65.1 percent by 2011. Relative cover of introduced grasses increased from 22.1 percent in 2008 to 32.8 percent in 2010, but decreased substantially to 16.7 in 2011, for an overall



	2008	2009	2010	2011
Native shrub	1.0	0.9	0.0	1.1
Native grass	62.5	48.7	58.0	65.1
Intro grass	22.1	31.5	32.8	16.7
Native forb	4.8	10.8	3.4	15.4
Intro forb	9.6	8.1	5.0	1.7

FIGURE **19.**— Relative percent cover of herbaceous vegetation by lifeform in the emergent wetland from 2008 to 2011; MIWP.

decrease during the monitoring period (Figure 19). Native species were more abundant than introduced, with a relative cover of 68.3 percent in 2008, 60.4 percent in 2009, 62.2 percent in 2010, and 80.6 percent in 2011 for all native plant species detected in the herbaceous layer within the emergent wetland.

The relatively large increase in total vegetative cover and corresponding drop in litter cover in 2011 may have been due to increased precipitation this year compared to the other years monitoring was conducted (Figure 20), also demonstrated by an increase in total cover of water in the monitoring plots. An increased water table may also have affected the composition of species in the emergent wetland. Cover of native species increased in 2011, while introduced species decreased. The decline in introduced species could be attributed to their inability to adapt to wetter conditions. The rise in cover of native riparian species was presumably because they are more tolerant of anaerobic conditions and because of less competition from exotic species. The dominant herbaceous species detected in 2011 (*i.e.* Baltic rush, pale spikerush, water primrose, and Pacific mosquitofern) were all natives and are all considered “obligate” wetland indicators in California, which means they almost always occur (estimated probability >99%) in wetlands under natural conditions (Reed 1988).

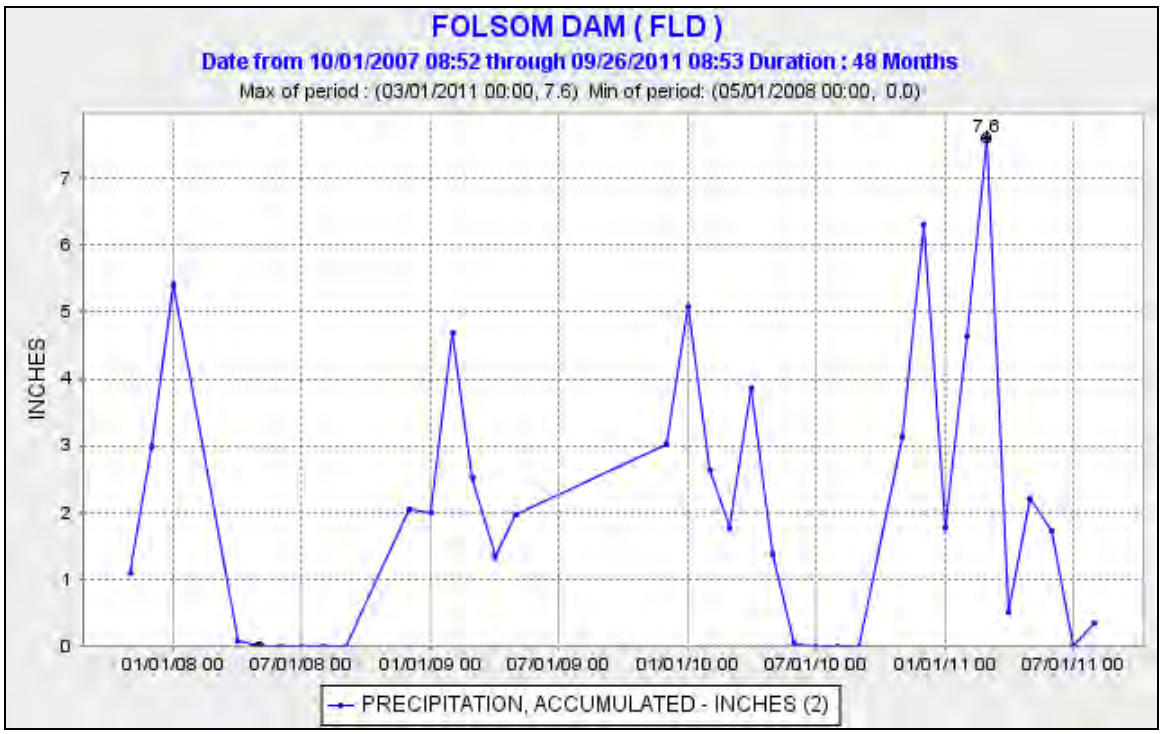


FIGURE 20.—Monthly precipitation at Folsom Dam. Source: California Department of Water Resources.

In the emergent wetland, narrow-leaved willow was the only overstory species recorded until 2011, when coyote bush was also detected. Both species were located at one end of one transect, for an average percent cover of 4.6 percent in 2008, 3.3 percent in 2009, 5.0 percent in 2010, and 10.3 percent in 2011 (Table 7). The average percent canopy cover as measured with a densiometer was 14 percent in 2008 and 2009, 15 percent in 2010, and 17 percent in 2011 (Table 8).

Trees within the emergent wetland vegetation type were not determined to be large enough to fall into prism plots for density measurements.

TABLE 7.— Percent cover of woody overstory < 12.2 m (40 ft) for the emergent wetland from 2008 to 2011; MIWP.

	Narrow-leaved willow				Coyote bush				Total			
Transect	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**	**2008**	**2009**	**2010**	**2011**
B1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B2	9.2	6.6	10.0	16.8	0.0	0.0	0.0	3.8	9.2	6.6	10.0	20.6
AVG	**4.6**	**3.3**	**5.0**	**8.4**	**0.0**	**0.0**	**0.0**	**1.9**	**4.6**	**3.3**	**5.0**	**10.3**

TABLE 8.—Average percent canopy cover of 3 points along each transect and total average percent canopy in the emergent wetland from 2008 to 2011; MIWP.

