# APPENDIX G

## Terrestrial Resources Monitoring Reports

**This Appendix Includes:**

- 2012 Annual Migration Report for the M&T Chico Ranch/Llano Seco Rancho Pumping Plant Temporary Maintenance Project Grassland Restoration and Bank Swallow Conservation Easement Mitigation Monitoring at Sacramento River National Wildlife Refuge, Rio Vista and Capay Unit
- 2011 M&T/Llano Seco Pumping Plant Riparian Vegetation Mitigation Monitoring Report
- 2010-2011 Bank Swallow Status Report
- Status of Yellow-billed Cuckoo Along the Sacramento River in 2010

# ANNUAL MITIGATION REPORT FOR THE M&T CHICO RANCH/LLANO SECO RANCO PUMPING PLANT TEMPORARY MAINTENANCE PROJECT

# GRASSLAND RESTORATION AND BANK SWALLOW CONSERVATION EASEMENT MITIGATION MONITORING AT SACRAMENTO RIVER NATIONAL WILDLIFE REFUGE, RIO VISTA UNIT AND CAPAY UNIT

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## INTRODUCTION

The M&T Ranch/Llano Seco Rancho Pumping Plant Temporary Maintenance Project resulted in impacts to riparian vegetation, including native grasslands and a Bank Swallow colony. The mitigation plan specified riparian vegetation restoration and monitoring and establishment of a Bank Swallow colony conservation easement as part of the requirements for this project in the October 2007 Mitigation Plan (Appendix E– Mitigation Monitoring Report Plan; Appendix F–Riparian Vegetation and Native Grassland Mitigation Plan; Appendix G– Bank Swallow Mitigation Plan). Sacramento National Wildlife Refuge Complex is responsible for native grassland restoration mitigation at the Rio Vista Unit and Capay Unit of Sacramento River National Wildlife Refuge (Refuge). These responsibilities included restoration implementation, maintenance, and monitoring (October 2007 Mitigation Plan Appendix E and Appendix F). The native grassland mitigation project is consistent with the long-term wildlife and habitat management goal of the Refuge and the associated riparian and floodplain wildlife and habitat objectives (USFWS 2005). This mitigation project has also been integrated with other work priorities identified in the annual habitat management plan (USFWS 2008). The Refuge is also responsible for management of the wildlife conservation easement for Bank Swallows and monitoring Bank Swallow colony occupancy during breeding season at the Capay Unit and Bank Swallow colony mitigation site (October 2007 Mitigation Plan Appendix G). Grassland restoration monitoring results are reported below.

LOCATION AND METHODS

## Riparian Vegetation

Off-site mitigation included 6.0 acres of native grassland restoration at the north-east corner of Cell 1.2 (USFWS 2008) of the Rio Vista Unit (Figure 1). The site is divided in two unequal parts by an east–west trending hedge of woody vegetation planted by The Nature Conservancy. The northwestern portion is dominated by Columbia complex, channeled soils, and the southeastern portion dominated by Columbia silt loam (Gowans 1967).

Figure 1. Sacramento River National Wildlife Refuge, Rio Vista Unit Cell 1.2– Native Grassland Mitigation Restoration Site.

The 6.0-acre Rio Vista Unit grassland restoration was drilled with native grass seed at 15 lbs. per acre in November 2007. Seed mixture was determined by Refuge staff (Appendix A).

In addition and beyond the requirements for mitigation, 800 plugs of deer-grass (*Muhlenbergia rigens*) were also planted in November 2007 along both shoulders of the swale forming the west boundary of the Rio Vista mitigation site.

On-site mitigation was conducted at the southeast corner of Cell 2 of the Capay Unit (USFWS 2008) immediately adjacent to the temporary maintenance project site (Figure 2). The site includes both natural recruitment adjacent to and beyond the western margin, and an understory native grass planting in the main portion of the site. The soils are dominated by Columbia silt loam (Begg 1968). Thus, mitigation included maintenance of 2.5 acres of natural recruitment of native grasses and forbs following a prescribed burn conducted by the Refuge. An additional 2.5 acres of native grassland understory was restored as part of the mitigation project. This grassland restoration forms the understory component of a Valley Oak Woodland restoration being implemented and maintained by TNC.

Figure 2. Sacramento River National Wildlife Refuge, Capay Unit Cell 2– Native Grassland Mitigation Restoration Site.

The 2.5-acre Capay Unit grassland restoration (Figure 2) was drilled with native grass seed at 15 lbs. per acre in December 2008. Again, seed mixture was determined by Refuge staff (Appendix B).

Restoration implementation, maintenance, and monitoring activities are further reported in Appendix A (Rio Vista Unit) and Appendix B (Capay Unit). Restoration and site maintenance followed standard up-to-date practices which have been implemented by the Refuge and restoration partners, primarily The Nature Conservancy–Sacramento River Project (Chico, CA; or, TNC), Hedgerow Farms (Winters, CA), CERUS Consulting (Chico, CA), and River Partners (Chico, CA).

Monitoring included Nested Frequency Frame Quadrat Transects and Fixed Photographic Stations at the Rio Vista Unit and Capay Unit. Results from these monitoring stations are included in Appendices C, D (Quadrat Transects), E and F (Photo Stations).

Photo stations give data between the qualitative and quantitative range capturing visual site characteristics through time, which are quickly interpreted (Elzinga *et al.* 1989). Nesting frequency frames yield quantitative data which shows plant community composition trends over time and are thus useful for tracking vegetation change, invasive plant species invasions, and restoration success (Elzinga *et al.* 1989).

## Bank Swallow Colony

Bank Swallow mitigation site (USFWS Conservation Easement) for toe-rock at the Capay Unit (October 2007 Mitigation Plan Appendix G) was established in 2008 at Chico M&T Ranch between 191.9 to 192.2 Left (Figure 3). The U.S. Fish & Wildlife Service is the grantee on the Conservation Easement. The Capay Unit colony site consists of Columbia fine sandy loam, 0 to 2 percent slopes, adjacent to (directly west of) Columbia silt loam, 0 to 2 percent slopes. At this mapping scale, on the active floodplain, which consists of mixed alluvium, both soil mapping units provide horizons with suitable textures for constructing burrows and establishing colonies, as well as unsuitable horizons of courser sands and gravel; however, the fine sandy loam mapping unit will have greater amounts of courser sands and gravels than the silt loam mapping unit. The mitigation site consists of Gianella fine sandy loam, 0 to 1 percent slopes, which is fairly equivalent to Columbia fine sandy loam at this subreach of the river.

The site has been monitored annually since 1986– 1986 through 1998 by the California Department of Fish and Game, and 1999 through 2011 via the Annual Cooperative Bank Swallow Colony Survey, with Sacramento National Wildlife Refuge Complex taking lead responsibilities for implementing the survey in Reach 2 and Reach 3. The survey provides long-term population indices of breeding bank swallows. Colony size and burrow occupancy is determined by taking the average of counts made by two observers of active burrows at each colony. Total active burrows at each colony provide an index of breeding swallows since each active burrow is potentially occupied by a breeding pair. Data records from this annual survey serve as mitigation monitoring for this report.

Figure 3. Chico M&T Ranch Bank Swallow Conservation Easement Mitigation Site.

RESULTS

**Riparian Vegetation– Rio Vista Unit**

Photo station images from July 31, 2011 again show a nearly complete stand of native perennial grasses, blue wild-rye and creeping ryegrass (Appendix E). Like 2008, a large majority of the native grasses were green, compared to 2009 and 2010 when a majority of these grasses were dormant. This appearance of dormancy was greatest during 2010 monitoring (Appendix E). The predominant dormant grass species was blue wild-rye, with the creeping rye-grass showing more green plant material. Few of the deer-grass plugs planted along the swale appear to have survived in 2008 and 2009, however several plants were observed in 2010 and 2011, mostly at the northern end of the swale. Yellow star-thistle *(Centaurea solstitalis)* invaded the grassland in 2008 and 2009, but due to control efforts was greatly reduced in 2010. Only minor amounts were observed in 2011, mostly at the edges of the road. Control efforts included broad-leaf herbicide applications and hand-pulling with the uprooted plants removed from the site.

Frequency frame data from the Rio Vista Unit for all years are presented in Appendix C and summarized in Table 1. During 2008 and 2009, blue wild-rye (*Elymus glaucus*) dominated the grassland (at around 65% frequency) and was nearly four times the frequency of creeping rye-grass (*Leymus triticoides*) in 2008 (17%). Creeping rye-grass increased substantially in 2009 (29%). Results for 2010 show a dominance of blue wild-rye (26%) followed by creeping rye-grass (14%). Slender wheatgrass (*Elymus*

*trachycalus*) was observed in the south transect this year (4%), possibly a native grass seed contaminant. These native grasses were also observed to be dormant (49%) and not distinguished with certainty, thus overall frequency of native grasses increased from 83 percent in 2008 to 93 percent in 2009 and 2010. Both blue wild-rye and creeping rye-grass decreased in 2011 (35% and 24%, respectively). The 2011 decline in native grass frequency seems to contradict frequency frame results, however photo station results show that the native grasses still dominate the site by cover. An actual measurement of plant cover would likely verify the photo station results.

Native and non-native forbs have been detected during various years and at relatively low frequencies compared to the native grasses planted at the site (Table 1). However, with the exception of black mustard (*Brassica nigra*) and horseweed (*Conyza* spp.), none have persisted in subsequent years. It is interesting to note that yellow star-thistle, while present at the site, has not been detected in the monitoring transects, and as stated above, has been greatly reduced through weed control measures. The particular species of Conyza must be positively identified since at least species occur in this region: Canadian horseweed (*C. canadensis*), a native, and South African horseweed (*C. bonariensis*) and many-flowered horseweed (*C. floribunda*), both non-natives. For the first time, two native forbs were detected in 2011, again at relative low frequencies (Table 1). While not detected in the monitoring transects, mugwort (*Artemisia douglasiana*) occurs in the grassland, especially at the northwestern end, however its abundance has steadily decreased. It has been particularly abundant to the west of the northern portion of the grassland.

Table 1. Plant species frequencies at North and South Rio Vista Monitoring Transects

| **Plants Observed in Monitoring Transects** | | **Frequency** | | | | |
|---|---|---|---|---|---|---|
| **Species/Acronym [1]** | **Common Name [1]** | **2008[2]** | **2009[3]** | **2010[4]** | **2011[5]** | **2012[6]** |
| *Elymus glaucus*/ELGL | Blue wild-rye | 66 | 64 | 26 | 35 | |
| *Leymus triticoides*/LETR | Creeping rye-grass | 17 | 29 | 14 | 24 | |
| *Elymus trachycalus*/ELTR | Slender wheat-grass | 0 | 0 | 4 | | |
| Dormant ELGL–LETR | | 0 | | 49 | | |
| Un ID native grass | | | | | 5 | |
| *Eremocarpus setigerus* | Turkey-mullin | | | | 4 | |
| *Euthamia occidentalis* | Western goldenrod | | | | 2 | |
| **Subtotal Native Grasses** | | 83 | 93 | 93 | 64 | |
| **Subtotal Native Plants** | | 83 | 93 | 93 | 70 | |
| *Erodium cicutqarium* | Red-stemmed filaree | 9 | 0 | 0 | 0 | |
| *Brassica nigra* | Black mustard | 6 | 2 | 1 | 5 | |
| *Polygonum arenastrum* | Common knotweed | 2 | 0 | 0 | 5 | |
| *Conyza spp.* | Horseweed | | 4 | 0 | 11 | |
| *Lotus corniculatus* | Bird's-foot-trefoil | | | 3 | 0 | |
| UnID non-native forb 1 | UnID non-native forb 1 | | | 4 | 0 | |
| *Chenopodium album* | Lamb's-quarters | | | | 1 | |
| *Bromus hordeaceus* | Soft chess | | | | 2 | |
| Un ID non-native grass | | | | | 4 | |
| Un ID grass (not subtotaled) | | | | | 1 | |
| **Subtotal non-native plants** | | 17 | 6 | 7 | 28 | |

[1] Native plants in Cambria font; Non-native plants in Calibri font.
[2] June 26, 2008 monitoring survey.
[3] June 25, 2009 monitoring survey.
[4] July 1, 2010 monitoring survey.
[5] July 13, 2011 monitoring survey.
[6] TBD.

**Riparian Vegetation– Capay Unit**

Understory vegetation at the 2.5-acre Valley Oak Woodland restoration consisted of 72 percent native species during the 2009 monitoring (Appendix D). Blue wild-rye (36%) was the dominate plant, followed by creeping rye-grass (14%) and mugwort (13%). California brome (*Bromus carinatus*) was also detected (9%) and like the slender wheatgrass reported from Rio Vista, was possibly a native grass seed contaminant. The remaining 28 percent of the understory species consisted of non-native grasses and forbs with Johnson-grass (*Sorghum halepense*) (8%), Bermuda-grass (*Cynodon dactylon*) (6%) and common knotweed (*Polygonum arenastrum*) (8%) being the most abundant (Appendix D).

Natural recruitment sites immediately east (just above the river bank) and west of the Valley Oak Woodland were monitored annually from 2008 through 2011 (Appendix F). The natural patch of creeping rye-grass above the bank was dominated by non-native grasses during this period, despite mowing treatments to reduce seed abundance of non-native grasses (Appendix F, Station1).

The relatively large area immediately west of Valley Oak Woodland restoration consisted of natural recruitment by mugwort, Santa Barbara sedge (*Carex barbarae*) and creeping rye-grass, with patches of Johnson-grass (Appendix F, Stations 2, 3. 4, 5). Weed control efforts to suppress Johnson-grass were somewhat successful in 2008, perhaps more so than in 2009 and 2010. Both mugwort and Johnson-grass co-occur at all four stations, at least in one or two years (Appendix F, Stations 2, 3. 4, 5). In 2008 and 2010, mugwort was dominate at Station 2 and Station 5, while Johnson-grass was dominant at Station 4 in 2009 (Appendix F). Black mustard and horse-weed appeared at the edges of the recruitment area, adjacent to the Valley Oak Woodland, in 2009 and 2010. While Johnson-grass occurs with mugwort at all four stations in 2011, the native mugwort appears to dominate most sites, perhaps except Station 4 (Appendix F).

**Bank Swallow Colony Survey– Capay Unit and Chico M&T Ranch Mitigation Site**

Survey results from the annual cooperative Bank Swallow Survey show declining trends, locally at the Capay Unit and overall for the Sacramento River along Reach 2 and Reach 3. (Table 2; Appendix G). During the 2007 survey, 217 burrows were recorded at the Capay Unit colony and 108 at the mitigation site. In 2008, the Capay Unit droped to 3 active burrows, the smallest "colony" ever recorded for reaches 2 and 3. After 2008, each survey resulted in no (zero) active burrows at the Capay Unit colony site. No active

colonies are also reported for the mitigation site in 2008 and 2010, while 23 burrows were observed in 2009 and 109 observed in 2011.

Table 2. Bank Swallow Colony Size at Capay Unit and Chico M&T Ranch Mitigation Site[1].

| | | | Average Number of Burrows | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **River Mile** | **Bank** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
| Capay Unit | 193.2 | R | 217 | 3 | 0 | 0 | 0 | TBD |
| M&T Ranch Mitigation Site | 191.9 to 192.2 | L | 108 | 0 | 23 | 0 | 109 | TBD |
| Sacramento River Reach 2&3 Total | 243 to 143 | | 17,640 | 17,660 | 16,259 | 10,662 | 11,710 | TBD |

[1]U.S. Fish and Wildlife Service 2011.

.DISCUSSION

**Riparian Vegetation– Rio Vista Unit**

During 2008 and 2009, restored native grasses, blue wild-rye and creeping rye-grass contributed 93 percent of the total species composition, declining slightly to 88 percent in 2010. Photo station results showed an almost complete dominance of native grasses, during this period. These photo station results are somewhat biased toward the native perennial grasses due to their height and robust stature. Visually, it appears that a large majority of the native grasses had gone dormant in both 2009 and 2010. These native grasses declined to about 60 percent in 2011. Native turkey mullin and western goldenrod accounted for 6 percent of other species detected, while horse-weed accounted for 10 percent. Interestingly, due to the distribution of these plants, the 2011 photo stations still show a dominance of the native perennial grasses.

Monitoring results show the mitigation project to be successful for native grassland restoration through the first three seasons of maintenance. Furthermore, 2010 monitoring confirmed the health of dormant 2009 native grasses. The 2011 monitoring suggests that, at least a portion of the 49 percent dormant native perennial grasses observed in 2010 may not have survived. Both native and non-native forbs increased during 2010 and 2011. Continued monitoring in 2012 is necessary to determine overall trends in native species composition and restoration success.

In 2007, the drilled native grasses germinated after early fall rains and maintained strong growth and vigor throughout the spring and summer of 2008. Site maintenance has been conducted annually from 2007 through 2009. While hand-pulling of yellow star-thistle occurred in 2010, no broadcast herbicide treatments were made. Herbicide application for primarily for black mustard occurred in spring 2011, at the northern end only. The majority of the horse-weed occurred in the southern portion during 2011. Reduced efforts for weed control, may account for increased composition of forbs at Rio Vista. Annual

maintenance (vegetation management for weed control) will be necessary for mitigation project success over the long-term.

**Riparian Vegetation– Capay Unit**

Although the Valley Oak Woodland understory mitigation site was dominated by native grasses in 2009, non-native species covered over a third of the area (as estimated by the survey transects). During 2010, weeds increased again at the understory site.

For the areas of natural recruitment, the creeping rye-grass patch above the river bank continues to be dominated by non-native grasses. Efforts to mow the non-native annuals to reduce seeds have not resulted in greater coverage of native grass. Perhaps, overbank flooding during spring will increase creeping rye-grass distribution. This observation has been made at other native grassland sites (e.g., Llano Seco Unit 1, Tract 1).

