Heavenly Creek SEZ Demonstration Project
Final Vegetation Monitoring Report

USDA FOREST SERVICE
LAKE TAHOE BASIN MANAGEMENT UNIT

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EXECUTIVE SUMMARY

This final report addresses riparian vegetation changes between 2006/2007 (pre-project) and 2012 (5 years post-project) following the 2007 mechanical treatments within the Heavenly Creek SEZ Fuels Reduction Project area. This is one component of a larger monitoring effort as documented in the Heavenly SEZ Fuels Reduction Project Monitoring Plan (Norman 2007). The intent of this component of the monitoring project was to track vegetation response over the five year post-project time frame at the Heavenly Creek SEZ fuel reduction site. Vegetation conditions have been monitored along 12 transects within four treatment units during four time frames (pre-project: 2006/2007 and post project: 2008, 2010, & 2012).

As of 2012, three of the four project objectives for vegetation were met. The first objective, to maintain or increase pre-project cover of native herbaceous plants (grasses and forbs) and native shrubs, was met for shrubs but not for herbaceous plants. Compared to pre-project conditions, mean native herbaceous plant cover decreased from 24% to 14% as of 2012, although an increase was seen from 2010 to 2012. Mean native shrub cover before and after treatment (2012) was not significantly different.

The second objective, to allow no more than a 25% increase in pre-project invasive plant cover, was met. The overall cover of invasive species had decreased in 2012 compared to pre-project conditions, although an increase was seen from 2010 to 2012. In addition, the number of invasive species at the site was constant from pre-project to 2008 and 2010, but decreased by two species in 2012.

The third objective, to maintain or increase the pre-project native plant diversity, was also met. Species richness, the total number of species present, had increased in 2012 compared to pre-project species richness; nine transects had an increase in species richness, while three decreased in species richness. Evenness, the equality of abundance of all species present, was not significantly different pre- versus post-project. The total number of species at the site decreased slightly one year after the project (from 61 to 58 species), then increased to 68 species in 2010 and 71 species in 2012.

The fourth objective, to maintain or increase the pre-project proportion of obligate wetland and facultative wetland species relative to facultative, facultative upland, and upland species, was met. Obligate wetland and facultative wetland species almost always or usually grow in water or soils that are saturated at least periodically. Upland and facultative upland species almost always or usually grow in uplands. Facultative species are intermediate and can grow in either type of site. In 2012, the proportion of plant species at the site that were obligate wetland and facultative wetland species had increased to 40% (27 species) compared to 37% (22 species) pre-project. However, approximately 75% of total cover was comprised of obligate wetland or facultative wetland species in 2012, compared to approximately 59% pre-project; the increased cover of wetland species was primarily due to an increase in *Carex* species (sedge species).

As of 2012, the greatest change in vegetation at the site has been the overall decrease in the total cover of native herbaceous plant species. This decrease has not occurred for all species evenly; the proportion of species that are obligate wetland species increased in 2012 as compared to pre-project conditions. The total cover of herbaceous species increased between 2010 and 2012, possibly indicating that a lag time for herbaceous vegetation response to changes in site conditions has been passed. The amount of bare ground has not changed post-project and remains low (less than ten percent cover) therefore erosion is not a concern at this time. An additional year of monitoring (in 2014) is recommended in order to assess project effects on native herbaceous species cover and other indicators of vegetation response.

ACKNOWLEDGEMENTS

We would like to acknowledge Beth Brenneman, former LTBMU Ecologist, for development of the monitoring plan. We would like to acknowledge Hugh Safford, R5 Regional Ecologist, for guidance and review of the 2008 report. We thank Theresa Cody and Sue Norman for review of the final report. Finally, we would like to thank Stuart Osbrack, Jody Fraser, Carlos Torres, Cristina McKernan, Stephanie McKnight, and Dionne Uzes for help with data collection. Their input was critical in the development of this document.

INTRODUCTION

A landscape analysis of the south shore of Lake Tahoe (South Shore Landscape Analysis 2004) found that fire suppression practices have affected riparian habitat conditions in stream environment zones (SEZs). The riparian zone and associated buffer zone (25 to 100 feet) of every creek and lake shore in the southern portion of the Lake Tahoe Basin are affected to varying degrees by overly-dense live and dead mixed-conifer forest stands, heavy ground fuels, and thick ladder fuels between the ground and overstory layers. Higher stand density in riparian zones creates higher risk of mortality due to fluctuations in the water table and susceptibility to bark beetles (South Shore Landscape Analysis 2004); in addition the increased fuel presents an increase in fire hazard. The current condition of SEZs within the Lake Tahoe Basin prompted the Tahoe Regional Planning Agency (TRPA) to amend its ordinances to allow for development and implementation of innovative techniques to reduce fire hazard within SEZs (TRPA Code of Ordinances, 71.4.C, amended 2004).

The USDA Forest Service Lake Tahoe Basin Management Unit (LTBMU) initiated a fuel reduction pilot project in 2007 to determine the feasibility of conducting mechanical fuel treatments in SEZs. The goals of the project were to demonstrate SEZ treatment methods using low-impact innovative-technology vehicles and techniques; reduce hazardous fuel by treating dead and down trees and fuel ladders and removing material from the project area; and to facilitate a desired vegetation structure and function through conifer thinning and removal. In order to maximize the utility of such methods, managers need to balance fuel treatments with maintaining the diversity and function of the SEZ. Riparian zones

are crucial ecosystem components that provide food and habitat for wildlife and macroinvertebrates, act as nutrient filters, provide refuges for regional diversity, and minimize soil erosion through bank stabilization (Naiman & Decamps 1997). Hydrology and interactions with local geomorphology are the most important factors influencing vegetative patterns and succession in riparian zones; plant species also entrap material along low gradient stream reaches which influences channel hydraulics (Naiman & Decamps 1997).

Vegetation monitoring was established in 2006 prior to project initiation in order to quantitatively assess if mechanical fuel treatments cause significant adverse impacts to non-target vegetation. This effort is one component of a larger monitoring effort for this project as documented in the Heavenly SEZ Fuels Reduction Project Monitoring Plan (Norman 2007). Results related to the soil quality monitoring component of this plan were previously presented in the Heavenly Creek SEZ Demonstration Project 2007 Soil Monitoring Report (Norman et al. 2008). For this study of vegetation, adverse impacts were defined as a reduction of native plant cover and diversity, and/or an increase in invasive species cover. A positive impact of this project was defined as an increase in the number and cover of obligate wetland and facultative wetland species. This report provides information on vegetation response to the SEZ project activities one, three, and five years after project implementation.

Project Objectives for Vegetation

The objectives of vegetation monitoring were to assess the impacts of the fuel treatment project on cover, diversity, and wetland indicator status of native riparian SEZ vegetation and on cover of invasive plant species. Specific project objectives included:

- Maintain or increase the pre-project cover of native herbaceous plants and shrubs between 2006 and 2012.
- Allow no more than a 25% increase in pre-project cover of invasive plant species between 2006 and 2012.
- Maintain or increase the pre-project native plant diversity between 2006 and 2012.
- Maintain or increase the pre-project proportion of obligate wetland and facultative wetland species relative to facultative, facultative upland, and upland species between 2006 and 2012.

METHODS

Site

The Heavenly Creek SEZ Demonstration Project is located on the Lake Tahoe Basin Management Unit of the USDA Forest Service within the city limits of South Lake Tahoe, CA. The project site is located southwest of the intersection of Al Tahoe Blvd and Pioneer Trail (Appendix 1). Prior to the fuels treatment project, this site had dense lodgepole pine forest with high mortality levels within the SEZ and associated SEZ buffers of Heavenly Valley Creek. In December 2002 a wildfire burned through the area

leaving incompletely burned fuels and causing further increases in tree mortality. The dense forest stands and heavy fuel loads continued to pose a wildfire threat and encroaching conifer vegetation continued to impact non-conifer riparian vegetation communities. For these reasons, this location was chosen as an area to demonstrate low-impact mechanical and manual techniques for vegetation and fuel reduction treatments within SEZs at both burned and unburned sites.

The project consisted of five units totaling 21 acres (Appendix 1). Unit 1 was a mixed conifer stand with both burned (1B) and unburned (1A) portions. Unit 2 was a dense lodgepole pine (*Pinus contorta*) stand with heavy tree mortality. Unit 3 was a dense lodgepole pine and Jeffrey pine (*Pinus jeffreyi*) stand. Unit 4 was an aspen (*Populus tremuloides*) stand encroached by lodgepole pine and white fir (*Abies concolor*). Unit 5 was comprised of three small sub-units. Sub-units 5a and 5b were located between an open meadow and the road; 5a was treated mechanically and 5b was hand treated. Sub-unit 5c was a very wet area dominated by graminoids and shrubs and was treated by hand because it never met soil moisture requirements (Table 1). The Unit 5 sub-units were not included in this vegetation assessment, because this monitoring effort was designed to assess the effects of mechanical treatment methods, and 5a was fairly small in size.

A primary concern when working in SEZs is to ensure that ground-water levels and soil moisture content are at acceptably low levels. Prior to project implementation, ground-water level was measured in each unit to ensure that it was at least two feet below the ground surface. Soil moisture was also measured prior to project implementation and following storm events during implementation. This was done by collecting a soil sample from a 6-12 inch depth and trying to form a ball by squeezing a handful of soil very firmly. Results were compared to the criteria appropriate for Tahoe Basin soil types (Table 1). No operations took place on soils which exhibited “very moist” or “wet” characteristics. Further details of soil conditions pre- and post-project implementation are presented by Norman et al. (2008).

