



**SACRAMENTO RIVER VEGETATION MAP:  
CROSS-WALK COMPARISON AND  
CALIBRATION BETWEEN MAPS CREATED IN  
1999 AND 2007**

**ERP P0620021 PROJECT REPORT**

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**Keywords:** riparian, vegetation map, Sacramento River, cross-walk

## 1.0 Purpose

The purpose of this report is to describe the Sacramento River Vegetation Map cross-walk process, with an aim to provide a comparison between maps produced in 1999 and 2007 by the CSU Chico Geographic Information Center (GIC) using nominal comparative statistics.

## 2.0 Introduction

A central aim of CALFED and the Sacramento River Monitoring and Assessment Project is to better understand landscape and riverscape change, particularly in areas undergoing land conversion and/or restoration. One methodology to accomplish this goal is map comparison; in effect, a comparison can be made between two maps of the same area, detailing the same subject, their areal extent, as well as their classification. Foremost the extent, resolution, and methodology of the two map products need to be similar, if not the same, to conduct a comparative change analysis such as the one described here.

Using two maps from 1999 and 2007 of riparian vegetation created by GIC, the project is interested in change between these two time periods to be summarized as the area changed from one type to another. To better understand the utility of such an analysis, its robustness, and potential quantification, we have described here the relationship between the two map products using a geospatial approach. The extent of the Sacramento River area mapped by GIC remained roughly the same -- Red Bluff to Colusa -- however codification of vegetation was purposefully altered to better align named vegetation types with those recognized by the California Department of Fish & Game, among many statewide organizations. Thus, while the methodology -- head's up digitizing within a GIS using backdrops of orthorectified aerial imagery -- remained the same, the vegetation classification used to describe the riverscape changed.

Therefore, we examined here a cross-walk between the vegetation classifications to enumerate the relationship between the two map products and provide some statistical confidence on their spatial coincidence.

## 3.0 Methods

To better understand the relationship between two map products, produced in different years with ostensibly similar methods, we compared the 1999 and 2007 versions of the Sacramento River Vegetation Map (as created by CSU Chico GIC) through an iterative random sampling procedure. Our intent was to achieve 90% stasis between map classes by adjusting classes not in agreement after successive random samples. We first created 10,000 random points using Hawth's random point generator<sup>1</sup> within the extent of mapped polygons. This initial random sample was attributed with the vegetation classification from both years (1999 and

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<sup>1</sup> <http://www.spatial ecology.com/htools/rndpnts.php>

2007) using Hawth’s intersect point tool<sup>2</sup> . After running contingency analyses in JMP IN 7 (SAS Institute Cary, NC), we determined that the initial seed of 10,000 points was insufficient to guide successive cross-walking. We repeated these steps but with a 50,000 point sample, but again the contingency analysis were unsatisfactory (< 50% stasis for vegetation classes). We then developed a stratified random point density approach wherein we used the frequency of polygons and their total area to determine an appropriate number of points per vegetation class polygon. In effect, smaller polygons were undersampled in the unstratified method. In total, we created 1,149,800 point locations randomly placed throughout the intersection of the two maps. It is from this large sample size that we derive our results.

## 4.0 Results

A cross-walk table that describes the basic relationship between 1999 map vegetation classes and 2007 map vegetation classes was created to define the differences between the mapping efforts of the two years (table 1). Using this table, we can report that six classes: BS, CW, GR, GB, OW, and VO had the same vegetation description in both 1999 and 2007. The majority of vegetation classes created in 2007, including BW, CS, BE, MW, GW, CA, PG, BC, FL, and LP, were created by the division of vegetation types used in the 1999 map. A total of three classes (D, MF, and TAM) were omitted from the 2007 map.

