

Analysis of California GAP Data:

Utility and Limitations of California GAP Data for Regional Conservation Planning within the Central Valley Flood Protection Program Systemwide Planning Area

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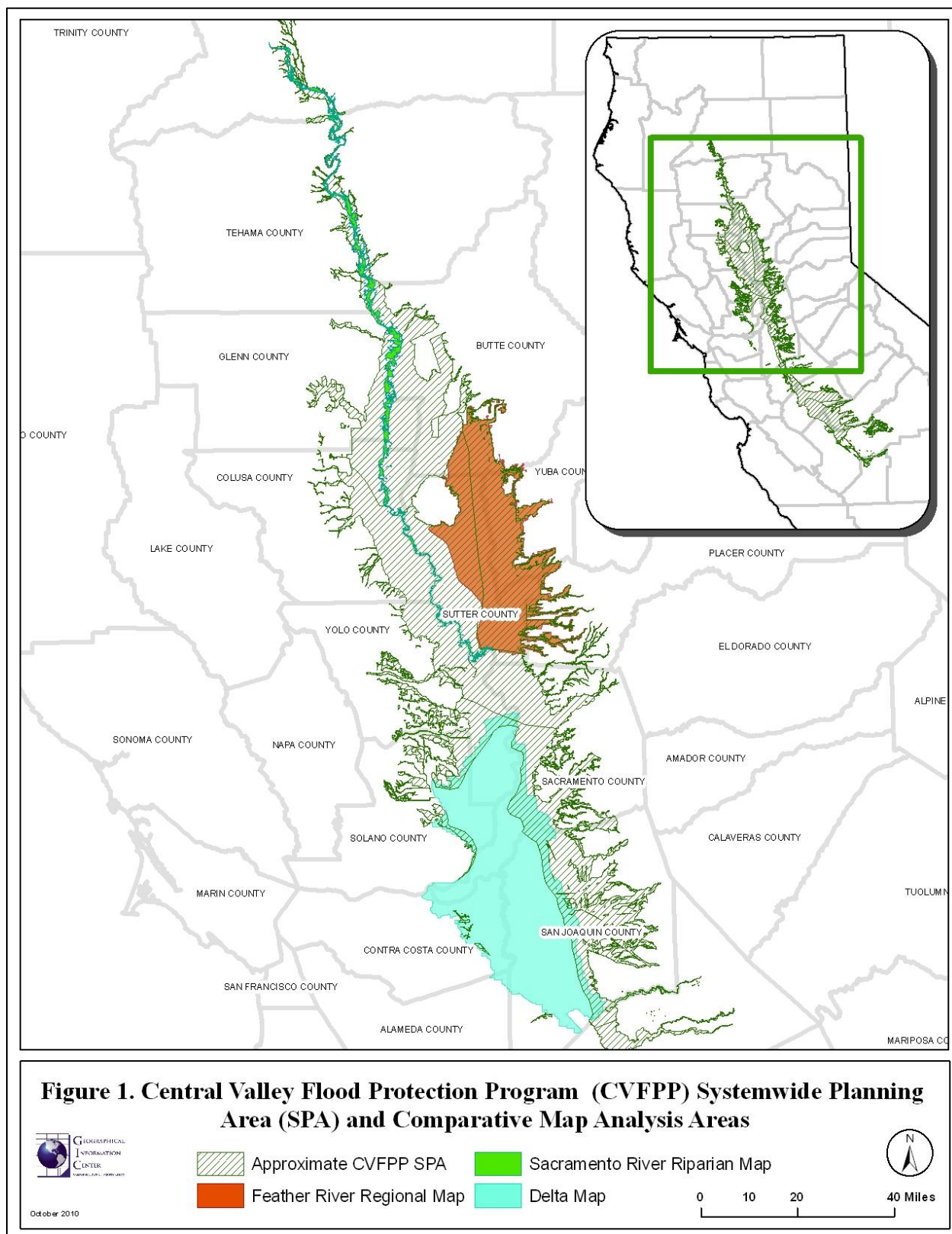
I. Introduction

This document presents a summary analysis of the California GAP Land Cover data set (GAP) recently completed by the National Gap Analysis Program (GAP 2009; Lennartz 2008). The GAP data set models regional land cover for a wide range of purposes including estimating distribution of biological resources and regional conservation planning. The stated goal of the GAP is:

“...to keep common species common by identifying those species and plant communities that are not adequately represented in existing conservation lands. Common species are those not currently threatened with extinction.”

The California GAP provides a relatively new statewide vegetation map. GIS (Geographic Information Systems) analysis methods applied by GAP are considered to produce better vegetation maps compared to previously state- or nation-wide products.

Analyses presented here are an evaluation of the GAP's utility in regional conservation planning, habitat change detection, and identifying potential restoration sites within the Central Valley Flood Protection Program (CVFPP) Systemwide Planning Area (project area). Three regions totaling over 1-million acres within the project area were selected for analyses based on availability of substantive and detailed digital land cover maps. These areas are: Sacramento River region 2007 Sacramento River Riparian Mapping (SRRM); 2010 CVFPP Feather River regional mapping (FRRM); and the 2007 Delta Region Department of Fish and Game Vegetation Map (Delta map). A comparison of the geographic areas contained within the CVFPP Systemwide Planning Area and these three analysis areas are presented in Figure 1.



II. Data

a. GAP Analysis Program Land Cover Data

GAP is a raster dataset depicting major vegetation and land cover types across the nation. This data was updated for California in 2009. According to the California GAP program metadata:

*“Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect, etc.) to model natural and semi-natural vegetation. The **minimum mapping unit for this dataset is approximately 1 hectare**. This dataset is intended only for use at very small scales and is **not intended for use at scales greater than 1:100,000**” (emphasis added).*

GAP data are presented at a pixel resolution of 0.25-acres, but this is substantially smaller than the stated minimum mapping unit of 1 hectare (or approximately 2.5-acres). An extensive discussion regarding computational techniques and methods used to produce the California GAP Land Covers is provided by Lennartz (2008). Definitions for Land Cover types are described by NatureServe (2008 and 2009).

GAP data is intended primarily as a means for tracking the efficacy of conservation efforts to capture the full complement of species across habitats characteristic of a region. GAP attempts to do this by identifying habitat types “not adequately represented on existing conservation lands” (GAP 2009). The approach utilized by GAP to accomplish this goal has been to model and map relatively general land cover types, with the highest thematic resolution corresponding to the Ecological Systems Classification of the United States (Comer et. al. 2003) as updated by NaturServ (2008). GAP thematic data depicts Land Cover in a nested fashion at three hierarchical levels. These classifications, from coarse- to fine-resolution are:

- **Level 1:** Coarse description of land cover based primarily on vegetative physiognomy;
- **Level 2:** Medium resolution mapping incorporating information on elevation and climate;
- **Level 3 (Ecological System Classification):** Finest resolution incorporating regionally specific information about land cover characteristics.

Within California, GAP data is divided into six Map Zones. The project area falls primarily within the California GAP Land Cover Zone 5 entitled “California’s Central Valley”.

Small areas of the western and northern portions of the project area fall into California Land Zone 4 and the Pacific Northwestern GAP project, respectively.

b. Comparative Data

Comparative analyses of GAP data presented here utilize relatively recent (less than 5-years old) orthorectified aerial imagery within three areas of the project. These data sets are:

i. Sacramento River Region 2007 Sacramento River Riparian Mapping

The 2007 Sacramento River Riparian Mapping (SRRM) effort by the Geographic Information Center (GIC) at California State University Chico, produced maps of extant riparian habitat along a portion of the Sacramento River within the Sacramento River Conservation Area (Carlson and Funes 2010). This data set describes vegetation cover for more than 45,000-acres.

The GIC's mapping approach employed an iterative process of aerial photo interpretation and field verification. The mapping methodology included the acquisition of aerial photo imagery, the development of a vegetation classification list, rapid assessment surveys, aerial photo interpretation, delineation of vegetation alliances as polygons in ArcGIS and final field verification of data. An independent validation and accuracy assessment was performed by field biologists from the University of California at Davis, information which was subsequently incorporated into a final validated map. Throughout the process, regular communication occurred between regional experts, agency scientists, and the photo interpreter.

Aerial imagery used for the SRRM map was flown by American Aerial Services of Northern California in June 2007, and supplemental aerial imagery was collected in June, 2008. Imagery was 1.2 foot resolution true-color. A detailed discussion of this dataset, its development, and thematic types (vegetation alliances) is presented by Carlson and Funes (2010).

ii. Feather River Regional Mapping project

The 2010 CVFPP Feather River Regional Mapping (FRRM) project is an ongoing effort to map all habitats occurring within the entire project area outside of the Sacramento-San Joaquin Delta, approximately 2,811,932 acres or 4,393 square miles. The Feather River Regional Mapping (FRRM) area encompasses more than 395,000 acres of the Feather River watershed and adjacent lands occurring within the project area.

The FRRM data is an unpublished data set recently developed by the Geographical Information Center at California State University, Chico. This data set was created from digitized aerial photo interpretation using the 2009 National Agricultural Inventory Program (NAIP) 1-meter resolution, true color imagery supplemented by imagery from ImageConnect Version 3.1.1.4 software (GlobExplorer 2007) and Google Earth.

Mapping for this project utilized sixteen thematic types adapted from and analogous to the “Group” level of the *National Vegetation Classification Hierarchy as Applied to California Vegetation* (Sawyer et al. 2009). Minimum mapping units for this data were ≥ 1.0 -acres with an average width ≥ 10 -meters.

iii. Delta Region Land Use Map

The “Vegetation and Land Use Classification and Map of the Sacramento-San Joaquin Delta” (Delta map) was produced by the Vegetation Classification and Mapping Program of the California Department of Fish and Game (Hickson and Keeler Wolf 2007). This data set was created from digitized aerial photo interpretation, mapping, and field data collection in conjunction with development of vegetation classifications using a suite of statistical analyses. An extensive and detailed discussion regarding information and methods to produce the Delta map and definitions of land use types is provided by Hickson and Keeler-Wolf (2007). This data set describes vegetation and land use for more than 725,000-acres.

c. Aerial Imagery

The following is a list of additional aerial imagery used to facilitate comparative analyses:

- USDA National Agricultural Imagery Program (NAIP) True Color Imagery flown 2009 – 1 Meter Resolution NAIP (USDA 2009);
- ImageConnect Version 3.1.1.4 (GlobExplorer 2007) – All imagery used as necessary. Available imagery varies within and between analysis areas;
- Google-maps (Google 2010) – 2010 and prior

III. Methods

a. Data Preparation

All comparative data sets used in analyses were reprojected, as necessary, into Albers NAD 83. GAP raster data was converted to an “ungeneralized” feature dataset (.shp) in order to accurately retain the pixilated geometry of the original data. Resultant GAP feature data was clipped by the geometry of each comparative data set (i.e. SRRM, FRRM and Delta project areas) to create precisely overlapping shapefiles for analysis. Preliminary summary analyses were performed on each of these data sets. Thematic crosswalks were developed for all land cover categories found between GAP and each comparative dataset. A spatial union was then performed between each clipped GAP feature data set and its comparative dataset. Acreages were then calculated for resultant (unioned) shapefiles.

Orthorectified aerial photographs were used to facilitate quantitative and qualitative analyses of original and derived shapefiles.

b. Analyses

Analyses presented here are intended to illustrate the relative utility of GAP data compared to other recent vegetation and land cover mapping efforts within the project area. Because GAP data is intended for use at scales no greater than 1:100,000, many comparative differences presented here can be attributed to differences in mapping resolution. GAP resolution also limits its usefulness for conservation planning, land cover change detection, and identification of potential habitat restoration sites at the regional scale (i.e. at practical scales across and within the project area).

For analysis purposes, limited flexibility in crosswalk interpretation was provided to allow reasonable comparison between thematic types that:

- were relatively similar, but not exact, analogs between datasets; and/or
- tended to be temporally variable or transitional types between other closely aligned land covers over short periods of time.

Examples of temporally variably land covers include: open water habitats, mudflats, floating aquatic vegetation, freshwater emergent vegetation and naturalized annual wetland vegetation. These land covers can be short-lived, transitioning rapidly amongst one-another, depending on site conditions. Furthermore, naturalized annual wetland vegetation can transition into naturalized annual upland vegetation in managed marshes, large drainages and

ephemeral wetland areas, depending on water management/conditions from year-to-year. Allowances for crosswalk flexibility are noted in analyses.

i. Quantitative Analyses

The following is a summary of quantitative analyses performed:

- Coverage summary for all data sets by respective thematic types: sum of acres, average map unit (polygon) size, percent of acres, sum of occurrences, frequency of occurrence;
- Comparative summary of thematic acreage for each dataset was performed based on vegetation crosswalks. As previously mentioned, some flexibility in crosswalk interpretation was allowed to facilitate reasonable comparisons between data sets. Comparative summary data includes: total acres of thematic agreement, percent thematic agreement, total acres of thematic conflict and % thematic conflict. These data are defined as follows:
 - **Thematic Acreage** – for each dataset, a sum of the total acres for each thematic type;
 - **Thematic Agreement** - thematic acreage mutually identified to similar or analogous thematic type by both comparative datasets;
 - **Thematic Conflict** - acreage mapped to a given thematic type by only one of either comparative datasets;
 - **Net Thematic Acreage** – sum acreage of Thematic Agreement and Thematic Conflict;
 - **% Thematic Agreement** - Thematic agreement/ Net Thematic Acreage; and,
 - **% Thematic Conflict** - Thematic Conflict/Net Thematic Acreage.
- Evaluation of quantitative data for thematic types (e.g. native vegetation) of particular interest to regional conservation planning; and,
- Analyses of thematic conflicts/differences between GAP and comparative data sets: sum of acres and percent difference.

ii. Qualitative Analyses

Qualitative analyses consisted of:

- Evaluating utility of thematic categories for describing vegetation and land use across selected project areas, particularly utility of GAP Levels 1-3 land covers;
- Visual assessment of GAP land cover maps in relation to available comparative heads-up digitized data sets and available aerial photos;
- Evaluation of habitat crosswalks, their utility and effects on quantitative analyses;
- Overall assessment of GAP utility in regional planning and conservation.

