REFERENCE SITE CONDITIONS FOR RESTORATION OF SEASONAL FRESHWATER WETLANDS AND COASTAL SAGE SCRUB NEAR SANTA CRUZ, CA, USA

Note: This report was excerpted from a survey and report to establish reference conditions for the University of California, Younger Lagoon Natural Reserve. It should be cited as "Reed, L.K., M. Hatch, K. Valenta, and K.D. Holl. 2011. Reference site characterization and restoration goals for northern coastal scrub and seasonal wetlands at Younger Lagoon Reserve. Report for the California Coastal Commission." Any questions about the report or data should be directed to Dr. Karen Holl, kholl@ucsc.edu.

Introduction

Habitats of the immediate coastal terrace have been highly modified throughout central California. The biologically rich and unique mosaic of coastal scrub, coastal prairie, and seasonal freshwater wetlands that was once widespread along the central and northern coast has been severely reduced in extent and remaining stands are often compromised by exotic species and altered disturbance regimes (Ford & Hayes 2007).

Defining restoration targets for communities such as the northern coastal scrub and seasonal freshwater wetlands (or coastal wet meadows) is challenging. The published literature on these specific habitats is also limited; in the case of seasonal wetlands, data are nearly nonexistent. In this report we seek to characterize a network of reference sites for northern coastal scrub and seasonal fresh water wetlands.

Coastal Scrub

The northern coastal scrub ecosystem is located along the coast from central to northern California and contains a dynamic plant community, with vegetation ranging from herbs to woody shrubs. The most common species present in northern coastal scrub habitats are *Baccharis pilularis* (coyote brush), *Toxicodendron diversilobum* (poison oak), *Artemisia californica* (California sagebrush), and *Lupinus arboreus* (yellow bush lupine) (Ford & Hayes 2007). Variation in community composition in northern coastal scrub habitats is strongly influenced by distance from the coast, by slope, and by aspect. Exposure to salt spray, coastal winds, and fog are abiotic factors that influence the distribution of this habitat and composition within it (Ford & Hayes 2007, Pollock & Dolman 1991). Coastal scrub is becoming an increasingly threatened habitat due to anthropogenic land conversion, such as urban and agricultural development (Ford & Hayes 2007, Pollock & Dolman 1991). Several associations are represented within northern coastal scrub communities (California Natural Diversity Database 2003). In this report we focus on associations with *Baccharis pilularis* because this is the dominant canopy species in existing scrub patches at YLR.

Perhaps the most locally relevant literature on coastal scrub communities is a term paper written by UCSC students Jacob Pollock and Brook Dolman (1991). They sought to define coastal scrub communities from the Pajaro River to Waddell Creek, which almost entirely overlaps our study area. Their report includes 776 observations from nine sites on the first marine terrace and to some extent, in the south, along coastal plains within 400 meters of the ocean. The observations were taken along paced 2-meter point transects in which the plant nearest each point was recorded as well as its nearest neighbor. They also noted environmental factors such as wind, soil type, and slope at each site. Based on these surveys they classified four species as indicators of northern coastal scrub (*Baccharis pilularis, Eriophyllum staechadifolium, Artemisia californica,* and *Erigeron glaucus*) and three (including one of the indicators) as pioneer species likely to colonize disturbed coastal scrub sites (*Baccharis pilularis, Toxicodendron diversilobum,* and *Achillea millefolium*). They noted in particular, high site to site variability in composition and diversity and a strong influence of wind on vegetation height. The report provides highly relevant localized information about this poorly understood habitat.

Seasonal Wetland

Coastal freshwater wetlands (or wet meadows) are a habitat of high conservation value, given that there are very few remaining along the central California coast. Wetlands in general are widely recognized for their habitat value and ecological services (Mitsch & Gosselink 2000). The conservation priority for these ecosystems is evidenced by the extensive regulatory framework in place to protect them (e.g. Coastal Zone Management Act and Clean Water Act) (Good 2010). Seasonal herbaceous wetlands, are among the more poorly understood and least protected of wetland habitats. Because these wetlands are completely dry during some parts of the year, they may be overlooked in wetland delineations or excluded from coarse classification schemes. Because they often exist in scattered patches within other habitats rather than consistently along major water ways, many of them may not warrant protection under section 404 of the Clean Water Act which designates protection of wetlands primarily when they are associated with "navigable water." Nonetheless, these seasonal wetlands provide critical habitat for numerous species and share many of the unique biogeochemical properties of other wetland types (Mitsch & Gosselink 2000).