The area of natural recruitment to the west of the Valley Oak Woodland generally shows the 2008 weed control treatment more effective than 2009 and 2010. While Johnson-grass is the primary weed at this site, it is still dominated by Santa Barbara sedge, creeping rye-grass and mugwort. Spring overbank flooding would also likely increase these native species. Johnson-grass is a hardy weed due to energy stored in the rhizomes, therefore herbicide spot treatments may be necessary to control this species.

**Bank Swallow Colony Survey– Capay Unit and Chico M&T Ranch Mitigation Site**

Survey results show active burrows at the Capay Unit declining to zero (Table 2; Appendix G). This coincides with the installation of toe-rock revetment at this colony site. Rock installation preparation methods, which include bank sloping, and the actual rock, which alters/prevents erosion, lateral bank movement/floodplain reworking, and associated shearing into vertical banks, have directly impacted the colony site rendering the habitat unsuitable for the Bank Swallow.

Fluctuating Bank Swallow activity at the mitigation site is attributed to erosion and bank movement into unsuitable floodplain soil textures for bank swallow burrow construction during 2008 through 2010. Bank erosion at the mitigation site periodically exposed course sands associated with gravel. Not only are the soil textures too course for burrow construction/adhesion, but the bank face is at a less-than-vertical angle providing predators easy access. Soils in the active floodplain consist of mixed alluvium, so this is not surprising. Continued erosion at the mitigation site would expose fine sandy loam at the bank face, while continued erosion at the Capay Unit would expose silt loam, thus potentially providing greater amounts of suitable soil textures for Bank Swallow burrow construction at the Capay Unit.

Small colony sites are especially dynamic, being created and lost at a relatively high rate compared to medium and large colonies (Garcia 2009). It would be worth investigating the frequency of small colony occurrence on fine sandy loam and large colony occurrence on silt loam. It is likely that fine sandy loam provides smaller contiguous shear bank surface than silt loam, thus a potential explanation for the location of small colonies. The dynamic nature of small colonies makes them extremely important for

long-term Bank Swallow conservation as does the larger, longer persisting large colonies (Garcia 2009).

The Bank Swallow needs eroding banks (associated with lateral migration and floodplain reworking) to establish breeding colonies on the middle Sacramento River (Garrison et al. 1987). The decline of burrows associated with placement of rock revetment (full bank rip-rap, toe-rock, rock groins) results in the permanent loss of Bank Swallow colony habitat (Schlorff 1997; Garcia et al. 2008). The overall declining population and habitat trends for the Bank Swallow on the middle Sacramento River are cause for great concern. Any future bank revetment projects should include mitigation which removes rock at a one-to-one ratio, at a minimum. Mitigating for rock revetment by creating conservation easements, alone, on eroding bank, while an important short-term conservation measure, would result in net losses of habitat. Long-term Bank Swallow colony habitat conservation must include rock removal (Moffatt et al. 2005).

## REFERENCES

Appendix E: Mitigation Monitoring and Report Plan. In: M&T Chico Ranch/Llano Seco Rancho Pumping Plant Final EA/IS Temporary Maintenance Project, October 2007.

Appendix F: Riparian Vegetation and Native Grassland Mitigation Plan. In: M&T Chico Ranch/Llano Seco Rancho Pumping Plant Final EA/IS Temporary Maintenance Project, October 2007.

Appendix G: Bank Swallow Mitigation Plan. In: M&T Chico Ranch/Llano Seco Rancho Pumping Plant Final EA/IS Temporary Maintenance Project, October 2007.

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**Appendix A**
**Native grassland mitigation restoration activities at the Rio Vista Unit, Sacramento National Wildlife Refuge**

Rio Vista Unit Site Preparation, Seeding and Maintenance

| Year/Crew | Date | Input | Target |
|---|---|---|---|
| **2005** | | | |
| Refuge | September | Burn (10 ac) | Surface preparation |
| Refuge | September | Disc & Float (6 ac) | Surface preparation |
| **2006** | | | |
| Refuge | Feb 8–9 | Bucaneer Plus – 10 qt (6 ac) | Johnsongrass |
| Contracted w/ Larry's Pest & Weed Control | Feb 9 | 2,4-D | Spot treat Yellow star-thistle, mustards |
| Refuge | June 2 | Bucaneer Plus – 6 qt (3 ac) | Spot treat Annual grasses |
| Contracted w/ Larry's Pest & Weed Control | June 2 | 2,4-D | Spot treat Yellow star-thistle, mustards |
| Refuge | Sept 6 | Bucaneer Plus – 10 qt | Annual grasses |
| **2007** | | | |
| Refuge | Jan 9 | Roundup Ultra – 8 qt (6 ac) | Johnsongrass |
| Refuge | Apr 2 | Bucaneer Plus – 5 qt (6 ac) | Johnsongrass |
| Refuge | Sept 25 | Bucaneer Plus – 2 qt | Spot treat Johnsongrass |
| Refuge | Nov 14 | Bucaneer Plus – 4 qt | Spot treat Johnsongrass |
| Refuge | Nov 19 | **Drill Grass Seed (6 acres)** | ELGL, LETR |
| Refuge | Nov 27 | **Plant Plugs** | MURI |
| **2008** | | | |
| Contracted w/ Larry's Pest & Weed Control | March 29 | Dri Clean 1.5 lbs/ac (6 ac) | Yellow star-thistle, mustards |
| Refuge | July 8 | Hand-pull (0.5 ac) | Yellow star-thistle |
| Refuge | July 25 | Hand-pull (0.125 ac) | Yellow star-thistle |
| Refuge | Aug 10 | Hand-pull | Yellow star-thistle |
| Refuge | Aug 24 | Hand-pull | Yellow star-thistle |
| **2009** | | | |
| Refuge | Feb | 2,4-D | Spot treat Yellow star-thistle, mustards |
| Refuge | June | Hand-pull | Yellow star-thistle |
| Refuge | July | Hand-pull | Yellow star-thistle |
| Refuge | Nov | 2,4-D | Spot treat Yellow star-thistle, mustards |
| **2010** | | | |
| | April | 2,4-D | Mustards |

| | | | |
|---|---|---|---|
| **2011** | | | |
| | April | 2,4-D | Mustards (north-end) |
| **2012** | | | |
| | TBD | TBD | TBD |

**Soils:** Columbia complex, channeled (N end); Columbia silt loam (S end)

Rio Vista Unit Seed Mixture and Planting

| Species | Ecotype | Frequency (%) | Rate | Method | Date |
|---|---|---|---|---|---|
| *Elymus glaucus* (ELGL) | Llano Seco | 75 | 10.5 lbs/acre | Truax Range Drill | 11/19/2007 |
| *Leymus triticoides* (LETR) | Yolo | 25 | 3.5 lbs/acre | Truax Range Drill | 11/19/2007 |
| *Muhlenbergia rigens* (MURI) | | | 800 plugs | Plug Transplants | 11/27/2007 |

Rio Vista Unit Grassland Monitoring

| Monitoring Activity | Frequency Frame Quadrat Transects[1] | Fixed Photographic Stations[2] |
|---|---|---|
| **2008** | **Dates** | |
| Establish Station | March 17 | March 17 |
| Monitoring | | March 17 |
| Monitoring | June 26 | June 26 |
| Monitoring | | July 25 |
| **2009** | | |
| Monitoring | June 25 | June 25 |
| **2010** | | |
| Monitoring | July 1 | July 1 |
| **2011** | | |
| Monitoring | July 13 | July 13 |
| **2012** | | |
| Monitoring | TBD | TBD |

[1] UTM coordinates in Appendix C.
[2] UTM coordinates in Appendix E.

**Appendix B**
**Native grassland mitigation restoration activities at the Capay Unit, Sacramento National Wildlife Refuge**

Capay Unit Site Preparation, Seeding and Maintenance

| Year/Crew | Date | Input | Target |
|---|---|---|---|
| **2008** | | | |
| Refuge | January | Burn (5ac) | Surface preparation |
| Refuge | Feb-Mar | **Natural Recruitment (2.5 ac) following Refuge Prescribed Burn** | Mugwort, Santa Barbara Sedge, Creeping Ryegrass (LETR) |
| Refuge | Feb 20–21 | Doze (2.5 ac) | Surface preparation |
| Refuge | Mar 6 | Float (2.5 ac) | Surface preparation |
| Refuge | Apr 4 | Buccaneer Plus – 3 qts (1 ac) | Weed control preparation |
| TNC | Apr 8 | **Plant (2.5 acres) Valley Oak Woodland** | Valley Oak (QULO) |
| TNC | June 8 | Roundup (2.5 ac) | Weed control preparation |
| TNC | Oct 8 | 2,4–D (2.5 ac) | Broad-leaf weed control |
| TNC | Dec 2 | **Drill Grass Seed (2.5 acres) Native Understory** | ELGL, LETR, HOBR, NAPU |
| **2009** | | | |
| Refuge | April | 2,4–D (2.5 ac) | Yellow star-thistle, mustards |
| **2010** | | | |
| Refuge | May | Mowed (2.5 ac) | Prep for herbicide spraying |
| Refuge | May | 2,4–D (2.5 ac) | Yellow star-thistle, mustards |
| **2011** | | | |
| | | NONE | |
| **2012** | | | |
| | TBD | TBD | TBD |

**Soils:** Columbia silt loam

Capay Unit Seed Mixture and Planting

| Species | Ecotype | Frequency (%) | Rate | Method | Date |
|---|---|---|---|---|---|
| *Elymus glaucus* (ELGL) | Llano Seco | 20 | 3 lbs/acre | Truax Range Drill | 12/02/2008 |
| *Leymus triticoides* (LETR) | Yolo | 20 | 3 lbs/acre | Truax Range Drill | 12/02/2008 |
| *Hordeum brachyantherum* (HOBR) | Yolo | 15 | 2.25 lbs/acre | Truax Range Drill | 12/02/2008 |
| *Nassella pulchra* | Llano Seco | 45 | 6.75lbs/acre | Truax Range Drill | 12/02/2008 |

| | | | | | |
|---|---|---|---|---|---|
| (NAPU) | | | | | |

Capay Unit Grassland Monitoring

| **Monitoring Activity** | **Frequency Frame Quadrat Transects**[1] | **Fixed Photographic Stations**[2] |
|---|---|---|
| **2008** | **Dates** | |
| Establish Station | | March 17 |
| Monitoring | | March 17 |
| Monitoring | | June 27 |
| Monitoring | | July 25 |
| **2009** | | |
| Establish Station | June 25 | |
| Monitoring | June 25 | June 25 |
| **2010** | | |
| Monitoring | | July 1 |
| **2011** | | |
| Monitoring | July 13 | July 13 |
| **2012** | | |
| Monitoring | TBD | TBD |

[1] UTM coordinates in Appendix D.
[2] UTM coordinates in Appendix F.

# Appendix C
# Rio Vista Unit Frequency Frame Data Records– 2008 through 2011

2008: Sacramento River National Wildlife Refuge, Rio Vista Cell 1.2 native grassland mitigation restoration monitoring data, 26 June 2008.

**Nested Frequency Frame Monitoring**

| | Meters along Transect | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 20 | 35 | 50 | 65 | 80 | | | |
| | Frame Number | | | | | | | | | | | | |
| | Transect 1 | | | | | Transect 2 | | | | | | | |
| **Species** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | | **Total** | **Frequency** |
| *Elymus glaucus - blue wild-rye* | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 3 | | 35 | **66.04%** |
| *Leymus triticoides - creeping rye-grass* | | 2 | 1 | 3 | | 1 | | | 2 | | | 9 | **16.98%** |
| *Artemisia douglasiana - mugwort* | | | | | | | | | | | | 0 | **0.00%** |
| *Erodium cicutqarium - red-stemmed filaree* | | | | | 3 | | 2 | | | | | 5 | **9.43%** |
| *Brassica nigra - black mustard* | 3 | | | | | | | | | | | 3 | **5.66%** |
| *Polygonum arenastrum - common knotweed* | | | | | | | | | | 1 | | 1 | **1.89%** |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | 53 | |
| | | | | | | | | | | | | | |

Data collected and recorded by Joe Silveira and Laura Shaskey, Sacramento National Wildife Refuge Complex

**Transect Identification and Locations - NAD 83 Zone 10 UTM Coordinates**

| Transect 1 - North Transect | Transect 2 - South Transect |
|---|---|
| North Point - 579120:4417476 ± 5 | North Point - 579288:4417404 ± 6 |
| South Point - 579205:4417444 ± 6 | South Point - 579375:4417380 ± 6 |

2009: Sacramento River National Wildlife Refuge, Rio Vista Cell 1.2 native grassland mitigation restoration monitoring data, 25 June 2009.

**Nested Frequency Frame Monitoring**

| | Meters along Transect | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 20 | 35 | 50 | 65 | 80 | | | |
| | Frame Number | | | | | | | | | | | | |
| | Transect 1 | | | | | Transect 2 | | | | | | | |
| **Species** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | | **Total** | **Frequency** |
| *Elymus glaucus - blue wild-rye* | 3 | 2 | 3 | 3 | *3* | 3 | *4* | *4* | *1* | *3* | | 29 | **64.44%** |
| *Leymus triticoides - creeping rye-grass* | | *2* | 2 | 2 | 1 | 3 | | | 3 | | | 13 | **28.89%** |
| *Artemisia douglasiana - mugwort* | | | | | | | | | | | | 0 | **0.00%** |
| *Erodium cicutqarium - red-stemmed filaree* | | | | | | | | | | | | 0 | **0.00%** |
| *Brassica nigra - black mustard* | | | | | | 1 | | | | | | 1 | **2.22%** |
| *Polygonum arenastrum - common knotweed* | | | | | | | | | | | | 0 | **0.00%** |
| *Conyza* | | | | | | 2 | | | | | | 2 | **4.44%** |
| | | | | | | | | | | | | 0 | **0.00%** |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | 45 | |
| | | | | | | | | | | | | | |

Data collected and recorded by Joe Silveira and Laura Shaskey, Sacramento National Wildife Refuge Complex

**Transect Identification and Locations - NAD 83 Zone 10 UTM Coordinates**

| Transect 1 - North Transect | Transect 2 - South Transect |
|---|---|
| North Point - 579120:4417476 ± 5 | North Point - 579288:4417404 ± 6 |
| South Point - 579205:4417444 ± 6 | South Point - 579375:4417380 ± 6 |

2010: Sacramento River National Wildlife Refuge, Rio Vista Cell 1.2 native grassland mitigation restoration monitoring data, 1 July, 2010.

**Nested Frequency Frame Monitoring**

| | Meters along Transect | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 20 | 35 | 50 | 65 | 80 | | | |
| | Frame Number | | | | | | | | | | | | |
| | Transect 1 | | | | | Transect 2 | | | | | | | |
| **Species** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | | **Total** | **Frequency** |
| *Elymus glaucus* (green) | 3 | | | | 1 | 3 | 3 | 3 | 3 | 3 | | 19 | **26.39%** |
| *Leymus triticoides* (green) | 2 | 2 | 2 | 2 | 2 | | | | | | | 10 | **13.89%** |
| *Elymus trachycalus* (green) | | | | | | | | | 3 | | | 3 | **4.17%** |
| treefoil?? | 2 | | | | | | | | | | | 2 | **2.78%** |
| DORMANT native species | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | | 35 | **48.61%** |
| unknown forb #1 | | | | | | | | | 3 | | | 3 | **4.17%** |
| salt heliatrope (T1) | | | | | | | | | | | | | |
| black mustard/ wild radish (T2) | | | | | | | | | | | | | |
| *conzya (T2)* | | | | | | | | | | | | | |
| turkey mullen (T2) | | | | | | | | | | | | | |
| knotweed (T2) | | | | | | | | | | | | | |
| ((star thistle)) | | | | | | | | | | | | | |
| ((spiney cocklebur)) | | | | | | | | | | | | | |
| ((black mustard/ wild radish)) | | | | | | | | | | | | | |
| ((mugwort)) | | | | | | | | | | | | | |
| ((turkey mullen)) | | | | | | | | | | | | | |
| | | | | | | | | | | | | 72 | |

Data collected and recorded by Joe Silveira and Laura Shaskey, Sacramento National Wildife Refuge Complex

**Transect Identification and Locations - NAD 83 Zone 10 UTM Coordinates**

| Transect 1 - North Transect | Transect 2 - South Transect |
|---|---|
| North Point - 579120:4417476 ± 5 | North Point - 579288:4417404 ± 6 |
| South Point - 579205:4417444 ± 6 | South Point - 579375:4417380 ± 6 |

2011: Sacramento River National Wildlife Refuge, Rio Vista Cell 1.2 native grassland mitigation restoration monitoring data, 13 July 2011

Nested Frequency Frame Monitoring

| | Meters along Transect | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 20 | 35 | 50 | 65 | 80 | | | |
| | Frame Number | | | | | | | | | | | | |
| | Transect 1 | | | | | Transect 2 | | | | | | | |
| **Species** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | | **Total** | **Frequency** |
| *Elymus glaucus (Creeping ryegrass)* | 3 | 4 | 3 | 2 | 3 | | 4 | 3 | 3 | 4 | | 29 | **35.37%** |
| *Leymus triticoides (Blue wildrye)* | 4 | 4 | 3 | 3 | 3 | | 3 | | | | | 20 | **24.39%** |
| *Artemisia douglasiana (Mugwort)* | | | | | | | | | | | | 0 | **0.00%** |
| *Erodium cicutarium (Red-stemmed filaree))* | | | | | | | | | | | | 0 | **0.00%** |
| *Brassica nigra (Black mustard)* | | | | | | 4 | | | | | | 4 | **4.88%** |
| *Polygonum arenastrum (Common knotweed)* | | | | | | | | | 1 | 3 | | 4 | **4.88%** |
| | | | | | | | | | | | | 0 | **0.00%** |
| *Conyza canadensis (Canadian horseweed)* | | | | | | | | | | | | 0 | **0.00%** |
| *Conyza bonariensis (South American horseweed)/ C. floribunda (Many-flowered horseweed)* | | | | | | | | | | | | 0 | **0.00%** |
| *Conyza spp. (Horseweed species)* | | | | | | | | 3 | 3 | 3 | | 9 | **10.98%** |
| *Un ID native grass* | | | | 4 | | | | | | | | 4 | **4.88%** |
| *Un ID annual grass* | | | | | 3 | | | | | | | 3 | **3.66%** |
| *Un ID grass* | | | | | | 1 | | | | | | 1 | **1.22%** |
| | | | | | | | | | | | | 0 | **0.00%** |
| *Eremocarpus setigerus (Turkey mullin/Dove weed)* | | | | | | | | | 3 | | | 3 | **3.66%** |
| *Euthamia occidentalis (Western goldenrod)* | | | | | | | | | 2 | | | 2 | **2.44%** |
| *Chenopodium album (Lamb's quarters)* | | | | | | | | 1 | | | | 1 | **1.22%** |
| *Bromus hordeaceus (Soft chess)* | | | | | | | | | | 2 | | 2 | **2.44%** |
| | | | | | | | | | | | | | |
| Total | | | | | | | | | | | | 82 | 100.00% |

Data collected and recorded by Joe Silveira and Barbora Hoagland, Sacramento National Wildlife Refuge Complex

**In Vicinity, not in Transect**

Transect 1

*Brassica nigra* (Black mustard)
*Lactuca serriola* (Prickly lettuce)
*Euthamia occidentalis* (Western goldenrod)
*Eremocarpus setigerus* (Turkey-mullin/Dove weed)
*Artemisia douglassiana* (Mugwort)

Transect 2

*Brassica nigra* (Black mustard)
*Lactuca serriola* (Prickly lettuce)
*Polygonum arenastrum* (Common knotweed)
*Verbascum blattaria* (Moth mullin)
*Briza minor* (Quaking-grass)

**Transect Identification and Locations - NAD 83 Zone 10 UTM Coordinates**

| Transect 1 - North Transect | Transect 2 - South Transect |
|---|---|
| North Point - 579120:4417476 ± 5 | North Point - 579288:4417404 ± 6 |
| South Point - 579205:4417444 ± 6 | South Point - 579375:4417380 ± 6 |

2012 Sacramento River National Wildlife Refuge, Rio Vista Unit Cell 1.2 grassland mitigation restoration monitoring frequency frame data place holder.