Table 1. Criteria for Soil Moisture Determination. Mechanical operations are not conducted when soils exhibit “very moist” or “wet” characteristics.

Soil Moisture	**Characteristics** (Coarse sands, loamy sands, very fine sands. Sandy loams, fine sandy loams, very fine sandy loams.)
Dry soils	Dry, loose, single grained flows thru fingers, will not form a ball with pressure.
Moist soils	Tends to stick together slightly, sometimes forms a very weak ball, but will shatter into single grains easily when tossed to a few inches height and caught in the hand.
Very moist soils	Forms a weak ball, when tossed in the air may break into smaller chunks but will not shatter easily into single grains.
Wet soils	Upon squeezing, free water may appear. Wet outline is left on hand.

Vegetation Monitoring Design

Thirteen transects were installed prior to project implementation using a stratified random sampling design to ensure SEZ vegetation and soil types were adequately sampled. Two to four 30 to 60 meter transects containing 40 to 60 $0.5m^2$ plots were established in each mechanical treatment unit (Table 2). The vegetation units were small, which constrained the number of transects that could be established within each unit. Each transect was monitored one time during pre-project monitoring in the fall of either 2006 or 2007. Post project monitoring occurred in 1 year post (2008), 3 years post (2010), and five years post (2012). In 2008, transect 4-2 could not be relocated, so the data from this transect was excluded from all analyses. In 2012, portions of transects 3-1, 3-2, and 3-3 were covered by large wood piles and wood chips, so the affected plots and line-intercept lengths were excluded from all analyses.

Table 2. Number of vegetation transects and plots analyzed within Heavenly Creek SEZ pilot project and total transect length within each mechanically-treated unit.

Heavenly Creek SEZ Unit	Number of transects	Total transect length in Unit (meters)	Number of $0.5m^2$ plots
1A	2	90	40
1B	3	180	60
2	2	120	40
3	4	137.5	34
4[#]	1	60	20
Total:	**12**	**630[*]**	**202[*]**

[#]Originally two transects were established in Unit 4 for a total of 120 meters and 40 plots in the unit. However transect 4-2 could not be relocated after project implementation and the data from this transect is excluded from all analyses.

[*]In 2012, portions of transects 3-1, 3-2, and 3-3 were covered by large wood piles and wood chips, and the affected plots and line-intercept lengths were excluded from all analyses. Eight plots and a total length of 42.5 meters were excluded from the analyses.

Ocular cover of each herbaceous species (native, non-native, and invasive) was recorded in $0.5m^2$ plots evenly spaced along each transect (Table 2). Cover was estimated as the vertical projection of the plant foliage and supporting parts as viewed from above, and was recorded as all the vegetation covering the ground surface (Elizinga et al. 1998). If a plant was rooted outside the plot but had branches or leaves overhanging the plot then the portion of the plant covering the plot was included in total cover estimates. Invasive plant species were analyzed separately from native plant species in order to address the management objectives. Invasive species were identified using the 2006 California Invasive Plant Inventory and Watch List (Cal-IPC 2006, updated 2007). Non-native species that were not listed by Cal-IPC as invasive were not included in the analyses of either native herbaceous species or invasive species.

Shrub cover was monitored using the line-intercept method. The locations on the tape at which the shrub began and the point at which it ended was recorded along each transect. A closed canopy was assumed for a species unless the gap in vegetation exceeded 5 cm.

The intercept lengths were summed up for each species and divided by the total tape length, which provided the total cover for each shrub species along each transect. No non-native or invasive shrub species occurred in the project area.

In addition to the vegetation community measurements mentioned above, a suite of environmental variables were also measured, including ground cover and overstory canopy cover. In 2008 through 2012, ground cover was calculated by using the four corners of the plot frame as point intercepts, summing the number of point intercepts for each category along each transect, dividing by total number of points per transect, and then multiplying by 100 to give percent cover. This method can provide a more accurate assessment of ground cover than ocular estimates (Keane & Lutes 2006). Ground cover categories were bare ground, basal vegetation, litter (organic material and woody debris <6" diameter), and large woody debris (>6" diameter). Pre-project overstory canopy cover was measured with a convex densiometer at the beginning, middle, and end of each transect. All post-project monitoring utilized digital hemispherical photographs that were analyzed using Gap Light Analyzer 2. Photographs were taken with a Canon EOS Digital Rebel XT camera and a 4.5 mm Sigma Circular Fisheye lens. Image processing followed the methods of Zhang et al. (2005). The hemispherical photographs capture tree canopy cover and cover from large *Salix* shrubs taller than approximately one meter.

Diversity

Whittaker's (1979) three types of diversity (alpha, gamma, and beta) were calculated for native plant species (herbs and shrubs) using PCORD 5 and Microsoft Excel 2010. Alpha diversity measures diversity at each transect, and was calculated using species richness. Species richness is a simple count of the total number of species per transect. Gamma diversity is a measurement of site diversity and was calculated as the total species richness of the site combining all transects. Larger values of gamma indicate greater diversity at the site. Beta diversity is a measure of transect diversity (alpha) relative to site diversity (gamma), and was calculated for each transect by dividing site richness (gamma) by transect richness (alpha). Therefore a beta value closer to one indicates that transect diversity is approaching diversity of the entire site, and larger beta values indicate that transect diversity is less than site diversity. The Kolmogorov-Smirnov test of normality was used to determine if a paired t-test was appropriate for analyzing differences between years. If the data did not follow a normal distribution the Wilcoxin Signed-Rank test ($\alpha \leq 0.10$) was used to compare median values between years. This test is appropriate to use with paired, non-parametric data. Transect evenness was measured with Pielou's *J* ($J = H'/\log(S)$), where H' is the Shannon-Wiener diversity index ($H' = -\sum p_i \log p_i$) and S is species richness. When relative abundance is the same for all species along a transect, Pielou's *J* equals 1; values of *J* closer to zero indicate less evenness in relative abundance along the transect.

Wetland Species

In 1996, the US Fish and Wildlife Service prepared a national list of species that occur in wetlands and determined wetland indicator status for each of the species; the list and

definitions were updated in 2012 (Table 3). A hydrophyte is any plant that grows in water or in soils that are saturated for at least part of the year (Tiner 1991). However, the presence of an obligate wetland species does not necessarily indicate the degree of wetness in a system as many obligates occur in permanently flooded wetlands but can also occur in seasonally flooded wetlands (Reed 1997). The proportion of obligate wetland, facultative wetland, facultative, facultative upland, and upland species was compared for each of the monitoring visits. Wetland indicator status of each species was obtained from the USDA Plants Database (http://plants.usda.gov/wetland.html). If a regional rating was not available the national rating was used. When a wetland rating was not available for a species it was considered to be an upland species, unless personal knowledge suggested otherwise in which case it was excluded from the analysis. If a plant had only been identified to genus (with the exception of *Carex*) it was excluded from the analysis. If the species was unknown for *Carex* it was considered to be a facultative wetland species.

Table 3. Explanation of categories identified by the US Fish and Wildlife Service to describe Wetland Indicator Status of plant species.

Wetland Type	Indicator Code	Definition
Obligate Wetland	OBL	Almost always is a hydrophyte, rarely in uplands
Facultative Wetland	FACW	Usually is a hydrophyte but occasionally found in uplands
Facultative	FAC	Commonly occurs as either a hydrophyte or non-hydrophyte
Facultative Upland	FACU	Occasionally is a hydrophyte but usually occurs in uplands
Obligate Upland	UPL	Rarely is a hydrophyte, almost always in uplands
No Indicator	NI	Insufficient information was available to determine an indicator status.

Data Analysis

Changes in the total native herbaceous, native shrub, and invasive plant cover were analyzed by comparing pre-project data (2006/2007) to post-project data (2008, 2010, and 2012). Summary statistics (mean, standard deviation, minimum, maximum, and median values) were calculated for each transect (native herbaceous, invasive species) and for the entire project site (native herbaceous, native shrub, invasive species). The Kolmogorov-Smirnov test of normality was used to determine if a paired t-test was appropriate for analyzing differences between years. If the data did not follow a normal distribution the Wilcoxin Signed-Rank test ($\alpha \leq 0.10$) was used to compare median values between years. This test is appropriate to use with paired, non-parametric data. Due to the low number of transects that followed a log normal distribution and the confounding problem with ignoring zeros in community data where these values often

account for half of the data (McCune & Grace 2002), data were not log transformed. Summary statistics (mean, median, minimum, maximum) were calculated for ground cover in 2008, 2010, and 2012. Ground cover data was not collected at five transects in 2008, therefore the data from these transects was excluded from all analyses of post-project ground cover. Summary statistics were also calculated for canopy cover in 2008, 2010, and 2012. Descriptive statistics were calculated in Microsoft Excel 2010 and statistical tests were conducted using SigmaStat 3.5.