Literature about the ecology and natural history of seasonal coastal freshwater wetlands is extremely limited. Subtle differences in edaphic conditions such as small scale topography and hydrology may have strong outcomes for potential vegetation as seen in other seasonally variable wetland habitats (Solomeshch et al. 2007, Mitsch & Gosselink 2000). Within our study area along the central coast of California, a variety of landscape attributes could lead to periodic and temporary hydric conditions sufficient to support the characteristic herbaceous wetland vegetation. The common use of tiling and other drainage features in farmlands of the central coast marine terrace suggests that such wetlands may have been common prior to the advent of cultivated agriculture in the area.

Methods

For each of the target habitats we compiled a list of potential reference sites by consulting local experts (Grey Hayes – Elkhorn Slough Coastal Training Program, Tim Hyland - California State Parks, Karen Holl – UCSC). We sought to constrain our site selection to the first marine terrace between Point Lobos in the south and Half Moon Bay in the north. Some exceptions were made for high quality habitats that were geographically close or similar in physiognomy to Younger Lagoon Reserve (YLR). After initial site visits were made some reference sites were excluded due to low native cover or limited spatial extent. Table 1 summarizes notes on reference site histories and current management. At each reference site, vegetation was characterized by surveying along 50-m transects (see modification of transect layout for wetlands discussed below) explicitly placed through vegetation patches with high native cover. The data were collected from 15 April through 6 May 2011.

Northern Coastal Coyote Brush Scrub

Four sites were selected to represent northern coastal scrub: Garrapata State Park and Point Lobos State Reserve at the south end of Monterey Bay, and Año Nuevo State Reserve and Whitehouse Creek north of Davenport. Within these sites we specifically searched for locations that were dominated by *Baccharis pilularis* and that had a topography and distance to the ocean similar to YLR; in particular we chose sites that were relatively flat and had scrub interspersed with grassland. We made this decision based on conversations with Grey Hayes and Tim Hyland who noted stark differences between scrub communities located on strongly sloped topography as compared with relatively flat sites. Pollock and Dolman (1991) also noted an apparent influence of distance to the ocean on coastal scrub communities in our study area.

Fifty meter transects were positioned in the target communities so as to maximize interception of areas with high native cover. Along each transect, we visually estimated absolute herbaceous species composition within a 1 × 0.25 m quadrat laid at a 90° angle from the transect tape. We placed the quadrat every five meters, alternating left and right sides, unless the area was dominated by shrub canopy, in which case we did not measure herbaceous cover. The visual estimates of each researcher were averaged to minimize observer bias (Elzinga et al. 2001). We recorded the species composition in cover class increments of 5%. We used the midpoint of each cover class for data analysis. In order to measure absolute cover of species in the shrub canopy, we recorded the beginning and ending points (to nearest 0.10 m) where the transect intercepted each shrub species. Values for each species were summed by transect prior to analysis. We surveyed a 2-m belt transect along each side of the transect tape to account for any species on site that were not present in the quadrats or intercepted by the line transect.

We monitored three transects at the Año Nuevo, Point Lobos, and Whitehouse Creek sites, and four transects at the Garrapata site. We characterized each site based on the means and variability among transects. Absolute cover values for herbaceous species were converted to relative cover prior to analysis while canopy species were summarized based on absolute cover in each transect. We report relative cover of herbaceous species and guilds to account for: (1) differences in productivity across reference sites (i.e. total cover at different sites varies inherently due to abiotic conditions) and (2) natural variation in total cover within localized microsites (i.e. total cover may be lower in highly shaded or flooded sites). Species were identified as native or exotic according to Hickman (1993). Richness is reported here as the total native richness observed along a transect including canopy species intercepted by the line transect, herbaceous species observed in the quadrats, and any native species found within the belt transect.

Seasonal Wetland

Originally five sites along the central coast were chosen to be used as reference sites. These included Año Nuevo, Whitehouse Creek, Wilder Ranch (Scaroni unit), Point Lobos, and Light House field. After a preliminary survey, Light House field was removed from the list due to limited potential for running multiple transects through high quality habitat. At each of these locations, we selected sites in areas that appeared to be wetland habitat primarily based on the presence of typical native wetland species. Presence of

standing water or evidence of hydric soils was also considered as the goal was to provide a baseline for the best freshwater wetland habitats along the central California coast.