IV. Results

a. GAP data vs. Sacramento River Riparian Mapping project

Table 1 presents a summary of thematic acreage, thematic agreement, and thematic conflict between GAP and SRRM shapefiles for GAP Level 3 (or analogous) land cover types mapped within the SRRM area based on the GAP-SRRM land cover crosswalk. A detailed vegetation crosswalk for GAP and SRRM data is provided in Appendix A.

Table 1. Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and SRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	SRRM	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
California Central Valley Riparian Woodland and Shrubland		13989	26775	11734	40.4%	17295	59.6%
<i>Corresponding or allowed SRRM Class(es)</i>	<i>Black walnut (Juglans hindsii)</i>		3010	1885			
	<i>Blackberry (Rubus discolor)</i>		521	208			
	<i>Box elder (Acer negundo)</i>		1114	553			
	<i>California sycamore (Platanus racemosa)</i>		324	135			
	<i>Fremont cottonwood (Populus fremontii)</i>		9684	4699			
	<i>Giant cane (Arundo donax)</i>		144	64			
	<i>Gooddin's black willow (Salix gooddingii)</i>		180	68			
	<i>Mixed willow</i>		2239	714			
	<i>Riparian scrub</i>		3251	1504			
	² <i>Valley oak (Quercus lobata)</i>		6307	1903			
³Open Water & Temperate Pacific Freshwater Mudflat		11223	12737	9338	63.9%	5284	36.1%
<i>Corresponding or allowed SRRM Class(es)</i>	<i>Water</i>		12556	9157			
	<i>Floating-leaved plants</i>		19	19			
	<i>Water primrose (Ludwigia peploides)</i>		154	154			
	<i>C attail-Bullrush</i>		8	8			
California Central Valley and Southern Coastal Grassland		3788	4778	1262	17.3%	6041	82.7%
<i>Corresponding or allowed SRRM Class(es)</i>	<i>California annual grasslands-herbaceous</i>		4235	1238			
	<i>Introduced perennial grassland</i>		543	24			
²California Central Valley Mixed Oak Savanna		2034	524	524	25.8%	1510	74.2%
	<i>Valley oak (Quercus lobata)</i>		524	524			

Table 1. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and SRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	SRRM	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
³Temperate Pacific Freshwater Emergent Marsh		169	152	79	32.6%	163	67.4%
<i>Corresponding or allowed SRRM Class(es)</i>	<i>Water</i>		60	60			
	<i>C attail-Bullrush</i>		86	5			
	<i>Floating-leaved plants</i>		4	4			
	<i>Water primrose (Ludwigia peploides)</i>		10	10			
California Coastal Closed-Cone Conifer Forest and Woodland		5		na			
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna		3487		na			
Central California Coast Ranges Cliff and Canyon		4		na			
Cultivated Cropland		9877		na			
Developed (Combines High-, Medium- and Low-Intensity Developed and Developed Open Space)		1840		na			
Introduced Upland Vegetation - Treed		2		na			
Mediterranean California Foothill and Lower Montane Riparian Woodland		9		na			
Mediterranean California Mesic Serpentine Woodland and Chaparral		17		na			
Mediterranean California Mixed Evergreen Forest		<1		na			
Northern and Central California Dry-Mesic Chaparral		54		na			
Northern California Coastal Scrub		3		na			
Undefined map unit		950		na			

Table 1. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and SRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	SRRM	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
³ No GAP Level 3 analog			2486	na			
<i>Includes SRRM Class(es), except as allowed</i>	<i>Gravel Bar</i>		1978	na			
	<i>Floating-leaved plants</i>		114	na			
	<i>Water primrose (Ludwigia peploides)</i>		394	na			
Overall		47451		22937	48.3%	24514	51.7%

¹See Appendix A for GAP-SRRM vegetation crosswalk

²524-acres of Riparian Valley Oak Habitat was allowed as GAP Level 3 "California Central Valley Mixed Oak Savannah" when thematic conflict arose

³SRRM classes "Water", "Floating-leaved plants", "Water primrose (*Ludwigia peploides*)", and "Cattail-Bullrush" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh", Temperate Pacific Freshwater Mudflat", and "Open Water"

Overall thematic agreement between gap and SRRM data was poor (52%). Thematic agreement was highest for “Open Water”, but thematic agreement for all analogous land cover types mapped by both data sets was very low, ranging from 44% for riparian habitat to 8% for emergent marsh and analogous habitats. SRRM land covers types “Floating-leaved plants” and “Water primrose (*Ludwigia peploides*)” were allowed as analogues for GAP “Temperate Pacific Freshwater Marsh” when overlap occurred. GAP data mapped 12 land cover types without comparable land cover type in the SRRM data. These included developed land covers and several vegetative land covers known not to occur within the SRRM project area. “Gravel Bar” was a regularly occurring SRRM land cover type, but did not have a GAP analogue. GAP data tended to map gravel bars as either “Developed” or grassland types.

For all comparable GAP and SRRM land cover types, relative abundance was similar. A comparative summary of GAP-SRRM data for GAP Level 3 land covers is presented in Table 2.

Table 2. Summary of comparative characteristics for the GAP-SRRM projects by GAP Level 3 or SRRM Analog land cover types

GAP Level 3	SRRM
California Central Valley and Southern Coastal Grassland	17% thematic agreement - Large portions of GAP data tended to include Gravel Bars, Water, Agriculture and areas of woody vegetation.
California Central Valley Mixed Oak Savanna	26% thematic agreement - Not really a significant component of comparative area due to historic clearing of this vegetation type. GAP frequently categorized California Riparian Woodland and Shrubland vegetation as "California Central Valley Mixed Oak Savanna"
California Central Valley Riparian Woodland and Shrubland	40% thematic agreement - majority of GAP identified as riparian agreed with SRRM data, but SRRM data identified almost twice as much riparian acreage as GAP
California Coastal Closed-Cone Conifer Forest and Woodland	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Central California Coast Ranges Cliff and Canyon	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Cultivated Cropland	Small portion of GAP acreage - much of this acreage was misclassified or consists of overextended polygon boundaries from adjacent, correctly identified agricultural lands
Developed (Includes High, Low and Medium Intensity and Developed Open Space)	Small portion of GAP acreage - much of this acreage was misclassified or consists of overextended polygon boundaries from adjacent, correctly identified developed lands and/or misclassified bare gravel and sand areas (such as gravel bars). Many point bar formations within the river dominated by bare cobble, gravel and sand were misidentified by GAP data as "Developed"
Introduced Upland Vegetation - Treed	Small portion of GAP acreage - no introduced stand types were mapped by the SRRM project
Mediterranean California Foothill and Lower Montane Riparian Woodland	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Mediterranean California Mesic Serpentine Woodland and Chaparral	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Mediterranean California Mixed Evergreen Forest	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Northern and Central California Dry-Mesic Chaparral	Small portion of GAP acreage - Land cover type does not occur within the SRRM area

Table 2. (continued) Summary of comparative characteristics for the GAP-SRRM projects by GAP Level 3 or SRRM Analog land cover types

GAP Level 3	SRRM
Northern California Coastal Scrub	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
Open Water (Fresh)	64% thematic agreement - Differences between data sets primarily reflect general nature of GAP data and scale its scale of intended use (1:100,000) and changes in open water channels between aerial imagery used for GAP ('99-'01) and SRRM (2007) data development. SRRM "Floating-leaved plants" and "Water primrose (<i>Ludwigia peploides</i>)" allowed as GAP Level 3 "Open Water (Fresh)"
Temperate Pacific Freshwater Emergent Marsh	32% thematic agreement - Includes floating vegetation as delineated by SRRM. GAP captured 22% of emergent marsh as mapped by SRRM project. Overall GAP mapped twice as much emergent marsh as SRRM
Temperate Pacific Freshwater Mudflat	Relative little acreage overall (<4.0 ac.). Lumped with GAP Level 3 "Open Water". Sacramento River water levels fluctuate and reveal mudflats and/or bare gravel and sand in places alternately covered by water at times

Detailed Summary Data for GAP in the Sacramento River Riparian Mapping area is presented in Appendix B.

Detailed Summary Data for Sacramento River Riparian Mapping Region is presented in Appendix C.

b. GAP data vs. Feather River Regional Mapping project

Table 3, below, presents a summary of thematic acreage, thematic agreement and thematic conflict between GAP and FRRM data for GAP Level 3 (or analogous) land cover types mapped within the FRRM area based on the GAP-FRRM land cover crosswalk. A detailed vegetation crosswalk for GAP and FRRM data is provided in Appendix D.

Table 3. Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and FRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	FRRM	Acres	% Thematic Agreement	Acres	% Thematic Conflict
²Temperate Pacific Freshwater Emergent Marsh		3286	2475	748	14.9%	4266	85.1%
<i>Corresponding or allowed FRRM Class(es)</i>	<i>Western North American freshwater aquatic vegetation (macrogroup)</i>		1013	146			
	<i>Arid west freshwater emergent marsh</i>		967	106			
	<i>Naturalized warm-temperate riparian and wetland group</i>		370	370			
	<i>Open water</i>		125	125			
³California Central Valley and Southern Coastal Grassland		40567	37558	20482	35.5%	37161	64.5%
<i>Corresponding or allowed FRRM Class(es)</i>	<i>California annual forb/grass vegetation</i>		20621	13961.736			
	<i>Mediterranean California naturalized annual and perennial grassland</i>		16065	5647.1672			
	<i>California warm temperate marsh/seep</i>		270	270			
	<i>Naturalized warm-temperate riparian and wetland group</i>		603	603			
California Central Valley Riparian Woodland and Shrubland		14330	17538	5897	22.7%	20074	77.3%
<i>Corresponding or allowed FRRM Class(es)</i>	<i>Southwestern North American introduced riparian scrub</i>		645	193			
	<i>Southwestern North American riparian evergreen and deciduous woodland</i>		14610	5240			
	<i>Southwestern North American riparian/wash scrub</i>		2283	464			
California Central Valley Mixed Oak Savanna		1595	5029	288	4.5%	6048	95.5%
<i>Corresponding or allowed FRRM Class(es)</i>	<i>California broadleaf forest and woodland</i>		5029	288			

Table 3. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and FRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	FRRM	Acres	% Thematic Agreement	Acres	% Thematic Conflict
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna		5647	<1	<i>na</i>			
<i>Corresponding or allowed FRRM Class(es)</i>	<i>California broadleaf forest and woodland</i>		<1	<i>na</i>			
California Mesic Chaparral		<1		na			
Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland		16		na			
Mediterranean California Foothill and Lower Montane Riparian Woodland		<1		na			
Northern and Central California Dry-Mesic Chaparral		198		na			
²Open Water		8526	12090	7655	59.1%	5306	40.9%
<i>Corresponding or allowed FRRM Class(es)</i>	<i>Western North American freshwater aquatic vegetation (macrogroup)</i>		90	90.0			
	<i>Arid west freshwater emergent marsh</i>		17	17.0			
	<i>Naturalized warm-temperate riparian and wetland group</i>		35	35.0			
	<i>Open water</i>		11948	7513			
Cultivated Cropland		294864	305726	264611	78.8%	71367	21.2%
Developed (Combines GAP Level 3 High-, Medium- and Low-Intensity Developed; Quarries, Mines, Gravel Pits and Oil Wells, and; Developed Open Space)		45467	50423	24516	34.3%	46858	65.7%
Not defined		23324		na			

Table 3. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and FRRM Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	FRRM	Acres	% Thematic Agreement	Acres	% Thematic Conflict
No GAP Level 3 analog			6981	na			
<i>Includes FRRM Class(es), except as allowed</i>	<i>California warm temperate marsh/seep</i>		2704	na			
	<i>Central and south coastal California seral scrub</i>		41	na			
	<i>Introduced North American Mediterranean woodland and forest</i>		168	na			
	<i>Bare gravel/sand</i>		450	na			
	<i>Naturalized warm-temperate riparian and wetland group</i>		3619	na			
Overall		437819		323908	74.0%	113911	26.0%

¹ See Appendix D for GAP-FRRM vegetation crosswalk

²FRRM classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", and "Open water" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh" and "Open Water"

³FRRM classes "California warm temperate marsh/seep" and "Naturalized warm-temperate riparian and wetland group" allowed as analogs to GAP Level 3 "California Central Valley and Southern Coastal Grassland"

Though overall thematic agreement between the GAP and FRRM data was fairly good (74%), this was largely a result of thematic agreement on “Cultivated Cropland” (79%), the major landcover type across the analysis area. Unlike GAP-SRRM data, thematic agreement for “Open Water” was relatively weak (59%), even when allowing for intermittently flooded SRRM aquatic and emergent vegetation types. Developed landcover types were a substantial portion of both GAP (45,467 ac.) and FRRM data (50,423 ac.), and included large areas of tailings piles from extensive hydraulic mining within the Feather River watershed. Thematic agreement for these land covers was low (34%), due in part to the general nature of GAP data and urban development in the years between GAP (2001) and FRRM (2009) reference imagery.

Similar to the GAP-SRRM comparison, thematic agreement was less than 40% for all major vegetation types. Even allowing for all FRRM mesic herbaceous types (i.e. FRRM “Naturalized warm-temperate riparian and wetland group” land cover), thematic agreement for “California Central Valley and Southern Coastal Grassland” GAP Level 3 land cover still fell below 37%. Thematic agreement between riparian habitat analogues was even lower, at around 26%. Lastly, thematic agreement was extremely poor for wetland (5%) and oak woodland (3%) land cover analogues.

Similar to the GAP-SRRM comparison, relative (rank) abundance for all comparable GAP and FRRM land cover types was the same. A comparative summary of GAP-FRRM data for GAP Level 3 land covers is presented in Table 4.