Year	Point	Transect		Transect Avg
		B1	B2	
2008	Point A Avg	0	82	
	Midpoint Avg	0	0	
	Point B Avg	0	0	
	Total Avg	0	28	14
2009	Point A Avg	0	84	
	Midpoint Avg	0	0	
	Point B Avg	0	0	
	Total Avg	0	28	14
2010	Point A Avg	0	88	
	Midpoint Avg	0	0	
	Point B Avg	0	0	
	Total Avg	0	30	15
2011	Point A Avg	0	98	
	Midpoint Avg	0	0	
	Point B Avg	0	0	
	Total Avg	0	33	17

Cottonwood/willow Riparian Woodland

The total and relative percentage of plant cover by lifeform in the herbaceous (*i.e.* understory) layer for the cottonwood/willow riparian woodland are shown in Table 9. Total cover of herbaceous vegetation increased significantly over the monitoring period (P=0.013) from 47.8 percent in 2008 to 55.7 percent in 2011 (Figure 21). In turn, total cover of litter decreased significantly from 49.9 percent in 2008 to 26.4 percent in 2011 (P=0.002). Total cover of bare ground was statistically equal over the study period, slightly decreasing from 1.5 percent to 0.1 percent. Finally, total cover of water significantly increased from 0.8 percent in 2008 to 17.8 percent in 2011 (P=0.014).

The most common shrub less than 1 m height in this vegetation community was narrow-leaved willow. Baltic rush and clustered field sedge were the most common grass and grass-like species in all years. The most common forb species in the cottonwood/willow riparian woodland were Himalayan blackberry and California grape in 2008 and 2011, Himalayan blackberry and bur-chervil in 2009, and Himalayan blackberry and Canada thistle in 2010. Himalayan blackberry, which was one of the most widespread plants detected within the MIWP, is an exotic species that is given an overall rating of “high” in the California Invasive Plant Inventory (Cal-IPC 2006-2011). This classification means that the species has severe ecological impacts. Himalayan blackberry should continue to be monitored closely to determine what effects, if any, the project has on the growth patterns of this species.

TABLE 9.—Total and relative percent cover of individual plant species detected in the herbaceous layer of transects in the Cottonwood/willow riparian woodland; MIWP.

Cottonwood/willow riparian	2008		2009		2010		2011	
	% total cover	% relative cover	% total cover	% relative cover	% total cover	% relative cover	% total cover	% relative cover
Narrow-leaved willow	0.1	0.2	0.0	0.0	0.0	0.0	0.5	0.9
Goodding black willow	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Poison oak	1.0	2.0	0.3	0.5	0.1	0.2	0.2	0.4
Blue oak	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Total native shrubs	1.2	2.4	0.3	0.5	0.1	0.2	0.7	1.3
Clustered field sedge	9.2	19.3	10.8	20.4	9.3	18.2	13.0	23.4
Foothill sedge	0.2	0.5	0.3	0.6	0.5	0.9	0.1	0.1
Needle spikerush	0.1	0.2	0.0	0.0	0.1	0.2	0.0	0.0
Pale spikerush	0.0	0.0	0.3	0.6	0.3	0.6	0.6	1.1
Blue wildrye	0.0	0.0	1.5	2.7	0.0	0.0	0.0	0.0
Baltic rush	14.8	31.0	15.4	29.1	15.0	29.5	15.2	27.4
Foothill needlegrass	2.3	4.8	2.4	4.6	3.3	6.5	2.2	4.0
Kentucky bluegrass	0.2	0.3	0.0	0.0	0.1	0.2	0.0	0.0
Common tule	0.0	0.0	0.2	0.4	0.0	0.0	0.1	0.1
Annual tule	1.9	4.0	1.0	1.7	1.6	3.2	2.0	3.6
Total native grasses	28.7	60.1	31.9	60.1	30.2	59.3	33.2	59.7
Ripgut brome	0.8	1.7	0.5	1.0	0.3	0.6	0.9	1.7
Smooth brome	0.0	0.0	0.1	0.2	0.2	0.4	0.1	0.1
Foxtail chess	0.3	0.6	1.0	1.7	0.5	1.0	1.2	2.2
Rye brome	0.3	0.6	0.4	0.8	0.4	0.8	0.1	0.1
Italian ryegrass	0.1	0.3	0.6	1.1	0.2	0.4	0.5	0.9
Rabbitsfoot grass	0.0	0.0	1.0	2.0	0.9	1.8	0.0	0.0
Medusa head	0.0	0.0	0.1	0.2	0.2	0.4	0.0	0.0
Total introduced grasses	1.5	3.2	3.7	7.0	2.7	5.4	2.8	5.0
Milkweed	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.4
Goose grass	0.2	0.3	0.5	1.0	0.2	0.3	0.6	1.1
Horkelia	0.6	1.3	1.0	1.7	0.4	0.8	0.6	1.1
Wild mint	0.2	0.5	0.3	0.5	0.0	0.0	0.2	0.4
California wild grape	0.7	1.5	0.5	1.0	0.1	0.2	0.9	1.7
Cocklebur	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.1
Pale smartweed	0.0	0.0	0.0	0.0	0.1	0.2	0.8	1.4
Water primrose	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Common duckweed	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Dwarf St. John's wort	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
Total native forbs	1.7	3.6	2.5	4.5	1.0	1.9	3.6	6.5
Bur-chervil	0.1	0.2	1.2	2.3	0.5	0.9	0.8	1.4
Canada thistle	0.1	0.2	0.3	0.5	1.2	2.3	0.2	0.4
Cutleaf geranium	0.4	0.8	0.6	1.1	0.7	1.4	0.6	1.1
Prickly lettuce	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.0
Clustered dock	0.2	0.3	0.3	0.6	0.0	0.0	0.3	0.6
Himalayan blackberry	13.7	28.8	11.3	21.4	14.4	28.2	13.2	23.7
Common sowthistle	0.1	0.2	0.2	0.4	0.0	0.0	0.1	0.1
Red clover	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.1
Hairy vetch	0.0	0.0	0.7	1.4	0.0	0.0	0.1	0.1
Milk thistle	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0
Total introduced forbs	14.7	30.7	14.8	27.9	17.0	33.2	15.4	27.5
Total vegetation	47.8	100.0	53.2	100.0	51.0	100.0	55.7	100.0
Total litter	49.9		34.3		36.6		26.4	
Total bare/rock	1.5		0.1		0.2		0.1	
Total water/algae	0.8		12.4		12.2		17.8	
TOTAL COVER	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