Once again, 50-m transects were positioned within high quality patches so as to maximize interception of areas with high native cover. Herbaceous species composition was measured by visual estimation of absolute cover for each species in ten 0.25-m^2 quadrats along the transect. Quadrats were place every 5 m on alternating sides of the transect. Cover of each species, bare ground, and litter were estimated in 5% intervals and the midpoint used for analyses. Litter was specifically defined as residue from previous year's growth while any senescent material that was recognizable as growth from earlier in the current growing season was counted as cover for that species (Holl & Reed 2010). After all cover estimates had been made, observers surveyed within 2 m of either side of the transect (a 4 × 50 m belt) for any species not encountered in the frames. Some transects had to be segmented because the wetland habitat did not always stretch 50 meters. In these cases we measured the whole length of the wetland area and then moved the transect 4-m away, parallel, in the same area to complete 50 meters.

Cover and richness analyses were completed in the same way as for coastal scrub habitat except that there was no shrub cover. In addition, we also categorized each species according to its wetland indicator status as listed for California on the USDA PLANTS database (plants.usda.gov). The wetland indicator status is an estimate of a plant species probability of occurrence in wetland habitats. Each plant species has been assigned one of five indicator status categories based on their frequency of occurrence by several federal agencies: obligate (OBL) > 99%, facultative wetland (FACW) = 67 - 99%, facultative (FAC) = 34 - 66%, facultative upland (FACU) = 1- 33%, and upland (UPL) < 1% (Wakeley 2002).

One of the quantitative methods for defining a wetland and delineating its boundaries based on vegetation criteria is to use the prevalence index. The prevalence index is a weighted average of wetland indicator status for all species in a sample from the plant community, not just a subset of dominants (Atkinson et al. 1993). To calculate the prevalence index, indicator status categories were assigned numerical ratings (i.e., OBL = 5, FACW = 4, FAC = 3, FACU = 2, and no wetland indicator status = 1) and weights were relative abundances of each species in the community. We used the formula:

$$WA = (c_1*i_1 + c_2*i_2 + ... + c_m*i_m)/100$$

where c_1, c_2..., c_m are the relative cover estimates for each species in the plot and i_1,i_2...i_m are the indicator status of each species (Atkinson et al. 1993).

Results

Northern Coastal Coyote Brush Scrub

Total shrub cover was fairly consistent within and between sites with the exception of Año Nuevo which had both higher mean cover and higher variance (Fig. 1). All sites had canopy cover greater than 40%. Canopy composition varied among sites (Fig. 2). *Baccharis pilularis* was common at all sites, which is not surprising since we selected

sites with high *B. pilularis* cover, but secondary canopy dominants varied among sites and included species such as *Artemisia californica, Eriophyllum staechadifolium, Toxicodendron diversilobum,* and *Mimulus aurantiacus*. Average transect level richness across all sites was 10.5 ± 1.6 (SE) and varied greatly among sites (Fig. 3); herbaceous species accounting for an average of 55.2 ± 6.6% (SE) of the species present on a transect.

All sites had important native herbaceous components. The spaces between shrub patches often included native grassland species such as *Nassella pulchra, Danthonia californica*, and *Carex harfordii*. Openings within shrub patches were often occupied by species such as *Scrophularia californica, Achillea millefolium*, and *Satureja douglasii*. These were mostly captured in the belt transects and their cover was not quantified since there were few frames that were left uncovered by shrub canopy. For a full species list see Appendix 1.

Seasonal Wetland

Wetland reference sites varied in their native cover and richness (Figs. 4 & 5). Native cover was highest at Point Lobos (94.4 ± 4.6%) and lowest at White House Creek (50.8 ± 10.4%). Transect-level richness ranged from 11.0 ± 1.2 species at Whitehouse Creek to 5.3 ± 1.2 species at Wilder Ranch (Fig. 5). Dominant species that were present at all sites included *Juncus phaeocephalus, J. patens, J. occidentalis, Carex harfordii,* and *Hordeum brachyantherum*. *Juncus balticus* and *Eleocharis macrostachea* were also important in some sites. For full species list see Appendix 1 and recommended species for restoration see Table 2. Transect level wetland indicator scores were consistent among the four reference sites ranging from 3.1±0.2 (SE) at Año Nuevo to 3.4± 0.1 (SE) at Whitehouse Creek (Fig. 6).