# Appendix D
# Capay Unit Frequency Frame Data Records– 2009

2009: Sacramento River National Wildlife Refuge, Capay Unit Cell 2, native grassland mitigation restoration monitoring data, 25 June 2009.

**Nested Frequency Frame Monitoring**

| | Meters along Transect | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 35 | 50 | 65 | 80 | 20 | 35 | 50 | 65 | 80 | | | |
| | Frame Number | | | | | | | | | | | | |
| | Transect 1 | | | | | Transect 2 | | | | | | | |
| **Species** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | | **Total** | **Frequency** |
| *Elymus glaucus - blue wild-rye* | 3 | 4 | 4 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | | 29 | **36.25%** |
| *Leymus triticoides - creeping rye-grass* | | | | | 3 | 3 | | | 3 | 2 | | 11 | **13.75%** |
| *Artemisia douglasiana - mugwort* | 3 | 2 | | | 3 | | | 2 | | | | 10 | **12.50%** |
| *Johnsongrass* | 3 | 3 | | | | | | | | | | 6 | **7.50%** |
| *Polygonum arenastrum - common knotweed* | | | | 1 | | | 2 | 3 | | | | 6 | **7.50%** |
| *Conyza* | 1 | | | | | | | | | | | 1 | **1.25%** |
| *Bromus californica* | 3 | | 1 | | | | 2 | | | 1 | | 7 | **8.75%** |
| *Kixia fluellen* | 2 | | | | | | | | | | | 2 | **2.50%** |
| *bermuda grass* | | 1 | | 4 | | | | | | | | 5 | **6.25%** |
| Non-native Forb #1 | 2 | | | | | | | | | | | 2 | **2.50%** |
| Non-native Forb #2 | | 1 | | | | | | | | | | 1 | **1.25%** |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | 80 | |
| | | | | | | | | | | | | | |

Data collected and recorded by Joe Silveira and Laura Shaskey, Sacramento National Wildife Refuge Complex

**Transect Identification and Locations - NAD 83 Zone 10 UTM Coordinates**

| Transect 1 - North Transect | Transect 2 - South Transect |
|---|---|
| NW Point - 590326:4394971 ± 5 | NW Point - 590330:4394947 ± 5 |
| SE Point - 590392:4394911 ± 5 | SE Point - 590379:4394876 ± 5 |

**Appendix E**
**Rio Vista Unit Fixed Photographic Station Results– 2008 through 2011**

RIO VISTA NATIVE GRASSLAND MONITORING

## Photo Points – NAD 83 Zone 10 UTM Coordinates

North Transect/ North Photo Point (view south) – 579120:4417476 ± 5

Date: 6/26/08

Date: 6/25/09

Date: 7/1/10

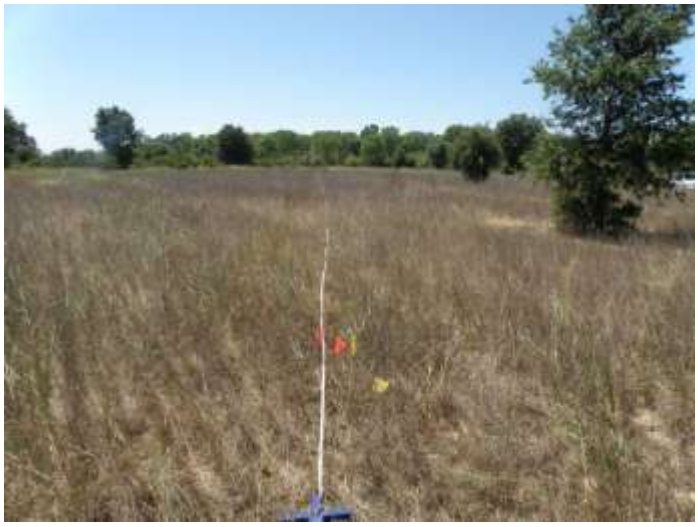
Date: 7/13/11

Date: X/X/12

North Transect/ South Photo Point (view north) – 579205:4417444 ± 6

Date: 6/26/08

Date:6/25/09



Date: 7/1/10

Date: 7/13/11

Date: X/X/12

South Transect/ North Photo Point (view south) – 579288:4417404 ± 6

Date: 6/26/08

Date: 6/25/09

Date: 7/1/10

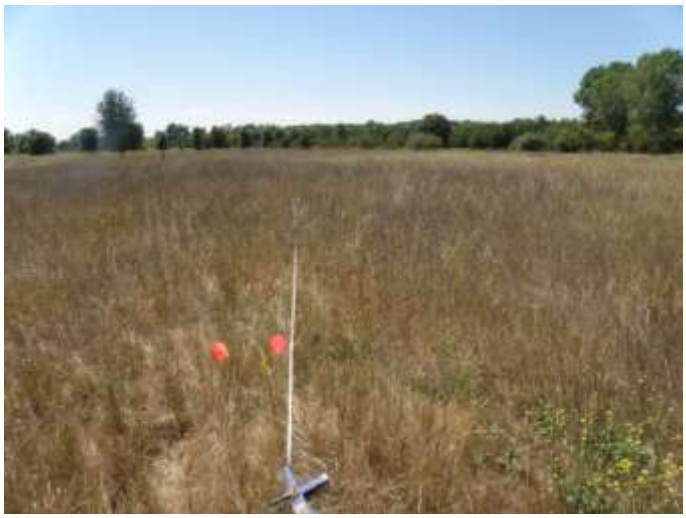
Date: 7/13/11

Date: X/X/12

South Transect/ South Photo Point (view north) – 579375:4417380 ± 6

Date: 6/26/08

Date: 6/25/09



Date: 7/1/10

Date: 7/13/11

Date: X/X/12

Swale Plug Monitoring/ North Photo Point (view north) – 579169:4417413 ± 5

Date: 6/26/08

Date: 6/25/09

Date: 7/1/10

NO PHOTO

Date: 7/13/11

Date: X/X/12

Swale Plug Monitoring/ South Photo Point (view south) – 579205:4417396 ± 5

Date: 6/26/08

Date: 6/25/09

Date: 7/1/10

NO PHOTO

Date: 7/13/11

Date: X/X/12

**Appendix F**
**Capay Unit Fixed Photographic Station Results**
**– 2008 through 2011**

## CAPAY NATIVE GRASSLAND MONITORING

### Photo Points – NAD 83 Zone 10 UTM Coordinates

Station 1: Mitigation along bank (UTM 590424, 4394984 +/-6)

Date: 6/27/08

Date: 6/25/09

Date: 7/1/10

Date: 7/13/11

Date: X/X/12

Station 2: Natural regeneration (UTM 590316, 4394983 +/-6)]

Date: 6/27/08

Date: 6/25/09

Date: 7/1/10

Date: 7/13/11

Date: X/X/12

Station 3: Natural regeneration (590313, 4394952 +/-6)

Date: 6/27/08

Date: 6/25/09

Date: 7/1/10

Date: 7/13/11

Date: X/X/12

Station 4: Natural regeneration (590303, 4394919 +/-6)

Date: 6/27/08

Date: 6/25/09

Date: 7/1/10

Date: 7/13/11

Date: X/X/12

Station 5: Natural regeneration (590302. 4394891 +/-6)

Date: 6/27/08

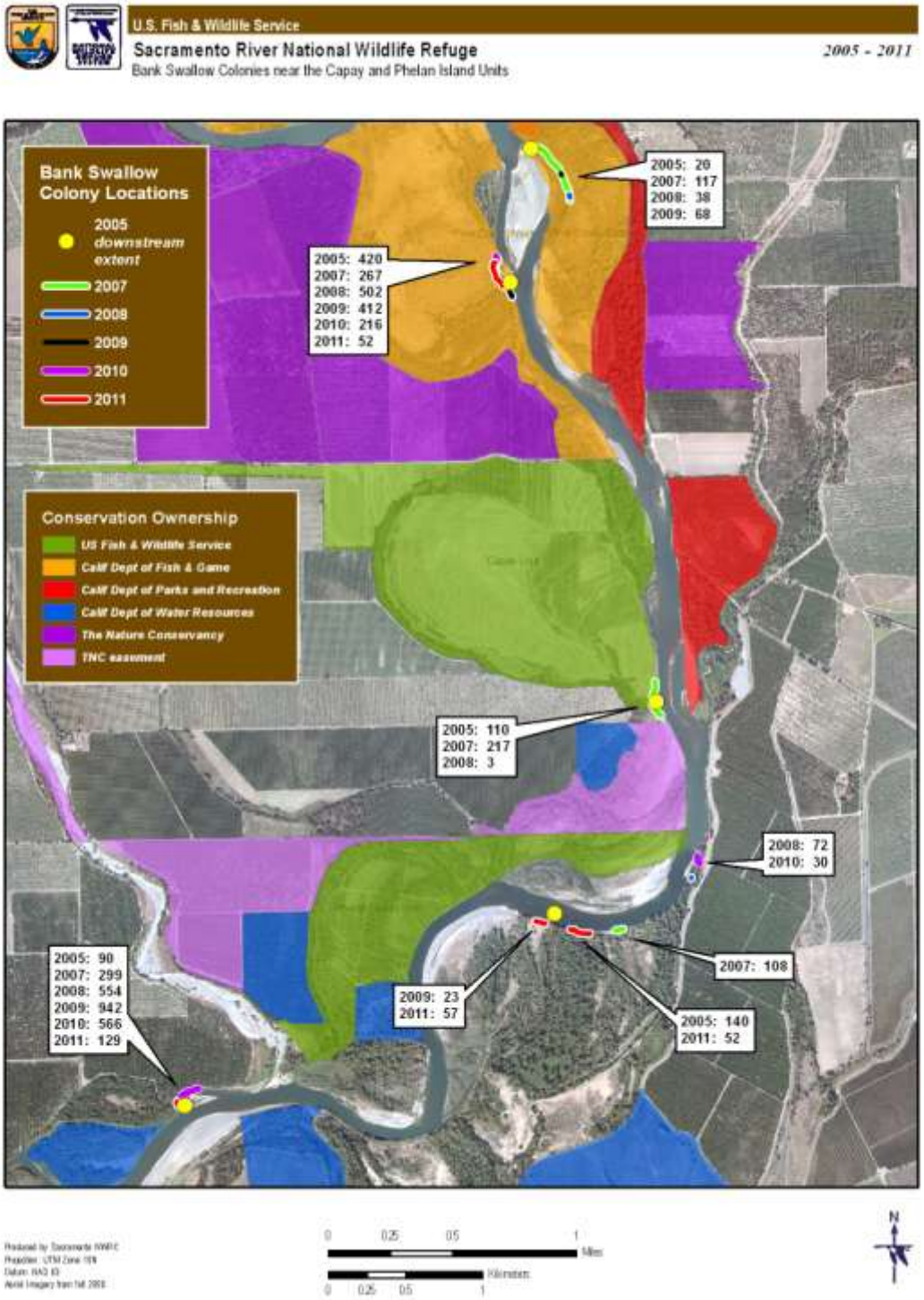
Date: 6/25/09

Date: 7/1/10

Date: 7/13/11

Date: X/X/12

**Appendix G**
**Bank Swallow Colony Survey Results– Capay Unit / Chico M&T Ranch and Vicinity– 2005 through 2011 (U.S. Fish and Wildlife Service 2011)**



# M&T/LLANO SECO PUMPING PLANT RIPARIAN VEGETATION MITIGATION MONITORING REPORT

### *Introduction*

Monitoring was conducted on September 26th, 27th and 28th, 2011 by Northern California Regional Land Trust (NCRLT) Land Projects Coordinator Zach Mendes at the Capay Unit of the U.S. Fish and Wildlife Service (USFWS) Sacramento National Wildlife Refuge Complex (SNWRC) and at Doe Island on the Llano Seco Rancho (**Figures 1** and **2**). Monitoring was performed to determine the status of riparian plantings completed as mitigation for the *M&T Chico Ranch/Llano Seco Rancho Pumping Plant Maintenance of Channel Alignment Sacramento River Mile 192.5 Project* (Project).

The M&T Chico Ranch, Llano Seco Rancho, California Department of Fish and Game (CDFG), and the USFWS SNWRC are responsible for overseeing implementation of planting and monitoring of riparian vegetation on the SNWRC and Llano Seco Rancho. As part of the monitoring requirements, the M&T Chico Ranch and Llano Seco Rancho are required to hire an environmental consultant to monitor and report their findings to CDFG and the USFWS SNWRC each year regarding the success of the plantings and any need for remedial actions. USFWS SNWRC and CDFG, as the federal and state lead agencies for the channel maintenance project, are responsible for ensuring that the monitoring reports are provided to the National Marine Fisheries Service and the USFWS Sacramento Field Office to satisfy the terms and conditions of the incidental take permit and Section 7 consultation for the project.

### *Project Background*

The primary objective of the Project is to protect the M&T Chico Ranch/Llano Seco Rancho pumping facility and the outfall for the City of Chico's Wastewater Treatment Plant through the placement of a longitudinal stone toe with tree revetment to stabilize the site. The Project has placed approximately 1,520 feet of rock and tree revetment on the west side of the Sacramento River and removed gravel on the east side of the river. Approximately 9,120 tons of rock has been placed to approximately half of the bank height to an elevation of approximately 120 feet above mean sea level and the base of the revetment is approximately 30 feet in width. Backfilling behind the stone toe will thicken the toe and provide a medium for revegetation. The top of the bench has been an average of approximately ten feet. Woody brush material has been incorporated into the revetment by anchoring the material with cables and partially sunken large boulders to prevent loss during overtopping flows. The brush portion of the revetment consists of multiple, alternative clusters of trees spaced approximately ten to 15 feet apart at two elevations to provide instream and object cover at a range of flows.

The Project removed approximately 1.73 acres of valley foothill riparian habitat. To mitigate these impacts, 3.46 acres of valley-foothill riparian habitat is being restored or enhanced for a restoration ratio of 2:1.

Restoration is being conducted at two separate locations (**Figures 1** and **2**):

1. 0.35 acre of Shaded Riparian Aquatic (SRA) habitat on the Capay Unit of the SRNWRC along the river bank where construction disturbance occurred between the bank and the revetment itself.

2. 3.46 acres of valley foothill riparian habitat at Doe Island on the Llano Seco Rancho easement property held in trust by NCRLT.

***Monitoring Methods***

The following metrics and methods were used to monitor the planted riparian habitat:

- **Percent survival**: Percent survival was calculated by dividing the number of established shrubs and trees by the total number planted.

- **Plant vigor**: A minimum of 25% of the plantings at each site were randomly selected and measured to determine canopy cover and stem diameter at stem midpoint (diameter at breast height [dbh] for trees 4 feet and taller), and height. Plant vigor was rated as excellent, good, fair, or poor.

- **Photographic Documentation**: Photographic documentation sampling points were established utilizing a Garmin hand-held global positioning system (GPS) unit.

- **Percent Linear Closure**: This performance standard for the Shaded Riparian Aquatic (SRA) habitat on the Capay Unit of the SRNWRC will be monitored in year 5 of the monitoring period.

***Results***

*Site Conditions and Photographic Documentation*

Tree, shrub, and grass/sedge plantings were completed at both units in the spring of 2009. Planting stakes and cardboard milk container grow tubes were used at both sites. Irrigation lines have been installed at each site and were in good condition. Some browsing of plants has occurred at both sites. A majority of the Capay Unit site was replanted in early fall of 2009 due to lack of adequate moisture. Some replanting occurred at the Doe Island site, as well. Field observation forms are included in **Appendix A**.

At the Capay Unit site, plantings include one row of trees, one row of mixed trees and shrubs, and one row of shrubs positioned perpendicular to the river bank, in addition to a Santa Barbara sedge plant at every tree location. Plantings include 98 shrubs consisting of arroyo willow, sandbar willow, and California rose, along with 85 trees comprised of Fremont cottonwood, western sycamore, and white alder.