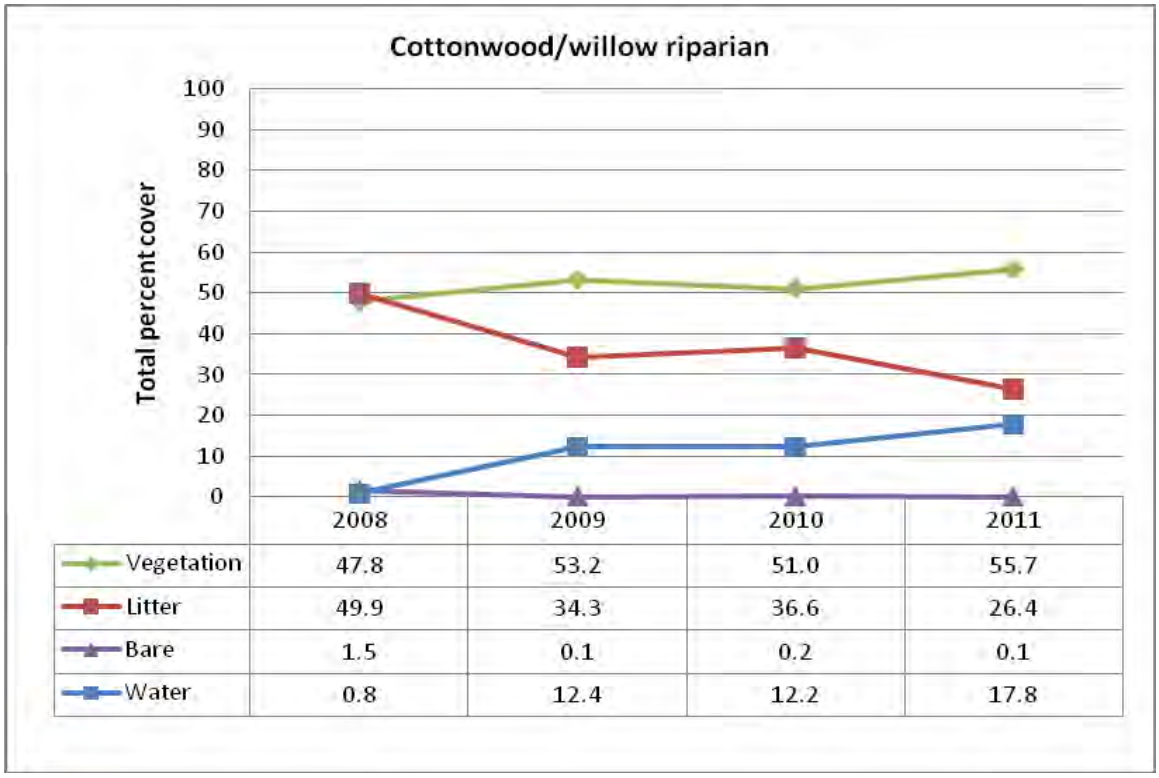


FIGURE 21.—Total percent cover of herbaceous vegetation, litter, bare ground, and water in the cottonwood/willow riparian woodland from 2008 to 2011; MIWP.

Native grasses and introduced forbs were the most common lifeforms in all years based on percent relative cover (Figure 22). Native grasses showed essentially no change among years (P=0.969), varying from a low of 58.2 percent relative cover in 2008 to a high of 60.1 percent in 2009. The relative cover of introduced forbs also changed very little (P=0.946), varying from 27.5 percent in 2011 to 33.0 percent in 2010. Native species were more abundant relative to introduced species, with a relative cover of 66.1 percent in 2008, 65.1 percent in 2009, 61.4 percent in 2010, and 67.6 percent in 2011 for all native plant species detected in the herbaceous layer within the cottonwood/willow riparian woodland. Statistically there was no change, although close, in the total percent cover of native species over the monitoring period, which increased from 31.7 percent in 2008 to 37.5 percent in 2011 (P=0.051; Figure 23). There was not a significant difference (P=0.384) in the total percent cover of introduced plant species from 2008 to 2011. Introduced species increased in total cover from 16.1 percent in 2008 to 18.0 percent in 2011.

Table 10 shows the percent cover of shrubs and trees in the mid-canopy overstory layer by individual species and by total cover for the entire transect. The frequency, *i.e.* the percentage of transects in which each species was detected, is also provided. The total percent cover was not always the sum of all individual species since there may have been some overlap in the cover of individual trees less than 12.2 m (40 ft) tall. The most common mid-canopy overstory species within the cottonwood/willow riparian woodland (based on average percent cover per transect and frequency in transects) were the three

