

Accuracy Assessment of Mid-Scale Central Valley Riparian Vegetation Map

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Introduction

In 2011, the Chico Geographical Information Center (GIC), under contract to the Department of Water Resources, produced a Central Valley Riparian Vegetation map for the Central Valley Flood Protection Program. The purpose of testing the accuracy of the mid-scale classification map was to determine if the Group and Macrogroup levels of the national vegetation classification hierarchy can accurately represent the classification of riparian and wetlands in this area. All maps supported by the California Department of Fish and Game (CDFG) Vegetation Classification and Mapping Program (VegCAMP) are compliant with the National Vegetation Classification System (NVC) and are tested for accuracy to provide the user of these maps with information on the relative accuracy and reliability of the product.

In the fall of 2010, prior to the mapping, a classification system and a key were developed using the Group or Macrogroup level of the NVC. The explanation of these classification concepts and how they relate to other levels of the National Vegetation Classification Hierarchy may be found at the following web site:

<http://www.natureserve.org/explorer/classeco.htm#heirarchy>

More effort will be put into testing the accuracy of the next level of resolution in the fine-scale map currently expected to be completed within the next 1.5 years.

The 15 natural or semi-natural mapping units from the classification were tested for accuracy. The term “semi-natural” is used in the National Vegetation Classification to denote types that are characterized by non-native but self-perpetuating stands of vegetation. No tests were required of other non-natural categories such as agricultural or urban mapping units. Table 1 shows the 15 vegetation categories tested in the accuracy assessment.

Table 1: Group/Macrogroup mapping units and component vegetation alliances (for reference) in the Accuracy Assessment

Group Code	Group Name	Included alliances as described in Sawyer et al. (2009):
RWF	Group - Southwestern North American riparian evergreen and deciduous woodland	<i>Acer negundo</i> alliance <i>Juglans hindsii</i> special and semi-natural stands <i>Platanus racemosa</i> alliance <i>Populus fremontii</i> alliance <i>Quercus lobata</i> “riparian” alliance <i>Salix gooddingii</i> alliance <i>Salix laevigata</i> alliance
VRF	Group - Vancouverian riparian deciduous forest (ecological system equivalent: Mediterranean California Foothill and Lower Montane Riparian Woodland)	<i>Alnus rhombifolia</i> alliance <i>Fraxinus latifolia</i> alliance <i>Salix lucida</i> alliance
IMF	Macrogroup - Introduced North American	includes stands of <i>Eucalyptus</i> , <i>Ailanthus</i> , and other non-native naturalized trees

	Mediterranean woodland and forest (no group subdivision below this)	
WVO	Group - Californian broadleaf forest and woodland	<i>Aesculus californica</i> Alliance <i>Quercus agrifolia</i> Alliance <i>Quercus douglasii</i> Alliance <i>Quercus wislizeni</i> Alliance <i>Quercus lobata</i> Upland Alliance <i>Umbellularia californica</i> Alliance
CSS	Group - Central and south coastal California seral scrub	<i>Baccharis pilularis</i> Alliance <i>Lotus scoparius</i> Alliance <i>Lupinus albifrons</i> Alliance <i>Heterotheca oregana</i> sub-shrub scrub (putative definition)
RWS	Group - Southwestern North American riparian/wash scrub	<i>Baccharis salicifolia</i> Alliance <i>Cephalanthus occidentalis</i> Alliance <i>Rosa californica</i> Alliance <i>Salix exigua</i> Alliance <i>Salix lasiolepis</i> Alliance <i>Sambucus nigra</i> Alliance
RIS	Group - Southwestern North American introduced riparian scrub	<i>Arundo donax</i> Semi-natural Stands <i>Tamarix</i> spp. Semi-natural Stands <i>Rubus armeniacus</i> semi-natural stands
CAI	Group - Mediterranean California naturalized annual and perennial grassland	<i>Aegilops triuncialis</i> Semi-natural Stands <i>Avena (barbata, fatua)</i> Semi-natural Stands <i>Brassica (nigra)</i> and other mustards Semi-natural Stands <i>Bromus (diandrus, hordeaceus)</i> – <i>Brachypodium distachyon</i> Semi-natural Stands <i>Centaurea (solstitialis, melitensis)</i> Semi-natural Stands <i>Centaurea (virgata)</i> Semi-natural Stands <i>Conium maculatum</i> – <i>Foeniculum vulgare</i> Semi-natural Stands <i>Cortaderia (jubata, selloana)</i> Semi-natural Stands <i>Cynosurus echinatus</i> Semi-natural Stands <i>Lolium perenne</i> Semi-natural Stands
CFG	Group - California annual forb/grass vegetation	<i>Ambrosia psilostachya</i> Provisional Alliance <i>Amsinckia (menziesii, tessellata)</i> Alliance <i>Artemisia douglasiana</i> {Putative, not in Sawyer et al 2009} <i>Artemisia dracuncululus</i> Alliance <i>Eschscholzia (californica)</i> Alliance <i>Lasthenia californica</i> – <i>Plantago erecta</i> – <i>Vulpia microstachys</i> Alliance