RESULTS

Native Herbaceous Plant Cover

As of 2012 native herbaceous cover (averaged across the entire project area) had decreased from pre-project conditions. In 2006/2007, average cover was 24 %, in 2008 it had decreased to 14%, in 2010 it had further decreased to 8%, and in 2012 it increased back to 14%. Most transects showed a pattern of decreasing herbaceous cover one and three years after project implementation, followed by an increase in herbaceous cover between three and five years after project completion. Only two transects (3-4 & 4-1) showed a decrease in native herbaceous cover from 2010 to 2012. The decrease in native herbaceous plant cover between 2006/2007 and 2012 was statistically significant ($p \leq 0.10$) along seven of 12 transects (1A-1, 1A-2, 1B-1, 1B-2, 1B-3, 2-1, 3-1) (Figure 1, Table 4). This decrease in native herbaceous cover could not be explained by changes in shrub cover, ground cover, or canopy cover (based on simple linear regression analyses).

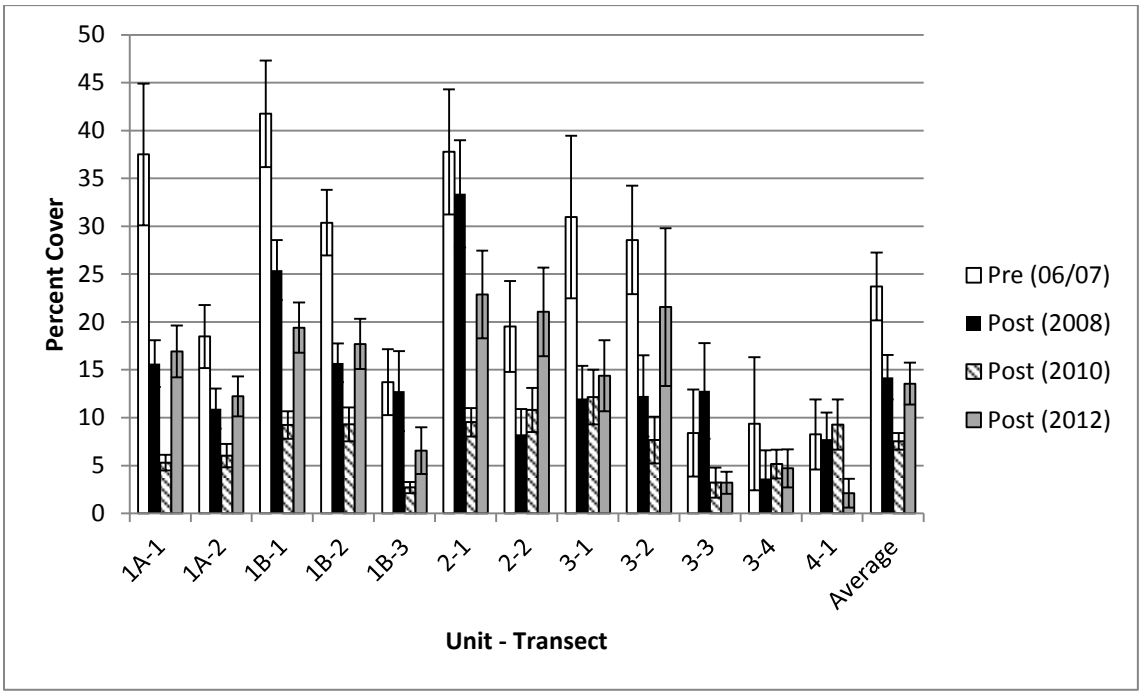

Figure 1. Mean ± SE native herbaceous cover by transect and averaged across all transects at the Heavenly Creek SEZ Demonstration Project during four years of monitoring visits.

Table 4. Summary statistics for native herbaceous plant cover (%) at the Heavenly Creek SEZ Demonstration Project in four monitoring years. Paired t-tests were used to test for a significant difference in pre-project cover and post-project cover as of 2012. If data were not normally distributed based on a Kolmogorov-Smirnov test (α<0.05; indicated by an asterisk*) the Wilcoxin Signed-Rank test was used instead of a paired t-test.

Unit-Transect	Year	Mean	Standard Deviation	Minimum	Maximum	Median	P-Value	Significant (α < 0.1)
1A-1*	2006/2007	37.50	33.16	1.00	117.00	30.00	<0.001	Yes-Decrease
	2008	15.65	10.88	0.00	35.00	13.25		
	2010	5.30	3.63	2.00	17.00	4.25		
	2012	16.93	12.08	1.00	55.00	15.50		
1A-2	2006/2007	18.48	14.76	0.00	54.00	14.00	0.048	Yes-Decrease
	2008	10.95	9.37	0.00	26.00	9.50		
	2010	6.03	5.47	1.00	25.50	4.75		
	2012	12.23	9.37	1.50	43.00	12.00		
1B-1	2006/2007	41.75	24.86	5.00	85.50	41.50	<0.001	Yes-Decrease
	2008	25.43	13.95	0.00	60.00	23.50		
	2010	9.23	6.44	3.00	30.00	7.25		
	2012	19.40	11.71	2.00	50.50	16.50		
1B-2*	2006/2007	30.38	15.27	7.00	63.00	26.50	0.005	Yes-Decrease
	2008	15.73	9.01	2.50	32.00	14.50		
	2010	9.30	7.97	1.00	35.00	7.00		
	2012	17.70	11.69	3.00	52.50	15.50		
1B-3*	2006/2007	13.70	15.40	0.00	45.00	6.50	0.089	Yes-Decrease
	2008	12.78	18.71	0.00	60.50	3.00		
	2010	2.70	2.59	0.50	9.00	2.00		
	2012	6.55	10.94	0.00	43.50	2.25		
2-1	2006/2007	37.78	29.21	5.00	83.00	35.00	0.03	Yes-Decrease
	2008	33.40	25.04	3.00	75.00	27.50		
	2010	9.53	6.65	2.50	25.00	7.50		
	2012	22.88	20.51	2.00	75.00	17.75		
2-2	2006/2007	19.53	21.28	0.00	78.00	12.00	0.831	No
	2008	8.28	11.80	0.00	50.00	5.00		
	2010	10.80	10.32	0.00	36.00	6.75		
	2012	21.05	20.70	0.00	65.00	18.00		
3-1	2006/2007	30.96	30.61	0.00	94.50	39.50	0.035	Yes-Decrease
	2008	12.00	12.37	0.00	36.50	6.00		
	2010	12.15	10.33	0.50	37.50	9.50		
	2012	14.38	13.41	0.00	44.50	15.00		
3-2	2006/2007	28.56	17.00	0.00	50.00	30.00	0.296	No
	2008	12.28	12.74	0.00	43.50	10.00		
	2010	7.67	7.30	0.50	23.50	7.50		
	2012	21.56	24.75	0.50	80.00	11.50		
3-3	2006/2007	8.40	10.18	0.00	25.00	6.50	0.313	No
	2008	12.80	11.17	0.00	25.00	17.00		
	2010	3.20	3.51	0.00	9.00	2.50		
	2012	3.20	2.59	0.00	6.00	4.00		
3-4	2006/2007	9.36	18.39	0.00	50.00	1.00	0.419	No
	2008	3.64	7.79	0.00	21.00	0.00		
	2010	5.14	3.97	0.00	9.50	7.50		
	2012	4.71	5.26	0.00	15.00	4.00		
4-1*	2006/2007	8.25	16.38	0.00	50.00	0.00	0.176	No
	2008	7.78	12.36	0.00	35.00	0.00		
	2010	9.28	11.69	0.00	33.00	2.00		
	2012	2.10	6.74	0.00	30.00	0.00		
All transects*	2006/2007	23.72	12.28	8.25	41.75	24.04	<0.001	Yes-Decrease
	2008	14.22	8.03	3.64	33.40	12.53		
	2010	7.53	3.02	2.70	12.15	8.45		
	2012	13.56	7.62	2.10	22.88	15.65		

Native Shrub Cover

Between pre-project and 2012, shrub cover increased at seven transects and decreased at three transects; two transects had no shrub cover during the four monitoring years (Figure 2). The increases in shrub cover were relatively small: less than 5% at five transects and less than 15% at two transects. Of the three transects that decreased in cover, two decreased by less than 3% but one decreased by 27%. Similarly, seven transects also had an increase in shrub cover from 2010 to 2012. Due to the variability in shrub cover between transects (Table 5), there was no statistically significant change in shrub cover pre-project (2006/2007) versus post-project (2012) (8.70% vs. 8.95%; Wilcoxin Signed-Rank test, p = 0.322) across the entire project area.