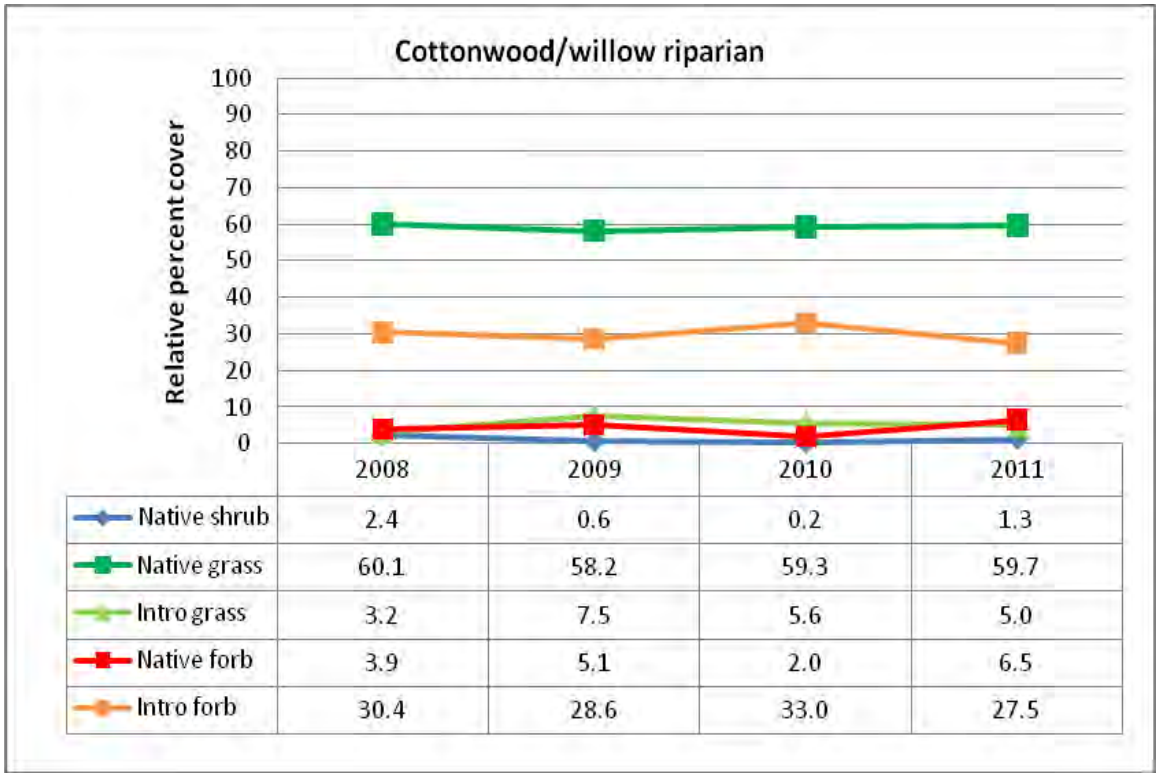


FIGURE 22. Relative percent cover of herbaceous vegetation by lifeform in the cottonwood/willow riparian woodland from 2008 to 2011; MIWP.

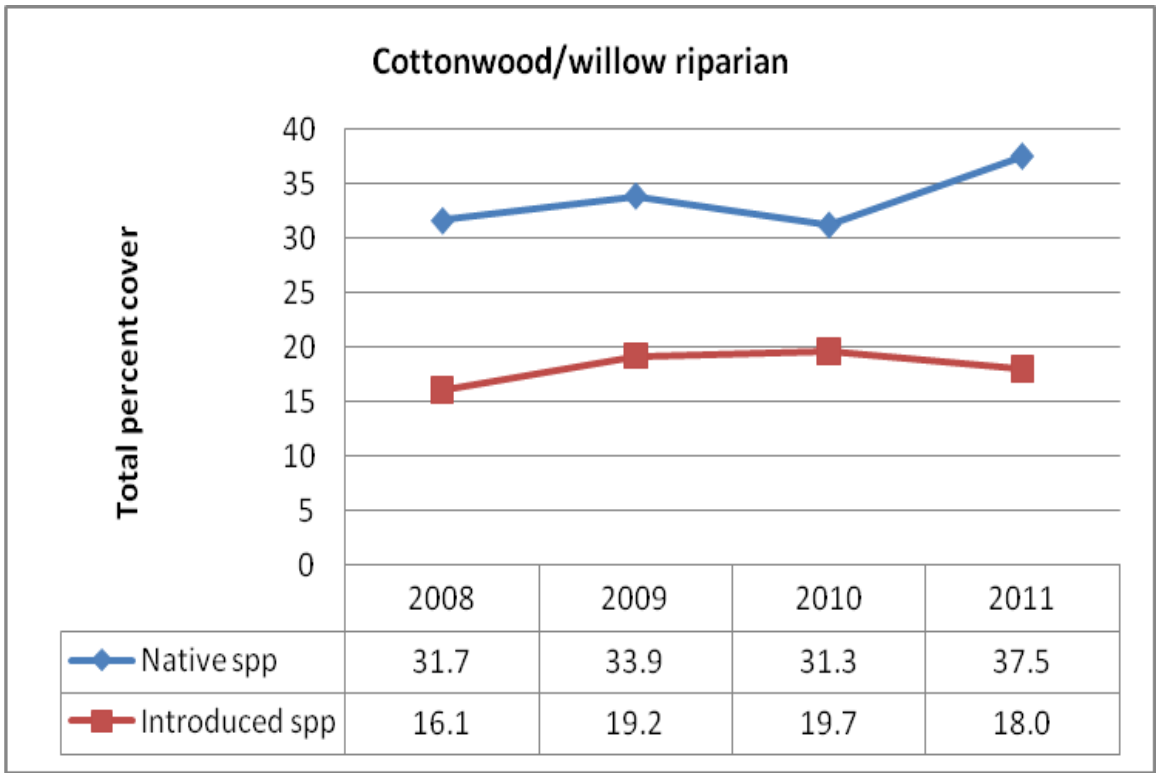


FIGURE 23. Total percent cover of native and introduced species in the herbaceous layer within the cottonwood/willow riparian woodland from 2008 to 2011; MIWP.

TABLE 10.—Total percent cover of woody overstory < 12.2 m (40 ft) and percent frequency that each species was detected in the cottonwood/ willow riparian woodland from 2008 to 2011; MIWP.