		<i>Lotus purshianus</i> Provisional Alliance <i>Plagiobothrys nothofulvus</i> Alliance
VPB	Group Californian mixed freshwater vernal pool/swale bottomland	<i>Alopecurus geniculatus</i> Provisional Alliance <i>Lasthenia fremontii</i> – <i>Downingia (bicornuta)</i> Alliance <i>Eleocharis macrostachya</i> Alliance <i>Eleocharis acicularis</i> Alliance <i>Eryngium aristulatum</i> Alliance <i>Grindelia (stricta)</i> Provisional Alliance <i>Centromadia (pungens)</i> Alliance <i>Deinandra fasciculata</i> Alliance <i>Lasthenia fremontii</i> – <i>Distichlis spicata</i> Alliance <i>Lasthenia glaberrima</i> Alliance <i>Layia fremontii</i> – <i>Achyrachaena mollis</i> Alliance <i>Montia fontana</i> – <i>Sidalcea calycosa</i> Alliance <i>Trifolium variegatum</i> Alliance
FEM	Group - Arid West freshwater emergent marsh	<i>Phragmites australis</i> Alliance (most are considered invasive weedy ecotypes) <i>Schoenoplectus acutus</i> Alliance <i>Schoenoplectus californicus</i> Alliance <i>Typha (angustifolia, domingensis, latifolia)</i> Alliance
WTM	Group - Californian warm temperate marsh/seep	<i>Carex barbarae</i> Alliance <i>Carex densa</i> Provisional Alliance <i>Carex nudata</i> Alliance <i>Juncus arcticus</i> (var. <i>balticus, mexicana</i>) Alliance <i>Juncus (oxymeris, xiphioides)</i> Provisional Alliance <i>Leymus triticoides</i> Alliance <i>Mimulus (guttatus)</i> Alliance
SSB	Group - Southwestern North American salt basin and high marsh	<i>Allenrolfea occidentalis</i> Alliance <i>Arthrocnemum subterminale</i> Alliance <i>Atriplex lentiformis</i> Alliance <i>Atriplex spinifera</i> Alliance <i>Cressa truxillensis</i> – <i>Distichlis spicata</i> Alliance <i>Frankenia salina</i> Alliance <i>Suaeda moquinii</i> Alliance
NRW	Group - Naturalized warm-temperate riparian and wetland group	<i>Lepidium latifolium</i> Semi-natural Stands <i>Persicaria lapathifolia</i> – <i>Xanthium strumarium</i> Provisional Alliance

FAV	Macrogrouop -Western North American Freshwater Aquatic Vegetation (includes Group - Temperate Pacific freshwater aquatic bed, Group - Temperate freshwater floating mat, and Group – Naturalized temperate Pacific freshwater vegetation)	<i>Hydrocotyle (ranunculoides–umbellata)</i> Alliance <i>Isoetes</i> spp. Provisional Alliance <i>Polygonum amphibium</i> Unique Stands <i>Sparganium (angustifolium)</i> Alliance <i>Ludwigia (hexapetala, peploides)</i> Semi-natural Stands <i>Myriophyllum strictum</i> <i>Cabomba caroliniana</i> <i>Egeria</i> (may also include <i>Eichhornia crassipes</i> stands, if discovered in mapping area) <i>Azolla (filiculoides, mexicana)</i> Provisional Alliance <i>Lemna (minor) and relatives</i> Provisional Alliance
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Sample Allocation and Data Collection

Accuracy assessment (AA) samples were allocated by CDFG once the draft map product was received from the mappers at the Chico Geographical Information Center (GIC). In general, stratified random sampling (Cochran 1977, Thompson 2002) was employed to obtain a sufficient number of observations within each map unit to make a reasonably precise statement about the accuracy of each map unit. See Appendix A for a detailed description of the accuracy assessment sample allocation.

From fall 2010 to summer 2011, 159 AA field surveys were collected to verify the 15 vegetation classes used in the map. Figure 1 shows the location of the AA field surveys in the study area. We attempted to sample at least an average of 8 replicates of each of the 15 main mapping units. Using the field key to vegetation map types (Appendix B), field crews tentatively identified the vegetation type in each of the 159 stands. Field staff collected field AAs without knowledge of the mappers' attributes for the polygons that were assessed. A set of digital photographs for surveys were taken and archived (in folders by survey date or polygon number). Surveys were quality controlled following entry into an MS Access database, including forms for entering and viewing data records. (Associated survey data are contained within a series of tables; other look-up reference tables provide functionality of the forms and data tables.) See Appendix C for examples of the AA field survey forms and the AA analysis database.