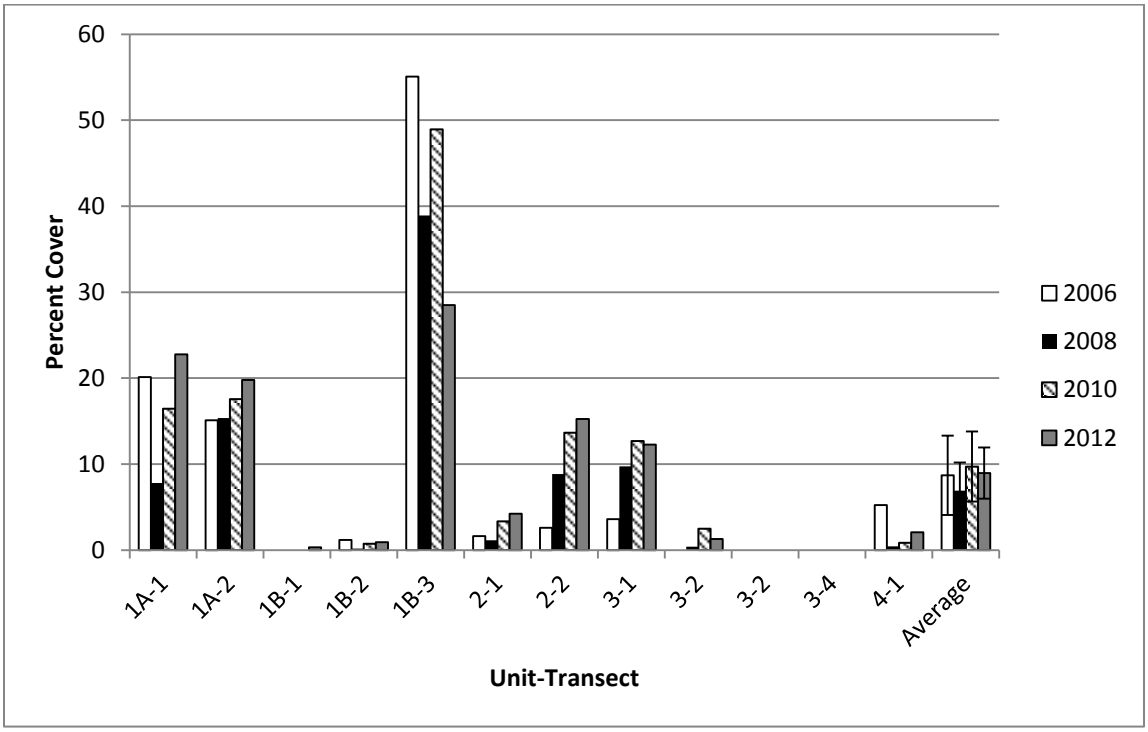

Figure 2. Native shrub cover by transect and averaged across all transects at the Heavenly Creek SEZ Demonstration Project during four monitoring visits.

Table 5. Summary statistics for native shrub cover (%) at the Heavenly Creek SEZ Demonstration Project in four monitoring years.

Unit-Transect	Year	Mean	Standard Deviation	Minimum	Maximum	Median
Shrubs (Entire Site)	2006/2007	8.71	15.98	0	55.08	2.10
	2008	6.91	11.34	0	38.92	0.80
	2010	9.72	14.15	0	48.92	2.92
	2012	8.95	10.31	0	28.5	3.17

Non-native Invasive Plant Species

Eleven invasive plant species were analyzed in this data. These species were *Agrostis stolonifera, Bromus tectorum, Cirsium vulgare, Dactylis glomerata, Phleum pratense, Poa pratensis, Rumex acetosella, Rumex crispus, Taraxacum officinale, Tragopogon dubius,* and *Verbascum thapsus*. Five of these species, *Bromus tectorum, Cirsium vulgare, Poa pratensis, Rumex acetosella,* and *Taraxacum officinale,* were present along the transects in every monitoring year. Compared to pre-project conditions, in 2012 the number of invasive plant species present at the project site had decreased from eight to six (Figure 3). The number of invasive species at the 12 individual transects decreased at three, increased at three, and did not change at six of 12 transects, between 2006/2007 and 2012 (Figure 3). Average invasive plant cover at the project site has been fairly low (less than 10%) in all four monitoring years (Figure 4). Invasive plant cover averaged across all transects was 4.9% pre-project, 0.8% in 2008, 1.1% in 2010, and 2.49% in 2012. Between the pre-project and 2012 visits, we measured a statistically significant ($p<0.10$) decrease in in overall invasive plant cover at the site and in invasive plant cover along two of 12 transects (2-1, 3-1) (Table 6).

The LTBMU Noxious Weeds Crew has treated the *Cirsium vulgare* (CIRVUL – bull thistle) infestations at least once a year from 2006 to the present. No other non-native invasive plant species were treated during this project. With the exception of the 2006 pre-project transect surveys, all transect surveys in 2007 through 2012 were completed before that year's first CIRVUL treatment occurred. Overall cover at the site of *Cirsium vulgare* was 0.06% in 2006/2007, 0.03% in 2008, 0.02% in 2010, and 0.002% in 2012.

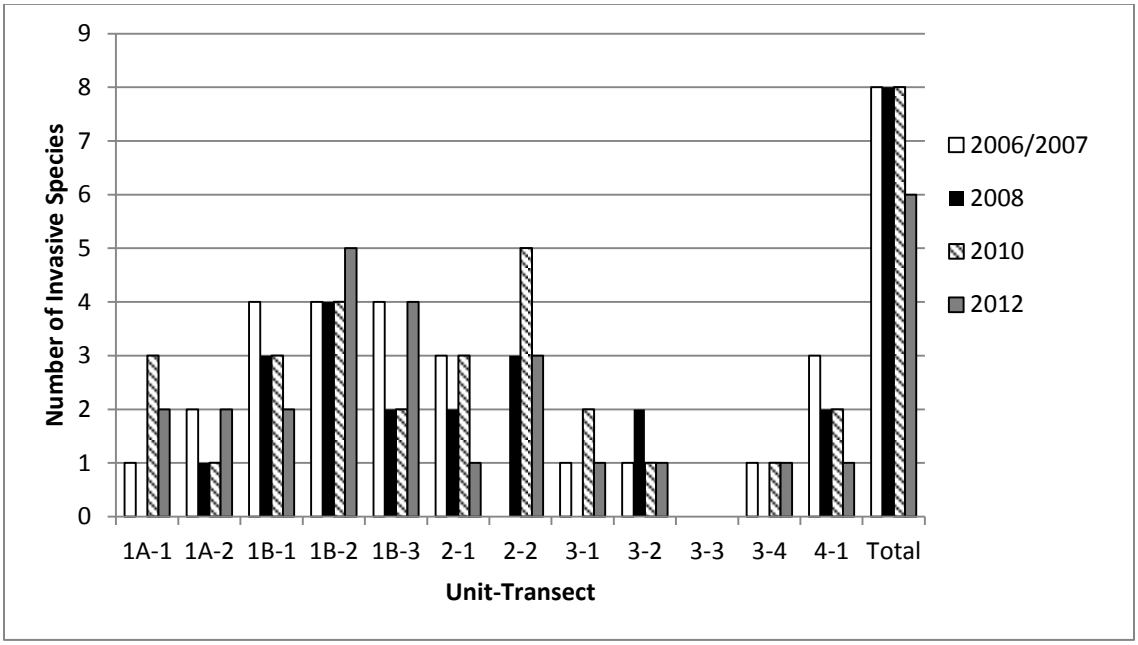

Figure 3. Total number of invasive plant species at each transect and along all transects at the Heavenly Creek SEZ Demonstration Project in four monitoring visits.

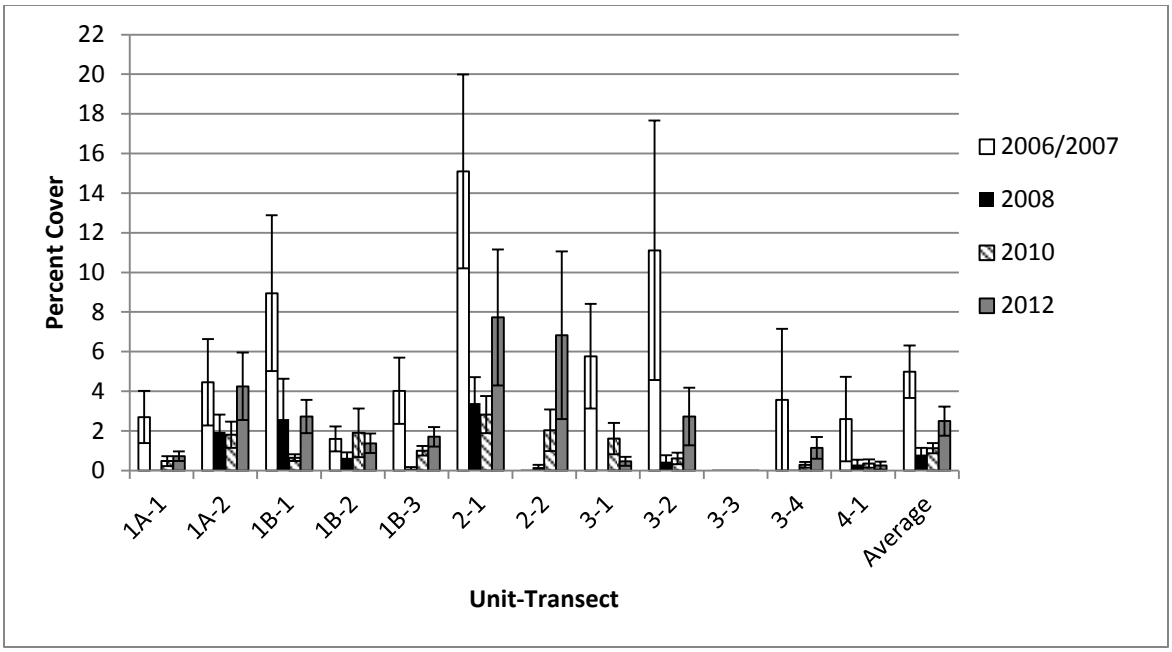

Figure 4. Mean ± SE invasive plant cover (%) by transect and averaged across all transects at the Heavenly Creek SEZ Demonstration Project during four monitoring visits.

Table 6: Summary statistics for invasive plant cover at the Heavenly Creek SEZ Demonstration Project in four monitoring years. Wilcoxin Signed-Rank tests were used to test for a significant difference in pre-project cover and 2012 post-project cover because none of the data were normally distributed based on Kolmogorov-Smirnov tests (α<0.05).