		S1	S2	S3	S5	T1	T2	T3	T4	T5	V1	V2	V3	V4	AVG	FREQ
Common fig	**2008**	0.0	0.0	0.0	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.2**	**7.7**
	2009	0.0	0.0	0.0	29.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.2**	**7.7**
	2010	0.0	0.0	0.0	25.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.0**	**7.7**
	2011	0.0	0.0	0.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**2.2**	**7.7**
Gray pine	**2008**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	**0.2**	**7.7**
	2009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	**0.2**	**7.7**
	2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	**0.3**	**7.7**
	2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	**0.3**	**7.7**
Cottonwood	**2008**	0.0	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.9**	**7.7**
	2009	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.1**	**7.7**
	2010	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.3**	**7.7**
	2011	0.0	0.0	0.0	0.0	0.0	24.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.9**	**7.7**
Firethorn	**2008**	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**	**7.7**
	2009	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**	**7.7**
	2010	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**7.7**
	2011	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**	**7.7**
Blue oak	**2008**	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	8.6	0.0	**2.2**	**23.1**
	2009	0.0	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	9.8	0.0	**2.8**	**23.1**
	2010	0.0	11.2	0.0	0.0	2.6	0.0	0.0	0.0	0.0	1.2	17.2	12.0	0.0	**3.4**	**38.5**
	2011	0.0	9.2	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	17.8	12.2	0.0	**3.1**	**30.8**
Interior live oak	**2008**	0.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	**0.8**	**15.4**
	2009	0.0	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	**1.0**	**15.4**
	2010	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	**1.3**	**15.4**
	2011	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	0.0	0.0	**1.5**	**15.4**
Narrow-leaf willow	**2008**	0.0	5.8	0.0	0.0	15.8	0.0	64.6	13.0	0.0	0.0	0.0	34.2	2.2	**10.4**	**46.2**
	2009	0.0	3.4	0.0	0.0	14.6	0.0	81.2	16.0	0.0	0.0	0.0	28.2	2.0	**11.2**	**46.2**
	2010	0.0	4.2	0.0	0.0	20.4	0.0	73.8	34.0	0.0	0.0	0.0	29.2	1.6	**12.6**	**46.2**
	2011	0.0	5.0	0.4	0.0	22.0	0.0	80.4	19.8	0.0	0.0	0.0	33.8	2.4	**12.6**	**53.8**
Goodding willow	**2008**	0.0	0.0	5.0	54.8	0.0	7.2	15.2	0.0	63.8	0.0	13.8	11.0	0.0	**13.1**	**53.8**
	2009	0.0	0.0	3.2	25.0	0.0	7.0	19.8	0.0	64.8	0.0	9.4	16.0	0.0	**11.2**	**53.8**
	2010	0.0	0.0	0.0	26.4	0.0	2.0	15.0	0.0	55.0	0.0	3.8	14.4	0.0	**9.0**	**46.2**
	2011	0.0	0.0	0.0	18.4	0.0	0.0	14.8	1.8	35.2	0.0	2.4	5.8	0.0	**6.0**	**46.2**
Arroyo willow	**2008**	94.4	62.2	17.2	0.0	22.0	27.0	0.0	0.0	0.0	41.0	10.0	15.4	0.0	**22.2**	**61.5**
	2009	72.8	36.8	12.6	0.0	21.0	24.2	0.0	0.0	0.0	31.2	11.4	15.4	0.0	**17.3**	**61.5**
	2010	72.2	42.4	15.0	0.0	23.0	32.6	0.0	0.0	0.0	36.4	15.8	15.8	0.0	**19.5**	**61.5**
	2011	76.0	44.4	16.4	0.0	23.6	38.8	0.0	0.0	0.0	31.4	29.4	16.6	0.0	**21.3**	**61.5**
Poison oak	**2008**	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	**0.8**	**15.4**
	2009	0.0	6.2	0.0	0.0	10.6	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	**1.4**	**23.1**
	2010	0.0	9.0	0.0	0.0	10.6	0.0	0.0	0.0	0.0	4.0	0.8	0.0	0.0	**1.9**	**30.8**
	2011	0.0	8.2	0.0	0.0	10.6	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	**1.5**	**23.1**
Total	**2008**	**94.4**	**83.2**	**22.2**	**54.8**	**42.6**	**42.6**	**79.7**	**13.0**	**63.8**	**47.0**	**26.4**	**53.2**	**2.2**	**48.1**	
	2009	**72.8**	**56.6**	**15.2**	**31.4**	**37.2**	**40.2**	**81.2**	**16.0**	**64.8**	**34.4**	**31.0**	**66.8**	**2.0**	**42.3**	
	2010	**72.2**	**63.4**	**15.0**	**28.6**	**44.0**	**44.4**	**73.8**	**34.0**	**55.0**	**47.0**	**32.2**	**52.8**	**1.6**	**43.4**	
	2011	**76.0**	**63.0**	**16.8**	**29.0**	**48.8**	**53.8**	**80.4**	**19.8**	**35.2**	**39.4**	**31.0**	**65.0**	**2.4**	**43.1**	

willow species – narrow-leaved, Goodding, and arroyo. The average percent cover of trees and shrubs in this layer was 48.1 percent in 2008,42.3 percent in 2009, 43.4 percent in 2010, and 43.1 in 2011 and included 10 species of woody plants. No significant differences were detected between years for the total cover of the mid-canopy or for cover of individual species in this layer, with the exception of Goodding willow, which significantly decreased from 13.1 in 2008 to 6.0 percent in 2011 (P=0.030). Total cover of this species has been on a gradual decline over the course of the monitoring period (Table 10).

Canopy cover for each transect within the cottonwood/willow riparian woodland is shown in Table 11. Average percentages based on densiometer readings from 3 points along each transect are listed. The average percent canopy cover per transect was 73 percent in both 2008 and 2009 and 75 percent in 2010 and 2011.

TABLE 11.—Average percent canopy cover of 3 points along each transect and total average percent canopy by transect in the cottonwood/willow riparian woodland from 2008 to 2011; MIWP.

Year	Point	Transect													Transect Avg
		S1	S2	S3	S5	T1	T2	T3	T4	T5	V1	V2	V3	V4	
2008	Point A Avg	99	85	94	47	0	32	9	94	49	47	89	86	95	
	Midpoint Avg	98	100	99	100	6	35	97	90	97	99	21	100	75	
	Point B Avg	97	94	100	30	17	78	94	35	87	100	98	99	83	
	Total Avg	98	93	97	59	8	48	67	73	77	82	69	95	84	**73**
2009	Point A Avg	99	86	85	51	34	37	13	98	43	49	91	98	86	
	Midpoint Avg	84	100	99	100	12	31	97	89	95	95	19	99	68	
	Point B Avg	95	97	97	32	10	88	98	23	83	99	95	84	80	
	Total Avg	93	94	94	61	18	52	69	70	73	81	68	94	78	**73**
2010	Point A Avg	97	95	90	44	35	55	32	94	41	56	85	85	84	
	Midpoint Avg	95	98	99	100	13	41	97	87	90	98	7	100	70	
	Point B Avg	97	91	97	41	24	85	100	25	88	99	94	99	79	
	Total Avg	97	95	95	62	24	60	76	69	73	84	62	95	78	**75**
2011	Point A Avg	99	88	71	45	33	60	41	96	31	63	80	79	94	
	Midpoint Avg	97	100	98	100	13	39	94	87	97	98	18	97	75	
	Point B Avg	97	99	97	38	26	95	100	26	82	99	96	100	81	
	Total Avg	98	96	89	61	24	65	78	69	70	87	65	92	83	**75**