Discussion

Northern Coastal Coyote Brush Scrub

In setting targets for restoring coastal scrub we recommend setting goals for both native shrub and native herbaceous community cover and richness. Our reference sites had several shrub species besides *Baccharis pilularis* which tends to dominate, particularly at degraded coastal scrub sites. At reference sites, we found a diverse assemblage of herbaceous species existing in and around the shrubs that dominate these communities. The California Natural Diversity Database (2003) likewise recognizes several northern coastal scrub associations between *Baccharis pilularis* and various native herbaceous species. In surveys of northern coastal scrub communities of Santa Cruz County, Pollock and Dolmon (1991) frequently encountered herbaceous species, particularly *Scrophularia californica* and *Achillea millefolium*. It is important to note that while the dominant species of northern coastal scrub are shrubs, much of the richness is comprised of herbaceous species and most of the special status species of these communities are herbs (Ford & Hayes 2007). Clearly, coastal scrub restoration efforts should include herbaceous components of these communities.

Seasonal Wetland

All the reference sites had >50% cover, however it is important to note that there was no evidence or record of tilling at any of the reference sites, whereas most of the first coastal terrace near Santa Cruz has been tilled. Our observed transect level richness varied among reference sites and there were >8 native species per transect in three of the four reference sites (Fig 5). Calculating the wetland indicator status of reference sites, provides an interesting insight into the degree to which each of these wetlands host obligate and facultative wetland species. We do not, however, recommend establishing criteria for overall wetland indicator status for evaluating coastal wetland restoration as there are many non-native species that are obligate or facultative wetland species, so restoration goals should focus on native cover and richness. However, selecting potential native species for restoration that are obligate or facultative wetland plants can help guide selection of species to include as part of wetland planting efforts. One other point worth reiterating is that we have reported herbaceous cover values in all habitat types as relative cover to correct for difference in total cover in different quadrats and sites.

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Figures

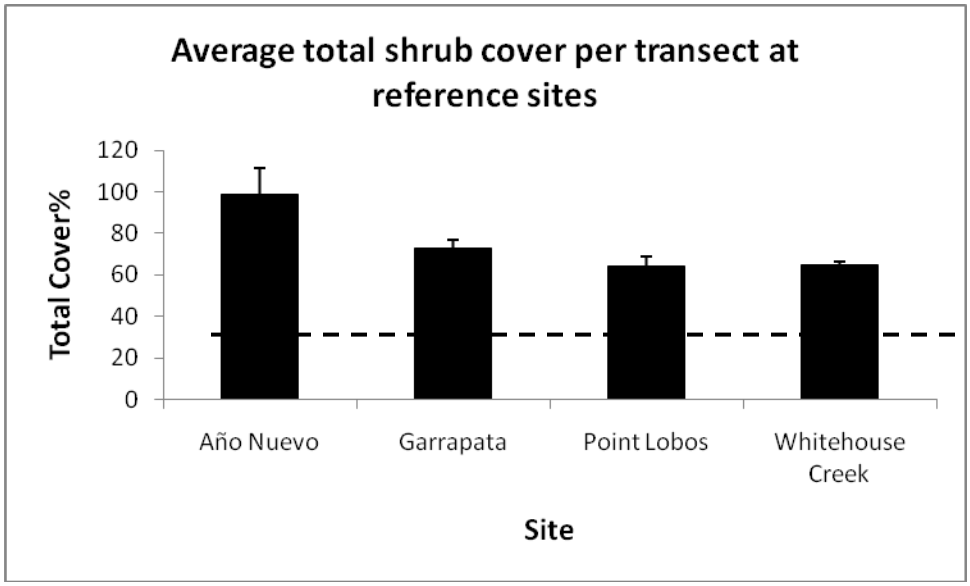

Figure 1. Mean absolute shrub cover at each coastal scrub reference site compared to the current target for YLR restoration. The dashed line indicates the current shrub cover target. Error bars represent one standard error.