Unit/ Transect	Year	Number of Invasive Species	Mean	Standard Deviation	Minimum	Maximum	Median	P-Value	Significant (α<0.1)
1A-1	2006/2007	1	2.700	5.913	0.000	25.000	0.000	0.241	No
	2008	0	0.000	0.000	0.000	0.000	0.000		
	2010	3	0.475	1.129	0.000	5.000	0.000		
	2012	2	0.725	1.082	0.000	4.000	0.500		
1A-2	2006/2007	2	4.450	9.730	0.000	31.000	0.000	0.622	No
	2008	1	1.950	3.900	0.000	10.000	0.000		
	2010	1	1.800	2.958	0.000	10.000	0.500		
	2012	2	4.250	7.641	0.000	25.000	0.750		
1B-1	2006/2007	4	8.950	17.590	0.000	70.000	1.000	0.167	No
	2008	3	2.600	9.108	0.000	40.000	0.000		
	2010	3	0.650	0.780	0.000	2.000	0.500		
	2012	2	2.725	3.747	0.000	14.000	1.000		
1B-2	2006/2007	4	1.600	2.817	0.000	10.000	0.000	0.850	No
	2008	4	0.650	1.171	0.000	4.000	0.000		
	2010	4	1.900	5.491	0.000	25.000	0.500		
	2012	5	1.375	2.229	0.000	8.000	0.250		

Unit/ Transect	Year	Number of Invasive Species	Mean	Standard Deviation	Minimum	Maximum	Median	P-Value	Significant (α<0.1)
1B-3	2006/2007	4	4.025	7.484	0.000	25.000	0.000	0.927	No
	2008	2	0.100	0.308	0.000	1.000	0.000		
	2010	2	1.000	1.088	0.000	4.000	0.750		
	2012	4	1.700	2.203	0.000	8.000	1.000		
2-1	2006/2007	3	15.100	21.877	0.000	70.000	0.000	0.098	Yes-Decrease
	2008	2	3.400	5.862	0.000	20.000	0.000		
	2010	3	2.825	4.187	0.000	15.000	0.500		
	2012	1	7.725	15.374	0.000	60.000	0.000		
2-2	2006/2007	0	0.000	0.000	0.000	0.000	0.000	0.125	No
	2008	3	0.175	0.494	0.000	2.000	0.000		
	2010	5	2.025	4.686	0.000	15.000	0.000		
	2012	3	6.825	18.933	0.000	80.000	0.000		
3-1	2006/2007	1	5.769	9.506	0.000	30.000	0.000	0.074	Yes-Decrease
	2008	0	0.000	0.000	0.000	0.000	0.000		
	2010	2	1.615	2.859	0.000	10.500	0.500		
	2012	1	0.462	0.828	0.000	3.000	0.000		
3-2	2006/2007	1	11.111	19.650	0.000	50.000	0.000	0.250	No
	2008	2	0.444	0.982	0.000	3.000	0.000		
	2010	1	0.611	0.858	0.000	2.000	0.000		
	2012	1	2.722	4.353	0.000	12.000	0.000		
3-3	2006/2007	0	No invasive species observed pre- or post-project monitoring.					-	-
	2008	0							
	2010	0							
	2012	0							
3-4	2006/2007	1	3.571	9.449	0.000	25.000	0.000	1.000	No
	2008	0	0.000	0.000	0.000	0.000	0.000		
	2010	1	0.286	0.393	0.000	1.000	0.000		
	2012	1	1.143	1.464	0.000	3.000	0.000		
4-1	2006/2007	3	2.600	9.539	0.000	42.000	0.000	0.625	No
	2008	2	0.300	1.129	0.000	5.000	0.000		
	2010	2	0.350	0.919	0.000	4.000	0.000		
	2012	1	0.250	0.896	0.000	4.000	0.000		
All transects	2006/2007	8	4.990	4.587	0.000	15.100	3.798	0.031	Yes-Decrease
	2008	8	0.802	1.174	0.000	3.400	0.238		
	2010	8	1.128	0.879	0.000	2.825	0.825		
	2012	6	2.492	2.550	0.000	7.725	1.538		

Native Plant Diversity

Overall, species richness at the project site increased significantly (p=0.015) from pre-project (site = 61, transect mean= 12.6) to 2012 (site = 71, transect mean=15.9) (Table 7). Species richness increased by one to 11 species at nine of 12 transects during this time period (Table 7). In comparison, overall evenness did not change significantly (p=0.546) from pre-project (mean=0.62) to 2012 (mean=0.59). Evenness increased at five of 12 transects and decreased at seven of 12 transects (Table 7). Evenness ranges from 0 to 1

Table 7. Alpha diversity (species richness and evenness) and beta diversity of native herbaceous and shrub plant species at Heavenly Creek SEZ demonstration project.

Name	Year	Species Richness	Evenness	Beta Diversity
1A-1	2006/2007	14	0.71	4.36
	2008	13	0.75	4.46
	2010	16	0.42	4.25
	2012	15	0.65	4.73
1A-2	2006/2007	21	0.64	2.90
	2008	13	0.58	4.46
	2010	16	0.37	4.25
	2012	25	0.47	2.84
1B-1	2006/2007	18	0.59	3.39
	2008	14	0.65	4.14
	2010	25	0.77	2.72
	2012	21	0.72	3.38
1B-2	2006/2007	14	0.63	4.36
	2008	20	0.80	2.90
	2010	26	0.71	2.62
	2012	25	0.73	2.84
1B-3	2006/2007	14	0.33	4.36
	2008	17	0.36	3.41
	2010	16	0.12	4.25
	2012	15	0.30	4.73
2-1	2006/2007	11	0.45	5.55
	2008	8	0.39	7.25
	2010	17	0.58	4.00
	2012	9	0.59	7.89
2-2	2006/2007	17	0.56	3.59
	2008	18	0.66	3.22
	2010	21	0.53	3.24
	2012	15	0.49	4.73
3-1	2006/2007	22	0.62	2.77
	2008	16	0.61	3.63
	2010	27	0.57	2.52
	2012	28	0.59	2.54
3-2	2006/2007	9	0.57	6.78
	2008	9	0.51	6.44
	2010	13	0.65	5.23
	2012	13	0.41	5.46
3-3	2006/2007	3	0.85	20.33
	2008	3	0.84	19.33
	2010	6	0.74	11.33
	2012	3	0.96	23.67
3-4	2006/2007	5	0.68	12.20
	2008	9	0.80	6.44
	2010	14	0.85	4.86
	2012	11	0.85	6.45
4-1	2006/2007	3	0.87	20.33
	2008	8	0.54	7.25
	2010	12	0.63	5.67
	2012	11	0.31	6.45

and approaches 1 when relative abundance is even between all species along the transect. Overall, beta diversity did not change significantly (p=0.733) from pre-project (median=7.58) to 2012 (median=6.31). Beta diversity increased at five of 12 transects and decreased at seven of 12 transects. Values of beta that are closer to one indicate that diversity along a transect is approaching the overall diversity of the site. Gamma diversity, which was 61 species prior to project implementation, decreased slightly to 58 species in 2008, but then increased to 68 species in 2010 and 71 species in 2012.

Wetland Indicator Status

Due to an increase in overall species diversity, the number of species in all wetland indicator status categories increased in 2012, with the exception of facultative upland species (Table 8, Figure 5). In 2006/2007 there were 37% obligate and facultative wetland species, and 63% facultative, facultative upland, and upland species (22 species and 38 species, respectively), while in 2012 there were 40% obligate and facultative wetland species, and 60% facultative, facultative upland, and upland species (27 and 41 respectively) (Table 8, Figure 5).

Table 8. Number of and percent cover of native herbaceous and native shrub species in each category of wetland indicator status at the Heavenly Creek SEZ Demonstration Project during four monitoring visits.

	Number of Species				Percent Cover			
	2006/2007	2008	2010	2012	2006/2007	2008	2010	2012
Obligate	7	9	8	10	3.86	3.46	2.97	9.08
Facultative wetland	15	12	15	17	15.30	9.95	9.73	9.19
Facultative	8	7	8	9	1.34	0.93	0.65	0.60
Facultative upland	16	12	17	15	8.76	4.33	2.19	3.89
Upland	14	15	16	17	3.15	2.45	1.63	1.75
No Info	1	3	4	3	0.02	0.02	0.07	0.02

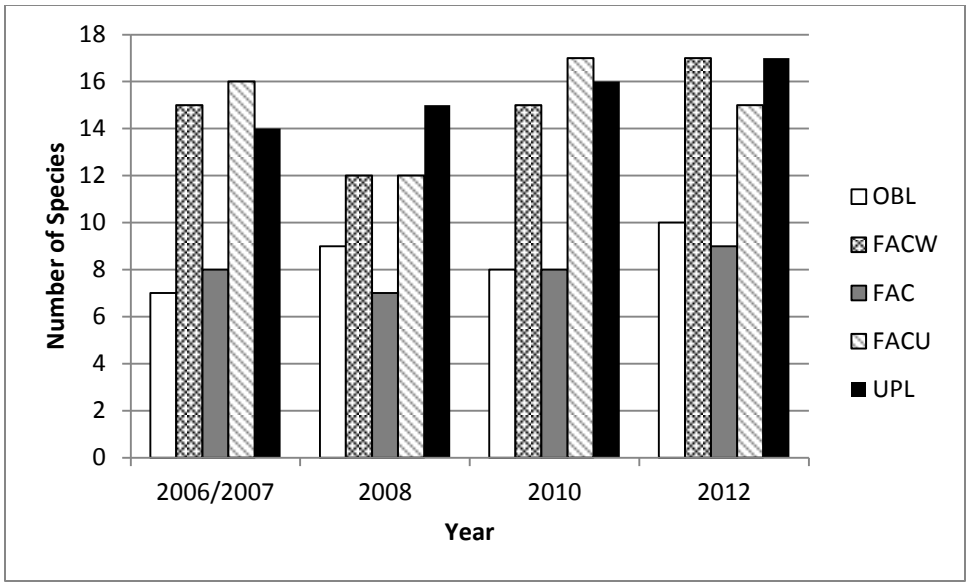

Figure 5. Total number of native herbaceous and shrub species in each category of wetland indicator status at the Heavenly Creek SEZ Demonstration Project during four monitoring visits. Wetland Status Abbreviations: OBL = obligate, FACW = facultative wetland, FAC = facultative, FACU = facultative upland, UPL = upland.