Table 1. Initial description of the relationship between the 1999 and 2007 maps

| 1999  |      | 2007 |                       |
|---|------|------|-----------------------|
| Category  | Code | Code | Category              |
| Berry Scrub*                                    | BS   | BS   | Blackberry Scrub      |
| Disturbed <sup>-</sup>                          | D    |      |                       |
| Giant Reed*                                     | GR   | GR   | Giant Reed            |
| Gravel and Sand Bars*                           | G    | GB   | Gravel Bar            |
| Great Valley Cottonwood Riparian Forest*        | CF   | CW   | Fremont Cottonwood    |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | BW   | CA Walnut             |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   |      |                       |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | CS   | CA Sycamore           |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | BE   | Box Elder             |
| Great Valley Riparian Scrub <sup>o</sup>        | RS   | MW   | Mixed Willow          |
| Great Valley Riparian Scrub <sup>o</sup>        | RS   | RS   | Riparian Scrub        |
| Great Valley Riparian Scrub <sup>o</sup>        | RS   | GW   | Goodding's Willow     |
| Herbland Cover <sup>o</sup>                     | HL   | CA   | CA Annuals            |
| Herbland Cover <sup>o</sup>                     | HL   | PG   | Introduced Perennials |

<sup>2</sup> <http://www.spatial ecology.com/htools/isect.php>

|  |     |    |                    |
|--|-----|----|--------------------|
| Open Water*                                    | OW  | OW | Open Water         |
| Tamarisk <sup>-</sup>                          | TAM |    |                    |
| Valley Freshwater Marsh <sup>°</sup>           | M   | BC | Bulrush/Cattail    |
| Valley Freshwater Marsh <sup>°</sup>           | M   | FL | Floating Leaf      |
| Valley Freshwater Marsh <sup>°</sup>           | M   | LP | Ludwigia peploides |
| Valley Oak*                                    | VO  | VO | Valley Oak         |
| *No Change<br>°Divided<br><sup>-</sup> Deleted |     |    |                    |

Although our stratified random sampling approach resulted in both high density and robust number of samples, the overall association between map classifications was statistically marginal with an overall accuracy rate of 39% between the two mapping efforts (See Appendix). We expect divergence, precisely because of landscape change in the intervening period of time; however there is clear class confusion between the two data sets. We show the relationship between non-field-validated 2007 classes to non-field-validated 1999 classes below to elucidate our statistical findings based on the perspective of what the relationship should be descriptively.

Table 2. Association between the 1999 and 2007 maps showing percent stasis in one-to-one and one-to-many relationships.

| 1999  |      | 2007 |                       | % 2007 in 1999 |
|---|------|------|-----------------------|----------------|
| Category  | Code | Code | Category              |                |
| Berry Scrub*                                    | BS   | BS   | Blackberry Scrub      | 7%             |
| Great Valley Cottonwood Riparian Forest*        | CF   | CW   | Fremont Cottonwood    | 26%            |
| Great Valley Cottonwood Riparian Forest*        | CF   | BE   | Box Elder             | 18%            |
| Great Valley Cottonwood Riparian Forest*        | CF   | BW   | CA Walnut             | 21%            |
| Gravel and Sand Bars*                           | G    | GB   | Gravel Bar            | 48%            |
| Herbland Cover <sup>°</sup>                     | HL   | CA   | CA Annuals            | 32%            |
| Herbland Cover <sup>°</sup>                     | HL   | PG   | Introduced Perennials | 4%             |
| Valley Freshwater Marsh <sup>°</sup>            | M    | BC   | Bulrush/Cattail       | 27%            |
| Valley Freshwater Marsh <sup>°</sup>            | M    | FL   | Floating Leaf         | 20%            |
| Valley Freshwater Marsh <sup>°</sup>            | M    | LP   | Ludwigia peploides    | 18%            |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | BW   | CA Walnut             | 58%            |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | CS   | CA Sycamore           | 73%            |
| Great Valley Mixed Riparian Forest <sup>-</sup> | MF   | BE   | Box Elder             | 50%            |
| Great Valley Riparian Scrub <sup>°</sup>        | RS   | MW   | Mixed Willow          | 27%            |
| Great Valley Riparian Scrub <sup>°</sup>        | RS   | RS   | Riparian Scrub        | 18%            |
| Great Valley Riparian Scrub <sup>°</sup>        | RS   | GW   | Goodding's Willow     | 27%            |
| Valley Oak*                                     | VO   | VO   | Valley Oak            | 6%             |

|            |  |  |  |  |
|------------|--|--|--|--|
| *No Change |  |  |  |  |
| *Divided   |  |  |  |  |
| *Deleted   |  |  |  |  |

## 5.0 Discussion

In general, the relationships were generally as one would expect; however, there are some causes for concern for any direct comparison between map classes. These concerns are addressed here.