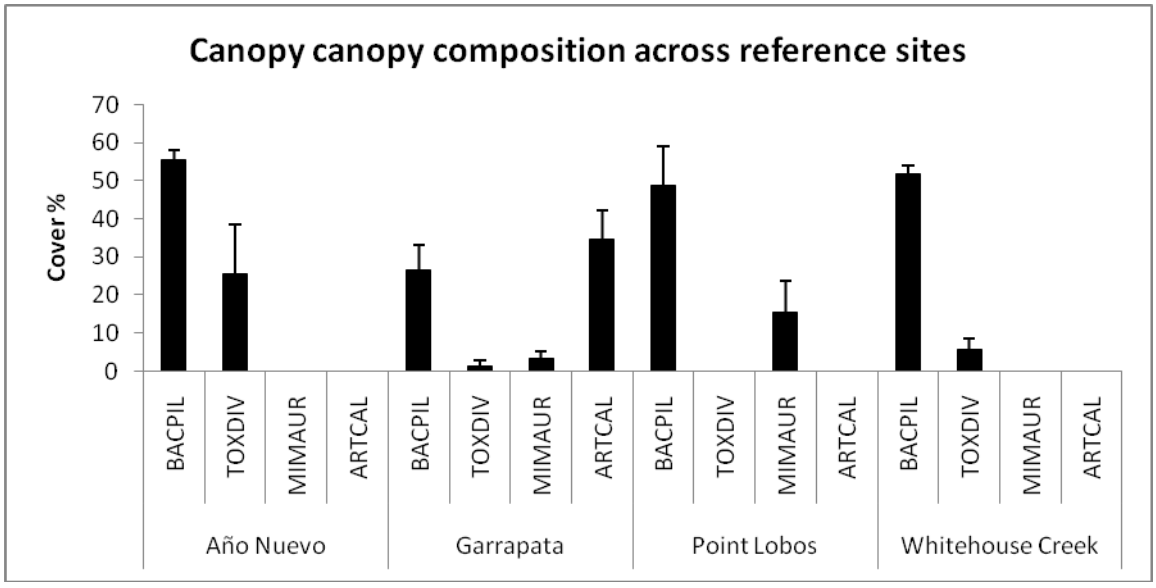

Figure 2. Comparison of canopy composition at each of the coastal scrub reference sites showing high site to site variability. BACPIL = *Baccharis pilularis*. TOXDIV = *Toxicodendron diversilobum*. MIMAUR = *Mimulus aurantiacus.* ARTCAL = *Artemisia californica*. Values are absolute cover. Error bars represent one standard error

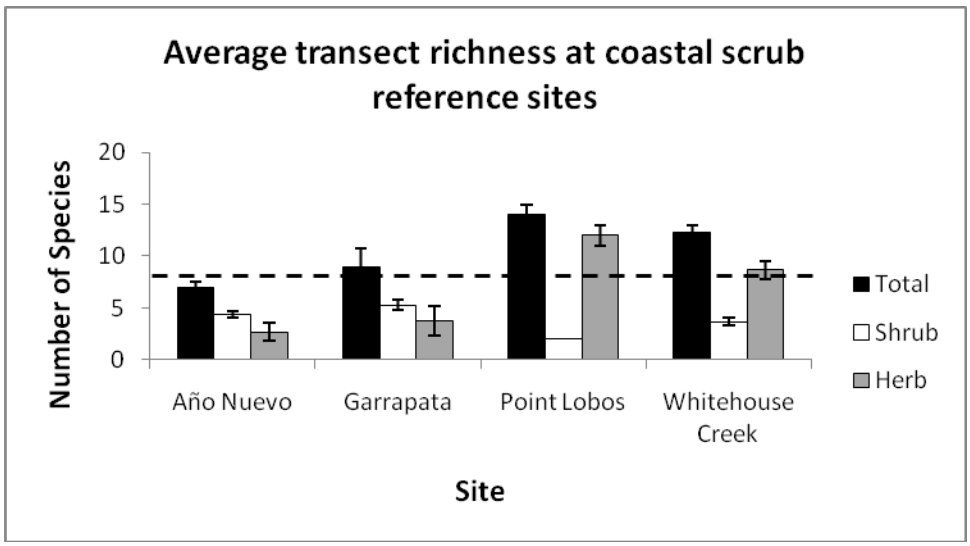

Figure 3. Transect level richness and contribution of shrubs and herbs to richness at each coastal scrub reference site. The line indicates the current stated richness target for coastal scrub. Error bars represent one standard error.