The Doe Island site was planted in order to connect a mature riparian corridor resulting from a historical river oxbow. Plantings were completed in 14 rows, alternating overstory species (trees/large shrubs) and understory species (small shrubs/grasses) in each row. Overstory species include valley oak, western sycamore, mule fat, box elder, elderberry, coyote brush, California rose, and California blackberry. Understory species include deer grass, creeping ryegrass, mugwort, California goldenrod, hoary nettle, evening primrose, California pipevine, and clematis. The site includes a total of 2058 plantings.

Photo points were established at each site using a Garmin hand-held GPS unit, with compass bearings taken to record direction of photo observation (**Figures 1** and **2**). Photos are included in **Appendix B**.

*Percent Survival*

All plants were evaluated to establish percent survival of plantings at each site.

This fall (2011) at the Capay Unit, 77 out of 183 tree/shrub plantings were determined to be alive, for a 42% survival rate. Out of 191 sedge plantings, 116 were found to be alive, resulting in a 61% survival rate. The survival rate of the entire community of plantings at the Capay Unit is 52%.

At the Doe Island site there were 2,038 original plantings made up of 1,028 overstory plantings and 1,010 understory plantings. This fall (2011) a total of 749 overstory plantings were determined to be alive, resulting in a 73% survival rate; and a total of 926 understory were determined to be alive, resulting in a 92% survival rate. The survival rate of the entire community of plantings at the Doe Island site is 82%.

*Plant Vigor*

Of 81 plants monitored at the Capay Unit, the following plant vigor ratings were determined: poor – 0, fair – 17, good – 23, excellent – 4, missing/dead – 37. Of 472 plants evaluated at the Doe Island site, the following plant vigor ratings were determined: poor – 43, fair – 95, good – 77, excellent – 80, missing/dead – 177. Plant vigor rating data sheets are provided in **Appendix A**.

### *Conclusion*

Plantings at the Capay Unit were of much smaller stature than those at the Doe Island site. This is partially due to planting dates; however, growing conditions at the Capay Unit are less conducive due to sandy soils. This may continue to impact plant vigor and survival until plantings are fully established. It is recommended that both sites be monitored throughout the late spring and summer to assure that irrigation lines are functioning and plants are receiving adequate water. This is more critical at the Capay Unit due to sandy soils as mentioned above.

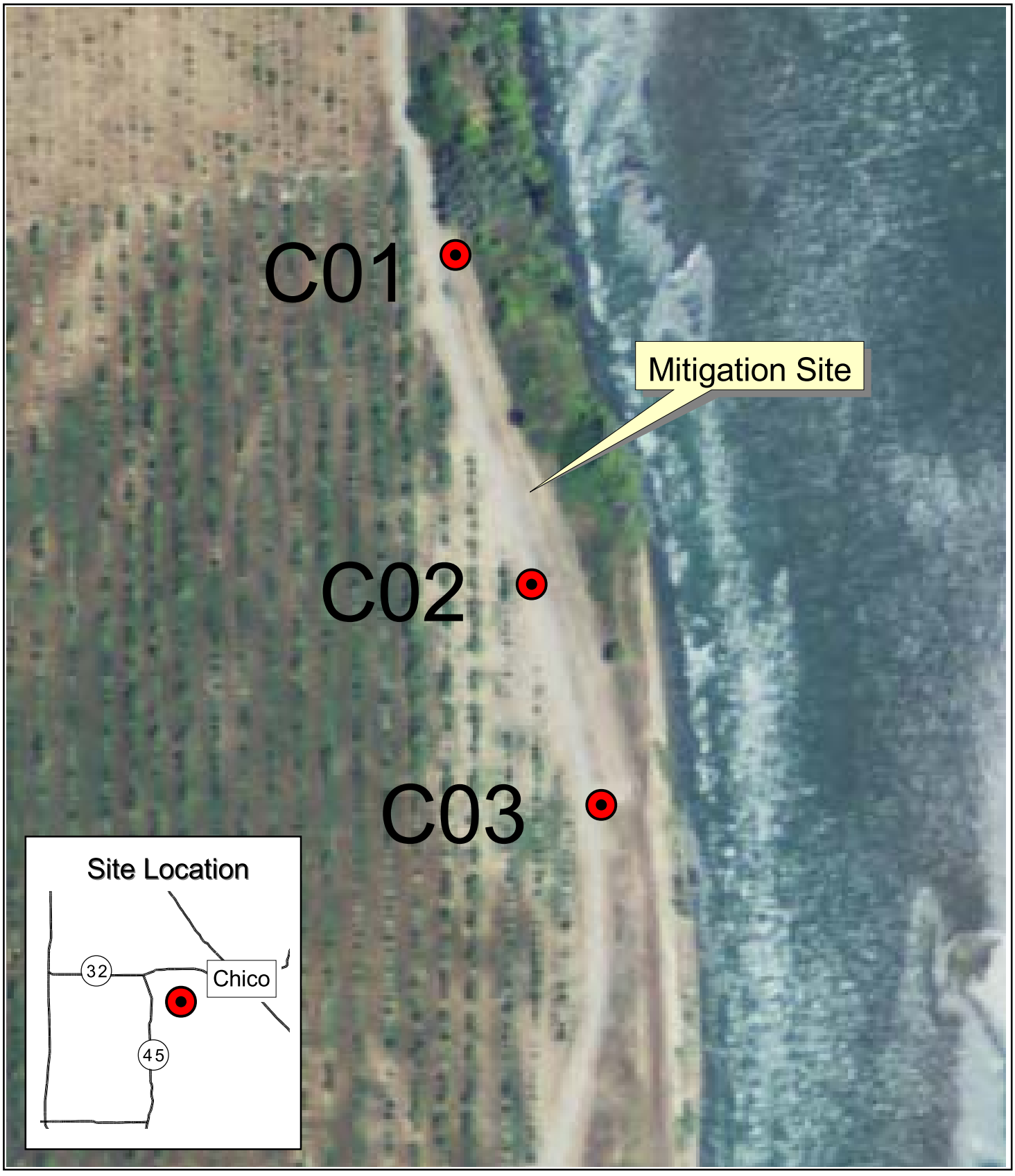
Furthermore, per Appendix F (Riparian Vegetation and Native Grassland Mitigation Plan) of the M&T Chico Ranch/Llano Seco Rancho Riparian Vegetation and Native Grassland Mitigation Plan, "during years subsequent to the first year of planting (i.e., 2009 through 2012), replanting of trees, shrubs, and herbaceous understory species will occur as needed to reach a survival goal of 60 percent after 5 years for the shoreline community and 80 percent for the riparian floodplain community. Specifically, if individual plants do not survive, larger individuals, which are more likely to persist, will be planted in place of those individuals. Consequently, if adequate survival and recruitment is occurring, little subsequent planting would be conducted." From the data collected, it appears that the riparian floodplain community at the Doe Island site is currently meeting its survival goal of 80% with a current survival rate of 82%, however, the shoreline community at the Capay Unit is short of its survival goal of 60% with a current survival rate of 52% and may require additional plantings.

### *Attachments*

Figure 1. Capay Unit
Figure 2. Doe Island

### *Appendices*

A. NCRLT Vegetation Monitoring and Photo-documentation Dataforms
B. Photos



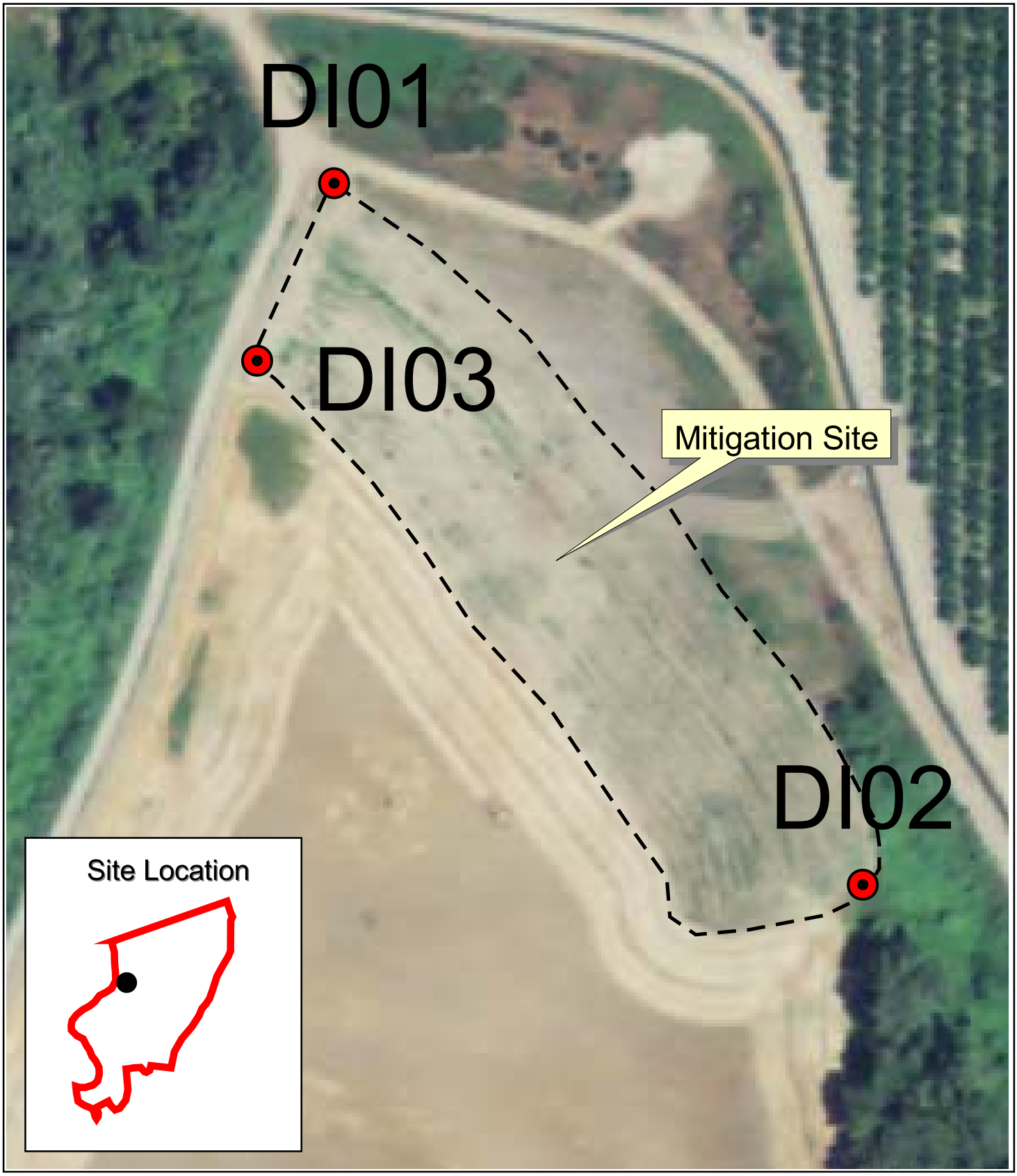

NORTHERN CALIFORNIA
REGIONAL LAND TRUST

N

0 100 Feet

Aerial Imagery: NAIP 2009
Prepared By: J. Watts
Date: 1/4/10

"Capay" Mitigation Site




NORTHERN CALIFORNIA
REGIONAL LAND TRUST

N

0 100 Feet

Aerial Imagery: NAIP 2009
Prepared By: J. Watts
Date: 1/4/10

"Doe Island" Mitigation Site

# Appendix A:
# Monitoring Data Forms

Field Observations Form
Photodocumentation Data Form
Vegetation Monitoring Data Form

# NCRLT Field Observations Form



**Site: Capay Unit** **County: Glenn**

**Date: 9-26-2011** **Monitor(s): Zach Mendes**

**Notes:** general observable conditions (weather, growing conditions, irrigation system, fencing/exclosures, vandalism, etc.)

weather: clear and warm
growing conditions: poor growth likely due to soil makeup
irrigation system: in good condition
fencing: none present
note: some western sycamores snapped at trunk

**Soil moisture:** 1-dry (crumbly and dusty, near wilting point), 2-damp (crumbly but not dusty, some moisture), 3-moist (soft and friable, available water), 4-wet (leaves hand damp, near or above field capacity).

| Sample | moisture at depth (cm) | | | Comments |
|---|---|---|---|---|
| | 0 | 10 | | |
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**Understory Vegetation:** height (cm), cover of all veg (%), seed (1-ripe, 2-immature, 3-none)

| Sample | Height | Cover | Seed | Dominate Plant Species |
|---|---|---|---|---|
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**Recommendations or follow-up required:**

# NCRLT Photodocumentation Data Form

**Site: Capay Unit** **County: Glenn** **USGS Quad: Ord Ferry** **Camera Used: Canon Powershot A2200**

**Date: 9-26-11** **Monitor's Name: Zach Mendes** **Camera Height (m): 2**

| Station ID | Photo ID | %CC | Compass Bearing (degrees) | UTM (x) | UTM (y) | Elevation (m) | GPS Accuracy (m) | Comments |
|---|---|---|---|---|---|---|---|---|
| **C01** | 1 | 0 | 230 | 590373 | 4395319 | 28 | 5 | |
| **C02** | 2 | 0 | 230 | 590399 | 4395210 | 28 | 5 | |
| **C02** | 3 | 0 | 20 | 590399 | 4395210 | 28 | 5 | |
| **C03** | 4 | 0 | 5 | 590421 | 4395139 | 28 | 5 | |
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# NCRLT Vegetation Monitoring Data Form



Percent survival: The number of established trees and shrubs that were planted during the initial planting are determined during each of the five years in the monitoring timeline.
Plant Vigor: During each of the 5 monitoring years, 25 percent of the plantings in each mitigation area are randomly selected and measured to determine canopy size, stem diameter at stem midpoint (diameter at breast height [dbh] for trees 4 feet and taller), and height. Plant vigor* is rated as excellent, good, fair, or poor.

**Site: Capay** **County: Glenn**

**Date: 9/26/2011** **Monitor's Name: Z. Mendes**

*Vigor: poor (discolored, growth stunted, plant stressed), fair (mostly green, average to below average growth, plant not remarkable), good (leaves green, average to above average growth ), excellent (rapid growth, plant thriving). #A/D/M: alive, dead, missing or not planted

| Plant ID | A/D/M# | Canopy Size (cm) | Stem Diamter (cm) | Height (cm) | Vigor Rating | Comments |
|---|---|---|---|---|---|---|
| 3-1a | M | | | | | |
| 3-1b | M | | | | | |
| 3-4a | A | 122 | NA | 114 | F | |
| 3-4b | A | 12.5 | NA | 25 | G | |
| 3-7a | A | 152 | 2.5 | 244 | E | |
| 3-7b | A | 25 | NA | 24 | G | |
| 3-11a | A | 117 | 0.6 | 135 | G | |
| 3-11b | A | 20 | NA | 30 | G | |
| 3-14a | A | 188 | 1.3 | 244 | E | |
| 3-14b | A | 18 | NA | 25 | F | |
| 3-20a | M | | | | | |
| 3-20b | M | | | | | |
| 3-25a | D | | | | | |
| 3-25b | M | | | | | |
| 3-30a | M | | | | | |
| 3-30b | A | 20 | NA | 30 | G | |
| 3-35a | A | 274 | 5 | 457 | E | |
| 3-35b | A | 30 | NA | 50 | F | |
| 3-40a | M | | | | | |
| 3-40b | A | 91 | NA | 61 | F | |
| 3-44a | A | 244 | 7.6 | 580 | G | |
| 3-44b | M | | | | | |
| 3-49a | A | 305 | 5 | 213 | G | |
| 3-49b | A | 25 | NA | 60 | G | |
| 3-52a | D | | | | | |
| 3-52b | M | | | | | |
| 3-56a | D | | | | | |
| 3-56b | A | 25 | NA | 25 | F | |
| 2-1a | A | 91 | 1.2 | 210 | F | |
| 2-1b | A | 99 | NA | 112 | F | |
| 2-5a | M | | | | | |
| 2-5b | A | 45 | NA | 61 | G | |
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|---|---|---|---|---|---|---|
| **2-9a** | **M** | | | | | |
| **2-9b** | **M** | | | | | |
| **2-13a** | **M** | | | | | |
| **2-13b** | **A** | 100 | NA | 112 | G | |
| **2-17a** | **M** | | | | | |
| **2-17b** | **A** | 75 | NA | 100 | G | |
| **2-22a** | **M** | | | | | |
| **2-22b** | **A** | 155 | NA | 130 | G | |
| **2-26a** | **M** | | | | | |
| **2-26b** | **M** | | | | | |
| **2-30a** | **A** | 91 | 0.6 | 198 | F | |
| **2-30b** | **D** | | | | | |
| **2-33a** | **M** | | | | | |
| **2-33b** | **A** | 100 | NA | 129 | E | |
| **2-38a** | **A** | 122 | 1.3 | 213 | G | |
| **2-38b** | **A** | 99 | NA | 75 | G | |
| **2-43a** | **M** | | | | | |
| **2-43b** | **A** | 74 | NA | 100 | G | |
| **2-46a** | **M** | | | | | |
| **2-46b** | **A** | 100 | NA | 70 | G | |
| **2-49a** | **A** | 90 | 1.25 | 259 | G | |
| **2-49b** | **A** | 75 | NA | 60 | G | |
| **2-55a** | **M** | | | | | |
| **2-55b** | **A** | 36 | NA | 50 | G | |
| **2-59a** | **A** | 75 | 0.5 | 180 | F | |
| **2-59b** | **A** | 80 | NA | 90 | G | |
| **2-65a** | **M** | | | | | |
| **2-65b** | **A** | 20 | NA | 40 | F | |
| **2-69a** | **M** | | | | | |
| **2-69b** | **A** | 25 | NA | 60 | F | |
| **2-74a** | **M** | | | | | |
| **2-74b** | **M** | | | | | |
| **2-78a** | **M** | | | | | |
| **2-78b** | **A** | 25 | NA | 25 | F | |
| **2-82a** | **M** | | | | | |
| **2-82b** | **M** | | | | | |
| **1-3a** | **A** | 61 | 0.6 | 152 | F | |
| **1-3b** | **M** | | | | | |
| **1-10a** | **A** | 244 | 1.3 | 183 | F | |
| **1-10b** | **A** | 30 | NA | 80 | F | |
| **1-15a** | **A** | 122 | 1.25 | 122 | G | |
| **1-15b** | **M** | | | | | |
| **1-45a** | **A** | 122 | 0.6 | 152 | G | |
| **1-45b** | **A** | 75 | NA | 30 | E | |
| **1-41a** | **M** | | | | | |
| **1-41b** | **A** | 100 | NA | 100 | G | |
| **1-38a** | **A** | 122 | NA | 91 | F | |
| **1-38b** | **M** | | | | | |