As of 2012, obligate wetland species were the only group whose total cover at the site had increased compared to pre-project conditions (Table 8, Figure 6). The proportion of total cover comprised of obligate and facultative wetland species increased between 2006/2007 and 2012, from 59.1% to 74.6% (Table 8, Figure 6). In all four monitoring years, facultative wetland species had the highest percent cover compared to species in the other categories of wetland indicator status, although the percent cover of obligate species was nearly as high in 2012. The large increase in cover of obligate wetland species seen in 2012 was due to increasing cover of several species of *Carex*.

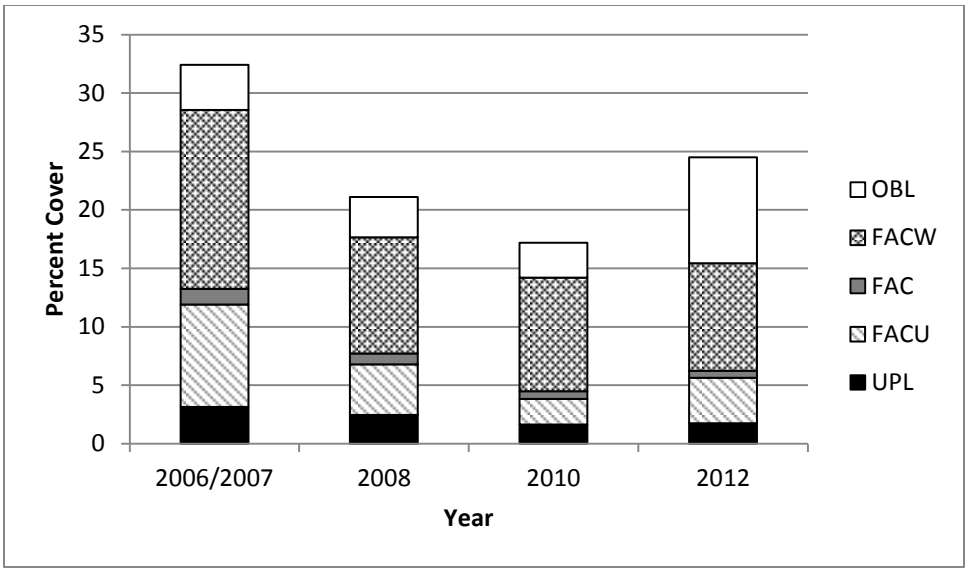

Figure 6. Percent cover of native herbaceous and shrub species in each category of wetland indicator status at the Heavenly Creek SEZ Demonstration Project during four monitoring visits. Wetland Status Abbreviations: OBL = obligate, FACW = facultative wetland, FAC = facultative, FACU = facultative upland, UPL = upland.

Ground Cover

Ground cover composition averaged across seven transects changed significantly in three categories between 2008 and 2012 (Figure 7). Basal vegetation increased from 3.5% to 10.3% (paired t-test; p=0.079), litter decreased from 88.1% to 65.5% (paired t-test; p=0.003), and large woody debris increased from 0% to 19.2% (signed-rank test; p=0.016). Bare ground decreased slightly from 8.4% to 5% but the decrease was not significant (paired t-test; p=0.258). Pre-project (2006/2007) ground cover monitoring did not follow the same protocol and thus could not be compared to post-project conditions.

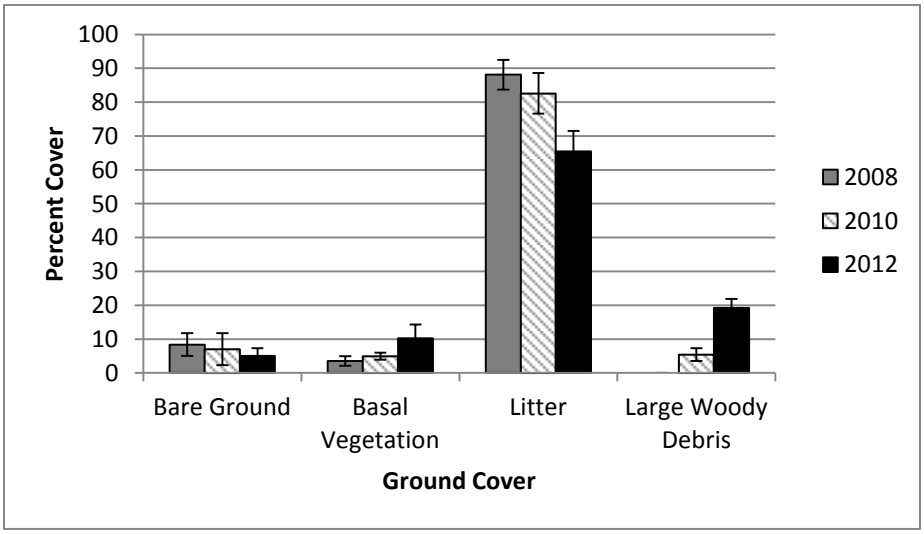

Figure 7. Mean ± standard error of percent ground cover at seven transects at the Heavenly Creek SEZ Demonstration project in three post-project monitoring years.

Canopy Cover

Between 2008 and 2012, canopy cover increased at 10 of 12 transects, decreased at two of 12 transects, and increased significantly across the entire site from 33.4% to 44.4% (paired t-test; p=0.009). Pre-project (2006/2007) canopy cover monitoring did not follow the same protocol and thus could not be compared to post-project conditions.

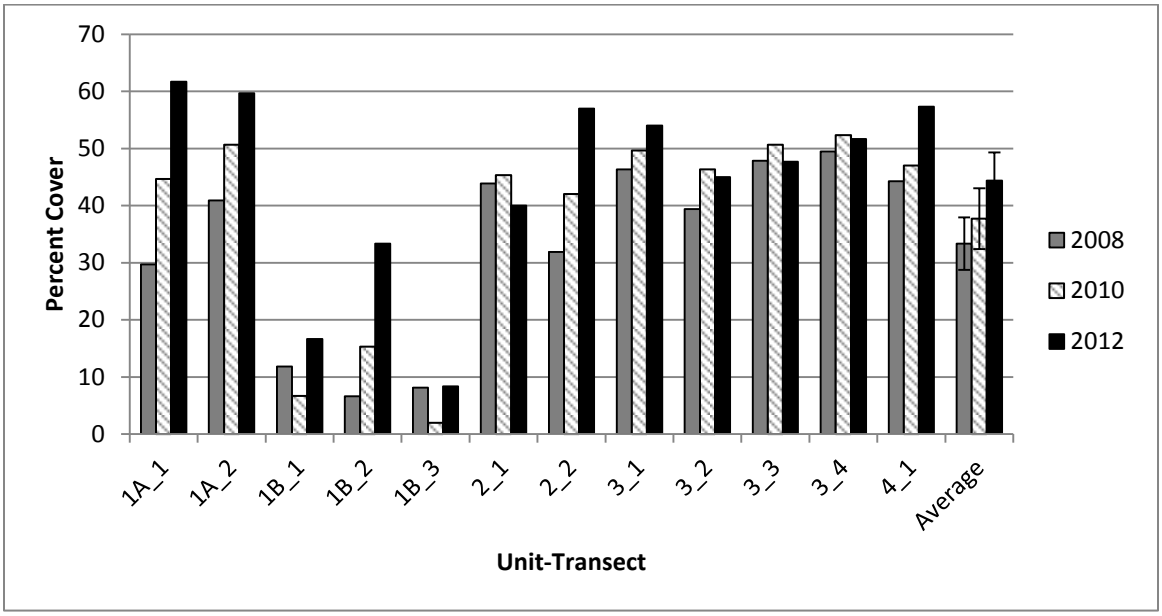

Figure 8. Mean ± standard error of percent canopy cover at twelve transects at the Heavenly Creek SEZ Demonstration project in three post-project monitoring years.

DISCUSSION

Riparian communities experience frequent disturbances due to seasonal variations in water levels, floods, erosion, abrasion, drought, and freezing; therefore the majority of riparian species are disturbance-adapted (Naiman & Decamps 1997). In order to detect plant community response to disturbance or habitat manipulations, it is important to provide adequate time to allow the response. This paper is the final report on the response of riparian vegetation within the Heavenly Creek SEZ Demonstration Project. It is important to understand that vegetation response could occur gradually over many years or progress slowly until a large disturbance event occurs. This report analyzes the vegetation response to project implementation after five growing seasons.