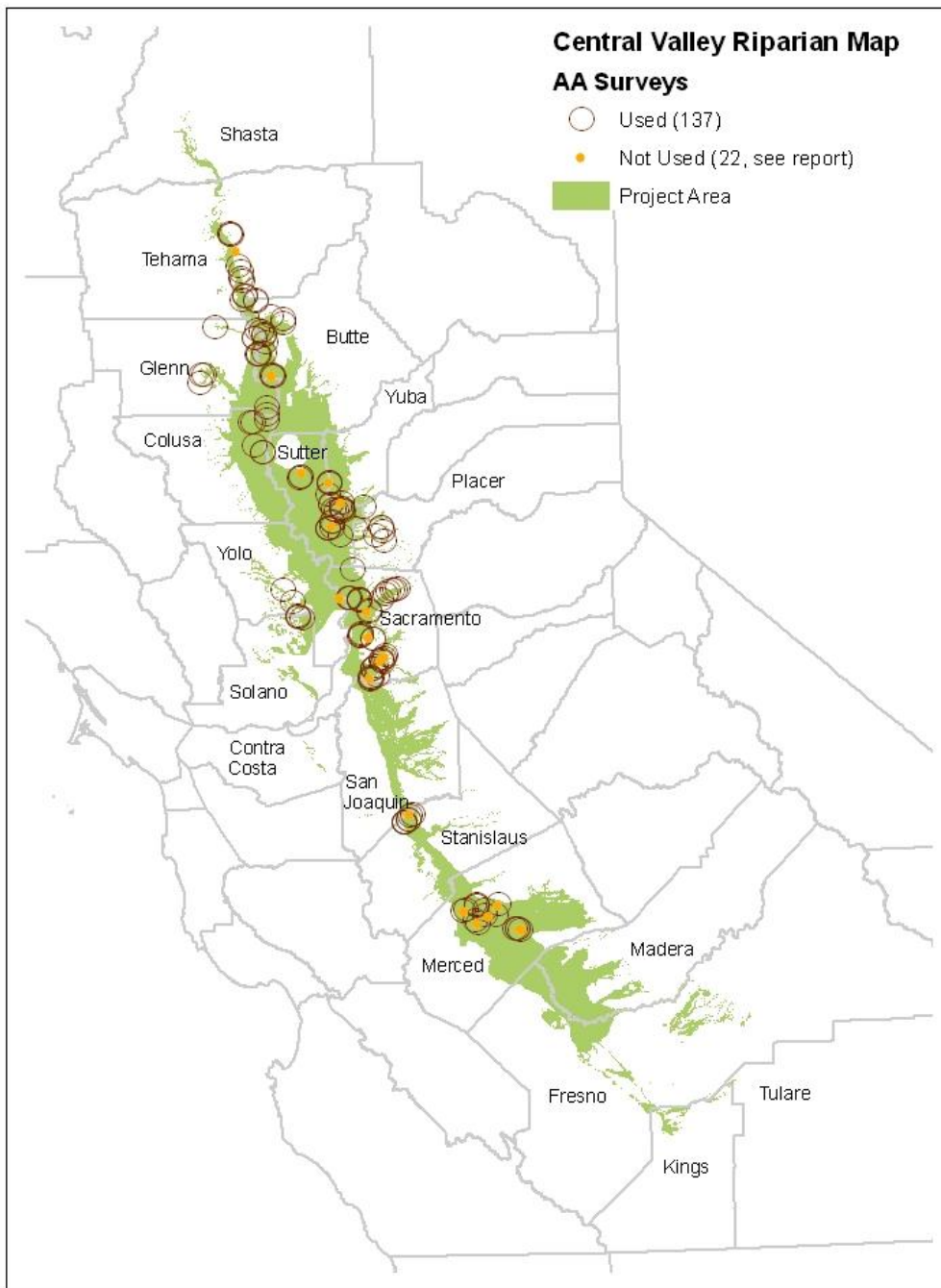


Figure 1: Location of the AA field surveys

Accuracy Assessment

Analysis and review were done by VegCAMP staff not directly involved in collecting the field data by querying the data contained in the AA database tables. Following data entry and review of the 159 samples, CDFG vegetation program staff removed 22 samples from consideration. These samples were removed due to issues with access, late-season vegetation identification, the inability to view a sufficient proportion of the individual vegetation stand being assessed or a significant change in land use, management, or vegetation since the date of the imagery on which the map was based. CDFG staff reviewed the tentative field calls of the sampling crews

and assigned final map units, then scored each of the remaining 137 individual samples for accuracy.

An accuracy assessment analysis helps the map users determine how much confidence can be assigned to each of the map units, and provides an understanding of the map's appropriateness for various applications. For more complicated classifications, the CDFG Vegetation Program has used a fuzzy logic method to compare the vegetation label assigned to each polygon in the map (i.e., the photo-interpreted map unit attribute) with the label assigned through ground-truthing. However, since this product used a broader classification system at the group level, the assessment was scored using a binomial (right/wrong) approach. The standard expectation of such products is that the average score per type assessed should meet the minimum 80% accuracy. If this is not reached, the scorers will analyze the problem with the low scores and offer an explanation and possible solutions to the mappers for the results.

As further explanation for scores that were not completely correct, but did have some similarity to the actual vegetation type as determined in the field, a "reason code" was assigned in the database to each polygon assessed explaining the goodness of fit based on the rules as shown in Table 2. (These are the codes that would be used to justify a fuzzy logic score of 0-5, if we would have used fuzzy logic in scoring.)

Table 2: AA database codes used for problematic results.

Reason Code	Explanation
A	PI completely correct
B	Correct Group OR next level up in hierarchy
C	Based on close ecological similarity
D	Correct Macro Group OR next level up in hierarchy
E	Overlapping cover of significant and similar species
F	Correct Division
G	Correct at Lifeform and some floristic/hydrologic similarity
H	Correct only at Lifeform
I	No similarity above Formation and incorrect Lifeform
J	Survey removed because significant change in polygon since date of imagery
K	Survey removed if represents less than or equal to 10 percent of polygon
L	Survey removed because field data is incomplete, inadequate or confusing

Results

Two forms of accuracy (users' and producers') can be estimated from the data (Story and Congalton 1986). Users' accuracy is conditional on the mapped classes and defined as the probability that a location mapped as class i is in fact class I . This provides an estimate of how well spatial mapping data actually represents what is found on the ground; i.e., if the user goes to a location mapped as class i , what is the probability it is in fact vegetation class I ?

Producers' accuracy, on the other hand, is conditional on the true vegetation class in the field. The producers' accuracy for class J is the probability that a location of vegetation class J in the field is mapped as class j . Producers' accuracy may inform the producers of remotely sensed

and mapped data how readily a mapping class may be detected by mapping whenever it occurs on the ground (Story and Congalton 1986, Lea and Curtis 2010). Table 3 depicts users' and producers' accuracy for each of the types. However, results for types with less than 8 samples each should be taken with lower credibility due to the likely high variance within the small sample size.

Table 3: Summary of the percent accuracy assessment of the vegetation map units (sorted by users' accuracy). Numbers in bold signify less than the 80% accuracy threshold. Red numbers indicate lower than preferred sample sizes, hence, low reliability of scores.

Map Code	NVC Group Name	Users' Accuracy	Users' Count (n)	Producers' Accuracy	Producers' Count (n)
FEM	Arid West freshwater emergent marsh	100	13	93	14
CSS	Central and south coastal California seral scrub	100	5	63	8
RWF	Southwestern North American riparian evergreen and deciduous woodland	100	15	71	21
CFG	California annual forb/grass vegetation	92	12	100	100
CAI	Mediterranean California naturalized annual and perennial grassland	90	10	64	14
VPB	Californian mixed freshwater vernal pool/swale bottomland	88	8	88	8
FAV	Western North American Freshwater Aquatic Vegetation	88	7	88	8
WVO	Californian broadleaf forest and woodland	79	14	73	15
IMF	Introduced North American Mediterranean woodland and forest	70	10	100	7
RWS	Southwestern North American riparian/wash scrub	58	12	100	7
RIS	Southwestern North American introduced riparian scrub	50	10	63	8
WTM	Californian warm temperate marsh/seep	44	9	50	8
NRW	Naturalized warm-temperate riparian and wetland group	43	7	43	7
SSB	Southwestern North American salt basin and high marsh	0	4	0	1
VRF	Vancouverian riparian deciduous forest	0	1	0	n/a

A contingency table (Table 4) displays the results of all samples as seen from the perspective of users' and producers' accuracy, allowing the reader to see what types were confused with other types from both the users' and producers' perspective.