Table 4. Summary of comparative characteristics for the GAP-FRRM projects by GAP Level 3 or FRRM Analog land cover types

GAP Level 3	FRRM
California Central Valley and Southern Coastal Grassland	36% thematic agreement - Due to temporal variability of closely aligned transitional habitats, comparison allowed for upland fringing FRRM classes “California annual forb/grass vegetation”, “Mediterranean California naturalized annual and perennial grassland”, “California naturalized warm-temperate marsh/seep”, and “Naturalized warm-temperate riparian and wetland group”. Large portions of GAP data tended to include open habitats such as Gravel Bars, Water, Agriculture and incorrectly categorized areas of woody vegetation.
California Central Valley Mixed Oak Savanna	5% thematic agreement - lumped with "California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna (below). Disparities between datasets emerge because of lumping or splitting at low or high resolution respectively (i.e. for mixes of grasslands and woodlands). GAP tended to regularly miscategorize very small spots within riparian habitat as Oak Savannah
California Central Valley Riparian Woodland and Shrubland	23% thematic agreement - relatively comparable acreage mapped to this thematic type by GAP (14,330 ac.) and FRRM (17,538 ac.), but low thematic agreement. Differences appear to have resulted from: higher resolution mapping by the FRRM; inclusion of riparian restoration sites by the FRRM; acreage incorrectly categorized as riparian habitat by GAP, and; low-resolution GAP data incorrectly delineating habitats/habitat boundaries
Cultivated Cropland	79% thematic agreement (similar to GAP-FRRM comparison) - generally very good agreement between GAP (294,864 ac.) and FRRM (305,726 ac.). This is a relatively extensive and contiguous land cover type throughout this analysis area, which may have contributed to the relatively high thematic agreement
Developed (Includes High, Low and Medium Intensity Developed, Developed Open Space, Quarries, Mines, Gravel Pits and Oil Wells)	34% thematic agreement - relatively comparable acreage mapped to this thematic type by GAP (45,467 ac.) and FRRM (50,423 ac.), but low thematic agreement. Differences appear to have resulted from: higher resolution mapping by the FRRM and low-resolution GAP data incorrectly categorizing habitats. Some large areas of mine-tailings also included riparian habitat extracted by FRRM data, but no well-captured by GAP
Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland	Small portion of GAP acreage - Land cover type does not occur within the SRRM area
California Mesic Chaparral	Small portion of GAP acreage - no similar vegetation types were mapped by the SRRM project

Table 4. (continued) Summary of comparative characteristics for the GAP-FRRM projects by GAP Level 3 or FRRM Analog land cover types.

GAP Level 3	FRRM
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	Allowed for "California Central Valley Mixed Oak Savannah", but no thematic agreement for any corresponding or analogous category. See comments on "California Central Valley Mixed Oak Savannah" (above) - categories lumped for comparative purposes.
Mediterranean California Foothill and Lower Montane Riparian Woodland	Negligible portion (< 0.5 ac.) of GAP coverage. Allowed for "California Central Valley Riparian Woodland and Shrubland" (above).
Open Water (Fresh)	59% thematic agreement - Due to temporal variability of closely aligned transitional habitats, comparison allowed for FRRM classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", and "Open Water". Differences between data sets primarily reflect general nature of GAP data and scale its scale of intended use (1:100,000), possibly compounded by changes in open water habitat and river channels between aerial imagery used for GAP ('99-'01) and FRRM (2009) data development
Temperate Pacific Freshwater Emergent Marsh	15% thematic agreement – Due to temporal variability of closely aligned transitional habitats, comparison allowed for FRRM classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", and "Open Water". Comparable overall acreage mapped to this thematic type by GAP (3,286 ac.) and FRRM (2,475 ac.), but low thematic agreement. Within the FRRM region, small acreage of generally small and dispersed occurrences difficult to accurately capture by relatively low-resolution GAP mapping.
Northern and Central California Dry-Mesic Chaparral	Small portion of GAP acreage (198 ac.) – No comparable FRRM land cover type.

Detailed Summary Data for GAP in the Feather River Regional Mapping Area is presented in Appendix F.

Detailed Summary Data for the Feather River Regional Mapping Area is presented in Appendix G.

c. GAP data vs. Delta Region Land Use map

Table 5, below, presents a summary of thematic acreage, thematic agreement and thematic conflict between GAP and Delta data for GAP Level 3 (or analogous) land cover types mapped within the Delta area based on the GAP-Delta land cover. A detailed land cover crosswalk for GAP and Delta data is provided in Appendix H.

Table 5. Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and Delta Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	Delta	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
² California Central Valley and Southern Coastal Grassland		35051	65570	23515	30.5%	53591	69.5%
Corresponding or allowed Delta Class(es)	Mediterranean California naturalized annual and perennial grassland		65184	23129			
	Naturalized warm-temperate riparian and wetland group		255	255			
	Vernal pool basin		104	104			
	California warm temperate marsh/seep		26	26			
³ California Central Valley Riparian		20593	12840	7147	27.2%	19140	72.8%
Corresponding or allowed Delta Class(es)	Southwestern North American introduced riparian scrub		1266	234			
	Southwestern North American riparian evergreen and deciduous woodland		6810	4257			
	Southwestern North American riparian/wash scrub		4058	1950			
	Western Dogwood Thicket		705	705			
Mediterranean California Foothill and Lower Montane Riparian Woodland		43	7	7	15.6%	36	84.4%
Corresponding or allowed Delta Class(es)	Southwestern North American introduced riparian scrub		<1	<1			
	Southwestern North American riparian evergreen and deciduous woodland		3	3			
	Southwestern North American riparian/wash scrub		3	3			
California Coastal Closed-Cone Conifer Forest and Woodland		10		na			
California Coastal Live Oak Woodland and Savanna		<1		na			
California Coastal Redwood Forest		<1		na			

Table 5. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and Delta Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	Delta	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
California Central Valley Mixed Oak Savanna		333	2206	1	0.0%	2537	100.0%
<i>Corresponding or allowed Delta Class(es)</i>	<i>California broadleaf forest and woodland</i>		2206	1			
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna		2152		<i>na</i>			
California Coastal Live Oak Woodland and Savanna		1		<i>na</i>			
Cultivated Cropland, Includes Delta Veg Class Agriculture		443359	474155	404006	78.7%	109501	21.3%
Developed (Combines High-, Medium- and Low-Intensity Developed and Developed Open Space)		78423	62243	47405	50.8%	45856	49.2%
Mediterranean California Northern Coastal Dune		16					
Northern and Central California Dry-Mesic Chaparral		75					
⁴Open Water		52006	59804	47796.7	74.7%	16217	25.3%
<i>Corresponding or allowed Delta Class(es)</i>	<i>Western North American freshwater aquatic vegetation (macrogroup)</i>		1149	1149			
	<i>Arid west freshwater emergent marsh</i>		594	594			
	<i>Naturalized warm-temperate riparian and wetland group</i>		12	12			
	<i>Southwestern North American salt basin and high marsh</i>		<1	<1			
	<i>Temperate Pacific tidal salt and brackish meadow</i>		1	1			
	<i>Open water</i>		58044	47797			
	<i>California warm temperate marsh/seep</i>		4	4			

Table 5. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and Delta Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	Delta	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
Southern California Coastal Scrub		275	28	1	0.3%	302	99.7%
<i>Corresponding or allowed Delta Class(es)</i>	<i>Central and south coastal California seral scrub</i>		28	<1			
⁴Temperate Pacific Freshwater Emergent Marsh		33071	22607	25062	81.9%	5555	18.1%
<i>Corresponding or allowed Delta Class(es)</i>	<i>Western North American freshwater aquatic vegetation (macrogroup)</i>		3192	2532			
	<i>Arid west freshwater emergent marsh</i>		9091	7726			
	<i>Naturalized warm-temperate riparian and wetland group</i>		7796	7796			
	<i>***Open Water (Fresh) (2273.9 Ac.)</i>		2274	2274			
	<i>California warm temperate marsh/seep</i>		254	254			
⁴Temperate Pacific Tidal Salt and Brackish Marsh		5828	9713	4997	47.4%	5547	52.6%
<i>Corresponding or allowed Delta Class(es)</i>	<i>Western North American freshwater aquatic vegetation (macrogroup)</i>		97	97			
	<i>Arid west freshwater emergent marsh</i>		2733	2733			
	<i>Naturalized warm-temperate riparian and wetland group</i>		1479	1479			
	<i>Southwestern North American salt basin and high marsh</i>		43	43			
	<i>Temperate Pacific tidal salt and brackish meadow</i>		4929	229			
	<i>Open water</i>		374	374			
	<i>California warm temperate marsh/seep</i>		59	59			

Table 5. (continued) Summary of thematic acreage, thematic agreement, and thematic conflict between GAP and Delta Data¹

GAP Level 3 or Analog		Total Acres		Thematic agreement		Thematic conflict	
		GAP	Delta	Acres	% of Total Acres mapped	Acres	% of Total Acres mapped
Not designated		54645	101	1	0.0%	54743	100.0%
<i>Corresponding Delta Class</i>	<i>"Unknown"</i>		101	1			
No GAP Level 3 analog			16608	na			
<i>Includes Delta Class(es), except as allowed</i>	<i>Bare Gravel and Sand</i>		8249	na			
	<i>Introduced Mediterranean Vegetation</i>		5943	na			
	<i>Vernal pool basin</i>		104	na			
	<i>California warm temperate marsh/seep</i>		69	na			
	<i>Vancouverian riparian deciduous forest</i>		610	na			
	<i>Southwestern North American salt basin and high marsh</i>		423	na			
	<i>Naturalized warm-temperate riparian and wetland group</i>		821	na			
	<i>Western Dogwood Thicket)</i>		357	na			
	<i>Unspecified habitat restoration Site</i>		31	na			
Overall		725882		559957	77.1%	165925	22.9%

¹ See Appendix H for GAP-Delta vegetation crosswalk

²Delta classes "California warm temperate marsh/seep", "Vernal pool basin", "Naturalized warm-temperate riparian and wetland group" allowed as analogs to GAP Level 3 "California Central Valley and Southern Coastal Grassland"

³Delta class "Western dogwood thicket" allowed as analogs to GAP Level 3 "California Central Valley Riparian"

⁴Delta classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", "Southwestern North American salt basin and high marsh", "Temperate Pacific tidal salt and brackish meadow", "California warm temperate marsh/seep" and "Open water" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh", "Temperate Pacific Tidal Salt and Brackish Marsh", and "Open Water"

Overall thematic agreement between GAP and Delta data was 77%; however, similar to the GAP-FRRM analysis, this was largely a result of agreement on “Cultivated Cropland”, the major landcover type across the analysis area. For analysis purposes, open water, freshwater emergent marsh, and tidal salt/brackish marsh land cover types were allowed as reasonably analogous. This resulted in the highest thematic agreement for freshwater emergent marsh (82%) and open water (75%), but still resulted in low (47%) thematic agreement for tidal salt/brackish marsh. Taken together, overall thematic agreement for open water and marsh land cover types was 76% (data not shown). Similar to the SRRM and FRRM analyses, thematic agreement for all other major vegetation types within the comparative area were below 40%.

Delta land cover types with no comparable type in GAP data were “Bare Gravel and Sand” and “Introduced Vegetation”. One Delta land cover type (“Unspecified habitat restoration site”) was not adequately defined for comparative purposes but constituted an extremely small area. GAP data with no Delta analog, included: “California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna”, “Mediterranean California Northern Coastal Dune”, and Northern and Central California Dry-Mesic Chaparral”. These land cover types, which might reasonably be expected within the vicinity of the analysis area, accounted for less than 1% of the GAP data.

Though thematic agreement was low for “Developed” land cover types, this may have been affected by rapid urban development in the time between creation of GAP and Delta data.

Similar to the previous comparisons, , relative (rank) abundance for all comparable GAP and Delta land cover types was fairly similar. A comparative summary of GAP-Delta data for GAP Level 3 land covers is presented in Table 6.

Table 6. Summary of comparative characteristics for the GAP-Delta projects by GAP Level 3 or Delta Analog land cover types

GAP Level 3	Delta
California Central Valley and Southern Coastal Grassland	31% thematic agreement - Similar to "California Central Valley Riparian Woodland and Shrubland" (below), GAP data generally, aligns very well with the Delta mapping effort, but tended to overestimate this habitat type. Overestimation of this habitat type, in conjunction with very general capture of vegetation boundaries lead to the substantial disparity between GAP and Delta data for this thematic type.
California Central Valley Mixed Oak Savanna	0% thematic agreement – GAP and Delta acreage for analogous oak woodland types was comparable, but thematic alignment was negligible.
California Central Valley Riparian Woodland and Shrubland	27% thematic agreement - poor alignment of GAP-Delta thematic analogs. GAP estimates for this data were almost double the acreage estimated by Delta data.
California Coastal Closed-Cone Conifer Forest and Woodland	Small portion of GAP acreage - no similar vegetation types were mapped by the SRRM project
California Coastal Live Oak Woodland and Savanna	See comments on "California Central Valley Mixed Oak Savannah" (above) - categories considered similar for comparative purposes, but not thematic agreement with Delta analog
California Coastal Redwood Forest	< 1 acre mapped by GAP
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	See comments on "California Central Valley Mixed Oak Savannah" (above) - categories considered similar for comparative purposes, but not thematic agreement with Delta analog
Cultivated Cropland	79% thematic agreement (similar to GAP-FRRM comparison) - generally very good agreement between GAP (443,359 ac.) and Delta (474,155 ac.). This is a relatively extensive and contiguous land cover type throughout this analysis area
Developed (Includes High, Low and Medium Intensity Developed and Developed Open Space)	51% thematic agreement - somewhat comparable acreage mapped to this thematic type by GAP (78,423 ac.) and FRRM (62,243 ac.), but weak thematic agreement. At low resolutions GAP appears to depict urbanized corridors and transportation networks more explicitly. At higher resolutions GAP data tended to overestimate urbanization of these corridors, whereas the Delta map extracted more detailed information. Differences appear to have resulted from: higher resolution mapping by the Delta and low-resolution GAP data. Low resolution GAP mapping tended to included isolated and fragmented vegetation in "Developed" theme types.