Native herbaceous cover was initially observed to decline in 2008, and that trend continued into 2010. In 2012 an increase in native herbaceous cover was observed at most transects and at the site overall, although herbaceous vegetation cover has not yet reached pre-project levels. This overall decrease in native herbaceous plant cover is significant and does not meet project objectives. However, the increase observed between 2010 and 2012 suggests that the herbaceous vegetation could be recovering from the project disturbance and responding to improved site conditions (e.g. greater water availability due to less evapotranspiration by conifers). Vegetation response to riparian

restoration activities can occur rapidly (within one growing season) or exhibit substantial lag times (Loheide & Gorelick 2006, Katz et al. 2009).

The pattern of declining herbaceous vegetation cover was discussed in the previous interim report and possibly attributed to below-average precipitation in 2008. However the decline continued into 2010, a year of above average precipitation, and the increase in 2012 was during a year of below-average precipitation (Figure 8). This suggests that precipitation may have less influence than site conditions in affecting herbaceous plant establishment and/or persistence.

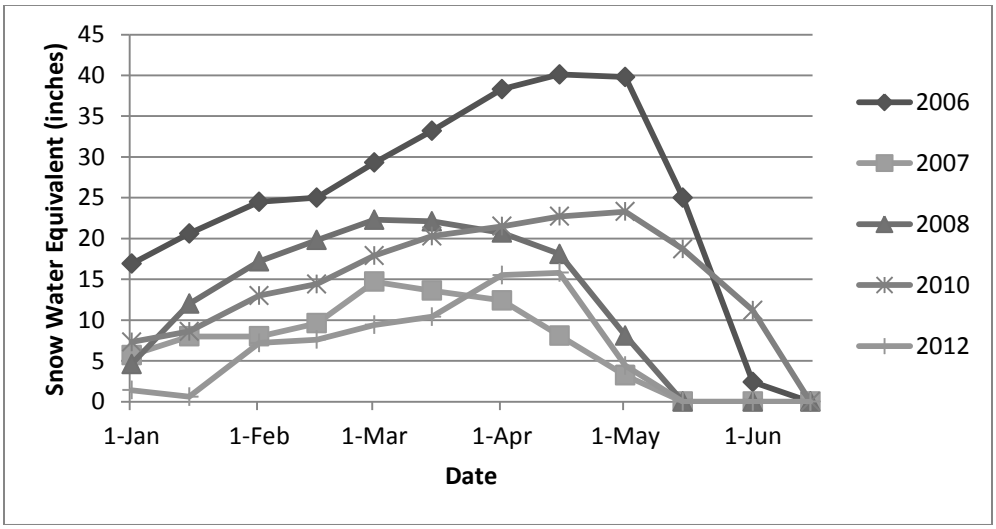

Figure 9. Snow-Water-Equivalent at the Heavenly SNOTEL Site (NRCS Heavenly SNOTEL Site 518) in monitoring years from 2006 to 2012.

An alternative explanation is that the changes in herbaceous cover could be attributed to observer differences between the four monitoring years. Studies have shown that changes in cover greater than 20-25% of the mean must be observed before the change can be attributed to factors other than observer bias (Hope-Simpson 1940, Greig-Smith 1983, Kennedy & Addison 1987). Between the pre-project and 2012 surveys, a 43% decrease in total cover of native herbaceous vegetation was observed; this amount of change is well above the threshold discussed above and therefore likely represents a true decline in cover.

Five years after project implementation there was no significant change in native shrub cover. Small increases were observed at some transects between 2006/2007 and 2012, as well as between 2010 and 2012. The project objective of maintaining or increasing native shrub cover has therefore been met, and project implementation does not appear to have had an adverse impact on native shrub cover. Any anticipated beneficial effects of project implementation, such as from reduced competition with conifers, have not yet been observed.

The number of invasive species at the project site overall had initially remained constant from 2006/2007 through 2008 and 2010 but decreased in 2012. The overall percent cover

of invasive species decreased significantly in 2012 compared to pre-project conditions, and invasive species cover along individual transects was constant or had decreased. Therefore project objectives for invasive species are currently being met. However, there was a trend at some transects as well as across the overall site of an increase in invasive species cover from 2010 to 2012, although invasive species cover has not returned to pre-project levels. The pattern of invasive species cover is similar to that of native herbaceous cover, and could be beginning to increase after an initial lag time in response to restoration activities. *Cirsium vulgare* (bull thistle) was the only invasive observed during monitoring that is treated by LTBMU staff. This species has been treated at least once a year from 2006 to the present and declined in cover during every monitoring year. However the decrease in invasive species cover does not appear to be attributable solely to the treatment efforts, because the cover of six other invasive species (*Bromus tectorum, Dactylis glomerata, Phleum pratense, Poa pratensis, Rumex acetosella,* and *Tragopogon dubius*) also decreased between pre-project and 2012 surveys.

Overall, species richness increased significantly between pre-project and 2012, both along individual transects and across the entire site. Gamma diversity (total number of species at the site) had increased from 61 species pre-project to 71 species in 2012. Beta diversity and species evenness were not significantly different pre- versus post-project. Therefore, overall species diversity has been maintained or increased, depending upon the index used; thus project objectives are currently being met.

Five years after project implementation, the proportion of plant species at the site that were obligate and facultative wetland species had increased to 40% compared to 37% pre-project. In addition, 75% of total cover was comprised of obligate and facultative wetland species in 2012, compared to 59% pre-project. The total cover of obligate wetland species increased more than the cover of any other category of species from 2010 to 2012, and the cover of obligate wetland species was greater in 2012 than it had been in 2006/2007. The increase in wetland species may be attributed to the project thinning. The removal of trees decreases the water loss due to evapotranspiration by trees (Wood 1975), increasing available water for herbaceous vegetation. Project implementation appears to have had the beneficial effect of promoting obligate and facultative wetland species diversity and abundance. Project objectives to maintain or promote obligate and facultative wetland species are currently being met.

Due to the lack of pre-project ground cover data, it is difficult to make definitive conclusions regarding the mechanisms for changes in ground cover composition and whether there is a relationship with the pre- to post-project decrease in herbaceous vegetation. Herbaceous vegetation cover was measured by ocular cover in the entire plot, while ground cover categories (including basal vegetation) were measured by point-intercept at the corners of the plot. Post-project changes in ground cover do not appear to be related to post-project changes in native herbaceous vegetation, with the exception of basal vegetation cover, which increased along with native herbaceous cover between 2010 and 2012. The amount of post-project bare ground has not changed and remains low (less than ten percent cover), therefore erosion is not a concern at this time. The post-project increase in large woody debris could be the result of additional forest thinning

work which occurred between 2010 and 2012, or the result of natural tree fall, which was noted on at least one transect in 2012. Following forest thinning, the remaining trees can be more susceptible to wind damage (Cremer et al. 1982). The decrease in litter cover between 2010 and 2012 could be due to increased decomposition rates if water availability and soil moisture have increased at the site as a result of conifer removal, or the litter is being covered up by the large woody debris.

The increase in canopy cover during the three visits following project implementation is likely due to thickening or expanding foliage on the remaining conifer trees and/or *Salix* shrubs. Large *Salix* shrubs taller than approximately one meter can be detected using hemispherical photography, and an increase in *Salix*, while not detected using the line-intercept method, would be a positive outcome for the demonstration project.

CONCLUSIONS

Our results indicate both positive and negative outcomes of project implementation. Project goals for invasive species, native species diversity, and wetland indicator species are currently being met: the number of invasive species is down and total cover has decreased overall (although increases were observed from 2010 to 2012); species diversity at transects and the entire project site has increased; and the proportion of obligate and facultative wetland species has increased. Contrary to project goals, total cover of native herbaceous species has decreased as of 2012 compared to pre-project conditions, although a reversal of the decline was observed between 2010 and 2012. Native shrub cover has not changed across the entire site, although small increases were observed along several transects. An additional year of monitoring in 2014 is recommended in order to assess the recovery of herbaceous species cover and monitor the status of invasive species cover. Additional monitoring could elucidate other long-term benefits of the fuels treatment activities.