Table 4: Contingency Table of AA results

	CAI - Mediterranean Calif naturalized annual and perennial grassland	CFG - California annual forb/grass vegetation	CSS - Central and south coastal California seral scrub	FAV - Naturalized temperate Pacific freshwater vegetation	FEM - Arid West freshwater emergent marsh	IMF - Introduced North American Mediterranean woodland and forest	NRW - Naturalized warm-temperate riparian and wetland group	RIS - Southwestern North American introduced riparian scrub	RWF - Southwest. N. Am. riparian evergreen and deciduous woodland	RWS - Southwestern North American riparian/wash scrub	SSB - Southwestern North American salt basin and high marsh	VPB - Calif mixed ann./perenn.freshwater vernal pool/swale bottomland	VRF -Vancouverian riparian deciduous forest	WTM - Californian warm temperate marsh/seep	WVO - Californian broadleaf forest and woodland	Total	Producers' % accuracy
CAI	9							3			1		1			14	64
CFG		11														11	100
CSS			5					2			1					8	63
FAV				7										1		8	88
FEM					13		1									14	93
IMF						7										7	100
NRW	1						3							3		7	43
RIS								5		2				1		8	63
RWF							1		15	2					3	21	71
RWS										7						7	100
SSB							1									1	0
VPB											1	7				8	88
VRF																	na
WTM		1					1				1	1		4		8	50
WVO						3				1					11	15	73
Total	10	12	5	7	13	10	7	10	15	12	4	8	1	9	14	137	
Users' % accuracy	90	92	100	100	100	70	43	50	100	58	0	88	0	44	79		

The horizontal axis in this table provides columns showing how the photo interpreters (producers) mapped the polygons as compared to how the field surveyors (users) assessed their polygons on the ground (shown as rows). For example, the producers attributed CSS to 5 polygons of all of the polygons surveyed during AA. While the accuracy assessment results classified all five of those polygons as CSS, the users also identified 3 other polygons as that map class.

For the assessed map units with at least 8 surveys per type, the overall binomial users' accuracy score averaged 79% and producers' accuracy averaged 76%. Since the preferred accuracy for vegetation mapping products is 80% (See Article 4 in [LAO Supplemental Report of the 2007 Budget Act, Item 3600-001-0001 – Dept. of Fish and Game](#)), the map almost met the map accuracy criteria. Those vegetation map units that did not meet the 80% expectation are reviewed here and additional suggestions for changes or improvements are discussed.

Discussion of individual examples of accuracy of less than 80%

Southwestern North American salt basin and high marsh Group (SSB) Perhaps the most distinct example was the apparent inability of the photo interpreters to distinguish this group from many other herbaceous groups. Four individual polygons were mapped SSB, although none of them were found to be SSB in the field. The single polygon that was found to be SSB in the field was mapped as NRW. The low accuracy for this type was due to inadequate familiarity with the group due to no previous training for the mapping of it. In the evolution of this project, portions of the northern and central San Joaquin Valley were added later and the photo interpreters had not been able to perform reconnaissance of the most expansive portion of the SSB extent in the study area prior to their need to map it. The signature of SSB is relatively predictable once it is learned. We expect the fine scale mapping follow up to this project will have much higher accuracy of this type than the current product because the mappers will have diagnosed the distinctive signature of the alliances within this group.

Naturalized warm-temperate riparian and wetland group (NRW) Users' accuracy for this group was 43% although the sample size was low (n=7). This group has been tentatively developed in the California version of the National Classification to represent stands that contain many weedy wetland vegetation indicators. The indicator species for this group may be widespread North American natives like *Xanthium strumarium* or *Persicaria lapathifolium*, or true non-natives such as *Lepidium latifolium*. All of these species individually or in combination are indicators of these Semi-natural Stands. Although all of these species share similar ecologies such as rapid colonization of seasonally drying wetlands, they do have different signatures at different times of the year. Results such as this suggest that the mappers should consider labeling all of these polygons by a broader category in the classification.

A likely choice for this broader category would be the Macrogroup MG075. Western North America Wet Meadow and Low Shrub Carr. This macrogroup contains 3 groups in California. In addition to the NRW, there is the group Californian warm temperate marsh/seep (WTM). This group is generally uncommon throughout its range due to riparian and seep modification in much of the state. This group includes *Carex barbarae* Alliance, *Carex densa* Provisional Alliance, *Carex nudata* Alliance, *Juncus arcticus* (var. *balticus*, *mexicana*) Alliance, *Juncus (oxymetris, xiphioides)* Provisional Alliance, *Leymus triticoides* Alliance and the *Mimulus (guttatus)* Alliance. The other group in this macrogroup is the Western Cordilleran montane-boreal summer-saturated meadow. This group is not represented in our study region, and is found at higher elevations in the mountains of the state. Interestingly, the NRW was commonly mistaken for WTM.

Southwestern North American introduced riparian scrub (RIS) Another problematic group, this represents semi-natural stands of *Arundo donax*, shrubby species of *Tamarix*, and introduced mesic or riparian brambles such as *Rubus armeniacus*. This type was mistaken for other types 3 times, 2 of which were Southwestern North American riparian/wash scrub (RIS) and one Californian warm temperate marsh/seep (WTM). The riparian context and shrubby nature of *Tamarix* and *Rubus armeniacus* could have led to the confusion. Other types were mistaken for this type 5 times, three of which were Mediterranean California naturalized annual and perennial grassland (CAI) and 2 of which were Central and south coastal California seral scrub (CSS). The mistakes for CAI can be explained by the similar moisture regimes of these two groups and the fact that many stands of these two groups interdigitate in the study area since both are a result of frequent human disturbance.

CSS in the study area is composed of shrubs such as *Baccharis pilularis* which often occupies similar areas to *Rubus* and may have been mistaken for it. *Conium maculatum* and *Foeniculum vulgare* are both indicators of the Mediterranean California naturalized annual and perennial grassland (CAI). These are stout tall herbs that resemble shrubs and also tend to grow in similar disturbed areas as RIS. It is likely that the NAIP 1 m imagery was inadequate to discern them from shrub cover some of the time.