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|---|---|---|---|---|---|---|
| **1-34a** | **A** | NA | NA | 46 | F | |
| **1-34b** | **M** | | | | | |

# NCRLT Field Observations Form



**Site: Doe Island** **County: Butte**

**Date: 9-27-11 & 9-28-11** **Monitor(s): Z. Mendes**

**Notes:** general observable conditions (weather, growing conditions, irrigation system, fencing/exclosures, vandalism, etc.)

weather: clear and warm
growing conditions: site has demonstrated good growth
irrigation system: in good condition
fencing: none present
note: some browsing of planted trees has occurred

**Soil moisture:** 1-dry (crumbly and dusty, near wilting point), 2-damp (crumbly but not dusty, some moisture), 3-moist (soft and friable, available water), 4-wet (leaves hand damp, near or above field capacity).

| Sample | moisture at depth (cm) | | | Comments |
|---|---|---|---|---|
| | 0 | 10 | | |
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**Understory Vegetation:** height (cm), cover of all veg (%), seed (1-ripe, 2-immature, 3-none)

| Sample | Height | Cover | Seed | Dominate Plant Species |
|---|---|---|---|---|
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**Recommendations or follow-up required:**

# NCRLT Photodocumentation Data Form



**Site: Doe Island** **County: Butte** **USGS Quad: Llano Seco** **Camera Used: Canon PowerShot A2200 14.1 MP**

**Date: 9-26-11** **Monitor's Name: Z. Mendes** **Camera Height (m): 2**

| Station ID | Photo ID | %CC | Compass Bearing (degrees) | UTM (x) | UTM (y) | Elevation (m) | GPS Accuracy (m) | Comments |
|---|---|---|---|---|---|---|---|---|
| **DI 1** | 1 | 0 | 210 | 588140 | 4384748 | 36 | 5 | |
| **DI 1** | 2 | 0 | 250 | 588140 | 4384748 | 36 | 5 | |
| **DI 2** | 5 | 0 | 60 | 588298 | 4384536 | 36 | 5 | |
| **DI 2** | 6,7 | 0 | 100 | 588298 | 4384536 | 36 | 5 | |
| **DI 3** | 3 | 0 | 340 | 588117 | 4384692 | 36 | 5 | |
| **DI 3** | 4 | 0 | 260 | 588117 | 4384692 | 36 | 5 | |
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# NCRLT Vegetation Monitoring Data Form

Percent survival: The number of established trees and shrubs that were planted during the initial planting are determined during each of the five years in the monitoring timeline.
Plant Vigor: During each of the 5 monitoring years, 25 percent of the plantings in each mitigation area are randomly selected and measured to determine canopy size, stem diameter at stem midpoint (diameter at breast height [dbh] for trees 4 feet and taller), and height. Plant vigor* is rated as excellent, good, fair, or poor.

*Please note that due to the high number of plantings on this site, only data collected for the "plant vigor" sub-sample are included on this datasheet. Survivorship data were documented in a different format following the planting map provided by Llano Seco Rancho and are available upon request.

**Site: Doe Island** **County: Butte**

**Date: 9/27/2011 & 9/28/2011** **Monitor's Name: Z. Mendes**

*Vigor: poor (discolored, growth stunted, plant stressed), fair (mostly green, average to below average growth, plant not remarkable), good (leaves green, average to above average growth ), excellent (rapid growth, plant thriving). #A/D/M: alive, dead, missing or not planted

| Plant ID | A/D/M# | Canopy Size (cm) | Stem Diamter (cm) | Height (cm) | Vigor Rating | Comments |
|---|---|---|---|---|---|---|
| **1-1a** | **A** | 275 | 3 | 275 | G | |
| **1-1b** | **A** | 91 | NA | 122 | E | |
| **1-3a** | **A** | 90 | 1.25 | 152 | F | |
| **1-3b** | **A** | 150 | 0.3 | 150 | F | |
| **1-8a** | **M** | | | | | |
| **1-8b** | **A** | 91 | NA | 90 | G | |
| **1-11a** | **A** | 61 | 0.6 | 213 | P | |
| **1-11b** | **A** | 183 | NA | 30 | E | |
| **1-16a** | **A** | 305 | 3 | 300 | G | |
| **1-16b** | **A** | NA | NA | NA | G | |
| **1-20a** | **M** | | | | | |
| **1-20b** | **A** | 122 | NA | 91 | E | |
| **1-26a** | **A** | 366 | 4 | 455 | G | |
| **1-26b** | **A** | NA | NA | NA | G | |
| **1-34a** | **A** | 244 | 2.5 | 457 | G | |
| **1-34b** | **A** | NA | NA | NA | G | |
| **1-38a** | **A** | 183 | NA | 91 | E | |
| **1-38b** | **M** | | | | | |
| **1-41a** | **A** | 61 | 5 | 305 | E | |
| **1-41b** | **A** | 60 | NA | 90 | G | |
| **1-44a** | **A** | 91 | 1.25 | 210 | F | |
| **1-44b** | **A** | 305 | 0.6 | 152 | E | |
| **1-50a** | **M** | | | | | |
| **1-50b** | **A** | 61 | NA | 107 | F | |
| **1-54a** | **M** | | | | | |
| **1-54b** | **M** | | | | | |
| **1-59a** | **A** | 244 | 1.25 | 168 | F | |
| **1-59b** | **M** | | | | | |
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|---|---|---|---|---|---|---|
| **1-63a** | **M** | | | | | |
| **1-63b** | **M** | | | | | |
| **1-68a** | **A** | 183 | 2.5 | 275 | F | |
| **1-68b** | **A** | 122 | NA | 107 | E | |
| **1-71a** | **A** | 30 | NA | 105 | F | |
| **1-71b** | **A** | 30 | NA | 105 | G | |
| **1-74a** | **M** | | | | | |
| **1-74b** | **M** | | | | | |
| **2-1a** | **A** | 210 | 2.5 | 270 | F | |
| **2-1b** | **A** | 180 | NA | 150 | E | |
| **2-3a** | **M** | | | | | |
| **2-3b** | **M** | | | | | |
| **2-8a** | **M** | | | | | |
| **2-8b** | **A** | 60 | NA | 90 | F | |
| **2-16a** | **A** | 30 | NA | 105 | F | |
| **2-16b** | **A** | 60 | NA | 122 | G | |
| **2-20a** | **M** | | | | | |
| **2-20b** | **A** | 122 | NA | 107 | E | |
| **2-26a** | **A** | 305 | 5 | 366 | E | |
| **2-26b** | **M** | | | | | |
| **2-28a** | **A** | 305 | 5 | 457 | G | |
| **2-28b** | **M** | | | | | |
| **2-34a** | **A** | 455 | 2.5 | 365 | E | |
| **2-34b** | **A** | NA | NA | NA | F | |
| **2-38a** | **A** | 300 | 6.25 | 396 | G | |
| **2-38b** | **A** | 122 | 0.6 | 213 | E | |
| **2-41a** | **A** | 305 | 5 | 518 | F | |
| **2-41b** | **M** | | | | | |
| **2-44a** | **A** | 183 | 1.25 | 212 | F | |
| **2-44b** | **M** | | | | | |
| **2-50a** | **M** | | | | | |
| **2-50b** | **M** | | | | | |
| **2-54a** | **M** | | | | | |
| **2-54b** | **A** | 122 | NA | 107 | E | |
| **2-59a** | **A** | 244 | 6.25 | 240 | G | |
| **2-59b** | **A** | 183 | NA | 106 | E | |
| **2-63a** | **A** | 61 | NA | 91 | F | |
| **2-63b** | **A** | 60 | NA | 90 | F | |
| **2-68a** | **A** | 76 | 1.25 | 198 | P | |
| **2-68b** | **A** | 61 | 1.25 | 107 | G | |
| **2-71a** | **M** | | | | | |
| **2-71b** | **M** | | | | | |
| **2-74a** | **A** | 152 | 1.25 | 305 | F | |
| **2-74b** | **M** | | | | | |
| **3-1a** | **M** | | | | | |
| **3-1b** | **A** | 183 | 0.6 | 198 | G | |
| **3-3a** | **A** | 366 | 5 | 548 | E | |
| **3-3b** | **M** | | | | | |

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|---|---|---|---|---|---|---|
| **3-8a** | **A** | 213 | NA | 107 | G | |
| **3-8b** | **A** | 91 | NA | 76 | P | |
| **3-11a** | **A** | 76 | 0.6 | 198 | P | |
| **3-11b** | **M** | | | | | |
| **3-16a** | **A** | 91 | 1.25 | 274 | P | |
| **3-16b** | **A** | 30 | NA | 61 | F | |
| **3-20a** | **A** | 15 | 0.3 | 137 | F | |
| **3-20b** | **A** | 152 | NA | 122 | E | |
| **3-26a** | **A** | 183 | 5 | 518 | E | |
| **3-26b** | **D** | | | | | |
| **3-28a** | **M** | | | | | |
| **3-28b** | **M** | | | | | |
| **3-34a** | **A** | 305 | NA | 91 | E | |
| **3-34b** | **A** | 213 | 0.6 | 183 | F | |
| **3-38a** | **M** | | | | | |
| **3-38b** | **M** | | | | | |
| **3-41a** | **A** | 610 | 13 | 760 | E | |
| **3-41b** | **A** | NA | NA | NA | F | |
| **3-44a** | **M** | | | | | |
| **3-44b** | **D** | | | | | |
| **3-50a** | **M** | | | | | |
| **3-50b** | **M** | | | | | |
| **3-54a** | **A** | 305 | 6.25 | 305 | P | |
| **3-54b** | **M** | | | | | |
| **3-59a** | **M** | | | | | |
| **3-59b** | **A** | 183 | 0.6 | 290 | F | |
| **3-63a** | **M** | | | | | |
| **3-63b** | **A** | 183 | NA | 46 | E | |
| **3-68a** | **M** | | | | | |
| **3-68b** | **A** | 152 | 0.6 | 183 | G | |
| **3-71a** | **A** | 46 | NA | 107 | F | |
| **3-71b** | **A** | 91 | NA | 105 | G | |
| **3-74a** | **D** | | | | | |
| **3-74b** | **A** | 138 | 0.3 | 137 | G | |
| **4-1a** | **A** | 244 | 5 | 240 | F | |
| **4-1b** | **A** | 305 | 0.6 | 274 | E | |
| **4-3a** | **A** | 122 | 3.8 | 366 | F | |
| **4-3b** | **D** | | | | | |
| **4-8a** | **A** | 91 | 1.25 | 305 | F | |
| **4-8b** | **A** | 457 | 0.6 | 275 | E | |
| **4-11a** | **M** | | | | | |
| **4-11b** | **A** | 305 | NA | 91 | E | |
| **4-16a** | **A** | 305 | 7.5 | 457 | G | |
| **4-16b** | **A** | 180 | 0.6 | 180 | E | |
| **4-20a** | **A** | 305 | 7.5 | 300 | G | |
| **4-20b** | **D** | | | | | |
| **4-26a** | **A** | 305 | 0.6 | 244 | G | |
| **4-26b** | **A** | 244 | 0.5 | 366 | F | |

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| **4-30a** | **A** | 183 | 3.8 | 274 | F | |
| **4-30b** | **M** | | | | | |
| **4-34a** | **A** | 152 | 3.8 | 259 | F | |
| **4-34b** | **A** | 91 | 0.3 | 137 | E | |
| **4-38a** | **A** | 61 | 2 | 290 | P | |
| **4-38b** | **D** | | | | | |
| **4-41a** | **A** | 305 | 4.4 | 366 | G | |
| **4-41b** | **A** | 152 | 1.25 | 275 | F | |
| **4-44a** | **A** | 180 | 3.8 | 365 | F | |
| **4-44b** | **D** | | | | | |
| **4-50a** | **A** | 152 | 2.5 | 274 | F | |
| **4-50b** | **A** | 61 | NA | 45 | G | |
| **4-54a** | **A** | 207 | 0.6 | 213 | F | |
| **4-54b** | **A** | 15 | 0.3 | 122 | F | |
| **4-59a** | **M** | | | | | |
| **4-59b** | **M** | | | | | |
| **4-63a** | **A** | 305 | 1.25 | 366 | E | |
| **4-63b** | **A** | 244 | 1.25 | 366 | G | |
| **4-68a** | **A** | 213 | 2.5 | 275 | F | |
| **4-68b** | **A** | 152 | 0.3 | 152 | E | |
| **4-71a** | **A** | 548 | 12.5 | 610 | E | |
| **4-71b** | **A** | | | | F | |
| **4-74a** | **A** | | | | P | |
| **4-74b** | **A** | | | | F | |
| **5-1a** | **M** | | | | | |
| **5-1b** | **A** | 91 | 0.3 | 152 | E | |
| **5-3a** | **A** | 122 | 3.2 | 305 | P | |
| **5-3b** | **M** | | | | | |
| **5-8a** | **A** | 91 | NA | 46 | F | |
| **5-8b** | **M** | | | | | |
| **5-11a** | **A** | 15 | NA | 107 | F | |
| **5-11b** | **A** | 305 | 0.15 | 183 | E | |
| **5-16a** | **A** | 122 | 30 | 244 | F | |
| **5-16b** | **A** | 91 | NA | 90 | E | |
| **5-20a** | **A** | 90 | 0.3 | 152 | G | |
| **5-20b** | **M** | | | | | |
| **5-26a** | **A** | 122 | 1.25 | 305 | G | |
| **5-26b** | **A** | 214 | 0.6 | 274 | E | |
| **5-34a** | **A** | 305 | 5 | 396 | E | |
| **5-34b** | **M** | | | | | |
| **5-38a** | **M** | | | | | |
| **5-38b** | **M** | | | | | |
| **5-41a** | **M** | | | | | |
| **5-41b** | **M** | | | | | |
| **5-44a** | **M** | | | | | |
| **5-44b** | **M** | | | | | |
| **5-50a** | **A** | 304 | 0.6 | 305 | G | |
| **5-50b** | **A** | 244 | 0.15 | 198 | G | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **5-54a** | **A** | 90 | 0.6 | 198 | P | |
| **5-54b** | **A** | 90 | NA | 91 | F | |
| **5-59a** | **D** | | | | | |
| **5-59b** | **A** | 305 | 1.25 | 300 | E | |
| **5-63a** | **A** | 92 | 2.5 | 274 | F | |
| **5-63b** | **A** | 183 | NA | 61 | F | |
| **5-68a** | **M** | | | | | |
| **5-68b** | **A** | 91 | 0.2 | 137 | E | |
| **5-71a** | **A** | 243 | 2 | 396 | G | |
| **5-71b** | **M** | | | | | |
| **5-74a** | **M** | | | | | |
| **5-74b** | **M** | | | | | |
| **6-1a** | **A** | 244 | 2.5 | 213 | F | |
| **6-1b** | **A** | 91 | 0.5 | 183 | F | |
| **6-3a** | **M** | | | | | |
| **6-3b** | **D** | | | | | |
| **6-8a** | **M** | | | | | |
| **6-8b** | **A** | NA | NA | NA | E | |
| **6-11a** | **M** | | | | | |
| **6-11b** | **A** | NA | NA | NA | G | |
| **6-16a** | **A** | 75 | NA | 107 | F | |
| **6-16b** | **A** | 304 | NA | 75 | E | |
| **6-20a** | **M** | | | | | |
| **6-20b** | **D** | | | | | |
| **6-26a** | **A** | 450 | 6.3 | 450 | G | |
| **6-26b** | **A** | 107 | NA | 75 | G | |
| **6-34a** | **A** | 305 | 5 | 366 | F | |
| **6-34b** | **A** | 244 | 0.2 | 183 | E | |
| **6-38a** | **A** | 244 | 2.5 | 214 | P | |
| **6-38b** | **D** | | | | | |
| **6-41a** | **A** | 60 | 1.25 | 180 | P | |
| **6-41b** | **M** | | | | | |
| **6-44a** | **A** | 244 | 3.8 | 300 | G | |
| **6-44b** | **A** | 61 | NA | 60 | E | |
| **6-50a** | **M** | | | | | |
| **6-50b** | **M** | | | | | |
| **6-54a** | **A** | 305 | 1.25 | 335 | G | |
| **6-54b** | **A** | 212 | 1.25 | 275 | G | |
| **6-59a** | **A** | 244 | 5 | 305 | F | |
| **6-59b** | **M** | | | | | |
| **6-63a** | **A** | NA | NA | NA | G | |
| **6-63b** | **M** | | | | | |
| **6-68a** | **A** | 61 | 1.25 | 215 | P | |
| **6-68b** | **A** | 183 | 1 | 183 | E | |
| **6-71a** | **A** | 183 | 2.5 | 244 | E | |
| **6-71b** | **A** | 213 | 0.5 | 210 | G | |
| **6-74a** | **M** | | | | | |
| **6-74b** | **M** | | | | | |