Table 6. (continued) Summary of comparative characteristics for the GAP-Delta projects by GAP Level 3 or Delta Analog land cover types

GAP Level 3	Delta
Open Water (Fresh)	75% thematic agreement - Includes GAP Level 3 Categories and analogous Delta landcover types ("Open Water", "Temperate Pacific Freshwater Emergent Marsh" and Temperate Pacific Tidal Salt and Brackish Marsh"). These types were not lumped, but considered as "thematically agreeing". Relatively good agreement, even when strictly considering "Open Water" categories as thematic agreement (77% thematic agreement). Differences between data sets primarily reflect general nature of GAP data and scale its scale of intended use (1:100,000). Open water areas depicted in aerial imagery used for GAP ('99-'01) and Delta ('02 and '05) are not expected to differ substantially, except as relates to water stage and tide.
Temperate Pacific Tidal Salt and Brackish Marsh	47% thematic agreement - Includes GAP Level 3 Categories and analogous/similar Delta landcover types ("Open Water", "Temperate Pacific Freshwater Emergent Marsh" and Temperate Pacific Tidal Salt and Brackish Marsh"). Extremely low agreement resulted when strictly considering Delta "salt basin and high marsh" and tidal salt and brackish meadow" types (4% thematic agreement).
Temperate Pacific Freshwater Emergent Marsh	82% thematic agreement - Includes GAP Level 3 Categories and analogous Delta landcover types ("Open Water", "Temperate Pacific Freshwater Emergent Marsh" and Temperate Pacific Tidal Salt and Brackish Marsh"). These types were considered as closely aligned or analogous. Relatively low agreement resulted when strictly considering "Freshwater Emergent Marsh" categories as thematic agreement (39% thematic agreement).

Detailed Summary Data for GAP in the Delta Region is presented in Appendix I.

Detailed Summary Data for Delta map is presented in Appendix J.

V. Discussion and Conclusions

a. GAP vs. Sacramento River Riparian Mapping project

Based on SRRM data, the low resolution of GAP resulted in overestimates of “California Central Valley and Southern Coastal Grassland” land cover. This was due to both misidentification and very general GAP polygon boundaries capturing gravel bars, open water, agriculture and woody vegetation as “California Central Valley and Southern Coastal Grassland ”.

Oak woodland types regularly mapped by the California GAP included “California Central Valley Mixed Oak Savanna” and “California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna”. These were generally small, but regularly occurring thematic inclusions which, in sum, estimated over 6,500-acres of oak woodland. Because blue oak-foothill pine habitat does not occur within the SRRM project area, areas mapped as such were considered wholly incorrect. Historically, “Savanna and California Central Valley Mixed Oak Savanna” may reasonably have been expected to occur in close proximity and within the SRRM area; however, due to land clearing, this is no longer the case. Though valley oak associations were mapped by the SRRM, the majority of this habitat was valley oak within riparian habitat and explicitly not mixed oak savannah. Except for a few small exceptions, valley oak stand mapped by SRRM were part of mixed riparian associations. Even when all SRRM valley oak associations were considered analogous to GAP level 3 “California Central Valley Mixed Oak Savanna” this accounted for only 27% of this habitat as mapped GAP.

Within the SRRM area, overall agreement between GAP and SRRM data was roughly 48%. Because of the nature of the SRRM mapping project, the majority of the SRRM area should have been categorized by GAP as “California Central Valley Riparian Woodland and Shrubland”. Though approximately 84% of areas mapped by GAP as “California Central Valley Riparian Woodland and Shrubland” were mapped into an analogous type by the SRRM, this was actually less than half the total riparian acreage mapped by the SRRM effort. Within the project area there was also a tendency for GAP coverage to misidentify gravel bar features along the Sacramento River as “Developed”. Though gravel bars consisted of only 4% of the entire mapped SRRM area, they were an important and regularly occurring component

throughout the SRRM project area. Lack of spatial information at this resolution is a characteristic of GAP at scales larger than the intended use.

Both GAP and SRRM data depicted little (<200 ac.) “Temperate Pacific Freshwater Emergent Marsh” or similar habitat.

“Open Water” was the largest source of concurrence between GAP and SRRM data. As mapped by GAP, this landcover type fell largely within the respective SRRM category for this land cover, though there was still substantial thematic conflict. Discrepancies between the data sets were due to the much more general portrayal of open water boundaries by GAP and, to a lesser extent, changes in the distribution of open water habitat between 2001 (GAP reference imagery) and 2007 (SRRM reference imagery).

Another source of conflict between these datasets included several GAP land cover types not found within the GAP-SRRM analysis area. Because SRRM data mapped only natural and semi-natural vegetation, this data excludes developed or agricultural land cover. Developed and agricultural lands, as mapped by GAP, constitute over 11,000 acres of this analysis area. Other thematic types not occurring within this analysis area, but mapped to a limited extent by GAP, include “Northern and Central California Dry-Mesic Chaparral” (54 ac.), “Mediterranean California Mesic Serpentine Woodland and Chaparral” (17 ac.) and Mediterranean California Foothill and Lower Montane Riparian Woodland” (9 ac.).

b. GAP vs. Feather River Regional Mapping project

As noted previously, high overall thematic agreement (74%) of the GAP-FRRM data was largely a result of agreement on “Cultivated Cropland”, the major landcover type across the analysis area. Conversely, thematic agreement for all major vegetation types was less than 40%, even when broad latitude was given for potentially comparable land cover types across GAP and FRRM data.

Poor thematic agreement for “Open Water”, as compared to the GAP-SRRM analysis, was probably accentuated by the inability of GAP to map regularly occurring, but narrow stream corridors, which fell below the resolution of the mapping effort. This, in conjunction with the more general and less accurate nature of GAP data resulted in low thematic agreement.

Overall, differences in thematic resolution between GAP (low) and FRRM (high) data, in conjunction with landscape changes occurring between creation of reference imagery (GAP

1999-2001; FRRM 2009) are among the primary reasons for low thematic agreement between these data.

c. GAP vs. Delta Region Land Cover map

Similar to the GAP-FRRM comparison, thematic agreement between GAP-Delta data was due primarily to agreement on “Cultivated Cropland”, the major landcover type across the analysis area. Furthermore, removal of extensive human-changed land cover types (e.g. “Cultivated Cropland”, “Pasture/Hay” and/or “Developed” land covers) reduces agreement between the data sets to 60-65%.

Good thematic agreement found for “Open Water” was due, in large part, to the fact that open water habitats within this region are expansive and adequately captured by both the low (GAP) and high (Delta) resolution mapping efforts. Similarly, both freshwater and salt/brackish marsh vegetation are relatively expansive features where they occur within this analysis area, allowing for more accurate mapping at both low and high resolution. Conversely, smaller, generally less frequent, land cover types resulted poorer thematic agreement between GAP and Delta data.

d. GAP Data Characteristics

Review of this data found several characteristics of GAP Land Cover that limit its utility for regional planning, change detection, and identification of potential habitat restoration sites. These characteristics include: lack of thematic detail (i.e. richness of land cover categories), lumping of diverse land cover types, spatial inaccuracies in mapping unit (polygon) boundaries at scales larger than 1:100,000, and errors in thematic identification (i.e. incorrect land cover classifications). A summary of key GAP data characteristics is presented in Table 7 (following page).

i. Thematic and spatial accuracy

At relatively small scales (i.e. when examining fairly large areas) GAP provides a good portrait of the extent and type of several general habitat types occurring across a region. *As mentioned previously, GAP data is intended for use at scales no greater than 1:100,000 (about the scale of a USGS 15"- quadrangle).* At larger scales, accuracy of the data breaks down, polygon boundaries become erratic, and thematic information tends to include small, but regularly occurring inclusions (i.e. small, isolated polygons within larger areas) of inaccurate thematic information.

Based on quantitative data presented here, GAP data coverage for comparison areas captures very general habitat characteristics at the local and regional scale. As a result, there is a tendency at all scales for simplification and lumping of vegetative characteristics into the larger, more general thematic types, with a concurrent loss of land cover characteristics. Based on field verified maps and aerial photo interpretation, several characteristics of GAP Land Cover data likely limit the utility of this data set for regional planning, change detection and identification of potential habitat restoration site. As noted previously, these include: lack of thematic detail, inaccuracies in mapping unit (polygon) boundaries and errors in thematic identification.

The tendency for GAP data to over-generalize land cover (e.g., to map both willow-dominated riparian scrub and valley-oak dominated riparian woodland as “California Central Valley Riparian Woodland and Shrubland”) is significant from a conservation planning standpoint, because important habitats and habitat characteristics are often lumped into more generic habitat categories. As a result of these GAP Land Cover data characteristics, it would be problematic to use GAP data to adequately characterize land cover for the purposes of resource planning and conservation, even at a regional scale.

At the scale for intended use, GAP data provides a useful depiction of the distribution and relative abundance of very general habitat types across the CVRFPP project area. Furthermore, a general comparison of GAP data *at its intended scale (1:100,000) of use* with FRRM and Delta data show very good general portrayals of most thematic types. This information might be used to infer which regions within the project boundary are most likely to retain healthier and more diverse populations of biological resources and, conversely, which regions are suffering the greatest loss of biological resources. These inferences are limited to very general habitat types and would require more detailed analyses to elucidate exactly what they mean in a practical context.

Table 7. Summary and comments on key GAP data characteristics based on comparative analyses.

GAP data characteristics	Comments
Data resolution	At scale of intended use (1:100,000), GAP data portrays the distribution of vegetation and landscape features fairly well. Graphic portrayal of landscape characteristics by GAP data rapidly breaks down at higher resolutions.
Spatial accuracy	For poorly distributed or infrequent vegetation types (e.g. declining habitats) GAP data had poor spatial accuracy at all scales.
	At the intended resolution, GAP data provides relatively accurate portrayal of the distribution of general, widespread vegetation types. Conversely, for poorly distributed or infrequent vegetation types (e.g. declining habitats) GAP data had poor spatial accuracy at all scales. At resolutions higher than the intended use, there were regular and substantial inaccuracies in mapping unit (polygon) boundaries and errors in thematic identification
	At resolutions higher than the intended use, there were regular and substantial inaccuracies in mapping unit (polygon) boundaries and errors in thematic identification
Thematic resolution	Thematic resolution of GAP data very general and designed to follow the International Ecological Classification Standards for Terrestrial Classification of "Ecological Systems". GAP level 3 thematic types designed to be synonymous with "Ecological Systems".
	GAP level 3 land covers tend to lump diverse land cover types (e.g. vernal pools, native perennial grasslands, nonnative ruderal vegetation lumped as "grassland") and/or does not depict range of important land cover sub-types (e.g. range of important, structurally characteristics riparian vegetation affecting key conservation resources often cannot be captured).
Thematic accuracy	Widespread landcover types with lower conservation values (i.e. open water, agricultural and developed landscapes) tended to highest thematic accuracy.
	Elimination of widespread land cover types substantially reduced thematic accuracy of GAP data, resulting in "lopsided" accuracy - extensive land covers pretty good, but infrequent, small land covers poor.
	Within the analysis areas, GAP data regularly failed to capture or properly categorize gravel bars and similar "bare ground" land covers.
Currency of data	GAP data based on older imagery (1999-2001) than comparative datasets, but incorporated derived digital elevation model data.
Portrayal of habitat restoration areas	GAP data tended to portray riparian restoration sites as agricultural lands, which look somewhat similar in aerial imagery.
	GAP data portrayed wetland restoration sites (primarily managed marsh) with accuracy comparable to other natural and semi-natural vegetation types.
Relative abundance of habitats	Irrespective of spatial and thematic limitations, relative (rank) abundance of land cover types for GAP data was very similar to all comparison data sets.

ii. Currency of maps

SRRM, FRRM and Delta maps utilize recent aerial imagery (2005-2010) relative to GAP (1999-2001). The significance of the time difference between GAP and the other data sets depends on the habitat type and region. Because of the coarse resolution of GAP data, changes in land cover since development of GAP have a variable influence on interpretation of the data (e.g. large and/or contiguous changes are more detectable than local and/or diffuse changes). Following is a discussion of some of the characteristics of habitat types within the analysis areas where change in habitat may be significant in relation to the time difference between imagery used for GAP and imagery used for all other data sets. A detailed analysis of these factors on comparisons between these data sets is beyond the scope of this project, but discussed here for clarification.

Riparian habitats, once established, are often rapidly developing types. Depending on site conditions, planted or naturally recruited trees, such as Fremont's cottonwood (*Populus fremontii*), can grow more than 50 feet in height within 8-years of establishment. Furthermore, within relatively active river channels, as found in portions of the Sacramento and Feather Rivers, substantial changes to river channel and associated forests often occur due to channel meander, erosion, and deposition.

Herbaceous habitat types, particularly managed marsh and herbaceous areas with human altered hydrology (e.g. herbaceous types with natural drainage and hydrology affected by distribution of water for summer irrigation or runoff) can also change rapidly, making them somewhat difficult to categorize, even within a span of 2-4 years.

In recent years habitat restoration efforts have had a measurable effect on the total acreage of some habitat types in California, particularly riparian forests. Many of these sites, if well-placed, grow extremely fast due to weed control and summer irrigation. Further complicating the matter is that habitat restoration is based on a palette of selected native species for a variety of reasons and, in some cases, may not be easy to categorize into "natural" types. Efforts by organizations such as River Partners and The Nature Conservancy have resulted in the planting of several thousand acres of riparian forest in the last 20 years. Most of these efforts have taken place within the SRRM along the Sacramento River between the cities of Colusa and Red Bluff.

Another relatively extensive form of habitat creation has been conversion of agricultural lands (primarily rice) to "managed marsh" or hunt clubs. These created wetlands are often more difficult to categorize than other types of restoration efforts because implementation is often based on regular vegetation manipulation and management for weedy, nonnative

herbaceous food plants for waterfowl. The goals, objectives, and management approach of the respective land manager generally determine the density, distribution, and composition of woody species found in a given managed marsh. With the exception of limited acreage within the Delta area (approximately 3,500-acres), the majority of managed marsh within the project area occurs outside of the comparative areas discussed here. The project area does, however, contain extensive managed marsh habitat within the Sacramento (>80,000-acres) and San Joaquin (>100,000 acres) Valleys (pers. comm. Dean Kwasny, State Wetlands Biologist, USDA NRCS, November 2010). Though these areas occur largely outside of analyses presented here, there is potential for GAP data to inaccurately capture recent expansion in managed marsh acreage. Furthermore, it was observed that the “GAP Protected Areas Database” states that “ecological disturbance events are suppressed” on state and federal managed marsh acreage within the project area, which may be fundamentally inaccurate in many cases.