Introduced North American Mediterranean woodland and forest (IMF) As tested by producers' accuracy, this group has a perfect score. However, users' accuracy for this type was only 70%. Three AA samples of this type were attributed to Californian broadleaf forest and woodland (WVO). WVO includes Valley and Blue Oak woodlands, Interior Live Oak, buckeye, and other upland woodlands. In some cases these stands occur adjacent to riparian woodlands of either native or non-native trees. A mistake confusing a native upland woodland with a non-native upland or riparian stand could easily occur due to the similar signature and mesic but upland nature of many of the stands of IMF which include *Ailanthus*, hybrid walnuts, Black Locust (*Robinia pseudo-acacia*), Eurasian Fig (*Ficus carica*), and *Eucalyptus* spp.

Californian broadleaf forest and woodland (WVO) This group was generally accurately mapped, but did not quite meet acceptable user standards (79%, n=14). The main reason for this was that 3 stands were mapped as WVO that were actually RWF - Southwestern North American riparian evergreen and deciduous woodland. When Valley oak (*Quercus lobata*) occurs adjacent to riparian settings there is regular difficulty distinguishing this alliance from the RWF riparian group characterized by *Acer negundo* alliance, *Juglans hindsii* special and semi-natural stands, *Platanus racemosa* alliance, *Populus fremontii* alliance, *Salix gooddingii* alliance, and *Salix laevigata* alliance. In fact, there is evidence supporting the concept of a "Quercus lobata riparian" alliance, which is a mixture of valley oak with other riparian species. This has yet to be resolved within the classification taxonomy of California vegetation, but points to the difficulty at times of distinguishing stands in riparian settings dominated by valley oak versus valley oak upland stands. Slightly more serious errors occurred as tested in producers' accuracy for WVO (73%, n=15). Three of the four errors were when WVO was mapped as Introduced North American Mediterranean woodland and forest (IMF). The reason for this error is discussed in the previous paragraph.

Southwestern North American riparian evergreen and deciduous woodland (RWF) also did not score at or above 80% producers' accuracy. This group scored perfectly in the users' accuracy, but was mistaken for other types 6 out of 21 times in tests for producers' accuracy. Three of those five mistakes were made by calling stands Californian broadleaf forest and woodland (WVO). This mistake can be explained when these two native woodlands can occur close to rivers and streams. Although WVO is typically an upland vegetation type, it is difficult to perceive minor topographic variance in some cases with the NAIP 2010 imagery. When more fine resolution digital elevation models are available, these issues of topographic position should be resolved.

Mediterranean California naturalized annual and perennial grassland (CAI). This type only had problems at the producers' accuracy (64%, n=14). The majority of the mislabeling occurred as a result of the mappers confusing it with Southwestern North American introduced riparian scrub (RIS). Confusing grassland with a scrub may seem difficult to do, but when shrub cover is low and patchy, and the surrounding herbaceous vegetation is non-native grasses, it becomes more understandable. A few of these errors were among the first polygons delineated when mappers tended to emphasize woody plants in a stand (e.g., shrubs), more than is allowed by the formal rules of the classification system (shrubs generally have at least 10% cover and are evenly distributed within the stand). This was corrected in later delineations.

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APPENDIX A
Accuracy Assessment Sample Allocation Process

Sample allocation for the Central Valley Riparian Mapping Project employed an analysis that balanced three goals: achieving target levels of samples for each module based on workload predictions for the staff conducting the accuracy assessment, distributing the samples amongst the vegetated mapping classes, and facilitating access to vegetation polygons based on land ownership and access efficiency.

The first step in the analysis was to create a series of subsets of the submitted vegetation module. The first isolated only the map unit types that were selected for accuracy assessment (the 15 vegetated types). The second subset removed polygons that had rapid assessments or reconnaissance surveys done within them. The third selected polygons that intersected the California Protected Areas Database (see <http://www.calands.org/>) in order to isolate polygons in publicly accessible areas. The last subset was for polygons within protected areas that were close to roads.

The next step was to summarize the number of polygons that were in the module by map unit and set targets for allocation based on what had been previously sampled and how many accessible polygons there were. Here is an example of this process:

Code	Group Name	total allocated	FRAA module	SJ1 module	Sac2 module	Allocation Target	Sac3 module count	SJ2 module count
RIS	Southwestern North American introduced riparian scrub	8	2	3	3	4	111	46
RWF	Southwestern North American riparian evergreen and deciduous woodland	13	5	4	4	2	1045	2067
RWS	Southwestern North American riparian/wash scrub	8	4	3	1	4	168	426
SSB	Southwestern North American salt basin and high marsh	1		1		15	1	925
VPB	Californian mixed freshwater vernal pool/swale bottomland	4		4		12	8	48
VRF	Vancouverian riparian deciduous forest	1			1	5		
WTM	Californian warm temperate marsh/seep	9	5	1	3	2	12	357
WVO	Californian broadleaf forest and woodland	12	6	2	4	2	69	57

So for example, Vancouverian riparian deciduous forest (VRF) was a very rare type in the project area. Only one polygon had been assessed in the first three modules and none were available for the last two. Had there been any, they would have been targeted, even if the

polygons had not satisfied the conditions of the subsets. On the other hand, RWF was one of the most common vegetation types in the area. Though the total number of stands assessed in early modules would have been enough to satisfy an even distribution of polygons between types, the reality is that an even distribution of vegetation types does not exist; and it is also important to have some representation of types throughout the study area.

Finally, starting with the rarest types and progressing to the most common, potential polygons were selected and examined over the 2009 NAIP imagery for accessibility. For example, even if they didn't meet the conditions of the subsets, all eight polygons of VPB from the Sac 3 module would have been examined to see if it might be possible to assess them from a distance survey, or if they were in publicly accessible land, but perhaps just a bit further than the cutoff of 500 m from a road. Once rarer polygons were selected, the more common ones were selected from the more restrictive subsets. Where possible, stands of different types would be selected within reasonable proximity for walking between stands to make the work more efficient. Polygons were selected in excess of the count targeted for each module and polygons were assigned a priority level, based on whether they were rare, core, or back-up polygons. Field maps made use of these priority levels to help field staff select the best polygons to sample.

APPENDIX B

Key to Groups and Mapping Units of the River Partners Project for Purposes of Mapping and Field Identification

Notes: Use MCV2 for definitions of Alliances. When in field use key to alliances to get to the group then look at group description to be sure you are correctly identifying the groups by its proper components.

Ground is naturally vegetated with native or non-native species at generally > 10% cover. Natural or semi natural vegetation (go to Roman numeral I on this page)...