Cottonwood: Some 50% of the points which occurred in Cottonwood in 1999 remained cottonwood in 2007. However, of the points considered cottonwood in 2007, only 26% were considered cottonwood in 1999, with the majority (49%) occurring in mixed forest. There exist some improbable transitions, such as cottonwood to cattail (9%), that might be supported by avulsion and channel abandonment, but without individual examination it is difficult to determine its veracity.

Valley Oak: Some 77% of points considered valley oak in 1999 remained so in 2007, which is reassuring. However, for valley oak in the 2007 map, 62% of the random points were considered mixed forest in 1999, indicating a possible underestimate in 1999. Other former classes include 'disturbed' and 'berry scrub', which seem unlikely from an ecological succession perspective.

Giant Reed (*Arundo donax*): Although this vegetation class was identified in both time periods, ostensibly for the purposes of tracking invasion, there is substantial confusion between these classes across time. In effect only 8% of giant reed remained giant reed between the two time periods. While it is possible that growing vegetation has obscured its identification, such as giant reed becoming cottonwood (25%), there are associations that are unlikely, such as giant reed becoming an annual grass (11%).

On the other hand, there are some class comparisons that do support successional trends -- transitions that we might expect in a dynamic riverscape setting over a period of time. These include open water to introduced perennials (62%) and gravel bar (41%), and gravel bar to mixed willow (32%) and Gooding's willow (27%).

## 6.0 Conclusions

We conclude that while the statistical association does not show a robust relationship between classes found in the 1999 and 2007 riparian map, the prescribed relationships found in Table 1 are generally borne out in sampling frequency (Appendix). We especially recommend caution when evaluating change between the Great Valley Cottonwood Riparian Forest and Great Valley Mixed Riparian Forest found in the 1999 map to aggregated association from 2007, as well as direct comparisons in scrub/willow types and valley oak. In principle, all forested types could be lumped to evaluate change in forest cover with high confidence. Furthermore, we feel that successional trend evaluation, such as water to gravel to willow scrub to forest is plausible and well supported by the statistical association.