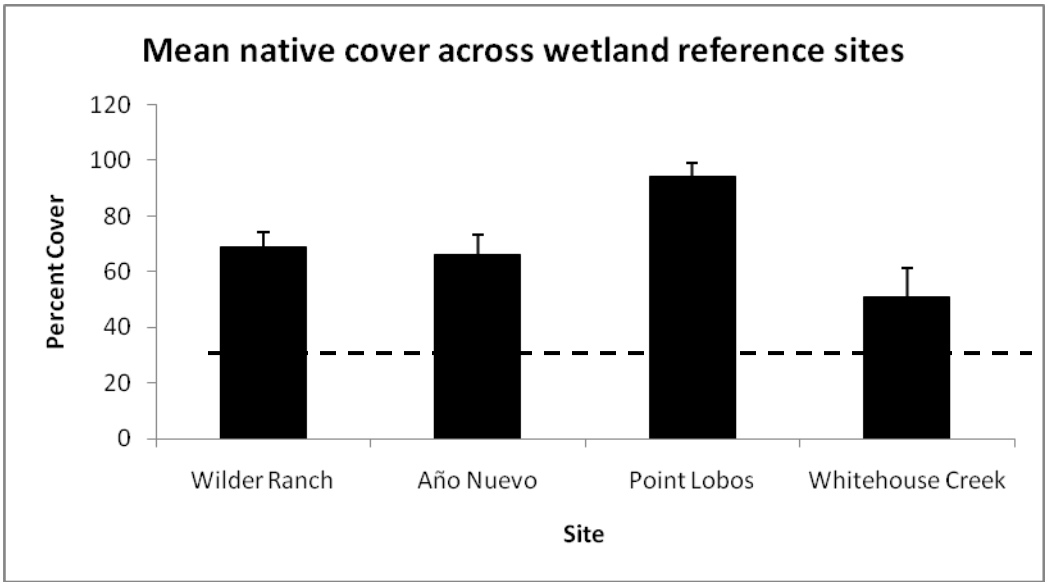

Figure 4. Relative native cover at seasonal wetland reference sites. The line indicates current target native cover in wetlands at YLR. Error bars represent one standard error.

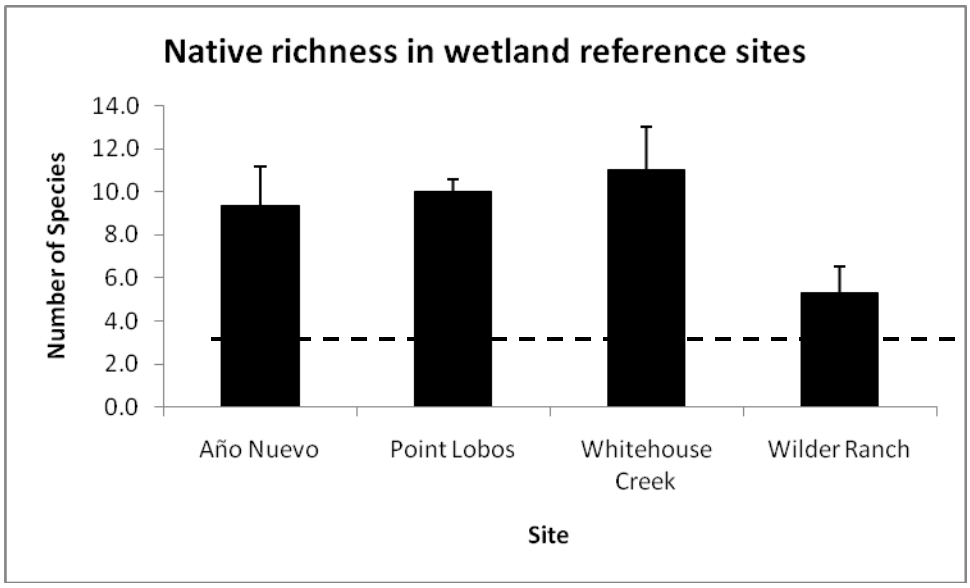

Figure 5. Native richness at seasonal wetland reference sites. The line indicates current target native richness in wetlands at YLR. Error bars represent one standard error.