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|---|---|---|---|---|---|---|
| **7-1a** | **A** | 183 | 3.8 | 366 | F | |
| **7-1b** | **A** | 457 | 1.25 | 244 | G | |
| **7-3a** | **A** | 305 | 4.4 | 305 | F | |
| **7-3b** | **A** | 61 | 0.6 | 213 | E | |
| **7-8a** | **M** | | | | | |
| **7-8b** | **A** | 61 | 0.6 | 183 | G | |
| **7-11a** | **A** | 152 | 3.2 | 335 | F | |
| **7-11b** | **A** | 30 | NA | 30 | P | |
| **7-16a** | **A** | 305 | 9 | 610 | E | |
| **7-16b** | **A** | 122 | NA | 61 | G | |
| **7-20a** | **A** | 91 | 0.3 | 130 | G | |
| **7-20b** | **M** | | | | | |
| **7-26a** | **A** | 244 | 5 | 366 | F | |
| **7-26b** | **M** | | | | | |
| **7-34a** | **A** | 244 | NA | 107 | E | |
| **7-34b** | **M** | | | | | |
| **7-38a** | **A** | 274 | 2.5 | 305 | P | |
| **7-38b** | **A** | 610 | 0.6 | 213 | E | |
| **7-41a** | **A** | 305 | 2.5 | 270 | E | |
| **7-41b** | **A** | 91 | NA | 90 | G | |
| **7-44a** | **M** | | | | | |
| **7-44b** | **M** | | | | | |
| **7-50a** | **M** | | | | | |
| **7-50b** | **A** | 183 | 0.3 | 180 | E | |
| **7-54a** | **M** | | | | | |
| **7-54b** | **A** | 305 | NA | 107 | G | |
| **7-59a** | **A** | 180 | NA | 90 | G | |
| **7-59b** | **M** | | | | | |
| **7-63a** | **A** | 75 | NA | 84 | E | |
| **7-63b** | **A** | 182 | NA | 61 | E | |
| **7-68a** | **A** | 213 | 2 | 198 | F | |
| **7-68b** | **A** | 213 | 1.25 | 305 | E | |
| **7-71a** | **A** | 46 | 0.3 | 153 | P | |
| **7-71b** | **M** | | | | | |
| **7-74a** | **A** | 90 | 3.2 | 396 | F | |
| **7-74b** | **A** | 457 | 0.5 | 180 | E | |
| **8-1a** | **A** | 213 | 1.25 | 210 | P | |
| **8-1b** | **A** | 183 | 1.25 | 275 | E | |
| **8-3a** | **A** | 210 | 5 | 457 | F | |
| **8-3b** | **M** | | | | | |
| **8-11a** | **A** | 91 | 2 | 304 | P | |
| **8-11b** | **M** | | | | | |
| **8-16a** | **A** | 152 | 0.3 | 198 | E | |
| **8-16b** | **A** | 91 | NA | 114 | E | |
| **8-20a** | **A** | 61 | 0.6 | 183 | G | |
| **8-20b** | **M** | | | | | |
| **8-26a** | **M** | | | | | |
| **8-26b** | **M** | | | | | |

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| **8-34a** | **A** | 183 | 0.3 | 175 | G | |
| **8-34b** | **M** | | | | | |
| **8-38a** | **A** | 76 | 7 | 396 | G | |
| **8-38b** | **A** | 75 | 0.3 | 191 | G | |
| **8-41a** | **M** | | | | | |
| **8-41b** | **A** | 518 | 2 | 290 | E | |
| **8-44a** | **A** | 122 | 6 | 396 | F | |
| **8-44b** | **A** | 120 | 0.4 | 175 | G | |
| **8-50a** | **M** | | | | | |
| **8-50b** | **M** | | | | | |
| **8-54a** | **A** | 61 | NA | 75 | P | |
| **8-54b** | **A** | 15 | 0.6 | 183 | P | |
| **8-59a** | **A** | 30 | NA | 107 | P | |
| **8-59b** | **M** | | | | | |
| **8-63a** | **A** | 275 | 2.5 | 305 | G | |
| **8-63b** | **A** | 61 | NA | 107 | G | |
| **8-68a** | **M** | | | | | |
| **8-68b** | **A** | 305 | NA | 46 | E | |
| **8-71a** | **M** | | | | | |
| **8-71b** | **A** | 30 | 0.4 | 175 | F | |
| **8-74a** | **D** | | | | | |
| **8-74b** | **M** | | | | | |
| **9-1a** | **A** | 244 | 2 | 274 | F | |
| **9-1b** | **A** | 122 | NA | 114 | G | |
| **9-3a** | **A** | 270 | 2.5 | 366 | F | |
| **9-3b** | **M** | | | | | |
| **9-11a** | **M** | | | | | |
| **9-11b** | **A** | 365 | 0.75 | 198 | E | |
| **9-16a** | **A** | 215 | 4 | 366 | G | |
| **9-16b** | **A** | 245 | NA | 45 | E | |
| **9-20a** | **A** | 45 | NA | 115 | G | |
| **9-20b** | **A** | 90 | NA | 115 | F | |
| **9-26a** | **A** | 366 | 7 | 395 | P | |
| **9-26b** | **M** | | | | | |
| **9-34a** | **M** | | | | | |
| **9-34b** | **M** | | | | | |
| **9-38a** | **M** | | | | | |
| **9-38b** | **M** | | | | | |
| **9-41a** | **A** | 244 | 6 | 360 | P | |
| **9-41b** | **A** | 305 | 0.5 | 183 | E | |
| **9-44a** | **A** | 244 | 5 | 396 | E | |
| **9-44b** | **M** | | | | | |
| **9-50a** | **A** | 275 | NA | 45 | F | |
| **9-50b** | **M** | | | | | |
| **9-54a** | **A** | 245 | 5 | 274 | F | |
| **9-54b** | **M** | | | | | |
| **9-59a** | **A** | 180 | 2.5 | 198 | F | |
| **9-59b** | **M** | | | | | |

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|---|---|---|---|---|---|---|
| **9-63a** | **M** | | | | | |
| **9-63b** | **M** | | | | | |
| **9-68a** | **D** | | | | | |
| **9-68b** | **M** | | | | | |
| **9-71a** | **M** | | | | | |
| **9-71b** | **M** | | | | | |
| **9-74a** | **M** | | | | | |
| **9-74b** | **NP** | | | | | |
| **10-1a** | **A** | 180 | 2.5 | 206 | P | |
| **10-1b** | **A** | 180 | NA | 30 | P | |
| **10-3a** | **A** | 122 | 0.4 | 16 | E | |
| **10-3b** | **M** | | | | | |
| **10-11a** | **A** | 275 | 4 | 396 | P | |
| **10-11b** | **M** | | | | | |
| **10-16a** | **A** | 304 | 5 | 395 | F | |
| **10-16b** | **A** | 122 | 0.5 | 152 | P | |
| **10-20a** | **A** | 183 | 0.6 | 305 | F | |
| **10-20b** | **M** | | | | | |
| **10-26a** | **M** | | | | | |
| **10-26b** | **A** | 76 | 0.6 | 213 | F | |
| **10-34a** | **A** | 274 | 5 | 335 | E | |
| **10-34b** | **A** | 61 | NA | 114 | G | |
| **10-38a** | **A** | 305 | 5 | 365 | F | |
| **10-38b** | **M** | | | | | |
| **10-41a** | **A** | 244 | 5 | 244 | F | |
| **10-41b** | **M** | | | | | |
| **10-44a** | **A** | 274 | 3 | 274 | F | |
| **10-44b** | **M** | | | | | |
| **10-50a** | **M** | | | | | |
| **10-50b** | **A** | 183 | NA | 61 | E | |
| **10-54a** | **A** | 183 | NA | 114 | F | |
| **10-54b** | **A** | 45 | 0.4 | 264 | F | |
| **10-59a** | **A** | 122 | 0.6 | 183 | F | |
| **10-59b** | **A** | 61 | NA | 114 | F | |
| **10-63a** | **M** | | | | | |
| **10-63b** | **M** | | | | | |
| **10-68a** | **A** | 76 | 2 | 175 | P | |
| **10-68b** | **A** | 61 | NA | 175 | G | |
| **10-71a** | **M** | | | | | |
| **10-71b** | **M** | | | | | |
| **10-74a** | **NP** | | | | | |
| **10-74b** | **NP** | | | | | |
| **11-1a** | **A** | 215 | 3 | 370 | G | |
| **11-1b** | **A** | 305 | 0.6 | 305 | E | |
| **11-3a** | **A** | 305 | 4 | 396 | G | |
| **11-3b** | **M** | | | | | |
| **11-11a** | **M** | | | | | |
| **11-11b** | **A** | 91 | 0.3 | 152 | G | |

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| **11-16a** | **A** | 90 | 4 | 320 | F | |
| **11-16b** | **A** | 90 | 0.4 | 213 | E | |
| **11-20a** | **A** | 213 | 3 | 335 | F | |
| **11-20b** | **A** | 91 | 0.3 | 152 | P | |
| **11-26a** | **A** | 305 | 5 | 305 | F | |
| **11-26b** | **M** | | | | | |
| **11-34a** | **M** | | | | | |
| **11-34b** | **A** | 76 | NA | 107 | G | |
| **11-38a** | **A** | 244 | 5 | 457 | F | |
| **11-38b** | **M** | | | | | |
| **11-41a** | **A** | 46 | 0.6 | 164 | G | |
| **11-41b** | **M** | | | | | |
| **11-44a** | **A** | 152 | 0.6 | 183 | G | |
| **11-44b** | **A** | 91 | 0.4 | 145 | F | |
| **11-50a** | **A** | 183 | 4 | 375 | F | |
| **11-50b** | **A** | 30 | NA | 30 | P | |
| **11-54a** | **A** | 305 | 2.5 | 244 | F | |
| **11-54b** | **A** | 30 | 0.3 | 183 | F | |
| **11-59a** | **M** | | | | | |
| **11-59b** | **M** | | | | | |
| **11-63a** | **A** | 274 | NA | 91 | F | |
| **11-63b** | **A** | 30 | NA | 30 | P | |
| **11-68a** | **A** | 23 | NA | 107 | P | |
| **11-68b** | **A** | 76 | NA | 105 | E | |
| **11-71a** | **M** | | | | | |
| **11-71b** | **A** | 90 | NA | 90 | E | |
| **11-74a** | **NP** | | | | | |
| **11-74b** | **NP** | | | | | |
| **12-1a** | **A** | 244 | 4.5 | 305 | G | |
| **12-1b** | **M** | | | | | |
| **12-3a** | **M** | | | | | |
| **12-3b** | **M** | | | | | |
| **12-8a** | **A** | 76 | 2.5 | 274 | P | |
| **12-8b** | **A** | 304 | 0.6 | 244 | E | |
| **12-11a** | **M** | | | | | |
| **12-11b** | **A** | 305 | 0.5 | 245 | E | |
| **12-16a** | **A** | 61 | 1.25 | 152 | P | |
| **12-16b** | **A** | 60 | NA | 60 | F | |
| **12-20a** | **A** | 46 | 1.25 | 23 | E | |
| **12-20b** | **A** | 91 | NA | 91 | P | |
| **12-26a** | **A** | 23 | 1.25 | 305 | F | |
| **12-26b** | **A** | 183 | 0.6 | 198 | E | |
| **12-34a** | **M** | | | | | |
| **12-34b** | **A** | 15 | 0.6 | 195 | F | |
| **12-38a** | **A** | 305 | 5 | 300 | G | |
| **12-38b** | **A** | 61 | NA | 60 | P | |
| **12-41a** | **M** | | | | | |
| **12-41b** | **A** | 30 | 0.3 | 152 | F | |

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| **12-44a** | **M** | | | | | |
| **12-44b** | **A** | 30 | 0.5 | 275 | G | |
| **12-50a** | **A** | 366 | 6.25 | 457 | E | |
| **12-50b** | **D** | | | | | |
| **12-54a** | **A** | 122 | 0.3 | 152 | F | |
| **12-54b** | **M** | | | | | |
| **12-59a** | **A** | 275 | 3 | | P | |
| **12-59b** | **M** | | | | | |
| **12-63a** | **D** | | | | | |
| **12-63b** | **M** | | | | | |
| **12-68a** | **A** | 30 | NA | 61 | P | |
| **12-68b** | **A** | 60 | | 115 | F | |
| **12-71a** | **M** | | | | | |
| **12-71b** | **A** | 60 | 0.5 | 120 | E | |
| **12-74a** | **NP** | | | | | |
| **12-74b** | **NP** | | | | | |
| **13-1a** | **A** | 183 | 4 | 366 | G | |
| **13-1b** | **M** | | | | | |
| **13-3a** | **A** | 275 | 7 | 457 | F | |
| **13-3b** | **A** | 60 | 0.5 | 152 | F | |
| **13-8a** | **A** | 122 | NA | 23 | G | |
| **13-8b** | **A** | 122 | 0.5 | 150 | E | |
| **13-11a** | **A** | 180 | 2.5 | 315 | F | |
| **13-11b** | **M** | | | | | |
| **13-16a** | **A** | 366 | 4.5 | 274 | F | |
| **13-16b** | **M** | | | | | |
| **13-20a** | **M** | | | | | |
| **13-20b** | **NP** | | | | | |
| **13-26a** | **A** | 244 | 2.5 | 270 | G | |
| **13-26b** | **A** | 182 | | | E | |
| **13-34a** | **A** | 183 | NA | 60 | P | |
| **13-34b** | **A** | 244 | 0.3 | 21 | E | |
| **13-38a** | **A** | 762 | 15 | 549 | E | |
| **13-38b** | **M** | | | | | |
| **13-41a** | **M** | | | | | |
| **13-41b** | **M** | | | | | |
| **13-44a** | **A** | 152 | NA | 76 | G | |
| **13-44b** | **M** | | | | | |
| **13-50a** | **A** | 244 | 3 | 335 | F | |
| **13-50b** | **M** | | | | | |
| **13-54a** | **M** | | | | | |
| **13-54b** | **M** | | | | | |
| **13-59a** | **NP** | | | | | |
| **13-59b** | **NP** | | | | | |
| **13-63a** | **NP** | | | | | |
| **13-63b** | **NP** | | | | | |
| **13-68a** | **NP** | | | | | |
| **13-68b** | **NP** | | | | | |

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|---|---|---|---|---|---|---|
| **13-71a** | **NP** | | | | | |
| **13-71b** | **NP** | | | | | |
| **13-74a** | **NP** | | | | | |
| **13-74b** | **NP** | | | | | |
| **14-1a** | **M** | | | | | |
| **14-1b** | **A** | 122 | NA | 114 | E | |
| **14-3a** | **A** | 91 | 0.3 | 191 | G | |
| **14-3b** | **A** | 30 | 0.4 | 189 | F | |
| **14-8a** | **A** | 122 | 3 | 305 | F | |
| **14-8b** | **A** | 183 | 0.3 | 152 | G | |
| **14-11a** | **A** | 274 | 3 | 274 | F | |
| **14-11b** | **M** | | | | | |
| **14-16a** | **A** | 15 | NA | 114 | P | |
| **14-16b** | **A** | 152 | 0.5 | 183 | G | |
| **14-20a** | **A** | 366 | 4 | 396 | G | |
| **14-20b** | **D** | | | | | |
| **14-26a** | **A** | 240 | 2.5 | 290 | E | |
| **14-26b** | **A** | 180 | 0.6 | 198 | P | |
| **14-34a** | **M** | | | | | |
| **14-34b** | **M** | | | | | |
| **14-38a** | **A** | 152 | NA | 91 | G | |
| **14-38b** | **M** | | | | | |
| **14-41a** | **M** | | | | | |
| **14-41b** | **M** | | | | | |
| **14-44a** | **M** | | | | | |
| **14-44b** | **A** | 122 | 0.3 | 152 | E | |
| **14-50a** | **A** | 305 | 3 | 274 | G | |
| **14-50b** | **D** | | | | | |
| **14-54a** | **A** | 244 | 4 | 305 | P | |
| **14-54b** | **A** | 122 | 0.3 | 152 | P | |
| **14-59a** | **NP** | | | | | |
| **14-59b** | **NP** | | | | | |
| **14-63a** | **M** | | | | | |
| **14-63b** | **M** | | | | | |
| **14-68a** | **NP** | | | | | |
| **14-68b** | **NP** | | | | | |
| **14-71a** | **NP** | | | | | |
| **14-71b** | **NP** | | | | | |
| **14-73a** | **NP** | | | | | |
| **14-74b** | **NP** | | | | | |
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# Appendix B:
# Photos

## Appendix B: M&T Riparian Restoration – Capay Unit

Photo Point C01, Direction of View – 354 degrees
UTM's – 590373 east, 4395319 north
Surveyor – Z. Mendes, Date – 9/26/11

Photo Point C02, Direction of View – 44 degrees
UTM's - 590399 east, 4395210 north
Surveyor – Z. Mendes, Date – 9/26/11

Photo Point C02, Direction of View – 20 degrees
UTM's – 590399 east, 4395210 north
Surveyor – Z. Mendes, Date – 9/26/11

Photo Point C03, Direction of View – 214 degrees
UTM's - 590421 east, 4395139 north
Surveyor – Z. Mendes, Date – 9/26/11

## Appendix B: M&T Riparian Restoration – Doe Island Unit

Photo Point DI-01, Direction of View – 210 degrees
UTM's – 588140 east, 4384748 north
Surveyor – Z. Mendes, Date 9-27-11

Photo Point DI-01, Direction of View – 210 degrees
UTM's - 588140 east, 4384748 north
Surveyor – Z. Mendes, Date 9-27-11

Photo Point DI-02, Direction of View – 340 degrees
UTM's - 588298 east, 4384748 north
Surveyor – Z. Mendes, Date 9-27-11

Photo Point DI-02, Direction of View – 260 degrees
UTM's – 588298 east, 4384748 north
Surveyor – Z. Mendes, Date 9-27-11

Photo Point DI-03, Direction of View – 60 degrees
UTM's – 588117 east, 4384692 north
Surveyor – Z. Mendes, Date 9-27-11

Photo Point DI-03, Direction of View – 100 degrees
UTM's – 588117 east, 4384692 north
Surveyor – Z. Mendes, Date 9-27-11

# 2010 – 2011 Bank Swallow Status Report, Sacramento and Feather Rivers


— **David Wright, DFG North Central Region, Resource Assessment Program**

— **with contributions from the Department of Water Resources (DWR), US Fish and Wildlife Service (USFWS), and other members of the Bank Swallow Technical Advisory Committee**



## Summary

The estimated number of Bank Swallows in Sacramento River surveys was reduced by about one-third in 2010 and 2011 relative to the preceding decade (Figure 1). The Sacramento River and its tributaries are considered to support more than 70% of the California population of this species. This serious recent decline, on top of previous declines in Bank Swallow populations in the State, is causing concern among members of the Bank Swallow Technical Advisory Committee.