Lastly, urbanization of farmland and grasslands has undoubtedly had a profound effect on the extent (i.e. loss) of these habitats and a range of habitat subtypes.

Again, determining the influence of landscape change versus generalized inaccuracies when comparing GAP to higher resolution data sets (i.e. SRRM, FRRM and Delta data) and aerial imagery depends on the amplitude and characteristic of the change.

iii. Change detection and identification of potential restoration sites

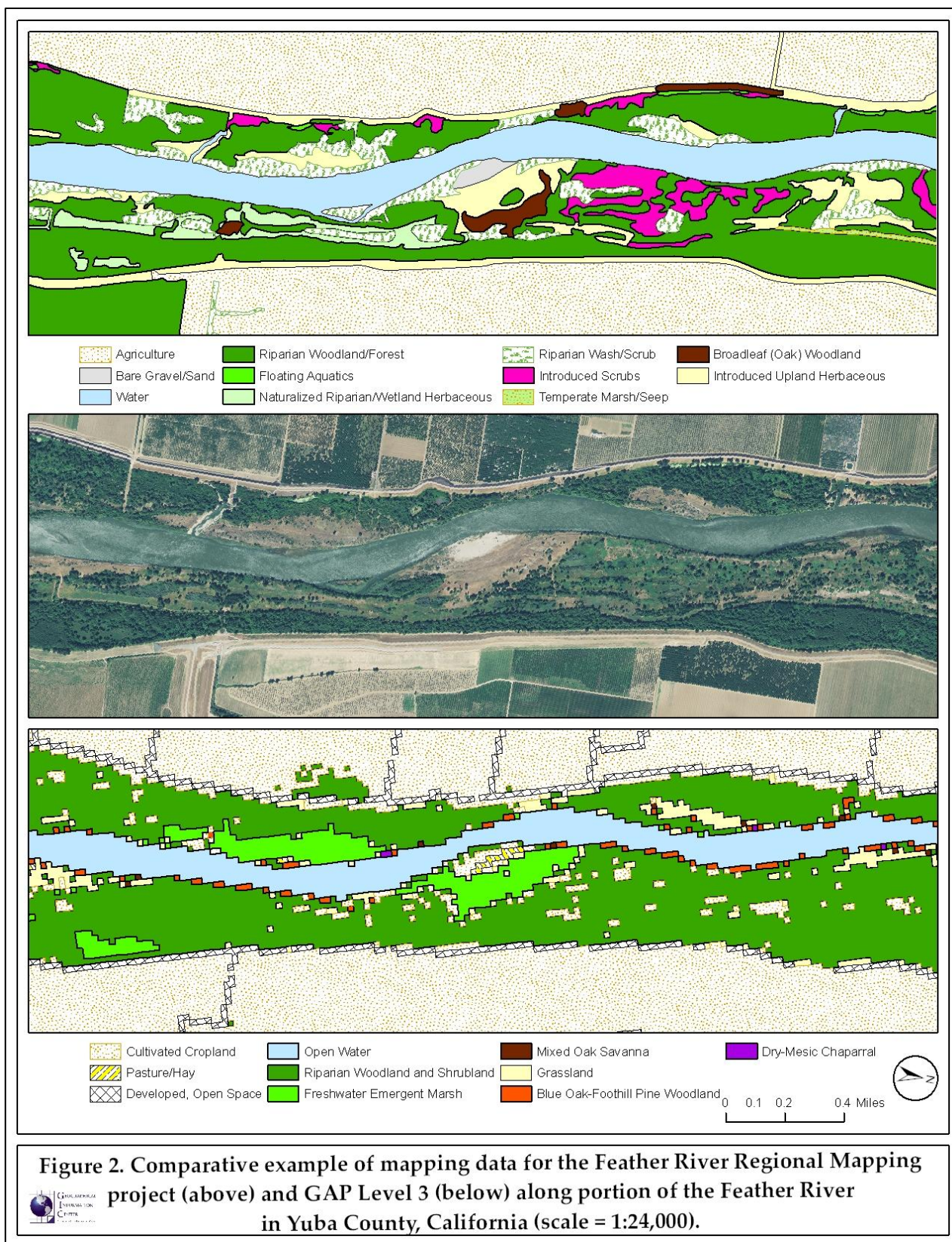
Because of the very general nature of the California GAP, it would be impractical to utilize GAP data for either change detection or identification of potential restoration sites. This is particularly true for habitat types of limited extent and/or those characterized poorly by GAP data.

iv. Comparison with field data

Because land cover data for the SRRM, FRRM and Delta maps were largely developed using field checks in conjunction with aerial photo interpretation by biologists from within each region, these maps have a much higher degree of accuracy. Delta project field data was provided to the California GAP remapping project (Todd Keeler-Wolf, pers. comm.), but because of the nature of the intended resolution of GAP data, similar fundamental issues consistently arose across all three data set comparisons. Additional field data was collected by GAP project, but the more localized, higher resolution data of the SRRM, FRRM and Delta projects resulted in more accurate data sets.

A comparative example of mapping data for the GAP and FRRM projects is presented in Figure 2, below. Scale of this data is approximately equivalent to a standard 7.5"-USGS topographic quadrangle (1:24,000). This figure provides a graphic representation of characteristic differences between GAP and comparative data sets described above. These include:

- A more general portrayal of GAP thematic data (e.g. more simplistic display of riparian vegetation types);
- Pixilated geometry and polygon boundaries of GAP data;
- Small, but regular inclusions of erroneous incorrect habitat types (e.g. "Blue Oak-Foothill Pine Woodland", "Dry-Mesic Chaparral" and mapped "Cultivated Cropland" within the riparian corridor); and
- More general mapping errors (e.g. "Freshwater Emergent Marsh") observable in GAP data due to incorrect mapping and/or changes in habitat since creation of the dataset.



VI. Utility of GAP for regional conservation planning and the CVFPP

As noted previously, GAP data is intended for use at resolutions no greater than 1:100,000. Many discrepancies observed between GAP and each comparative data set are related to limits of GAP resolution. Resolution of GAP data also limits its practical use in conservation planning at the regional scale. As with change detection and identification of restoration sites, the utility of GAP for regional planning would be largely limited to providing a general or cursory indication of potential land cover and associated biological resources for large areas. Based on the analyses presented here, utility of GAP data for regional conservation planning is substantially limited. Conservation requirements and objectives within the project area will require more detailed data to ensure accurate and adequate information is used in regional planning efforts. This is true for commoner, as well as declining and regulated biological resources, within the project area.

In this review of GAP program data, it is evident that GAP data may serve as a limited tool for inferring the occurrence and relative abundance of very general habitat types, provided this data is interpreted by knowledgeable resource personnel. The GAP program may provide a useful bridge between very general land cover maps and more detailed regional mapping efforts (as stated in GAP program metadata; GAP 2009). The GAP framework also lends itself to development of a hierarchical system for mapping and monitoring resources from a national (general) to regional (detailed) scale. Most importantly, this may lend itself to more effective mapping of biological resources associated with or dependent upon mapped land cover types.

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Appendix A **GAP-Sacramento River Riparian Mapping project vegetation crosswalk**

GAP Level 3 or Analog	SRRM Vegetation Class Name
California Central Valley & Southern Coastal Grassland	California annual grasslands-herbaceous
	Introduced perennial grassland
¹ California Central Valley Riparian Woodland and Shrubland	Box elder (<i>Acer negundo</i>)
	Blackberry (<i>Rubus discolor</i>)
	Black walnut (<i>Juglans hindsii</i>)
	California sycamore (<i>Platanus racemosa</i>)
	Fremont cottonwood (<i>Populus fremontii</i>)
	Giant cane (<i>Arundo donax</i>)
	Gooding's black willow (<i>Salix gooddingii</i>)
	Mixed willow
	Riparian scrub
	Valley oak (<i>Quercus lobata</i>)
No analog	Gravel bar
² Temperate Pacific Freshwater Emergent Marsh	² Cattail-Bulrush
	² Floating-leaved plants
	² Water primrose (<i>Ludwigia peploides</i>)
² Open Water & Temperate Pacific Freshwater Mudflat	² Open Water
¹ California Central Valley Mixed Oak Savanna	No analog
California Coastal Closed-Cone Conifer Forest & Woodland	
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	

Appendix A (*continued*) GAP-Sacramento River Riparian Mapping project vegetation crosswalk

GAP Level 3 or Analog	SRRM Vegetation Class Name
Central California Coast Ranges Cliff and Canyon	No analog
Developed	
Introduced Upland Vegetation – Treed	
Mediterranean California Foothill and Lower Montane Riparian Woodland	
Mediterranean California Mesic Serpentine Woodland and Chaparral	
Mediterranean California Mixed Evergreen Forest	
Northern and Central California Dry-Mesic Chaparral	
Northern California Coastal Scrub	

¹524-acres of Riparian Valley Oak Habitat was allowed as GAP Level 3 "California Central Valley Mixed Oak Savannah" when thematic conflict arose

²SRRM classes "Water", "Floating-leaved plants", "Water primrose (*Ludwigia peploides*)", and "Cattail-Bullrush" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh" and "Open Water (Fresh) and Temperate Pacific Freshwater Mudflat"

Appendix B Summary GAP data for Sacramento River Riparian Mapping area

GAP Levels 1-3 Land Cover Type	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Forest and woodland systems	21.7	0.34	64	0.05%	0.21%
Conifer dominated forest and woodland (xeric-mesic)	4.8	0.25	19	0.01%	0.06%
California Coastal Closed-Cone Conifer Forest and Woodland	4.8	0.25	19	0.01%	0.06%
Mixed deciduous/coniferous forest and woodland (xeric-mesic)	0.0	0.00	1	0.00%	0.00%
Mediterranean California Mixed Evergreen Forest	0.0	0.00	1	0.00%	0.00%
Mixed deciduous/coniferous forest and woodland (mesic-wet)	16.9	0.38	44	0.04%	0.15%
Mediterranean California Mesic Serpentine Woodland and Chaparral	16.9	0.38	44	0.04%	0.15%
Grassland systems	3787.7	0.82	4636	7.98%	15.50%
Sand prairie, coastal grasslands and loams	3787.7	0.82	4636	7.98%	15.50%
California Central Valley and Southern Coastal Grassland	3787.7	0.82	4636	7.98%	15.50%
Human land use	11716.9	2.16	5424	24.69%	18.14%
Agriculture	9877.1	5.59	1768	20.82%	5.91%
Cultivated Cropland	9877.1	5.59	1768	20.82%	5.91%
Developed	1839.8	0.50	3656	3.88%	12.23%
Developed, High Intensity	71.2	0.96	74	0.15%	0.25%
Developed, Low Intensity	478.9	0.45	1062	1.01%	3.55%
Developed, Medium Intensity	125.2	0.42	297	0.26%	0.99%
Developed, Open Space	1164.6	0.52	2223	2.45%	7.43%
Recently disturbed or modified	1.9	0.15	13	0.00%	0.04%
Introduced vegetation	1.9	0.15	13	0.00%	0.04%
Introduced Upland Vegetation - Treed	1.9	0.15	13	0.00%	0.04%
Riparian and wetland systems	14167.4	2.13	6650	29.86%	22.24%

Appendix B. (continued) Summary GAP for Sacramento River Riparian Mapping area

GAP Levels 1-3 Land Cover Type	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Floodplain and riparian	13998.0	2.25	6235	29.50%	20.85%
California Central Valley Riparian Woodland and Shrubland	13988.7	2.25	6209	29.48%	20.76%
Mediterranean California Foothill and Lower Montane Riparian Woodland	9.3	0.36	26	0.02%	0.09%
Freshwater herbaceous marsh, swamp, or baygall	169.4	0.41	415	0.36%	1.39%
Temperate Pacific Freshwater Emergent Marsh	169.4	0.41	415	0.36%	1.39%
Shrubland, steppe and savanna systems	5577.3	0.47	11784	11.75%	39.41%
Chaparral	54.0	0.17	323	0.11%	1.08%
Northern and Central California Dry-Mesic Chaparral	54.0	0.17	323	0.11%	1.08%
Deciduous dominated savanna and glade	5520.8	0.48	11447	11.63%	38.28%
California Central Valley Mixed Oak Savanna	2033.8	0.48	4207	4.29%	14.07%
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	3487.0	0.48	7240	7.35%	24.21%
Scrub shrubland	2.6	0.18	14	0.01%	0.05%
Northern California Coastal Scrub	2.6	0.18	14	0.01%	0.05%
Sparse and barren systems	7.5	0.29	26	0.02%	0.09%
Cliff, canyon and talus	4.0	0.36	11	0.01%	0.04%
Central California Coast Ranges Cliff and Canyon	4.0	0.36	11	0.01%	0.04%
Playa, wash and mudflat	3.5	0.23	15	0.01%	0.05%
Temperate Pacific Freshwater Mudflat	3.5	0.23	15	0.01%	0.05%
Not Defined	12170.5	9.33	1305	25.65%	4.36%
Total/Overall	47450.9	1.59	29902	100.00%	100.00%