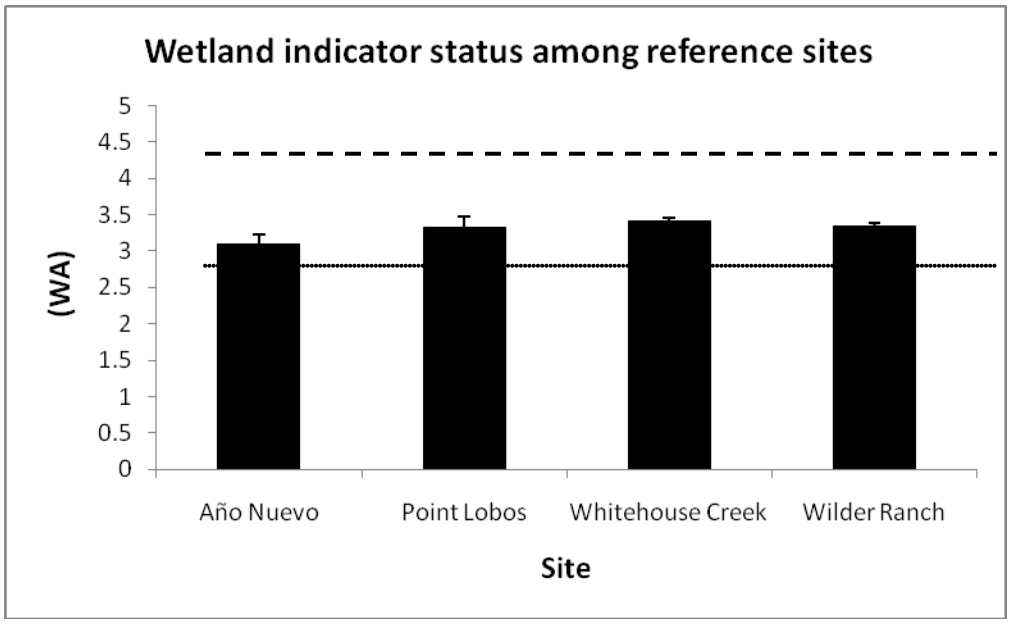

Figure 6. Wetland indicator status (WA) for each wetland reference site. The flat upper dotted line indicates current WA in wetland five at YLR while the fine lower dotted line indicates current WA for wetland 4. Error bars represent one standard error.

Table 1. Reference site history and management notes based on communications with Jeff Frey and Portia Halbert of California State Parks.

Site	History Notes	Current Management	Native Cover	Native Richness
Garrapata Scrub	Grazed until 1984. No evidence or record of tilling.	None.	72.6±4.2%	9.0± 1.7
Point Lobos Scrub	State Park land since 1933. No known history of cultivation. Middens and other artifacts in the area indicate heavy past use by Native Americans.	Monterey pine removal in 2010. Burned a few times in the last 15 years.	64.3±4.5%	14.0±1.0
Año Nuevo Scrub	State Park land since 1950's. Site is believed to have been historically cultivated. There are mature Monterey pine groves nearby and Monterey pine stumps and coast live oak seedlings in the survey area. This site may be in the early seral stages of a woodland succession.	None.	98.9±12.3 %	7.0±0.6
Whitehouse Creek Scrub	No evidence or record of tilling.	Gorse removal, pine removal, eucalyptus removal.	65.1±1.2%	12.3±0.7
Point Lobos Wetland	State Park land since 1933. No known history of cultivation. Middens and other artifacts in the area indicate heavy past use by Native Americans.	Burned a few times in the last 15 years.	94.4±8.0%	10.0±0.6
Wilder Ranch Wetland (Scaroni	No evidence or record of tillage, no evidence of modified hydrology, grazed until ~1988.	Spot treatment for Harding grass by herbicide or hand pulling.	68.9±9.4%	5.3±1.2

Unit)				
Año Nuevo Wetland	State Park land since 1950's. No evidence or record of tillage but trenching around the site indicates past manipulation of hydrology.	None.	66.3±12.3 %	9.3±1.9
Whitehouse Creek Wetland	No evidence or record of tilling. Evidence of trenching and other drainage modifications nearby but not in surveyed areas.	Spot treatment for Harding grass and gorse by herbicide or hand pulling.	50.8±18.0 %	11.0±1.2

Table 2. Recommended species for coyote brush scrub restoration pallet. The asterisks indicate species that are considered particularly appropriate for restoration at YLR based on their commonness among reference sites or presence at sites with environmental conditions particularly similar to YLR. GEO=Geophyte, GRM=Graminoid, PF=Perennial Forb, PG=Perennial Grass, S=Shrub.

Species	**Functional Group**
*Chlorogalum pomeridianum**	GEO
Calochortus uniflora	GEO
Triteleia hyacinthina	GEO
Carex harfordii	GRM
Juncus occidentalis	GRM
Juncus patens	GRM
Juncus phaeocephalus	GRM
*Achillea millefolium**	PF
Aster chilensis	PF
*Camissonia ovata**	PF
Cirsium brevistylum	PF
*Satureja douglasii**	PF
*Scrophularia californica**	PF
Sidalcia malviflora	PF
Sisyrinchium bellum	PF
*Bromus carinatus**	PG
Deschampsia cespitosa	PG
*Elymus glaucus**	PG
Hordeum brachyantherum	PG
*Nassella pulchra**	PG
*Artemisia californica**	S
Baccharis douglasii	S
*Baccharis pilularis**	S
Eriophyllum staechadifolium	S
Heteromeles arbutifolia	S
Lotus scoparius	S
*Mimulus aurantiacus**	S
*Rubus ursinus**	S
*Rhamnus californica**	S

Table 3. Recommended species for seasonal wetland restoration pallet. The asterisks indicate species that are considered particularly appropriate for restoration at YLR based on their commonness among reference sites or presence at sites with environmental conditions particularly similar to YLR. AF=Annual Forb, AG= Annual Grass, PF=Perennial Forb, PG=Perennial Grass, PGRM=Perennial Graminoid, AG=Annual Gramminoid.