## Background

The Bank Swallow (*Riparia riparia*) was listed as a California threatened species in 1989, and a recovery plan prepared in 1992 (CDFG 1992). The Department of Fish and Game's (DFG) North Central Region participates in a multi-party Bank Swallow working group, which formed after rocking of a major Bank Swallow colony site in 2005, and has since been renamed the Bank Swallow Technical Advisory Committee (BANS-TAC). Currently, BANS-TAC is working to develop an up-to-date conservation strategy for the species. Some previous years' monitoring reports are archived on the online DFG Document Library.

Bank Swallows congregate in breeding colonies and construct nesting burrows in near-vertical river banks and similar formations. These burrows are readily counted. Previous reports have used an occupancy factor (e.g., 45 percent) to convert burrow counts to Bank Swallow pair estimates. Our recent work, however, recommends use of burrow counts directly as an index of Bank Swallow population (Wright et al. 2011); therefore, this report revises the past practice of reporting estimated pair numbers and instead reports all counts, both present and past data, in numbers of burrows. As a rule of thumb, breeding pairs are roughly half the number of counted burrows (Wright et al. 2011).

Over the period from 1999 up to 2009, the Bank Swallow population along the Sacramento River appeared relatively stable with about 16,000-18,000 burrows in the long-term monitoring section, which extends from Red Bluff to Colusa (see below).

**Sacramento River – Long-term monitoring section: Red Bluff to Colusa** (data from USFWS – Joe Silveira, Jennifer Isola, and DWR – Adam Henderson, Danika Tsao)

This section (river mile [RM] 243 – 144; termed Reaches 2 and 3) has been monitored for Bank Swallow burrows almost annually since 1986, constituting a unique data set for a threatened species. USFWS, DWR and DFG staff coordinate in conducting the monitoring surveys, which take place during the first weeks of June.

Bank Swallow burrows in this section declined substantially in 2010 and 2011 relative to the preceding decade (Figure 1). In 2010 we counted 10,660 burrows in the long-term monitoring section, a 34% decline from the previous year's count. The 2011 count in this section also remained low with 11,700 burrows counted. The 2010 and 2011 counts bracketed a figure of 11,000 burrows, which is 35% below the figure of 17,000 burrows around which monitoring counts hovered from 1999-2009.

Viewed over the entire scope of data since 1986, the recent reduction suggests a return to the 1993-1998 years of substantially lower Bank Swallow population along the middle Sacramento River (Figure 2).

**Sacramento River – Flanking reaches: Redding to Red Bluff, and Colusa to Verona** (data from DWR, DFG North Region, and DFG North Central Region)

The 2011 monitoring count for the Redding to Red Bluff section (RM 298-244, Reach 1) was 994 burrows in 6 colonies, compared to 2010: 667 burrows in only 2 colonies; 2009: 1253 burrows, 6 colonies[1]; and 2008: 1358 burrows, 6 colonies.

The 2011 monitoring count for the Colusa to Verona section (RM 143-80, Reach 4) was 500 burrows in 6 colonies. This was down from 2010 during which 1344 burrows in 10 colonies were counted, and from 2009 during which 1364 burrows in 11 colonies were counted.

[1] 2009 Reach 1 data include one colony on Cow Creek close to its confluence with the Sacramento River. This colony was not active during 2010 or 2011.

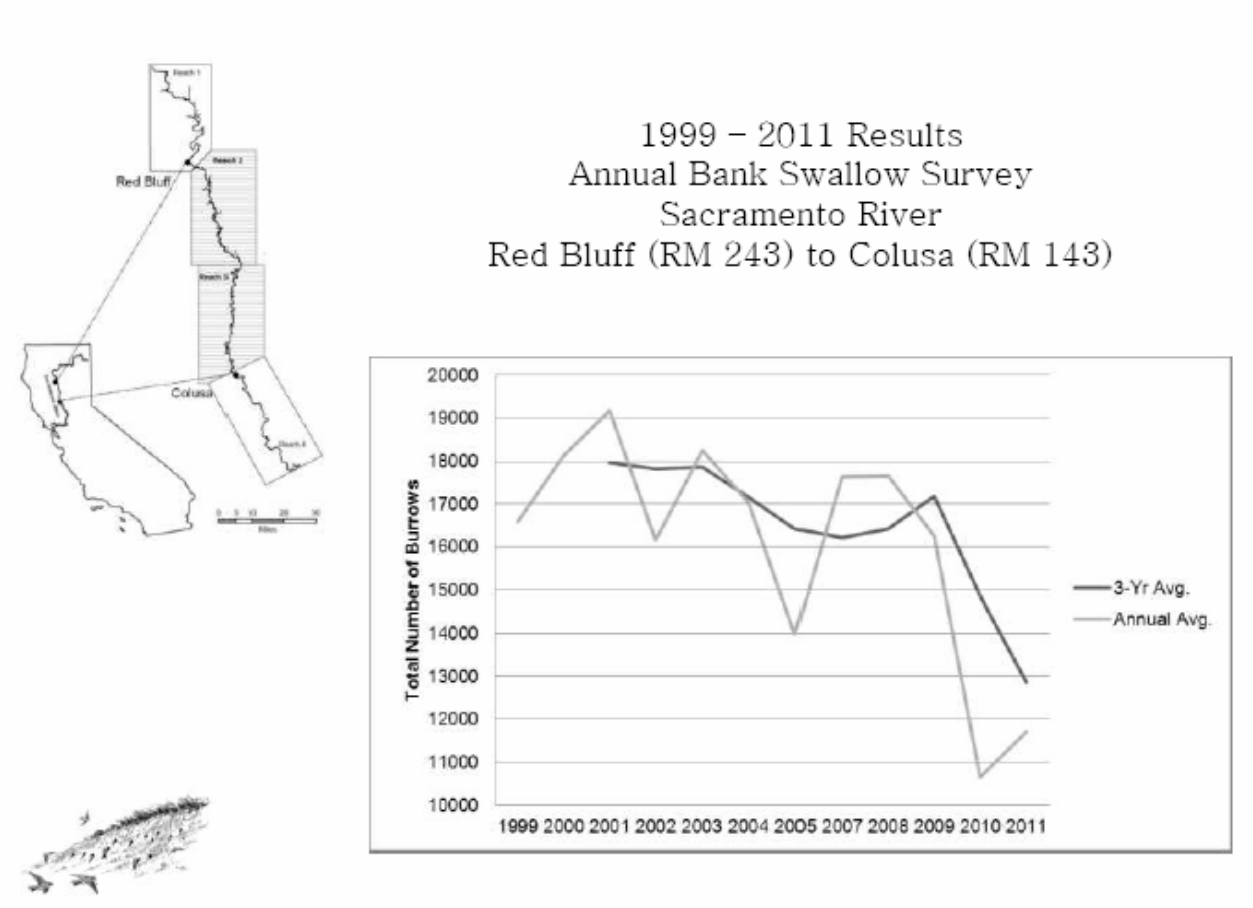


**Figure 1**. Annual burrow counts and 3-year moving-average number of burrows of Bank Swallows on the long-term monitoring section: Red Bluff to Colusa, Sacramento River. Numbers of nesting pairs are approximately half the numbers of burrows. Counts dropped substantially in 2010 and 2011. (Figure courtesy of USFWS: J. Silveira and J. Isola)

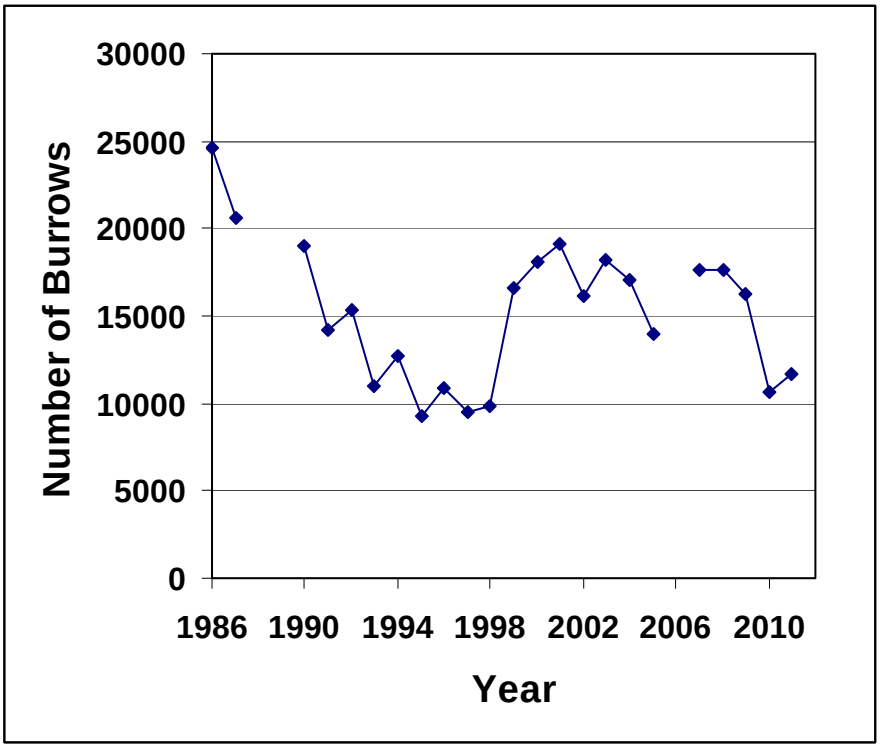


**Figure 2**. Long-term monitoring of Bank Swallow – time series of burrow counts for Red Bluff to Colusa monitoring section. Only years with complete data are included. The recent decline (2010 and 2011) raises concern about a possible return to the 1993-1998 years of substantially lower population levels. As a rough rule of thumb, approximately half of burrows counted support a breeding pair.

**Lower Feather River** (contributed by Ryan Martin, DWR)

The lower Feather River supports fewer Bank Swallows than the middle Sacramento River and was not surveyed regularly prior to 2008.

Monitoring results from the Feather River also showed a 2010-2011 drop in overall population estimate for Bank Swallows. The June 2010 survey counted 1832 burrows in 14 colonies which was an overall decrease in burrows of 35 percent from 2009. Results from the June 2011 Feather River survey were 2517 burrows in 23 colonies. Although this was an increase over the 2010 count and compares to the 2009 count of 2810 burrows, it is below 2008 and 2003 estimates of 3780 and 3600 burrows, respectively, and is less than half of a 1988 Feather River count of about 6600 burrows (Table 1).

There may be a trend of decreasing colony size, with an average colony size in 2011 of 109 burrows, 2010 average of 131 burrows, versus an average of 140 burrows per colony in 2009.

**Table 1. Feather River Summary**

| Survey Year | Burrow Count |
|---|---|
| 2011 | 2517 |
| 2010 | 1832 |
| 2009 | 2808 |
| 2008 | 3787 |
| No counts 2004-2007 | |
| 2003 | 3594 |
| 2002 | 2274 |
| No counts 1989-2001 | |
| 1988 | 6592 |
| 1987 | 7 colonies ranging in size from 140 to 2000 burrows (Humphrey and Garrison 1987) |

## Discussion

The monitoring results for 2010 and 2011 represent a serious decline in the number of nesting Bank Swallows along the Sacramento and Feather rivers. Since previous estimates suggest more than 70 percent of California's Bank Swallow population nests along the Sacramento River (CDFG 1992), this reduction in numbers has serious implications for the statewide population. This recent decline on top of previous reduction in the Bank Swallow population within the state is causing significant concern among participants of the Bank Swallow Technical Advisory Committee.

Pinpointing a particular cause of the recent reduction in numbers is problematic with available data. Factors likely influencing Bank Swallow numbers include recent habitat

loss (banks armored for erosion prevention, for example using rock rip-rap, at two major colony sites from 2005-2009) and high spring flows causing bank collapse. Cumulative loss of Bank Swallow nesting habitat due to bank hardening (Figure 3) has long been associated with the long-term Bank Swallow population decline (Garrison et al. 1987, Moffatt et al. 2005, Garcia et al. 2008, Girvetz 2010). Bank collapse during nesting season destroys burrows and can kill adult swallows, eggs or chicks. Other factors such as weather effects on insect populations or effects on survival of adult or young birds during migration or on their Central and South American winter grounds have not been ruled out.

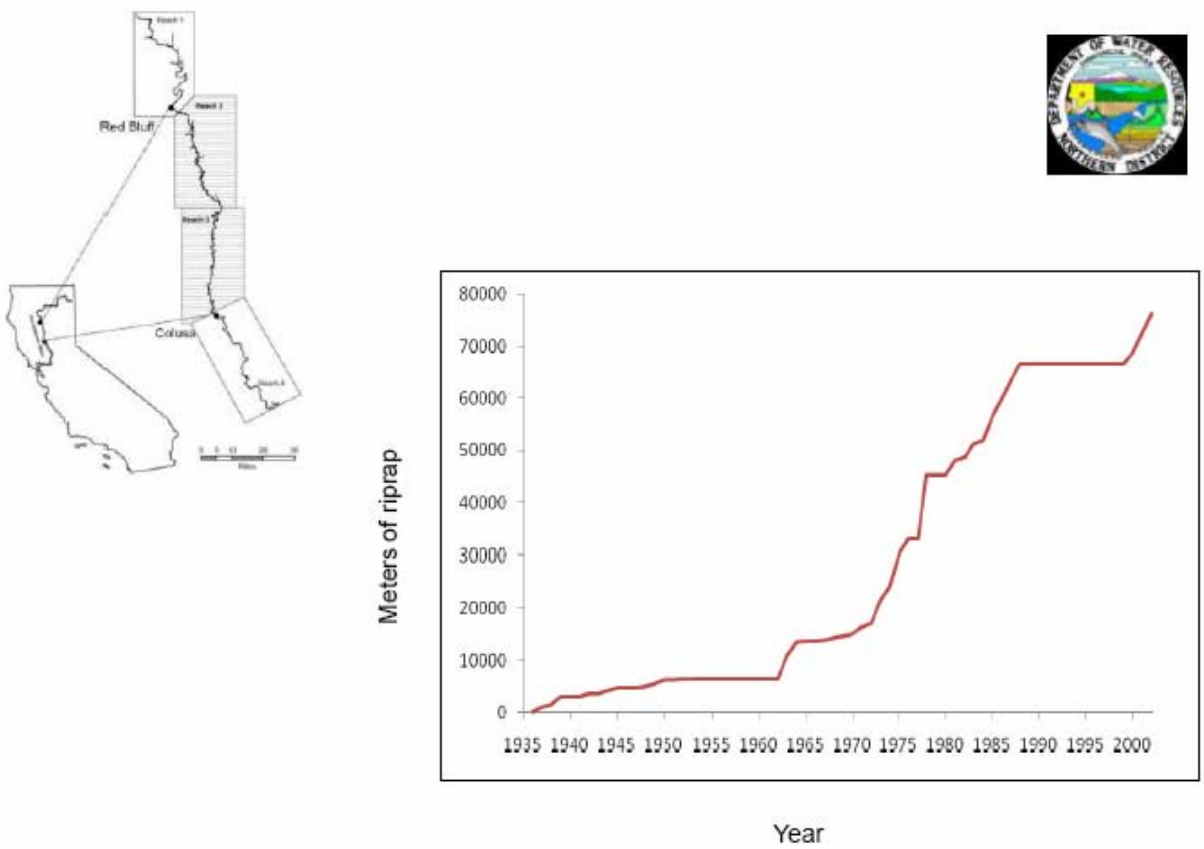


**Figure 3**. Expansion over time in the extent of hardened bank (riprap) on the Sacramento River, Red Bluff to Colusa. The latest available data correspond to nearly 50 miles of riprap. (Figure courtesy Department of Water Resources: A. Henderson)

Bank Swallow monitoring along the Sacramento and Feather Rivers will continue, and for 2012 is scheduled for early June. If burrow counts remain low, we believe a discussion of prompt conservation actions available should be undertaken.

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# Status of the Yellow-billed Cuckoo along the Sacramento River in 2010

Submitted to: California Department of Fish and Game

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## EXECUTIVE SUMMARY

The Yellow-billed Cuckoo is a state endangered species in California with breeding populations along the Sacramento River, Kern River, and Lower Colorado River. In 2010, from mid June until mid August, we conducted an extensive survey of the riparian habitat preferred by the cuckoo along the Sacramento River from Red Bluff to Colusa. We located 18 individual cuckoos using call playback surveys, spanning the entire study region. We performed an occupancy analysis using a range of territory sizes (15-75 ha) because territory size is not known for this population. Occupancy estimates predict that approximately 38 territories were occupied, depending on the size of territories. A population estimate derived from the occupancy estimate would be 38-76 cuckoos since each territory could be occupied by an individual or a pair. We did not find any significant relationships between cuckoo presence and various vegetation structure and composition measures. We believe that the Yellow-billed Cuckoo population has declined in the Sacramento Valley since the last survey during 2000, which is a cause for conservation concern for this important breeding area. Restoration of riparian habitat and further monitoring and research are needed to assist the recovery of the Sacramento Valley breeding population.