I. Trees evenly distributed and conspicuous throughout stand. In areas where vegetation cover is greater than about 20 percent, tree canopy may be as low as 10 percent over denser layers of shrub and herbaceous species. In areas where vegetation is less than 20 percent total cover, trees may cover somewhat less than 10 percent (as low as about 8 percent) but are evenly distributed across the stand.

1. Riparian or wetland stands, dominant or characteristic trees are largely winter deciduous and are regularly associated with bottomland (riparian) conditions in vicinity of permanent water bodies or with prevalent fluvial disturbance in intermittently flooded settings ...

2. Stands composed largely of native species...

3. Forest or woodland stands not strongly dominated by *Alnus*, *Fraxinus*, or *Salix lucida*, usually associated with bottomland settings, but may not be directly adjacent to surface water especially later in the growing season. Some stands of *Quercus lobata* alliance may have co-dominance of *Fraxinus latifolia*, or *Alnus rhombifolia*, but not strongly dominated by either: Group (RWF) - Southwestern North American riparian evergreen and deciduous woodland (ecological system equivalents: California Central Valley Riparian Woodland and Shrubland); Includes the following alliances in the mapping area:

Acer negundo alliance

Juglans hindsii special and semi-natural stands

Platanus racemosa alliance

Populus fremontii alliance

Quercus lobata "riparian" alliance

Salix gooddingii alliance

Salix laevigata alliance

3'. Forest or woodland stands usually closely tied to flowing water throughout the growing season and dominated or characterized by *Alnus*, *Fraxinus*, or shining willow (*S. lucida*). Generally with cooler and moister soil conditions than previous group. May have some species from previous group, but none are dominant or co-dominant: Group (VRF) - Vancouverian riparian deciduous forest (ecological system equivalent: Mediterranean California Foothill and Lower Montane Riparian Woodland) Includes the following alliances in the mapping area:

Alnus rhombifolia alliance

Fraxinus latifolia alliance
Salix lucida alliance

2'. Stands strongly dominated by non-native introduced trees, either evergreen or deciduous: Macrogroup (IMF) - Introduced North American Mediterranean woodland and forest (no group subdivision below this); includes stands of *Eucalyptus*, *Ailanthus*, and other non-native naturalized trees

1'. Stands of upland forests and woodlands, not generally tied to immediate vicinity of permanent water bodies or with prevalent fluvial disturbance in intermittently flooded settings: Group (WVO) - Californian broadleaf forest and woodland (ecological system equivalent). Includes the following alliances in the mapping area:

Aesculus californica Alliance
Quercus agrifolia Alliance
Quercus douglasii Alliance
Quercus wislizeni Alliance
Quercus lobata Upland Alliance
Umbellularia californica Alliance

II. Not as in I (trees less than 10%, etc.)

A. Woody shrubs or sub-shrubs not characteristic of alkaline or saline soils (no salt crust or pale gray fine textured soils present) conspicuous throughout stand. When total vegetation cover is over ca. 20 percent, the tree layer, if present, generally less than 10 percent cover in stand; herbaceous species may total higher cover than shrubs. Shrubs are always at least 10 percent cover ...

1. Shrublands of relatively dry upland conditions, shrub roots typically not reaching water table. Stands dominated by drought-deciduous or facultatively drought-deciduous shrubs or sub-shrubs (perennials, woody at the base); stands locally associated with open gravel bars, sand banks, and other quickly drying and often disturbed settings: Group (CSS) - Central and south coastal California seral scrub. Includes the following alliances in the mapping area:

Baccharis pilularis Alliance
Lotus scoparius Alliance
Lupinus albifrons Alliance
Heterotheca oregana sub-shrub scrub (putative definition)

1'. Shrublands of riparian conditions. Shrubs generally tapping into moisture or water table for most of the growing season...

2. Stands with native riparian shrubs such as *Baccharis*, *Cephalanthus*, *Rosa*, *Sambucus*, or *Salix* dominant or diagnostically present: Group (RWS) - Southwestern North American riparian/wash scrub (ecological system equivalents: California Central Valley Riparian Woodland and Shrubland) Includes the following alliances in the mapping area:

Baccharis salicifolia Alliance
Cephalanthus occidentalis Alliance
Rosa californica Alliance
Salix exigua Alliance

Salix lasiolepis Alliance
Sambucus nigra Alliance

2'. Stands with non-native riparian shrubs or tall perennial reeds strongly dominant; Group (RIS) - Southwestern North American introduced riparian scrub. Includes the following alliances in the mapping area:

Arundo donax Semi-natural Stands
Tamarix spp. Semi-natural Stands
Rubus armeniacus semi-natural stands

A'. Woody shrubs not present or conspicuous, or if present typically relatively low stature (< 1 m) composed of genera such as *Frankenia*, *Salicornia*, *Atriplex*, *Allenrolfea*, or *Suaeda*; associated with saline or alkaline soils. If alkaline shrubs absent, non-woody herbaceous vegetation, including graminoid and forb species, dominant throughout stand ...

1. Herbaceous vegetation not found in permanently wet sites; may be in uplands or in low lying areas that are flooded in the winter, but dry by spring (e.g., vernal pools)....

2. Stands of uplands or of early-drying soils within riparian corridors (exposed gravel and sand bars, levee banks, etc.) ...

3. Non-native grasses and forbs strongly dominate. Most stands are upland vegetation but some stands of *Lolium*, *Cortaderia*, and *Conium* may also occur in transitional wetland settings (early drying wetlands): Group (CAI) - Mediterranean California naturalized annual and perennial grassland. Includes the following semi-natural stands in the mapping area:

Aegilops triuncialis Semi-natural Stands
Avena (barbata, fatua) Semi-natural Stands
Brassica (nigra) and other mustards Semi-natural Stands
Bromus (diandrus, hordeaceus)–*Brachypodium distachyon* Semi-natural Stands
Centaurea (solstitialis, melitensis) Semi-natural Stands
Centaurea (virgata) Semi-natural Stands
Conium maculatum–*Foeniculum vulgare* Semi-natural Stands
Cortaderia (jubata, selloana) Semi-natural Stands
Cynosurus echinatus Semi-natural Stands
Lolium perenne Semi-natural Stands

3'. Native grasses and forbs are characteristic, if non-natives present, they are not strongly dominant in cover: Group (CFG) - California annual forb/grass vegetation (system analog: California Dry Grassland).