Appendix C Summary Data for Sacramento River Riparian Mapping project

Riparian Group	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Box elder (<i>Acer negundo</i>)	1114.5	1.6	717	2.35%	4.89%
Blackberry (<i>Rubus discolor</i>)	521.4	0.8	650	1.10%	4.43%
Black walnut (<i>Juglans hindsii</i>)	3010.3	3.1	963	6.34%	6.56%
California annual grasslands-herbaceous	4234.8	5.9	715	8.92%	4.87%
Cattail-Bulrush	85.7	0.8	103	0.18%	0.70%
California sycamore (<i>Platanus racemosa</i>)	324.5	1.5	219	0.68%	1.49%
Fremont cottonwood (<i>Populus fremontii</i>)	9683.5	5.8	1664	20.41%	11.34%
Floating-leaved plants	136.7	0.8	168	0.29%	1.15%
Gravel bar	1977.9	3.3	604	4.17%	4.12%
Giant cane (<i>Arundo donax</i>)	143.7	0.1	1995	0.30%	13.60%
Goodding's black willow (<i>Salix gooddingii</i>)	180.4	2.0	92	0.38%	0.63%
Water primrose (<i>Ludwigia peploides</i>)	557.9	1.4	408	1.18%	2.78%
Mixed willow	2238.8	2.0	1098	4.72%	7.48%
Water	12616.0	14.3	881	26.59%	6.01%
Introduced perennial grassland	542.7	1.3	403	1.14%	2.75%
Riparian scrub	3250.6	2.2	1491	6.85%	10.16%
Valley oak (<i>Quercus lobata</i>)	6831.4	2.7	2500	14.40%	17.04%
Total/Overall	47450.9	3.2	14671	100.00%	100.00%

Appendix D **GAP-Feather River Regional Mapping project vegetation crosswalk**

GAP Level 3 Analog	FRRM Land Cover
Cultivated Cropland	Agriculture
No Gap Level 3 Analog	Bare Gravel and Sand
California Central Valley and Southern Coastal Grassland	California Introduced Annual and Perennial Herbaceous
	California Annual Forb/Grass Vegetation
Southern California Coastal Scrub	Central and South Coastal California Seral Scrub
¹ Temperate Pacific Freshwater Emergent Marsh	¹ Western North American freshwater aquatic vegetation (macrogroup)
¹ Temperate Pacific Freshwater Emergent Marsh	¹ Arid West Freshwater Emergent Marsh
Introduced Upland Vegetation – Treed (GAP Level 2)	Introduced Mediterranean Forest
No Gap Level 3 Analog	^{1,2} Naturalized Warm Temperate Riparian/Wetland
California Central Valley Riparian Woodland and Shrubland	Riparian Introduced Riparian Scrub
	Riparian Evergreen and Deciduous Woodland
	Southwestern North America riparian wash/scrub
Developed (Combines High-, Medium- and Low-Intensity Developed; Quarries, Mines, Gravel Pits and Oil Wells, and; Developed Open Space)	Urban/Developed/Industrial
¹ Open Water (Fresh)	¹ Open Water
No Gap Level 3 Analog	² California Warm Temperate Marsh/Seep
California Central Valley Mixed Oak Savanna	California Broadleaf Forest and Woodland
California Mesic Chaparral	No analog
Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland	
Mediterranean California Foothill and Lower Montane Riparian Woodland	
Northern and Central California Dry-Mesic Chaparral	

¹FRRM classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", and "Open water" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh" and "Open Water" when thematic conflict arose

²FRRM classes "California warm temperate marsh/seep" and "Naturalized warm-temperate riparian and wetland group" allowed as analogs to GAP Level 3 "California Central Valley and Southern Coastal Grassland" when thematic conflict arose

Appendix E Common vegetation alliances of the FRRM and Delta mapping areas

Riparian Evergreen and Deciduous Woodland includes:

- 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

Introduced North American Mediterranean forest (no group subdivision below this), includes stands of *Eucalyptus*, *Ailanthus*, and other non-native naturalized trees

Californian broadleaf forest and woodland includes:

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

Central and south coastal California seral scrub includes:

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

Southwestern North America riparian wash/scrub includes:

- Baccharis salicifolia* Alliance
- Cephalanthus occidentalis* Alliance
- Rosa californica* Alliance
- Salix exigua* Alliance
- Salix lasiolepis* Alliance
- Sambucus nigra* Alliance

Riparian introduced scrub includes:

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

California Introduced Annual and Perennial Herbaceous includes:

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

California annual forb/grass vegetation includes:

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

Freshwater emergent marsh includes:

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

Californian warm temperate marsh/seep includes:

Carex barbarae Alliance
Carex densa Provisional Alliance
Carex nudata Alliance
Juncus arcticus (var. *balticus, mexicana*) Alliance
Juncus (oxymers, xiphioides) Provisional Alliance

Leymus triticoides Alliance
Mimulus (guttatus) Alliance

Naturalized warm-temperate riparian/wetland includes:

Lepidium latifolium Semi-natural Stands
Persicaria lapathifolia–*Xanthium strumarium* Provisional Alliance

Floating aquatic vegetation includes:

Ludwigia (hexapetala, peploides) Semi-natural Stands
Myriophyllum strictum
Cabomba carolinensis
Egeria
Azolla (filiculoides, mexicana) Provisional Alliance
Lemna (minor) and relatives Provisional Alliance
Note: may also include *Eichhornea crassipes* stands, if discovered in mapping area

¹Vernal pool basin includes:

Vernal Pools

¹Vancouverian riparian deciduous forest includes:

Alnus rhombifolia / *Cornus sericea*
Alnus rhombifolia / *Salix exigua* (*Rosa californica*)
White Alder (*Alnus rhombifolia*)
White Alder (*Alnus rhombifolia*) - Arroyo willow (*Salix lasiolepis*) restoration

¹Western dogwood thicket includes:

California Dogwood (*Cornus sericea*)
Cornus sericea - *Salix exigua*
Cornus sericea - *Salix lasiolepis* / (*Phragmites australis*)
Baccharis pilularis / Annual Grasses & Herbs
Buttonbush (*Cephalanthus occidentalis*)
California Wild Rose (*Rosa californica*)
Mexican Elderberry (*Sambucus mexicana*)
Narrow-leaf Willow (*Salix exigua*)
Salix exigua - (*Salix lasiolepis* - *Rubus discolor* - *Rosa californica*)
Salix lasiolepis - (*Cornus sericea*) / *Scirpus* spp.- (*Phragmites australis* - *Typha* spp.) complex unit
Salix lasiolepis - Mixed brambles (*Rosa californica* - *Vitis californica* - *Rubus discolor*)

¹Southwestern North American salt basin and high marsh includes:

Alkali Heath (*Frankenia salina*)
Alkaline vegetation mapping unit
Allenrolfea occidentalis mapping unit
Frankenia salina - *Distichlis spicata*

Pickleweed (*Salicornia virginica*)
Salt scalds and associated sparse vegetation
Suaeda moquinii - (*Lasthenia californica*) mapping unit

¹Temperate Pacific tidal salt and brackish meadow includes:

California Hair-grass (*Deschampsia caespitosa*)
Deschampsia caespitosa - *Lilaeopsis masonii*
Distichlis spicata - Annual Grasses
Distichlis spicata - *Juncus balticus*
Distichlis spicata - *Salicornia virginica*
Salicornia virginica - *Cotula coronopifolia*
Salicornia virginica - *Distichlis spicata*
Saltgrass (*Distichlis spicata*)

Agricultural – Evidence of current or recent agricultural activity

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

Bare Gravel Sand - Ground covered by cobble, gravels, sand or fines

Water - Standing water covers the mapping area with vegetation absent or very sparse

¹ Vegetation alliances found only in Delta vegetation mapping data

Appendix F Summary GAP data for Feather River Regional Mapping area

Gap Levels 1-3 Land Cover Types	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Aquatic	8525.7	8.4	1017	1.95%	1.43%
Open water	8525.7	8.4	1017	1.95%	1.43%
Open Water (Fresh)	8525.7	8.4	1017	1.95%	1.43%
Forest and woodland systems	15.6	0.3	48	0.00%	0.07%
Conifer dominated forest and woodland (xeric-mesic)	15.6	0.3	48	0.00%	0.07%
Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland	15.6	0.3	48	0.00%	0.07%
Grassland systems	40566.6	3.3	12216	9.27%	17.14%
Sand prairie, coastal grasslands and lomas	40566.6	3.3	12216	9.27%	17.14%
California Central Valley and Southern Coastal Grassland	40566.6	3.3	12216	9.27%	17.14%
Human land use	340330.5	11.3	30146	77.73%	42.30%
Agriculture	294863.9	46.5	6341	67.35%	8.90%
Cultivated Cropland	294863.9	46.5	6341	67.35%	8.90%
Developed	43873.7	2.0	22483	10.02%	31.55%
Developed, High Intensity	1823.6	2.6	691	0.42%	0.97%
Developed, Low Intensity	9347.9	1.8	5181	2.14%	7.27%
Developed, Medium Intensity	8162.1	3.1	2606	1.86%	3.66%
Developed, Open Space	24540.1	1.8	14005	5.61%	19.65%
Mining	1592.9	1.2	1322	0.36%	1.86%
Quarries, Mines, Gravel Pits and Oil Wells	1592.9	1.2	1322	0.36%	1.86%
Riparian and wetland systems	17615.5	1.4	12461	4.02%	17.49%
Floodplain and riparian	14329.7	1.4	10554	3.27%	14.81%
California Central Valley Riparian Woodland and Shrubland	14329.7	1.4	10552	3.27%	14.81%
Mediterranean California Foothill and Lower Montane Riparian Woodland	0.0	0.0	2	0.00%	0.00%
Freshwater herbaceous marsh, swamp, or baygall	3285.8	1.7	1907	0.75%	2.68%
Temperate Pacific Freshwater Emergent Marsh	3285.8	1.7	1907	0.75%	2.68%

Appendix F. (continued) Summary GAP data for Feather River Regional Mapping area

Gap Levels 1-3 Land Cover Types	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Shrubland, steppe and savanna systems	7441.0	0.6	12531	1.70%	17.58%
Chaparral	198.6	0.3	747	0.05%	1.05%
California Mesic Chaparral	0.2	0.2	1	0.00%	0.00%
Northern and Central California Dry-Mesic Chaparral	198.4	0.3	746	0.05%	1.05%
Deciduous dominated savanna and glade	7242.4	0.6	11784	1.65%	16.54%
California Central Valley Mixed Oak Savanna	1595.0	0.4	4322	0.36%	6.06%
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	5647.4	0.8	7462	1.29%	10.47%
Not defined	23324.4	8.2	2845	5.33%	3.99%
Total/Overall	437819.2	6.1	71264	100.00%	100.00%

Appendix G Summary Data for Feather River Regional Mapping project.

Riparian Group	Total Acres	Average Acreage	County of Polygons	% of Total Acreage	% frequency of Occurrence
Agriculture	305726.3	1358.8	225	69.83%	2.99%
Bare Gravel and Sand	449.6	4.9	92	0.10%	1.22%
California Introduced Annual and Perennial Herbaceous	16064.8	16.9	948	3.67%	12.59%
California Annual Forb/Grass Vegetation	20620.8	99.6	207	4.71%	2.75%
Central and South Coastal California Seral Scrub	40.6	2.9	14	0.01%	0.19%
Floating Aquatic Vegetation	1102.7	3.3	338	0.25%	4.49%
Freshwater Emergent Marsh	983.6	3.8	261	0.22%	3.47%
Introduced Mediterranean Forest	168.2	3.9	43	0.04%	0.57%
Naturalized Warm Temperate Riparian/Wetland	4627.3	40.9	113	1.06%	1.50%
Riparian Introduced Riparian Scrub	645.1	2.8	227	0.15%	3.02%
Riparian Evergreen and Deciduous Woodland	14609.5	6.3	2328	3.34%	30.92%
Southwestern North America riparian wash/scrub	2283.0	3.6	630	0.52%	8.37%
Urban/Developed/Industrial	50423.1	145.3	347	11.52%	4.61%
Open Water	12072.8	18.2	662	2.76%	8.79%
California Warm Temperate Marsh/Seep	2973.3	8.3	358	0.68%	4.76%
California Broadleaf Forest and Woodland	5028.6	6.8	735	1.15%	9.76%
Total	437819.2		7528.0	100.00%	100.00%

Appendix H GAP-Delta Vegetation mapping project vegetation crosswalk

GAP Level 3 Analog	Vegetation Group	Alliances
Cultivated Cropland	Cultivated cropland	Agriculture
No GAP Level 3 analog	Bare Gravel and sand	Levee Rock Riprap
		Sparsely or Unvegetated Areas; Abandoned orchards
		Tidal mudflats
¹ California Central Valley and Southern Coastal Grassland	Mediterranean California naturalized annual and perennial grassland	Bromus diandrus - Bromus hordeaceus
		California Annual Grasslands - Herbaceous
		Italian Rye-grass (Lolium multiflorum)
		Lolium multiflorum - Convolvulus arvensis
		Pampas Grass (Cortaderia selloana - C. jubata)
		Poison Hemlock (Conium maculatum)
		Rabbitsfoot grass (Polypogon maritimus)
		Ruderal Herbaceous Grasses & Forbs
		Tall & Medium Upland Grasses
Southern California Coastal Scrub	Central and south coastal California seral scrub	Coyotebush (Baccharis pilularis)
		Microphyllous Shrubland
No GAP Level 3 analog	³ Western North American freshwater aquatic vegetation (macrogroup)	Algae
		Brazilian Waterweed (Egeria - Myriophyllum) Submerged
		Floating Primrose (Ludwigia peploides)
		Generic Floating Aquatics
		Hydrocotyle ranunculoides
		Ludwigia peploides
		Milfoil - Waterweed (generic submerged aquatics)
		Pondweed (Potamogeton sp.)
		Water Hyacinth (Eichhornia crassipes)
No GAP Level 3 analog	Introduced Mediterranean vegetation	Acacia - Robinia
		Eucalyptus
		Exotic Vegetation Stands
		Tobacco brush (Nicotiana glauca) mapping unit
		Tree-of-Heaven (Ailanthus altissima)
No GAP Level 3 analog	Unspecified habitat restoration site	Restoration Sites
No GAP Level 3 analog	"Unknown"	Unknown