The average number of trees per acre within the cottonwood/willow riparian woodland was 223 in 2008, 259 in 2009, 150 in 2010, and 129 in 2011 (Table 12). Statistical analysis identified no significant changes in the number of trees per acre within each vegetation cover type or within the cottonwood/willow riparian woodland community as a whole. Although not statistically significant, there was a notable decrease in 2010. In most cases, this drop was likely due to an increase in tree size (*i.e.* DBH) over time, which led to a decrease in tree density (*i.e.* number of trees per acre). Generally, there was not an observable increase in mortality of large trees during the monitoring period; however a fair number of downed Goodding willow of larger size appeared to be caused by a wind storm in 2008.

TABLE 12.—Average number of trees per acre by species and vegetation cover type in the cottonwood/willow riparian woodland from 2008 to 2011; MIWP.

Average number of trees per acre									
Vegetation cover type	Year	Species							TOTAL
		Austrian pine	Gray pine	Cotton-wood	Blue oak	Narrowleaf willow	Goodding willow	Arroyo willow	
Narrowleaf willow	**2008**	0.0	0.0	0.0	0.0	297.5	0.0	0.0	297.5
	2009	0.0	0.0	1.7	0.0	398.4	41.5	0.0	441.6
	2010	0.0	0.0	1.7	0.0	228.6	35.9	0.0	266.2
	2011	0.0	0.0	1.3	0.0	134.9	28.7	0.0	164.9
Cottonwood/Arroyo willow	**2008**	6.4	0.0	45.5	1.6	113.6	5.4	27.9	200.4
	2009	6.4	0.0	42.2	3.0	113.6	5.4	26.5	197.1
	2010	6.4	0.0	28.9	2.3	113.6	6.8	9.5	167.4
	2011	3.6	0.0	30.1	2.3	56.8	6.7	8.8	108.3
Goodding willow	**2008**	0.0	0.0	3.4	0.0	113.6	79.2	1.2	197.4
	2009	0.0	0.0	3.0	0.0	227.3	88.5	1.8	320.6
	2010	0.0	0.0	3.0	0.0	57.5	71.4	0.0	131.8
	2011	0.0	0.0	3.1	0.0	57.5	73.8	0.0	134.3
Cottonwood/Goodding willow	**2008**	0.0	0.0	13.2	0.0	0.0	27.9	0.0	41.1
	2009	0.0	0.0	13.2	0.0	0.0	32.3	0.0	45.6
	2010	0.0	0.0	13.5	0.0	0.0	25.4	0.0	38.9
	2011	0.0	0.0	13.4	0.0	0.0	24.9	0.0	38.2
Cottonwood/Goodding willow/ Narrowleaf willow/Arroyo willow	**2008**	0.0	2.1	46.7	5.5	236.9	35.2	13.8	340.1
	2009	0.0	2.1	43.1	5.5	208.6	47.7	12.0	318.9
	2010	0.0	1.6	37.6	3.7	57.5	32.6	4.3	137.1
	2011	0.0	1.6	35.5	3.1	114.1	31.0	4.3	189.5
AVERAGE ALL POINTS	**2008**	2.0	0.5	27.3	1.7	152.9	26.3	12.0	222.6
	2009	2.0	0.5	25.7	2.2	179.3	37.6	11.2	258.5
	2010	2.0	0.4	20.4	1.6	92.2	30.0	3.9	150.4
	2011	1.1	0.4	20.2	1.4	73.4	28.8	3.7	129.0

The four most abundant tree species measured in prism plots were cottonwood and narrow-leaved, Goodding, and arroyo willows. The number of trees within each size class varied for each species, as is demonstrated in Figure 24. Cottonwood was relatively

evenly distributed among size classes and was the only species with individual trees greater than 32” DBH. A large quantity of narrow-leaved willow fell into the smallest size classes, with none greater than 8” DBH. The majority of arroyo willow also fell into the smaller size classes. Although most Goodding willow were 14” DBH or less, individual trees of this species were as large as 32” DBH.

Photos taken at the end of each transect and at photo stations throughout the area are shown in Appendix A.