Includes the following alliances in the mapping area:

Ambrosia psilostachya Provisional Alliance
Amsinckia (menziesii, tessellata) Alliance
Artemisia douglasiana {Putative, not in MCV}
Artemisia dracunculus Alliance

Eschscholzia (californica) Alliance
Lasthenia californica–*Plantago erecta*–*Vulpia microstachys*
Alliance
Lotus purshianus Provisional Alliance
Plagiobothrys nothofulvus Alliance

2'. Stands growing in seasonally flooded depressions including pools, or swales characterized by native largely annual (sometimes perennial in the case of *Eleocharis macrostachya*) herbs including the genera *Eryngium*, *Downingia*, *Lasthenia*, *Limnanthes*, *Trifolium*, and *Psilocarphus*. Group (VPB) Californian mixed annual/perennial freshwater vernal pool/swale bottomland.

Includes the following alliances in the mapping area:

Alopecurus geniculatus Provisional Alliance
Lasthenia fremontii–*Downingia (bicornuta)* Alliance
Eleocharis macrostachya Alliance
Eryngium aristulatum Alliance
Lasthenia fremontii–*Distichlis spicata* Alliance
Lasthenia glaberrima Alliance
Layia fremontii–*Achyrrachaena mollis* Alliance
Montia fontana–*Sidalcea calycosa* Alliance
Trifolium variegatum Alliance

1'. Stands of herbaceous or saline or alkaline shrub vegetation in obligate or facultative wetland settings (soil moisture is at least regularly persistent later in the growing season than adjacent upland settings)...

3. Stands of self-supporting plants either emerging out of water or growing in wet to moist soil without standing water...

4. Stands of tall obligate wetland herbaceous species such as bulrushes, cattails, and reeds that are typically emergent from water at least in the early portion of the growing season:

Group (FEM) - Arid West freshwater emergent marsh.

Includes the following alliances in the mapping area:

Phragmites australis Alliance (most are considered invasive weedy ecotypes)
Schoenoplectus acutus Alliance
Schoenoplectus californicus Alliance
Typha (angustifolia, domingensis, latifolia) Alliance

4'. Stands not dominated by tall obligate wetland emergent species...

5. Stands of native obligate or facultative fresh-water wetland herbaceous species generally shorter than 1 m in height and not including species of rank, large leaved dicots such as *Xanthium* or *Persicaria (Polygonum)* spp...

6. Stands of herbaceous species including members of the genera *Carex*, *Juncus*, *Leymus*, and *Mimulus*, that are tied to permanent or semi-permanent bodies of fresh water: Group (WTM) - Californian warm temperate marsh/seep. Includes the following alliances in the mapping area:

Carex barbarae Alliance

Carex densa Provisional Alliance

Carex nudata Alliance

Juncus arcticus (var. *balticus*, *mexicana*) Alliance

Juncus (oxymeris, xiphioides) Provisional Alliance

Leymus triticoides Alliance

Mimulus (guttatus) Alliance

6'. Herbaceous annual or perennial plants, (sometimes including subshrubs such as *Allenrolfea*, *Suaeda*, or other alkaline species) that are associated with alkaline or saline soils (exhibiting a whitish crust or pale coloration) limited to lower basins or margins of basins from near Willows south to the southern San Joaquin Valley: Group (SSB) Southwestern North American salt basin and high marsh. Includes the following alliances in the mapping area:

Allenrolfea occidentalis Alliance

Arthrocnemum subterminale Alliance

Atriplex lentiformis Alliance

Atriplex spinifera Alliance

Cressa truxillensis–*Distichlis spicata* Alliance

Frankenia salina Alliance

Suaeda moquinii Alliance

5'. Stands of tall annual or perennial herbs of reservoir margins, seasonal ponds, mesic meadows, disturbed or managed wetlands composed of weedy wetland forbs including *Lepidium*, *Polygonum (Persicaria)*, *Xanthium*, etc.: Group (NRW) - Naturalized warm-temperate riparian and wetland group. Includes the following semi-natural stands in the mapping area:

Lepidium latifolium Semi-natural Stands

Persicaria lapathifolia–*Xanthium strumarium* Provisional Alliance

3'. Stands of either native or non-native hydrophytes (at least in part supported by water), either rooted underwater or floating in water throughout the main growing season, not emerging significantly from water surface....

7. Stands are dominated by non-native, usually invasive hydrophytic species: Group (FAV) – Naturalized temperate Pacific freshwater vegetation. Includes the following semi-natural stands in the mapping area:

Ludwigia (hexapetala, peploides) Semi-natural Stands

Myriophyllum strictum

Cabomba caroliniana

Egeria

(may also include *Eichhornia crassipes* stands, if discovered in mapping area)

7'. Stands are dominated by native species...

8. Stands characterized by native rooted hydrophytes: Macrogroup MG109 (FAV). Western North American Freshwater Aquatic Vegetation (includes Group - Temperate Pacific freshwater aquatic bed). Includes the following alliances in the mapping area:

Hydrocotyle (ranunculoides–umbellata) Alliance

Isoetes spp. Provisional Alliance

Polygonum amphibium Unique Stands

Sparganium (angustifolium) Alliance

8'. Stands are dominated by native species of floating (not rooted in substrate) hydrophytes: Group (FAV) - Temperate freshwater floating mat; Includes the following alliances in the mapping area:

Azolla (filiculoides, mexicana) Provisional Alliance

Lemna (minor) and relatives Provisional Alliance

Ground is not vegetated with an even cover of native or naturalized plants > 10%. If heavily vegetated, dominated by clearly defined agricultural species planted rather than naturalized.... Agriculture or unvegetated... (see below for category characteristics:

Ground covered with annual or perennial agriculture.... AGR Agriculture

Ground covered by urban landscapes such as houses, other buildings, roads, etc ...
URB Urban

Ground covered by riverwash such as cobbles, gravels, or sand bars ... BGS Bare Gravel Sand