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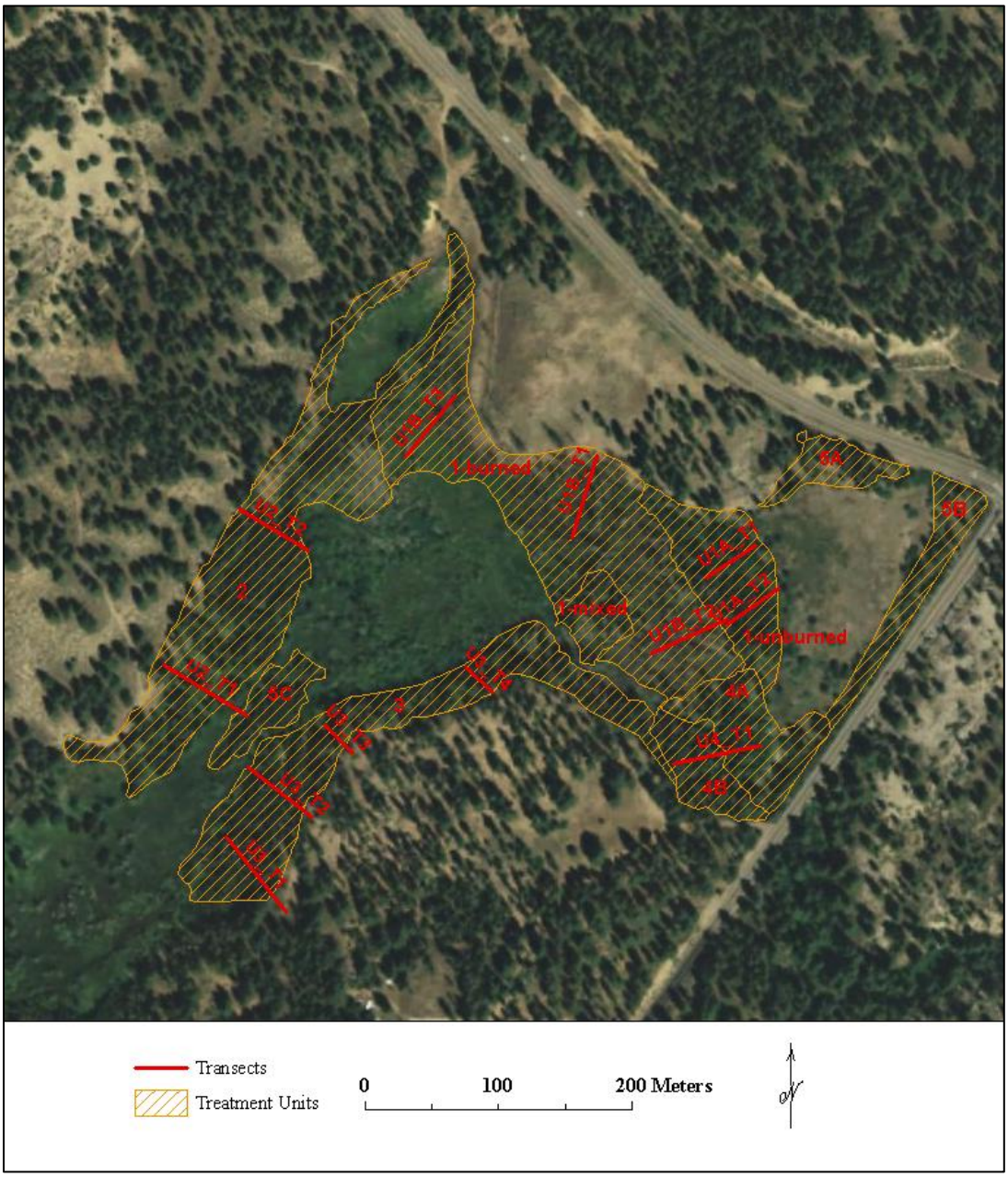
APPENDIX 1. Heavenly Creek SEZ Demonstration Project: Treatment Unit Boundaries and Vegetation Monitoring Transects



Appendix 2. Species present along transects at the Heavenly Creek SEZ Demonstration Project during three survey visits.

Species	Pre-project	2008	2010	2012	Wetland Status[1]	Native/Invasive (Rating)[2]
Achillea millefolium	x	x	x	x	FACU	N
Achnatherum occidentale	x	x	x	x	UPL	N
Achnatherum lemmonii				x	NO INFO	N
Agoseris retrorsa		x	x	x	UPL	N
Agrostis pallens				x	FACU	N
Agrostis sp.	x	x	x	x	FACU	N
Agrostis stolonifera			x	x	FACW	I (Limited)
Allophyllum gilioides		x	x		UPL	N
Arnica chamissonis	x	x	x	x	FACW	N
Artemisia tridentata			x	x	UPL	N
Aster occidentalis	x	x	x	x	UPL	N
Bromus carinatus	x	x	x	x	UPL	N
Bromus tectorum	x	x	x	x	UPL	I (High)
Calamagrostis sp.	x				FACW	N
Calyptridium umbellatum				x	UPL	N
Carex aquatilis			x	x	OBL	N
Carex athrostachya	x				FACW	N
Carex canescens		x	x	x	OBL	N
Carex lanuginosa	x		x	x	OBL	N
Carex lasiocarpa		x			OBL	N
Carex lenticularis		x			OBL	N
Carex microptera			x		FACU	N
Carex multicostata			x	x	FACW	N
Carex nebrascensis	x	x	x	x	OBL	N
Carex phaeocephala		x			UPL	N
Carex sp. 1	x	x	x	x	FACW	N
Carex sp. 2	x	x	x	x	FACW	N
Carex sp. 3	x	x		x	FACW	N
Carex utriculata	x		x		OBL	N
Cerastium sp.		x			NO INFO	N
Chenopodium album		x		x	FAC	I (Not Listed)
Circaea alpina	x				FAC	N
Cirsium andersonii			x	x	UPL	N
Cirsium vulgare	x	x	x	x	FACU	I (Moderate)
Claytonia perfoliata	x		x		FAC	N
Collinsia sp.		x	x		NO INFO	N
Collomia sp.	x	x			UPL	N
Cryptantha sp.	x	x	x	x	UPL	N

Species	Pre-project	2008	2010	2012	Wetland Status[1]	Native/Invasive (Rating)[2]
Dactylis glomerata	x				FACU	I (Limited)
Danthonia sp.		x			UPL	N
Elymus elymoides	x	x	x	x	FACU	N
Elymus glaucus			x	x	FACU	N
Elymus trachycaulus			x	x	FAC	N
Epilobium angustifolium	x	x	x	x	FACU	N
Epilobium ciliatum	x	x	x	x	FACW	N
Equisetum arvense	x	x	x	x	FAC	N
Erigeron sp.	x				UPL	N
Eriogonum spergulinum			x	x	UPL	N
Festuca idahoensis	x	x	x	x	FACU	N
Fragaria virginiana	x	x	x	x	FACU	N
Galium aparine	x	x	x	x	FACU	N
Galium palustre	x		x	x	FACU	N
Gayophytum diffusum	x	x	x	x	UPL	N
Geranium richardsonii			x	x	FACW	N
Geum macrophyllum	x	x	x	x	FAC	N
Glyceria elata		x	x	x	OBL	N
Hieracium albiflorum	x	x		x	UPL	N
Hordeum brachyantherum	x	x	x	x	FACW	N
Juncus arcticus	x	x	x	x	FACW	N
Juncus ensifolius	x				FACW	N
Juncus nevadensis				x	FACW	N
Juncus orthophyllus			x	x	FACW	N
Lathyrus lanzwertii		x	x		FACU	N
Lonicera conjugialis		x	x	x	FAC	N
Lotus purshianus	x				UPL	N
Lupinus breweri	x	x	x	x	UPL	N
Lupinus fulcratus	x	x	x	x	UPL	N
Lupinus grayi			x		UPL	N
Lupinus lepidus			x	x	UPL	N
Luzula comosa		x		x	FAC	N
Mimulus guttatus	x	x		x	OBL	N
Mimulus primuloides	x			x	OBL	N
Muhlenbergia filiformis	x	x	x		FACW	N
Orthilia secunda	x				FACU	N
Osmorhiza chilensis	x	x	x	x	FACU	N
Paeonia brownii				x	UPL	N
Penstemon rydbergii	x	x	x		FACU	N
Phacelia hastata	x	x	x	x	UPL	N

Species	Pre-project	2008	2010	2012	Wetland Status[1]	Native/Invasive (Rating)[2]
Phleum pratense	x				FACU	I (Watch List)
Phlox gracilis			x	x	FACU	N
Poa pratensis	x	x	x	x	FAC	I (Limited)
Poa secunda	x	x			FACU	N
Poaceae sp. 1	x		x	x	NO INFO	N
Poaceae sp. 2			x		NO INFO	N
Polemonium californicum			x		NO INFO	N
Polygonum douglasii	x		x	x	FACU	N
Potentilla glandulosa	x	x	x	x	FAC	N
Potentilla gracilis	x			x	FAC	N
Prunella vulgaris	x				FACU	N
Pseudostellaria jamesiana				x	NO INFO	N
Ranunculus occidentalis			x	x	FACW	N
Ribes nevadense	x	x			FAC	N
Ribes roezlii	x	x	x	x	UPL	N
Rorippa nasturtium-aquaticum	x	x	x		OBL	N
Rosa woodsii		x	x	x	FACU	N
Rumex acetosella	x	x	x	x	FACU	I (Moderate)
Rumex crispus		x	x		FAC	I (Limited)
Salix lemmonii	x	x	x	x	FACW	N
Salix lucida	x	x	x	x	FACW	N
Senecio integerrimus	x		x		FACU	N
Sidalcea oregana	x	x	x	x	FACW	N
Silene lemmonii		x			NO INFO	N
Sisyrinchium idahoensis			x	x	FACW	N
Smilacina stellata		x	x	x	FAC	N
Solidago canadensis				x	FACU	N
Spergularia rubra				x	FAC	I (Not listed)
Stellaria longipes	x	x	x	x	FACW	N
Taraxacum officinale	x	x	x	x	FACU	I (Watch List)
Tragopogon dubius	x		x		NO INFO	I (Watch List)
Trifolium longipes	x	x	x	x	FAC	N
Trisetum spicatum	x				UPL	N
Verbascum thapsus		x			FACU	I (Limited)
Veronica peregrina		x		x	OBL	N
Viola glabella	x				FAC	N
Viola macloskeyi	x	x	x	x	OBL	N

[1] Wetland Status follows the US Fish & Wildlife 2012 National Wetland Plant List as of December 2012.
[2]Rating follows the California Invasive Plant Council Invasive Plant Inventory as of December 2012.