Appendix H (continued) GAP-Delta Vegetation mapping project vegetation crosswalk

GAP Level 3 Analog	Vegetation Group	Alliances
³ Temperate Pacific Freshwater Emergent Marsh	³ Arid west freshwater emergent marsh	American Bulrush (<i>Scirpus americanus</i>)
		Broad-leaf Cattail (<i>Typha latifolia</i>)
		California Bulrush (<i>Scirpus californicus</i>)
		Common Reed (<i>Phragmites australis</i>)
		Hard-stem Bulrush (<i>Scirpus acutus</i>)
		Mixed Scirpus / Floating Aquatics (<i>Hydrocotyle</i> - <i>Eichhornia</i>) Complex
		Mixed Scirpus / Submerged Aquatics (<i>Egeria</i> - <i>Cabomba</i> - <i>Myriophyllum</i> spp.) complex
		Mixed Scirpus Mapping Unit
		Narrow-leaf Cattail (<i>Typha angustifolia</i>)
		<i>Scirpus acutus</i> - (<i>Typha latifolia</i>) - <i>Phragmites australis</i>
		<i>Scirpus acutus</i> - <i>Typha angustifolia</i>
		<i>Scirpus acutus</i> Pure
		<i>Scirpus acutus</i> - <i>Typha latifolia</i>
		<i>Scirpus californicus</i> - <i>Eichhornia crassipes</i>
		<i>Scirpus californicus</i> - <i>Scirpus acutus</i>
		<i>Scirpus</i> spp. in managed wetlands
		<i>Typha angustifolia</i> - <i>Distichlis spicata</i>
No GAP Level 3 analog	^{1, 3} Naturalized warm-temperate riparian and wetland group	Intermittently or temporarily flooded undifferentiated annual grasses and forbs
		Managed alkali wetland (<i>Crypsis</i>)
		Managed Annual Wetland Vegetation (Non-specific grasses & forbs)
		Perennial Pepperweed (<i>Lepidium latifolium</i>)
		<i>Polygonum amphibium</i>
		Seasonally Flooded Grasslands
		Seasonally flooded undifferentiated annual grasses and forbs
		Shallow flooding with minimal vegetation at time of photography
		Smartweed <i>Polygonum</i> spp. - Mixed Forbs
		Temporarily Flooded Grasslands
² California Central Valley Riparian	Southwestern North American introduced riparian scrub	Blackberry (<i>Rubus discolor</i>)
		Giant Cane (<i>Arundo donax</i>)

Appendix H (continued) GAP-Delta Vegetation mapping project vegetation crosswalk

GAP Level 3 Analog	Vegetation Group	Alliances
3California Central Valley Riparian	Southwestern North American riparian evergreen and deciduous woodland	Acer negundo- Salix gooddingii
		Black Willow (Salix gooddingii)
		Black Willow (Salix gooddingii) - Valley Oak (Quercus lobata) restoration
		Box Elder (Acer negundo)
		Fremont Cottonwood (Populus fremontii)
		Hinds walnut (Juglans hindsii)
		Intermittently or Temporarily Flooded Deciduous Shrublands
		Oregon Ash (Fraxinus latifolia)
		Quercus lobata - Acer negundo
		Quercus lobata - Alnus rhombifolia (Salix lasiolepis - Populus fremontii - Quercus agrifolia)
		Quercus lobata - Fraxinus latifolia
		Quercus lobata / Rosa californica (Rubus discolor - Salix lasiolepis / Carex spp.)
		Salix gooddingii - Populus fremontii - (Quercus lobata-Salix exigua-Rubus discolor)
		Salix gooddingii - Quercus lobata / Wetland Herbs
		Salix gooddingii / Rubus discolor
		Salix gooddingii / wetland herbs
		Shining Willow (Salix lucida)
		Temporarily or Seasonally Flooded - Deciduous Forests
Developed (Combines High- , Medium- and Low- Intensity Developed and Developed Open Space)	Developed/Urban	Urban Developed - Built Up
No GAP Level 3 analog	Vancouverian riparian deciduous forest	Alnus rhombifolia / Cornus sericea
		Alnus rhombifolia / Salix exigua (Rosa californica)
		White Alder (Alnus rhombifolia)
		White Alder (Alnus rhombifolia) - Arroyo willow (Salix lasiolepis) restoration
No GAP Level 3 analog	² Western dogwood thicket	California Dogwood (Cornus sericea)
		Cornus sericea - Salix exigua
		Cornus sericea - Salix lasiolepis / (Phragmites australis)

Appendix H (*continued*) GAP-Delta Vegetation mapping project vegetation crosswalk

GAP Level 3 Analog	Vegetation Group	Alliances
No GAP Level 3 analog	¹ Vernal pool basin	Vernal Pools
³ Open Water	³ Open water	Water
² California Central Valley Riparian	Southwestern North American riparian/wash scrub	Arroyo Willow (<i>Salix lasiolepis</i>)
		Baccharis pilularis / Annual Grasses & Herbs
		Buttonbush (<i>Cephalanthus occidentalis</i>)
		California Wild Rose (<i>Rosa californica</i>)
		Mexican Elderberry (<i>Sambucus mexicana</i>)
		Narrow-leaf Willow (<i>Salix exigua</i>)
		<i>Salix exigua</i> - (<i>Salix lasiolepis</i> - <i>Rubus discolor</i> - <i>Rosa californica</i>)
		<i>Salix lasiolepis</i> - (<i>Cornus sericea</i>) / <i>Scirpus</i> spp.- (<i>Phragmites australis</i> - <i>Typha</i> spp.) complex unit
		<i>Salix lasiolepis</i> - Mixed brambles (<i>Rosa californica</i> - <i>Vitis californica</i> - <i>Rubus discolor</i>)
³ Temperate Pacific Tidal Salt and Brackish Marsh	³ Southwestern North American salt basin and high marsh	Alkali Heath (<i>Frankenia salina</i>)
		Alkaline vegetation mapping unit
		<i>Allenrolfea occidentalis</i> mapping unit
		<i>Frankenia salina</i> - <i>Distichlis spicata</i>
		Pickleweed (<i>Salicornia virginica</i>)
		Salt scalds and associated sparse vegetation
		<i>Suaeda moquinii</i> - (<i>Lasthenia californica</i>) mapping unit
No GAP Level 3 analog	³ Temperate Pacific tidal salt and brackish meadow	California Hair-grass (<i>Deschampsia caespitosa</i>)
		<i>Deschampsia caespitosa</i> - <i>Lilaeopsis masonii</i>
		<i>Distichlis spicata</i> - Annual Grasses
		<i>Distichlis spicata</i> - <i>Juncus balticus</i>
		<i>Distichlis spicata</i> - <i>Salicornia virginica</i>
		<i>Salicornia virginica</i> - <i>Cotula coronopifolia</i>
		<i>Salicornia virginica</i> - <i>Distichlis spicata</i>
California Coastal Live Oak Woodland and Savanna	California broadleaf forest and woodland	Coast Live Oak (<i>Quercus agrifolia</i>)
California Central Valley Mixed Oak Savanna		Valley Oak (<i>Quercus lobata</i>)

Appendix H (*continued*) GAP-Delta Vegetation mapping project vegetation crosswalk

GAP Level 3 Analog	Vegetation Group	Alliances
No GAP Level 3 analog	^{1,3} California warm temperate marsh/seep	Creeping Wild Rye Grass (<i>Leymus triticoides</i>)
		Horsetail (<i>Equisetum</i> spp.)
		Intermittently Flooded Perennial Forbs
		<i>Juncus balticus</i> - meadow vegetation
		<i>Juncus bufonius</i> (salt grasses)
		<i>Lepidium latifolium</i> - <i>Salicornia virginica</i> - <i>Distichlis spicata</i>
		Santa Barbara Sedge (<i>Carex barbarae</i>) Stands
		Temporarily Flooded Perennial Forbs
		Valley Oak (<i>Quercus lobata</i>) restoration

¹Delta classes "California warm temperate marsh/seep", "Vernal pool basin", "Naturalized warm-temperate riparian and wetland group" allowed as analogs to GAP Level 3 "California Central Valley and Southern Coastal Grassland"

²Delta class "Western dogwood thicket" allowed as analogs to GAP Level 3 "California Central Valley Riparian"

³Delta classes "Western North American freshwater aquatic vegetation (macrogroup)", "Arid west freshwater emergent marsh", "Naturalized warm-temperate riparian and wetland group", "Southwestern North American salt basin and high marsh", "Temperate Pacific tidal salt and brackish meadow", "California warm temperate marsh/seep" and "Open water" allowed as analogs to GAP Level 3 "Temperate Pacific Freshwater Emergent Marsh", "Temperate Pacific Tidal Salt and Brackish Marsh", and "Open Water"

Appendix I Summary GAP Data for Delta Vegetation mapping area

Gap Levels 1-3 Land Cover Types	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Aquatic	52005.8	15.9	3274	7.2%	2.7%
Open water	52005.8	15.9	3274	7.2%	2.7%
Open Water (Fresh)	52005.8	15.9	3274	7.2%	2.7%
Forest and woodland systems	10.2	0.3	34	0.0%	0.0%
Conifer dominated forest and woodland (mesic-wet)	0.2	0.2	1	0.0%	0.0%
California Coastal Redwood Forest	0.2	0.2	1	0.0%	0.0%
Conifer dominated forest and woodland (xeric-mesic)	10.0	0.3	33	0.0%	0.0%
California Coastal Closed-Cone Conifer Forest and Woodland	10.0	0.3	33	0.0%	0.0%
Grassland systems	35051.3	2.1	16324	4.8%	13.5%
Sand prairie, coastal grasslands and lomas	35051.3	2.1	16324	4.8%	13.5%
California Central Valley and Southern Coastal Grassland	35051.3	2.1	16324	4.8%	13.5%
Human land use	521781.8	11.4	45810	71.9%	37.9%
Agriculture	443358.8	45.5	9747	61.1%	8.1%
Cultivated Cropland	443358.8	45.5	9747	61.1%	8.1%
Developed	78423.0	2.2	36063	10.8%	29.9%
Developed, High Intensity	6689.8	4.1	1618	0.9%	1.3%
Developed, Low Intensity	19804.2	1.5	12953	2.7%	10.7%
Developed, Medium Intensity	27016.5	4.3	6283	3.7%	5.2%
Developed, Open Space	24912.5	1.6	15209	3.4%	12.6%
Riparian and wetland systems	59535.3	1.4	41980	8.2%	34.7%
Floodplain and riparian	20635.7	0.9	23944	2.8%	19.8%
California Central Valley Riparian Woodland and Shrubland	20592.9	0.9	23827	2.8%	19.7%

Appendix I. (continued) Summary GAP Data for Delta Vegetation mapping area

Gap Levels 1-3 Land Cover Types	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Mediterranean California Foothill and Lower Montane Riparian Woodland	42.8	0.4	117	0.0%	0.1%
Freshwater herbaceous marsh, swamp, or baygall	33071.3	2.0	16219	4.6%	13.4%
Temperate Pacific Freshwater Emergent Marsh	33071.3	2.0	16219	4.6%	13.4%
Salt, brackish and estuary wetland	5828.3	3.2	1817	0.8%	1.5%
Temperate Pacific Tidal Salt and Brackish Marsh	5828.3	3.2	1817	0.8%	1.5%
Shrubland, steppe and savanna systems	2836.1	0.4	7775	0.4%	6.4%
Chaparral	75.4	0.3	276	0.0%	0.2%
Northern and Central California Dry-Mesic Chaparral	75.4	0.3	276	0.0%	0.2%
Deciduous dominated savanna and glade	2485.3	0.3	7188	0.3%	5.9%
California Central Valley Mixed Oak Savanna	333.2	0.3	1197	0.0%	1.0%
California Coastal Live Oak Woodland and Savanna	0.2	0.2	1	0.0%	0.0%
California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna	2151.9	0.4	5990	0.3%	5.0%
Scrub shrubland	275.4	0.9	311	0.0%	0.3%
Southern California Coastal Scrub	275.4	0.9	311	0.0%	0.3%
Sparse and barren systems	16.5	0.8	20	0.0%	0.0%
Beach, shore and sand	16.5	0.8	20	0.0%	0.0%
Mediterranean California Northern Coastal Dune	16.5	0.8	20	0.0%	0.0%
Not defined	54644.5	9.8	5592	7.5%	4.6%
Total/Overall	725881.4	6.0	120809	100.0%	100.0%