Standing water covers the mapping area with vegetation absent or very sparse cover...
WAT Water

APPENDIX C

Example of the AA field survey forms and the AA analysis database form

Dead Mans
1818

Rio Vista
039

CALIFORNIA NATIVE PLANT SOCIETY - ACCURACY ASSESSMENT FIELD FORM
(Revised March 10, 2009)

Polygon #:	Air photo #:	Date:	Name(s) of surveyors:	<input checked="" type="checkbox"/>
SAC 24387		12/08/10	MADG RDB	<input checked="" type="checkbox"/>
GPS waypoint #:	GPS name:	GPS datum:	Zone:	<input checked="" type="checkbox"/>
VEG101208 0907	VEG	(e.g. NAD 83)	10 11 (circle one)	<input checked="" type="checkbox"/>
UTM field reading:	UTMN	UTME	GPS Error:	<input checked="" type="checkbox"/>
	4 3 8 9 1 2 3	5 9 0 4 3 1	1.5 ft / m / pdop	<input type="checkbox"/>
Is GPS within stand?	(Yes/No) If No, cite from GPS point to stand, the distance (in meters) and bearing (degrees)			<input type="checkbox"/>
Inclination	Estimated waypoint #:	Elevation:		<input type="checkbox"/>
		16 ft (m)		<input type="checkbox"/>
Has the vegetation changed since air photo taken? Yes/No. If Yes, What has changed? <input type="checkbox"/>				
Vegetation name / map unit code: <input type="checkbox"/>				
Primary	QULO, WVO			Do you agree with the polygon delineation? (yes/no) If no, explain: we would separate WVO from RWF
Secondary	POFR, RWF			
Tertiary				
Confidence in map code ID: L M (H) Explain:	Other types within poly:			<input checked="" type="checkbox"/>
	The southern tip of the polygon (~2 acres) is POFR w/ some QULO			<input type="checkbox"/>
Camera #:	Photograph #'s:	<input type="checkbox"/>		
F12	1445 - 1448 (N)	<input type="checkbox"/>		
Slope exposure:	Slope steepness:	<input type="checkbox"/>		
NE NW SE SW Flat Variable/All	0° 1-5° 5-25° >25° (circle one)	<input type="checkbox"/>		
Sample size: 1/2 hectare / entire polygon / other	(% of polygon sampled) <input type="checkbox"/>			
Site location, history, stand age, comments: <input type="checkbox"/>				
Large QULO near center of polygon appear w/o much understory - looks like WVO (possible clearing, house adjacent). Smaller trees to the north and east of the large central QULO are mostly QULO w/ some riparian associates. This portion could combine w/ POFR to south of RWF. <input type="checkbox"/>				
Disturbance: Clearing (Yes/No) Level:	Exotics (Yes/No) Level:	<input type="checkbox"/>		
		<input type="checkbox"/>		
Tree DBH: T1 (<1" dbh), T2 (1-6" dbh), T3 (6-11" dbh), T4 (11-24" dbh), T5 (>24" dbh), T6 multi-layered (T3 or T4 layer under T5, >60% cover)	<input type="checkbox"/>			
% Cover - Tree Conifer/Hardwood: 1/20 Shrub: 1 Herbaceous: 1 Total % Vasc Veg cover: 20	<input type="checkbox"/>			
Height Class - Conifer/Hardwood: 1/07 Shrub: 03 Herbaceous: 1	<input type="checkbox"/>			
Height classes: 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m	<input type="checkbox"/>			
Species (List up to 20 major species), Stratum, and Approximate % cover. Stratum categories: T= Overstory tree, U= Low-Medium Tree, S = Shrub, H= Herb, N= Non-vascular. % cover intervals for reference: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, 75%. <input type="checkbox"/>				
Strata Species % cover	Strata Species % cover	<input checked="" type="checkbox"/>		
T Quercus lobata 15		<input type="checkbox"/>		
T Populus fremontii 4		<input type="checkbox"/>		
T Fraxinus latifolia 1		<input type="checkbox"/>		
S Toxicodendron diversilobum 1		<input type="checkbox"/>		
Rare or Unusual Species: <input type="checkbox"/>				
Estimated Population Size: <input type="checkbox"/>				
Dom vegetation cover (phenology): full / partial? Explain: POFR has lost most of its lvs <input type="checkbox"/>				
Adjacent alliance and direction: AG (N) 1 1 <input type="checkbox"/>				

DataViewer : Form

DbaseID: Stand_ID (PolyNum): Alliance

Date: Surveyors:

GPS Waypt (PointID): GPS_name: UTMN: UTME: GPS_datum:

GPS_error: GPS error type: GPSnSats: GPSFixType: UTM_zone:

Altitude: ft_mElevation:

GPS_in_stand: Distance: Bearing: Secant (Incl): UTMN_fin: UTME_fin:

Field Alliance 1:

Group 1: Californian broadleaf forest and woodland

Field Alliance 2:

Group 2: Southwestern North American riparian evergreen and deciduous woodland

Field Alliance 3:

Group 3:

Juno Data Comments:

Initial PI: Californian broadleaf forest and woodland

Final alliance:

Final Call: Californian broadleaf forest and woodland

Reviewers Notes:

Call Justification:

Change_in_veg: If so, How_veg_change:

FieldKeyConfidence: FieldKeyConfExplain:

Check if surveyor agreed with polygon delineation

PolygonDelineationExplain:

Other types within poly:

Photo:

Subsample: General exposure General steepness

Conif%: Hdwd%: Shrub%: Herb%: = 21% Total cover:

Con. Ht. Hdwd Ht. Shrub Ht. Herb Ht. Tree DBH

Site_history:

Impacts:

Final db #	CodeImpact	Intensity	Other

Record:

Final db #	Stratum	CodeSpecies	Species_name	% Cover	txtComments	txtCurrPlantsSymbol
Sac24387	Tree	QULO	Quercus lobata Née	15		QULO
Sac24387	Tree	POFR2	Populus fremontii S. Watson	4		POFR2
Sac24387	Tree	FRLA	Fraxinus latifolia Benth.	1		FRLA
Sac24387	Shrub	TODI	Toxicodendron diversilobum (Torr. & A. Gray) Greene	1		TODI