## 7.0 Appendix

Table A1. Contingency analysis comparison of GIC mapped areas in 1999 and 2007

### Contingency Table

GIC 2007 By GIC 1999

| Count      | BS                   | CF                      | D                     | G                       | GR                    | HL                      | M                      | MF                       | OW                       | RS                      | VO                    | Total 2007 |
|------------|----------------------|-------------------------|-----------------------|-------------------------|-----------------------|-------------------------|------------------------|--------------------------|--------------------------|-------------------------|-----------------------|------------|
| Col %      |                      |                         |                       |                         |                       |                         |                        |                          |                          |                         |                       |            |
| Row %      |                      |                         |                       |                         |                       |                         |                        |                          |                          |                         |                       |            |
| BC         | 0<br>0<br>0          | 76<br>0.06<br>8.91      | 8<br>0.04<br>0.94     | 2<br>0<br>0.23          | 0<br>0<br>0           | 13<br>0.02<br>1.52      | 226<br>0.61<br>26.49   | 8<br>0<br>0.94           | 495<br>0.18<br>58.03     | 25<br>0.02<br>2.93      | 0<br>0<br>0           | 853        |
| BE         | 92<br>2.04<br>0.33   | 4900<br>3.55<br>17.69   | 331<br>1.8<br>1.19    | 368<br>0.28<br>1.33     | 115<br>2.41<br>0.42   | 2215<br>2.6<br>8        | 223<br>0.6<br>0.8      | 13825<br>4.15<br>49.9    | 949<br>0.34<br>3.43      | 4686<br>4.28<br>16.91   | 0<br>0<br>0           | 27704      |
| BS         | 760<br>16.86<br>6.61 | 882<br>0.64<br>7.67     | 34<br>0.18<br>0.3     | 93<br>0.07<br>0.81      | 45<br>0.94<br>0.39    | 460<br>0.54<br>4        | 1172<br>3.18<br>10.19  | 4519<br>1.36<br>39.3     | 811<br>0.29<br>7.05      | 2628<br>2.4<br>22.85    | 96<br>1.19<br>0.83    | 11500      |
| BW         | 287<br>6.37<br>0.35  | 17477<br>12.66<br>21.1  | 708<br>3.85<br>0.85   | 1665<br>1.27<br>2.01    | 380<br>7.95<br>0.46   | 4414<br>5.19<br>5.33    | 518<br>1.41<br>0.63    | 47627<br>14.29<br>57.51  | 1410<br>0.5<br>1.7       | 8072<br>7.38<br>9.75    | 263<br>3.26<br>0.32   | 82821      |
| CA         | 239<br>5.3<br>0.18   | 6955<br>5.04<br>5.26    | 3935<br>21.38<br>2.98 | 42542<br>32.54<br>32.19 | 526<br>11.01<br>0.4   | 42322<br>49.77<br>32.02 | 1561<br>4.23<br>1.18   | 7114<br>2.13<br>5.38     | 12246<br>4.36<br>9.26    | 14138<br>12.93<br>10.7  | 599<br>7.43<br>0.45   | 132177     |
| CS         | 27<br>0.6<br>0.62    | 441<br>0.32<br>10.07    | 198<br>1.08<br>4.52   | 19<br>0.01<br>0.43      | 0<br>0<br>0           | 157<br>0.18<br>3.58     | 31<br>0.08<br>0.71     | 3202<br>0.96<br>73.11    | 50<br>0.02<br>1.14       | 203<br>0.19<br>4.63     | 52<br>0.64<br>1.19    | 4380       |
| CW         | 852<br>18.9<br>0.32  | 68552<br>49.66<br>25.68 | 8428<br>45.78<br>3.16 | 11991<br>9.17<br>4.49   | 1170<br>24.49<br>0.44 | 11601<br>13.64<br>4.35  | 1387<br>3.76<br>0.52   | 129489<br>38.84<br>48.51 | 5027<br>1.79<br>1.88     | 27982<br>25.59<br>10.48 | 446<br>5.53<br>0.17   | 266925     |
| FL         | 0<br>0<br>0          | 134<br>0.1<br>5.51      | 0<br>0<br>0           | 102<br>0.08<br>4.2      | 0<br>0<br>0           | 22<br>0.03<br>0.9       | 482<br>1.31<br>19.83   | 256<br>0.08<br>10.53     | 1332<br>0.47<br>54.79    | 103<br>0.09<br>4.24     | 0<br>0<br>0           | 2431       |