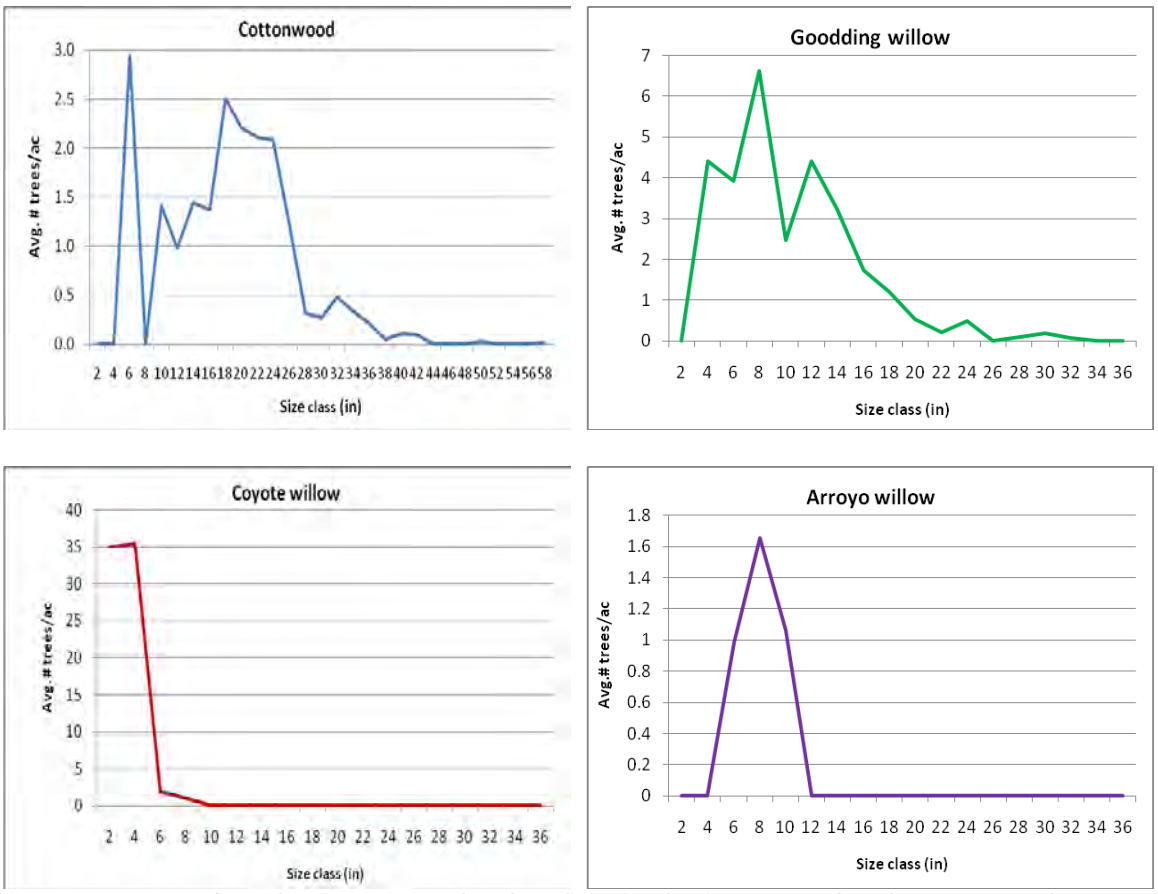


FIGURE 24.—Number of trees per acre by size class for the four most abundant tree species within the cottonwood/willow riparian vegetation type in 2011; MIWP.

Conclusions

In statistical comparisons of baseline data within the cottonwood/willow riparian woodland community from 2008 to 2010, results were fairly consistent over the three years of monitoring. Most variables were statistically equal over time, which provides some level of uniformity within the baseline data. The exceptions included a significant decrease in the total percent cover of litter and a significant increase in the total percent

cover of water from 2008 to 2010. These results were likely correlated; the increase in ground covered by water in a wetter year replaced ground that would presumably be covered by litter in a drier year. In areas that had been inundated by water for long periods, willow die-back was observed in 2010. In 2011, when construction began, these trends continued; however statistical analysis indicated significant increases in total percent herbaceous cover of vegetation and of native species and a significant decrease in total percent overstory cover of Goodding willow since 2008. Based on developing trends over the monitoring period, these results did not appear to be linked to project activities. For example, total percent vegetative cover gradually increased over the course of monitoring for a significant change from 2008 to 2011, but there was not a significant increase from 2010 (pre-project) to 2011 (during project; P=0.148). In the emergent wetland community, there was a considerable increase in total percent vegetative cover in 2011; however this increase appeared to be due to higher precipitation this year. Future analysis should determine if any trends can be attributed to project activities when comparing the condition of wetland vegetation pre- and post-construction.

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Appendix A

Mormon Island Wetland Preserve Photo Stations 2008-2011

Transects

Transect B1-A

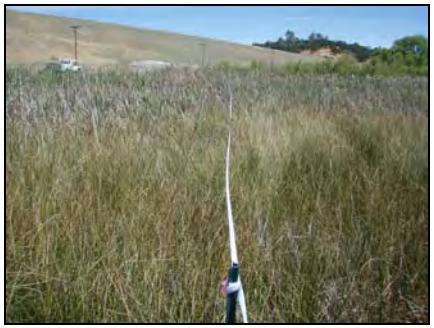
2008

2009

2010

2011

Transect B1-B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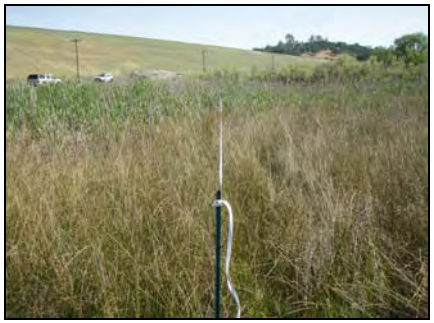
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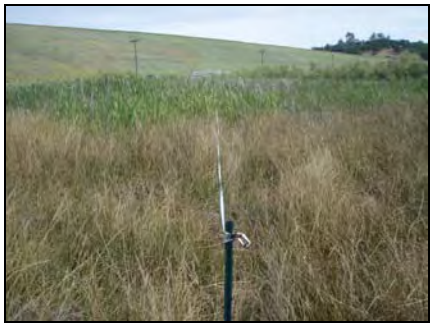
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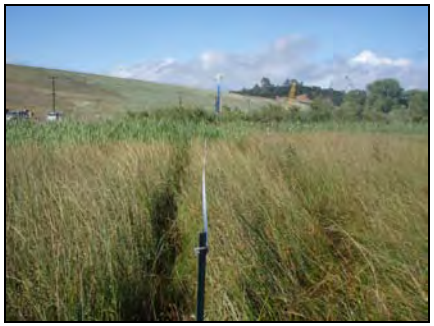