Appendix J Summary Data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
California Central Valley and Southern Coastal Grassland	65373.4	20.4	3202	9.01%	12.49%
Bromus diandrus - Bromus hordeaceus	914.4	13.6	67	0.13%	0.26%
California Annual Grasslands - Herbaceous	31600.8	33.5	944	4.35%	3.68%
Italian Rye-grass (<i>Lolium multiflorum</i>)	5267.4	16.5	319	0.73%	1.24%
<i>Lolium multiflorum</i> - <i>Convolvulus arvensis</i>	35.9	7.2	5	0.00%	0.02%
Poison Hemlock (<i>Conium maculatum</i>)	765.6	5.9	129	0.11%	0.50%
Rabbitsfoot grass (<i>Polypogon maritimus</i>)	732.1	15.3	48	0.10%	0.19%
Ruderal Herbaceous Grasses & Forbs	25849.1	16.5	1567	3.56%	6.11%
Tall & Medium Upland Grasses	0.6	0.6	1	0.00%	0.00%
Vernal Pools	207.6	1.7	122	0.03%	0.48%
California Central Valley Riparian Woodland and Shrubland	15822.8	2.4	6548	2.18%	25.54%
<i>Acer negundo</i> - <i>Salix gooddingii</i>	34.6	3.1	11	0.00%	0.04%
<i>Alnus rhombifolia</i> / <i>Cornus sericea</i>	32.1	1.6	20	0.00%	0.08%
<i>Alnus rhombifolia</i> / <i>Salix exigua</i> (<i>Rosa californica</i>)	419.7	1.6	260	0.06%	1.01%
Arroyo Willow (<i>Salix lasiolepis</i>)	465.6	1.8	266	0.06%	1.04%
Black Willow (<i>Salix gooddingii</i>)	650.2	2.0	330	0.09%	1.29%
Black Willow (<i>Salix gooddingii</i>) - Valley Oak (<i>Quercus lobata</i>) restoration	93.3	6.2	15	0.01%	0.06%
Blackberry (<i>Rubus discolor</i>)	1204.5	1.9	620	0.17%	2.42%
Box Elder (<i>Acer negundo</i>)	45.2	1.6	29	0.01%	0.11%
Buttonbush (<i>Cephalanthus occidentalis</i>)	8.4	0.9	9	0.00%	0.04%
California Dogwood (<i>Cornus sericea</i>)	116.9	1.5	78	0.02%	0.30%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
California Wild Rose (<i>Rosa californica</i>)	98.3	1.8	54	0.01%	0.21%
<i>Cornus sericea</i> - <i>Salix exigua</i>	122.3	1.9	64	0.02%	0.25%
<i>Cornus sericea</i> - <i>Salix lasiolepis</i> / (<i>Phragmites australis</i>)	823.4	3.3	249	0.11%	0.97%
Fremont Cottonwood (<i>Populus fremontii</i>)	648.4	2.2	296	0.09%	1.15%
Hinds walnut (<i>Juglans hindsii</i>)	20.8	2.3	9	0.00%	0.04%
Intermittently or Temporarily Flooded Deciduous Shrublands	536.3	2.2	245	0.07%	0.96%
Mexican Elderberry (<i>Sambucus mexicana</i>)	17.3	2.5	7	0.00%	0.03%
Narrow-leaf Willow (<i>Salix exigua</i>)	296.3	1.1	264	0.04%	1.03%
Oregon Ash (<i>Fraxinus latifolia</i>)	1.3	0.6	2	0.00%	0.01%
<i>Quercus lobata</i> - <i>Acer negundo</i>	67.9	3.1	22	0.01%	0.09%
<i>Quercus lobata</i> - <i>Alnus rhombifolia</i> (<i>Salix lasiolepis</i> - <i>Populus fremontii</i> - <i>Quercus agrifolia</i>)	369.4	2.7	136	0.05%	0.53%
<i>Quercus lobata</i> - <i>Fraxinus latifolia</i>	316.9	9.1	35	0.04%	0.14%
<i>Quercus lobata</i> / <i>Rosa californica</i> (<i>Rubus discolor</i> - <i>Salix</i> <i>lasiolepis</i> / <i>Carex</i> spp.)	818.3	3.9	212	0.11%	0.83%
<i>Salix exigua</i> - (<i>Salix lasiolepis</i> - <i>Rubus discolor</i> - <i>Rosa</i> <i>californica</i>)	1092.4	1.6	674	0.15%	2.63%
<i>Salix gooddingii</i> - <i>Populus fremontii</i> - (<i>Quercus lobata</i> - <i>Salix exigua</i> - <i>Rubus discolor</i>)	1764.9	3.4	522	0.24%	2.04%
<i>Salix gooddingii</i> - <i>Quercus lobata</i> / Wetland Herbs	432.7	4.2	103	0.06%	0.40%
<i>Salix gooddingii</i> / <i>Rubus discolor</i>	143.2	2.8	51	0.02%	0.20%
<i>Salix gooddingii</i> / wetland herbs	651.4	2.5	259	0.09%	1.01%
<i>Salix lasiolepis</i> - (<i>Cornus sericea</i>) / <i>Scirpus</i> spp. - (<i>Phragmites australis</i> - <i>Typha</i> spp.) complex unit	493.4	1.9	263	0.07%	1.03%
<i>Salix lasiolepis</i> - Mixed brambles (<i>Rosa californica</i> - <i>Vitis californica</i> - <i>Rubus discolor</i>)	1538.0	2.4	654	0.21%	2.55%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Shining Willow (<i>Salix lucida</i>)	78.5	11.2	7	0.01%	0.03%
Temporarily or Seasonally Flooded - Deciduous Forests	140.3	2.9	48	0.02%	0.19%
Valley Oak (<i>Quercus lobata</i>)	2027.0	3.4	592	0.28%	2.31%
Valley Oak (<i>Quercus lobata</i>) restoration	95.7	3.5	27	0.01%	0.11%
White Alder (<i>Alnus rhombifolia</i>)	149.9	1.3	113	0.02%	0.44%
White Alder (<i>Alnus rhombifolia</i>) - Arroyo willow (<i>Salix lasiolepis</i>) restoration	7.9	4.0	2	0.00%	0.01%
California Coastal Live Oak Woodland and Savanna	83.5	2.3	37	0.01%	0.14%
Coast Live Oak (<i>Quercus agrifolia</i>)	83.5	2.3	37	0.01%	0.14%
GAP Level 3: No analog	100.5	2.7	37	0.01%	0.14%
Unknown	100.5	2.7	37	0.01%	0.14%
GAP Level 3: No analog; - Agriculture (Gap Level 2)	474154.9	400.5	1184	65.32%	4.62%
Agriculture	474154.9	400.5	1184	65.32%	4.62%
GAP Level 3: No analog - Scrub shrubland (GAP Level 2)	359.3	3.5	104	0.05%	0.41%
Alkaline vegetation mapping unit	28.1	7.0	4	0.00%	0.02%
<i>Allenrolfea occidentalis</i> mapping unit	260.6	5.4	48	0.04%	0.19%
<i>Suaeda moquinii</i> - (<i>Lasthenia californica</i>) mapping unit	70.6	1.4	52	0.01%	0.20%
GAP Level 3: No analog - Bare Gravel and Sand	8314.6	8.7	953	1.15%	3.72%
Levee Rock Riprap	792.9	2.5	314	0.11%	1.22%
Salt scalds and associated sparse vegetation	65.7	0.9	73	0.01%	0.28%
Sparsely or Unvegetated Areas; Abandoned orchards	7428.1	13.8	538	1.02%	2.10%
Tidal mudflats	27.9	1.0	28	0.00%	0.11%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
GAP Level 3: No analog - Introduced Vegetation	5943.5	3.5	1697	0.82%	6.62%
<i>Acacia - Robinia</i>	85.9	1.3	64	0.01%	0.25%
<i>Eucalyptus</i>	187.8	2.7	70	0.03%	0.27%
Exotic Vegetation Stands	5663.6	3.6	1555	0.78%	6.07%
Tobacco brush (<i>Nicotiana glauca</i>) mapping unit	1.8	1.8	1	0.00%	0.00%
Tree-of-Heaven (<i>Ailanthus altissima</i>)	4.3	0.6	7	0.00%	0.03%
GAP Level 3: No analog: Site Dependant	30.9	3.1	10	0.00%	0.04%
Restoration Sites	30.9	3.1	10	0.00%	0.04%
GAP Level 3: No analog – Developed (GAP Level 2)	62243.4	15.9	3905	8.57%	15.23%
Urban Developed - Built Up	62243.4	15.9	3905	8.57%	15.23%
Open Water (Fresh)	60691.2	68.3	888	8.36%	3.46%
Water	60691.2	68.3	888	8.36%	3.46%
Southern California Coastal Scrub	80.0	2.6	31	0.01%	0.12%
<i>Baccharis pilularis</i> / Annual Grasses & Herbs	52.1	2.4	22	0.01%	0.09%
Coyotebush (<i>Baccharis pilularis</i>)	27.6	3.5	8	0.00%	0.03%
Microphyllous Shrubland	0.3	0.3	1	0.00%	0.00%
Temperate Pacific Freshwater Emergent Marsh	22900.3	3.7	6137	3.15%	23.94%
Algae	398.1	2.4	163	0.05%	0.64%
Brazilian Waterweed (<i>Egeria - Myriophyllum</i>) Submerged	3004.9	3.7	807	0.41%	3.15%
Broad-leaf Cattail (<i>Typha latifolia</i>)	363.5	2.4	152	0.05%	0.59%
California Bulrush (<i>Scirpus californicus</i>)	419.6	1.7	252	0.06%	0.98%
Common Reed (<i>Phragmites australis</i>)	371.9	1.5	244	0.05%	0.95%
Creeping Wild Rye Grass (<i>Leymus triticoides</i>)	2.6	1.3	2	0.00%	0.01%
Floating Primrose (<i>Ludwigia peploides</i>)	185.8	1.3	148	0.03%	0.58%
Generic Floating Aquatics	454.7	1.5	309	0.06%	1.21%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
Giant Cane (<i>Arundo donax</i>)	61.3	0.6	96	0.01%	0.37%
Hard-stem Bulrush (<i>Scirpus acutus</i>)	186.5	3.0	62	0.03%	0.24%
Horsetail (<i>Equisetum</i> spp.)	83.1	5.9	14	0.01%	0.05%
<i>Hydrocotyle ranunculoides</i>	7.3	0.7	10	0.00%	0.04%
Intermittently Flooded Perennial Forbs	19.4	4.9	4	0.00%	0.02%
Intermittently or temporarily flooded undifferentiated annual grasses and forbs	3605.4	14.8	243	0.50%	0.95%
<i>Ludwigia peploides</i>	86.5	1.4	64	0.01%	0.25%
Managed Annual Wetland Vegetation (Non- specific grasses & forbs)	603.2	10.6	57	0.08%	0.22%
Milfoil - Waterweed (generic submerged aquatics)	71.0	2.7	26	0.01%	0.10%
Mixed Scirpus / Floating Aquatics (<i>Hydrocotyle</i> - <i>Eichhornia</i>) Complex	345.4	1.4	241	0.05%	0.94%
Mixed Scirpus / Submerged Aquatics (<i>Egeria</i> - <i>Cabomba</i> - <i>Myriophyllum</i> spp.) complex	420.2	1.4	309	0.06%	1.21%
Mixed Scirpus Mapping Unit	433.4	1.9	226	0.06%	0.88%
Pampas Grass (<i>Cortaderia selloana</i> - <i>C. jubata</i>)	18.6	1.4	13	0.00%	0.05%
<i>Polygonum amphibium</i>	267.3	3.1	87	0.04%	0.34%
Pondweed (<i>Potamogeton</i> sp.)	5.2	0.6	8	0.00%	0.03%
Santa Barbara Sedge (<i>Carex barbarae</i>) Stands	15.1	3.0	5	0.00%	0.02%
<i>Scirpus acutus</i> - (<i>Typha latifolia</i>) - <i>Phragmites australis</i>	1704.2	3.1	549	0.23%	2.14%
<i>Scirpus acutus</i> - <i>Typha angustifolia</i>	907.6	4.6	197	0.13%	0.77%
<i>Scirpus acutus</i> Pure	1481.2	2.1	711	0.20%	2.77%
<i>Scirpus acutus</i> - <i>Typha latifolia</i>	2552.2	5.0	515	0.35%	2.01%
<i>Scirpus californicus</i> - <i>Eichhornia crassipes</i>	13.9	1.7	8	0.00%	0.03%
<i>Scirpus californicus</i> - <i>Scirpus acutus</i>	676.1	3.3	203	0.09%	0.79%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
<i>Scirpus</i> spp. in managed wetlands	2426.7	28.5	85	0.33%	0.33%
Seasonally Flooded Grasslands	49.7	1.6	31	0.01%	0.12%
Seasonally flooded undifferentiated annual grasses and forbs	811.9	5.8	141	0.11%	0.55%
Shallow flooding with minimal vegetation at time of photography	370.2	5.6	66	0.05%	0.26%
Smartweed <i>Polygonum</i> spp. - Mixed Forbs	58.9	3.7	16	0.01%	0.06%
Temporarily Flooded Grasslands	7.6	1.1	7	0.00%	0.03%
Temporarily Flooded Perennial Forbs	185.9	93.0	2	0.03%	0.01%
Water Hyacinth (<i>Eichhornia crassipes</i>)	224.2	3.5	64	0.03%	0.25%
Temperate Pacific Tidal Salt and Brackish Marsh	9783.1	10.8	905	1.35%	3.53%
Alkali Heath (<i>Frankenia salina</i>)	2.4	0.6	4	0.00%	0.02%
American Bulrush (<i>Scirpus americanus</i>)	15.3	2.6	6	0.00%	0.02%
California Hair-grass (<i>Deschampsia caespitosa</i>)	1.2	0.6	2	0.00%	0.01%
<i>Deschampsia caespitosa</i> - <i>Lilaeopsis masonii</i>	0.5	0.3	2	0.00%	0.01%
<i>Distichlis spicata</i> - Annual Grasses	4730.3	28.7	165	0.65%	0.64%
<i>Distichlis spicata</i> - <i>Juncus balticus</i>	29.6	4.2	7	0.00%	0.03%
<i>Distichlis spicata</i> - <i>Salicornia virginica</i>	20.3	10.1	2	0.00%	0.01%
<i>Frankenia salina</i> - <i>Distichlis spicata</i>	24.2	2.0	12	0.00%	0.05%
<i>Juncus balticus</i> - meadow vegetation	45.4	2.4	19	0.01%	0.07%
<i>Juncus bufonius</i> (salt grasses)	6.5	3.2	2	0.00%	0.01%
<i>Lepidium latifolium</i> - <i>Salicornia virginica</i> - <i>Distichlis spicata</i>	54.2	2.4	23	0.01%	0.09%
Managed alkali wetland (<i>Crypsis</i>)	2918.4	16.0	182	0.40%	0.71%
Narrow-leaf Cattail (<i>Typha angustifolia</i>)	97.2	1.9	50	0.01%	0.20%
Perennial Pepperweed (<i>Lepidium latifolium</i>)	1671.8	4.6	360	0.23%	1.40%
Pickleweed (<i>Salicornia virginica</i>)	14.8	1.0	15	0.00%	0.06%

Appendix J (continued) Summary data for Delta Mapping project

VegCAMP Delta Vegetation Types (grouped by GAP Level 3 Analog)	Total Acres	Average Acreage	Count of Polygons	% of Total Acreage	% Frequency of Occurrence
<i>Salicornia virginica</i> - <i>Cotula coronopifolia</i>	2.5	1.3	2	0.00%	0.01%
<i>Salicornia virginica</i> - <i>Distichlis spicata</i>	5.0	2.5	2	0.00%	0.01%
Saltgrass (<i>Distichlis spicata</i>)	140.4	2.9	49	0.02%	0.19%
<i>Typha angustifolia</i> - <i>Distichlis spicata</i>	3.0	3.0	1	0.00%	0.00%
Total	725881.4		25638	100.00%	100.00%