Species	**Wetland Indicator Status**	**Growth Form**
*Aster chilensis**	FAC	PF
*Juncus patens**	FAC	PGRM
*Juncus bufonius**	FACW	AGRM
*Distichlis spicata**	FACW	PG
*Hordeum brachyantherum**	FACW	PG
Carex subracteata	FACW	PGRM
Juncus mexicanus	FACW	PGRM
*Juncus phaeocephalus**	FACW	PGRM
Eryngium sp.	NL	AF
*Rumex salicifolia**	NL	PF
*Deschampsia cespitosa**	NL	PG
Carex dudleyi	NL	PGRM
*Juncus occidentalis**	NL	PGRM
*Scirpus cernuus**	OBL	AGRM
*Scirpus koilolepis**	OBL	AGRM
*Baccharis douglasii**	OBL	PF
*Euthamia occidentalis**	OBL	PF
*Carex harfordii**	OBL	PGRM
*Eleocharis macrostachya**	OBL	PGRM
*Juncus balticus**	OBL	PGRM
*Lilaea scilloides**	OBL	AGRM

Appendix 1. Complete list of species identified during spring 2011 surveys.

Species	Functional Group	Origin
Epilobium ciliatum	AF	N
Sanicula maritima	AF	N
Stachys adjugoides	AF	N
Anagalis arvensis	AF	E
Cirsium vulgare	AF	E
Erodium cicutarium	AF	E
Geranium dissectum	AF	E
Lythrum hyssopifolium	AF	E
Picris echioides	AF	E
Sonchus asper	AF	E
Stellaria media	AF	E
Vicia sp.	AF	E
Galium sp.	AF	?
Aira caryophyllea	AG	E
Briza minor	AG	E
Bromus diandrus	AG	E
Bromus hordeaceus	AG	E
Bromus madritensis	AG	E
Hordeum murinum ssp. *leporinum*	AG	E
Lolium multiforum	AG	E
Polypogon monspeliensis	AG	E
Vulpia myuros	AG	E
Chlorogalum pomeridianum	GEO	N
Calochortus uniflora	GEO	N
Triteleia hyacinthine	GEO	N
Carex dudleyi	GRM	N
Carex harfordii	GRM	N
Carex subbracteata	GRM	N
Eleocharis macrostachya	GRM	N
Juncus balticus	GRM	N
Juncus bufonius	GRM	N
Juncus capitatus	GRM	N
Juncus mexicanus	GRM	N
Juncus occidentalis	GRM	N
Juncus patens	GRM	N
Juncus phaeocephalus	GRM	N
Scirpus cernuus	GRM	N

Scirpus koilolepus	GRM	N
Achillea millefolium	PF	N
Aster chilensis	PF	N
Camissonia ovata	PF	N
Cirsium brevistylum	PF	N
Eryngium sp.	PF	N
Euthamia occidentalis	PF	N
Gnaphalium sp.	PF	N
Rumex salicifolia	PF	N
Satureja douglasii	PF	N
Scrophularia californica	PF	N
Sidalcia malviflora	PF	N
Sisyrinchium bellum	PF	N
Plantago lanceolata	PF	E
Rumex acetosella	PF	E
Rumex crispus	PF	E
Convolvulus sp.	PF	?
Bromus carinatus	PG	N
Deschampsia cespitosa	PG	N
Distichlis spicata	PG	N
Elymus glaucus	PG	N
Hordeum brachyantherum	PG	N
Nassella pulchra	PG	N
Holcus lanatus	PG	E
Phalaris aquatica	PG	E
Artemisia californica	S	N
Baccharis douglasii	S	N
Baccharis pilularis	S	N
Eriophyllum staechadifolium	S	N
Heteromeles arbutifolia	S	N
Lotus scoparius	S	N
Mimulus aurantiacus	S	N
Rhamnus californica	S	N
Rhus ovata	S	N
Rubus ursinus	S	N
Salvia melifera	S	N
Toxicodendron diversilobum	S	N
Pinus radiata	T	N
Quercus agrifolia	T	N