2011

Transect B2-A

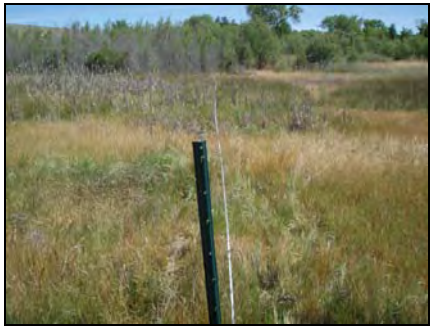
2008

2009

2010

2011

Transect B2-B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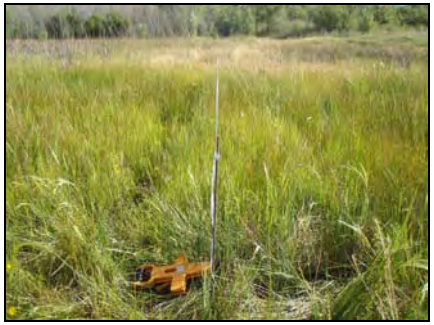
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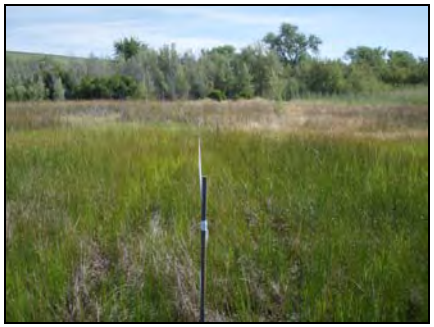
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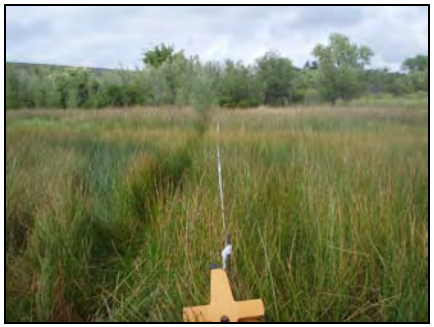

2011

Transect S1-A

2008

2009

2010

2011

Transect S1-B

2008

2009

2010

2011

Transect S2-A

2008

2009

2010

2011

Transect S2-B

2008

2009

2010

2011

Transect S3-A

2008

2009

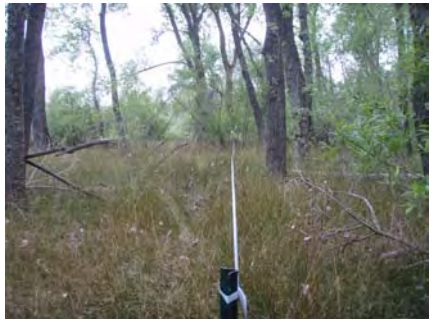
2010

2011

Transect S3-B

2008

2009


2010

2011

Transect S5-A

2008

2009

2010

2011

Transect S5-B

2008

2009

2010

2011

Transect T1-A

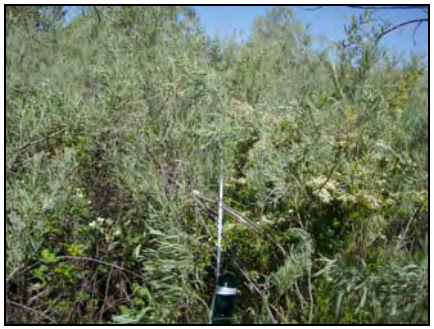
2008

2009

2010

2011

Transect T1-B


2008

2009

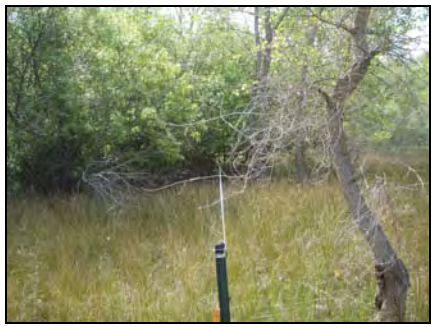
2010

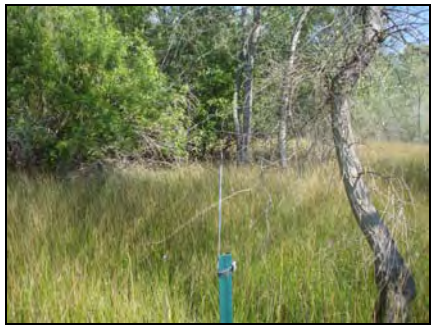
2011

Transect T2-A

2008

2009


2010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Transect T2-B

2008

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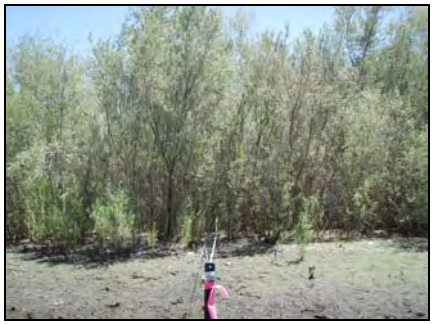
2010

2011

Transect T3-A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2011

Transect T3-B

2008

2009

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2011

Transect T4-A

2008

2009

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2011

Transect T4-B

2008

2009

2010

2011

Transect T5-A

2008

2009

2010

2011

Transect T5-B

2008

2009

2010

2011

Transect V1-A

2008

2009

2010

2011

Transect V1-B

2008

2009

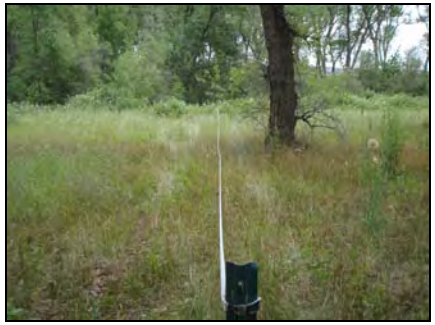
2010

2011

Transect V2-A

2008

2009


2010

2011

Transect V2-B

2008

2009

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2011

Transect V3-A

2008

2009

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2011

Transect V3-B

2008

2009

2010

2011

Transect V4-A

2008

2009

2010

2011

Transect V4-B

2008

2009

2010

2011

Photo Stations

Station P1 – south

2008

2009

2010

2011

Station P1 – west

2008

2009

2010

2011

Station P2 - north

2008

2009

2010

2011

Station P2 - south

2008

2009

2010

2011

Station P3 – north

2008

2009

2010

2011

Station P3 – south

2008

2009

2010

2011

Station P4 – east

2008

2009

2010

2011

Station P4 - south

2008

2009

2010

Station P4 – west

2008

2009

2010

2011

Station P5 – east

2008

2009

2010

2011

Station P5 – north

2008

2009

2010

2011

Station P5 - south

2008

2009

2010

2011