| GB         | 0<br>0<br>0          | 1099<br>0.8<br>1.71     | 146<br>0.79<br>0.23   | 31197<br>23.86<br>48.54 | 247<br>5.17<br>0.38   | 2151<br>2.53<br>3.35    | 78<br>0.21<br>0.12     | 1586<br>0.48<br>2.47     | 26100<br>9.3<br>40.61    | 1653<br>1.51<br>2.57    | 11<br>0.14<br>0.02    | 64268      |
| GR         | 10<br>0.22<br>0.2    | 737<br>0.53<br>14.6     | 6<br>0.03<br>0.12     | 1118<br>0.86<br>22.15   | 416<br>8.71<br>8.24   | 381<br>0.45<br>7.55     | 14<br>0.04<br>0.28     | 710<br>0.21<br>14.06     | 312<br>0.11<br>6.18      | 1344<br>1.23<br>26.62   | 0<br>0<br>0           | 5048       |
| GW         | 0<br>0<br>0          | 473<br>0.34<br>16.63    | 0<br>0<br>0           | 772<br>0.59<br>27.14    | 0<br>0<br>0           | 98<br>0.12<br>3.44      | 0<br>0<br>0            | 387<br>0.12<br>13.6      | 347<br>0.12<br>12.2      | 768<br>0.7<br>26.99     | 0<br>0<br>0           | 2845       |
| LP         | 27<br>0.6<br>0.19    | 97<br>0.07<br>0.7       | 70<br>0.38<br>0.5     | 287<br>0.22<br>2.06     | 4<br>0.08<br>0.03     | 448<br>0.53<br>3.21     | 2546<br>6.91<br>18.27  | 750<br>0.22<br>5.38      | 9307<br>3.32<br>66.77    | 403<br>0.37<br>2.89     | 0<br>0<br>0           | 13939      |
| MW         | 22<br>0.49<br>0.03   | 7125<br>5.16<br>10.76   | 97<br>0.53<br>0.15    | 21072<br>16.12<br>31.83 | 305<br>6.38<br>0.46   | 4260<br>5.01<br>6.43    | 979<br>2.66<br>1.48    | 5312<br>1.59<br>8.02     | 9213<br>3.28<br>13.92    | 17819<br>16.29<br>26.92 | 0<br>0<br>0           | 66204      |
| OW         | 614<br>13.62<br>0.22 | 6324<br>4.58<br>2.3     | 829<br>4.5<br>0.3     | 11597<br>8.87<br>4.22   | 244<br>5.11<br>0.09   | 5570<br>6.55<br>2.03    | 23687<br>64.26<br>8.62 | 20864<br>6.26<br>7.6     | 197390<br>70.34<br>71.87 | 7525<br>6.88<br>2.74    | 8<br>0.1<br>0         | 274652     |
| PG         | 53<br>1.18<br>0.5    | 371<br>0.27<br>3.47     | 57<br>0.31<br>0.53    | 1186<br>0.91<br>11.1    | 20<br>0.42<br>0.19    | 382<br>0.45<br>3.57     | 979<br>2.66<br>9.16    | 338<br>0.1<br>3.16       | 6645<br>2.37<br>62.18    | 651<br>0.6<br>6.09      | 5<br>0.06<br>0.05     | 10687      |
| RS         | 856<br>18.99<br>1.09 | 10925<br>7.91<br>13.94  | 599<br>3.25<br>0.76   | 5987<br>4.58<br>7.64    | 991<br>20.75<br>1.26  | 4365<br>5.13<br>5.57    | 1814<br>4.92<br>2.31   | 32376<br>9.71<br>41.3    | 5983<br>2.13<br>7.63     | 14101<br>12.89<br>17.99 | 398<br>4.94<br>0.51   | 78395      |
| VO         | 669<br>14.84<br>0.64 | 11475<br>8.31<br>10.93  | 2963<br>16.1<br>2.82  | 727<br>0.56<br>0.69     | 314<br>6.57<br>0.3    | 6179<br>7.27<br>5.89    | 1164<br>3.16<br>1.11   | 65025<br>19.5<br>61.95   | 3007<br>1.07<br>2.86     | 7262<br>6.64<br>6.92    | 6186<br>76.71<br>5.89 | 104971     |
| Total 1999 | 4508                 | 138043                  | 18409                 | 130725                  | 4777                  | 85038                   | 36861                  | 333388                   | 280624                   | 109363                  | 8064                  | 1149800    |
| Tests      | <b>N</b>             | <b>DF</b>               | <b>-LogLike</b>       | <b>RSquare (U)</b>      |                       | Likelihood Ratio        | Pearson                |                          |                          |                         | Matched               | 447801     |
|            | 1149800              | 160                     | 548643.32             | 0.2542                  | <b>ChiSquare</b>      | 1097287                 | 1212030                |                          |                          |                         | Percent               | 38.94599   |
|            |                      |                         |                       |                         | <b>Prob&gt;ChiSq</b>  | 0                       | 0                      |                          |                          |                         |                       |            |