## INTRODUCTION

The western population of the Yellow-billed Cuckoo (*Coccyzus americanus*) in the United States is distinguished by its affinity for riparian habitat during the breeding season (Hughes 1999). Loss of riparian forests due to changing land use and alterations of river flow regime in the last 150 years have drastically reduced the amount of riparian forest in the landscape and hence the available breeding habitat for this neotropical migrant (Laymon and Halterman 1987). As a riparian obligate, the range of the species in the west has been severely restricted to remaining isolated riparian forest fragments. The western population of cuckoos once ranged from northern Mexico to the Canadian border, however now they only breed in significant numbers in California, Arizona, New Mexico and Texas (Gaines and Laymon 1984, Laymon and Halterman 1989, Hughes 1999). The species was listed as state endangered in California in 1988. The USFWS has designated the western population as a distinct population segment (DPS), which is a candidate for federal listing (US Fish and Wildlife Service 2001).

In California, the breeding range of the Yellow-billed Cuckoo once extended from the Mexican border, along the southern coast, and through the entire Central Valley (Grinnell and Miller 1944). They are now generally restricted to the Sacramento Valley, the Kern River, and the lower Colorado River with individuals occasionally reported in other areas (Laymon and Halterman 1987). The Sacramento Valley is believed to be a major population center for the species (Halterman et al. 2001). The Sacramento River also represents an area where cuckoo habitat potentially has increased. From 1996-2006 over 2000 ha of riparian was restored along the Sacramento River (Golet et al. 2008).

These restoration efforts represent new habitat that is potentially suitable for cuckoos and which did not exist, or was not mature enough for occupancy, during the last major survey effort in 2000.

Major survey efforts along the Sacramento River were conducted in 1972-73 (Gaines 1974, Gaines and Laymon 1984), 1977 (Gaines and Laymon 1984), 1987-90 (Laymon and Halterman 1989, Halterman 1991), and 1999-2000 (Halterman et al 2001). These surveys were done by foot and canoe, visiting suitable habitat patches, with each study varying in extent along the Red Bluff to Colusa stretch of the river. Focused cuckoo surveys were undertaken in 1998 (Greco 1999, Girvetz and Greco 2009), 2007 and 2008 (Hammond personal communication) along limited sections of the Sacramento River. The more focused surveys added to our knowledge of cuckoo habitat preferences and established that cuckoos will use restored habitat that was 4 years old (Hammond personal communication). These latter efforts were not aimed at estimating cuckoo population size.

The cuckoo's elusive nature requires broadcasting a recording of its call to illicit a playback response. Methods that rely on passively detecting individuals, such as point counts, do not adequately survey for cuckoos. For example, in 5551 individual sampling events during point count surveys conducted by PRBO from 1993 through 2004 in the Sacramento Valley without call playback, there were only 8 cuckoo detections. Call-playback surveys increase the probability of detecting cuckoos relative to unsolicited calls (Halterman 2009). The interpretation of cuckoo responses to playback surveys has changed over time. Prior to 2003 it was thought that sex and pairing status could be discerned by the type of call, but telemetry studies found that interpretation to be

incorrect (Halterman 2009). Differences in the interpretation of older cuckoo surveys make multi-year comparisons challenging.

In 2010, we undertook a comprehensive survey of Yellow-billed Cuckoos in the riparian habitat along the Sacramento River. The objectives of the survey were, 1) to survey all riparian areas for the presence of Yellow-billed Cuckoos using the latest survey methods, 2) to estimate the size of the Sacramento River population, 3) to document nests of breeding cuckoos, 4) to identify habitat characteristics associated with breeding cuckoos, and 5) to compare our results to previous surveys of the river.

# METHODS

## Study Region

We defined the "study region" as the area along the Sacramento River between Red Bluff and Colusa (104 river miles) that was within 2 km of the main stem of the river (Figure 1). Our study region is the core of the cuckoo breeding range in the Sacramento Valley, as shown by the most recent large scale survey (Halterman et al. 2001). This section of the river passes through Tehama, Butte, Glenn, and Colusa counties from north to south. State Highway 32, which crosses the river at Hamilton City, roughly divides the study region in half. The habitat along the river consists of riparian scrub and riparian forest patches surrounded by an agricultural matrix. Other habitats include gravel bars, grasslands, and wetlands. Riparian forests in this region range from low willow (*Salix* sp.) dominated to tall Fremont cottonwood (*Populus fremontii*) dominated (all plant scientific names from USDA Plants Database, http://plants.usda.gov). California black walnut (*Juglans californica*), valley oak (*Quercus lobata*), California sycamore (*Platanus racemosa*), and boxelder (*Acer negundo*) are also present. The riparian forest understory varies from grass dominated to a well developed shrub layer. Riparian scrub consists of small trees (< 5m) and shrubs, with similar species composition as the riparian forest. In many cases, riparian scrub exists as part of the early successional stages of forest development. Restoration efforts in the region have resulted in an increase in the extent of riparian forest of different ages (Golet et al. 2008).

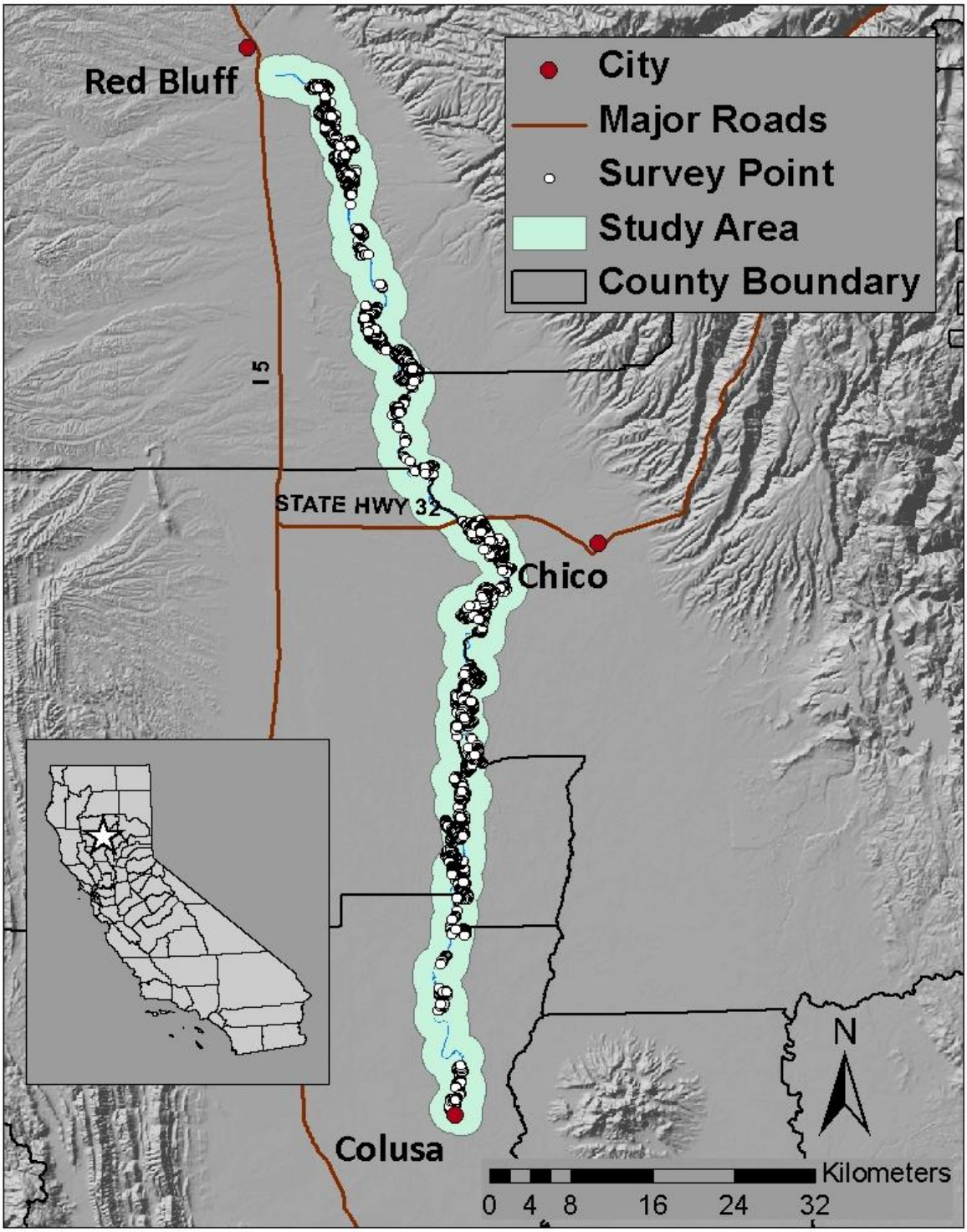


Figure 1. Map of study region, Sacramento Valley, California, including 2010 Yellow-billed Cuckoo survey points.

## Survey Sites

We selected survey sites (management units or isolated habitat patches) within the study region that met our criteria for potentially suitable cuckoo habitat using a combination of satellite imagery, aerial photos (flown in 2007), GIS analyses, and ground-truthing visits. We surveyed restored and remnant riparian forest. We considered mature riparian habitat to be suitable to cuckoos based on previous studies in the Sacramento Valley (Girvetz and Greco 2009), and in other regions. In remnant forests, we selected riparian areas with tall trees (> 4 m). If trees were 3-4 m tall and adjacent (within 50 m) to tall trees, we also included those in the survey. We surveyed restored areas if they were over 4 years old and if they had developed a canopy layer at least 4 m tall. Gravel bars, grasslands, and riparian areas with widely spaced trees (>50 m apart) were not included in the survey. Isolated, narrow stringers of riparian habitat less than 30 m wide also were not surveyed.

Survey routes, a series of survey points that can all be visited in one morning, were established within each survey site. In cases where the riparian habitat was narrow (less than 200 m wide) or the density of the understory plants prevented timely navigation, survey routes were established along the perimeter of the habitat. We prioritized surveying suitable habitat on public lands, but we also surveyed private lands that were immediately adjacent to the river. Areas only accessible from the river were surveyed from a boat or the riverbank. Where safe landing was possible, we surveyed the habitat along the high water line. For boat surveys we secured the boat and silenced the motor in order to conduct the survey.

## Playback Surveys

The call-playback survey method we used is specific to Yellow-billed Cuckoos and was developed and refined over the past decade (Halterman et al. 2001, Johnson et al. 2006, McNeil et al. 2010). The method was adopted by the Western Yellow-billed Cuckoo Working Group to facilitate compilation and comparison of data from the entire range.

Surveys began at sunrise and concluded by noon or when weather conditions (i.e. wind, rain, heat) decreased detectability. At a survey point, the surveyor first paused for one minute to listen for any spontaneously calling cuckoos and to record the GPS coordinates onto a standardized data form. Next, the recording was broadcast 5 times using a portable speaker, each call separated by one minute of silence. The recording is of a single cuckoo, from the Kern River, CA population (provided by Halterman), giving several "kuk" notes followed by several "kowlp" notes. If no cuckoos were detected, the surveyor moved 100 m and repeated the playback protocol. Surveys were done every 100 m in part because cuckoos can have a large territory and may not be detected in the portion of the territory in which the surveyor was conducting the playback. Additionally, 100-150 m may be the distance in which the surveyor is able to hear and detect the call of the cuckoo (Halterman 2009). Due to time constraints and safety, survey points were approximately 150-200 m apart when conducted from the boat. The increased distance among survey points conducted from the boat does not affect the detectability of cuckoos, but may reduce the amount of area surveyed. If a cuckoo was detected, the playback ceased and the relative location (distance and bearing) and behavioral notes (type of response, type of call, nesting activity) were recorded. Following a detection, the

surveyor moved 300 m along the route before the call-playback was resumed to avoid detecting the same individual.

We attempted to survey each site four times during the breeding season (mid-June to late August). The first round was from June 14-29, the second round from June 30-July 15, the third round from July 15-29, and the fourth round from July 31-August 17. At least 12, but no more than 20 days, separated successive rounds for any single transect.

Our aim was to locate and visually observe all the cuckoos we detected with special attention to activity that indicated breeding (copulation, carrying nest material or food). Surveyors were instructed to spend time observing birds and looking for nests. Cuckoos are sensitive to disturbance around their nests (Halterman personal communication), so all attempts were made to minimize impacts (Martin and Geupel 1993) which included not lingering for excessive periods of time.

## Occupancy Analysis

Surveys used to quantify the abundance or population of a species traditionally regarded the actual count as the population size estimate. However, if the probability of detection for a species is less than certain ($p < 1.00$) that approach can underestimate population size because sites that contained the species, but in which no detections were made, are not accounted for (MacKenzie et al. 2005). This problem is especially relevant to population analyses of rare and elusive species (MacKenzie et al. 2005).

We used the occupancy modeling methods outlined by MacKenzie et al. (2005) and the program PRESENCE (Hines 2006) to estimate occupancy for Yellow-billed Cuckoos along the Sacramento River. Using presence and absence data collected during the repeated visits to an area, we can estimate the probability of detection and the

proportion of areas occupied. We calculated occupancy estimates both by holding the probability of detection constant, as well as allowing it to vary among survey rounds.

In order to calculate occupancy we had to define the size of the "area" in which we were calculating occupancy. Ideally, the "area" used in cuckoo occupancy analyses would correspond to the size of a cuckoo territory. Although the protocol calls for surveying cuckoos every 100 m, it is thought that the size of a cuckoo territory is larger than a 100 m radius circle (3.1 ha). On the Kern River, Henneman (2009) defined the area of a cuckoo territory as a 300m radius circle (28.3 ha) in occupancy analyses based on nest searching efforts and local knowledge of the birds during that season. On the Middle Rio Grande in New Mexico, Johanson et al. (2007) selected a 500 m radius circle (78.5 ha) for cuckoo territories based on detection clumping patterns and local knowledge of the birds that year.

In a telemetry study along the San Pedro River, Arizona, Halterman (2009) found that home ranges during the breeding season varied by pairing status, sex, and the presence of a nest for 23 radio-tagged cuckoos. Using 95% kernel density estimates, the average home range varied from 15.8 ha (n=7 females) to 54.8 ha (n=7 unmated individuals) with an overall average of 38.6 ha (n=23). Because territory size in the Sacramento region is unknown, home range varied widely in the Arizona telemetry study (Halterman 2009), and the lack of consensus among studies using occupancy analyses (e.g. Henneman 2009 and McNeil et al. 2010), or other approaches (Johanson et al. 2007), we selected a range of potential territory sizes varying from 15 to 75 ha. These areas correspond to a circular territory with radius varying from 218-489 m. We calculated occupancy estimates for this range of territory sizes.

## GIS Analysis

We used ArcGIS 9.2 (ESRI 2006) to quantify the amount of habitat surveyed in 2010. We buffered survey points by 150 m which is a conservative estimate of the distance that the playback survey would elicit a response from a cuckoo. The multiple circles from the buffer were dissolved using GIS to form non-overlapping polygons. We then used GIS to remove any area of the polygon that overlapped with the main river channel. We consider the total area of the polygons minus any area that overlapped with open water to be the total area that we surveyed; this area equaled 5560 ha. We then used GIS to determine how many territories would fit into that area using the range of territory sizes of 15-75 ha. Occupancy estimates were calculated for each of the five territory sizes.

We also used data on land ownership and riparian restoration status (provided by The Nature Conservancy) and data on riparian habitat types (Geographical Information Center, California State University, Chico) to assess the amount and extent of riparian forest. The area of publicly and privately owned land was determined. The amount of riparian habitat within each of the landowner categories was also determined. We included the following vegetation categories in our riparian habitat assessment: black walnut (*Juglans californica)*, boxelder (*Acer negundo*), California sycamore (*Platanus racemosa*), Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), mixed willow (*Salix* sp.), riparian scrub, and valley oak (*Quercus lobata*).

## Vegetation Features

To measure the vegetation characteristics of the survey routes we stopped every 300 m along the survey route and established the center of the vegetation plot within riparian habitat at a randomly chosen distance (between 12-50 m) perpendicular to the

survey route. We also measured vegetation features at every point where a cuckoo was detected. The surveyor would go to the detection survey point, then follow the bearing and distance estimate to the location where the cuckoo was heard or seen, and then conduct the vegetation survey. We created an 11.3 m radius plot to measure tree related characteristics and a 5 m radius plot to measure characteristics of small trees and cover below 1.4 m. In cases where we could not directly survey the vegetation (e.g. boat surveys, extremely thick vegetation), we estimated as many vegetation characteristics as possible.

The height of the canopy, four convex spherical densiometer readings, and the tree species present along with the percent cover in each of four height categories (1.4-5 m, 5-15 m, 15-30 m, and greater than 30 m) were recorded within an 11.3 m radius plot. The number of trees within each of four DBH (diameter at breast height = 1.4 m) categories (0-<8 cm, 8-<23 cm, 23-38 cm, and greater than 38 cm) were counted. Proportions were also recorded for the amount and type of vegetative cover below 1.4 m. We determined if these vegetation variables were significant predictors of cuckoo presence by examining the slopes of individual variables in a logistic regression analysis.

# RESULTS

## Survey Sites

We selected 48 sites covered by a total of 68 survey routes, which were surveyed from June 14 through August 17, 2010 (Appendix 1). Several large sites required multiple routes to adequately cover the habitat. Four routes were surveyed by boat. There were 1400, 1559, 1525, and 1498 call points respectively for survey rounds one through four. Fewer points were surveyed during the first round because mechanical problems with the boat prevented us from accessing a few routes.

## Playback Surveys

A total of 24 Yellow-billed Cuckoo detections were made during the 2010 breeding season (Table 3, Figure 2), with the majority occurring in the second and third survey rounds (Table 1). Cuckoos were detected north (8 detections) and south (16 detections) of State Highway 32, which roughly divides the study region in half. The great majority of detections were the direct result of the call-playback, with only three resulting from the detection of a spontaneous call. Of the 24 detections, 17 were by call only, 6 were by call and visual, and one was visual.

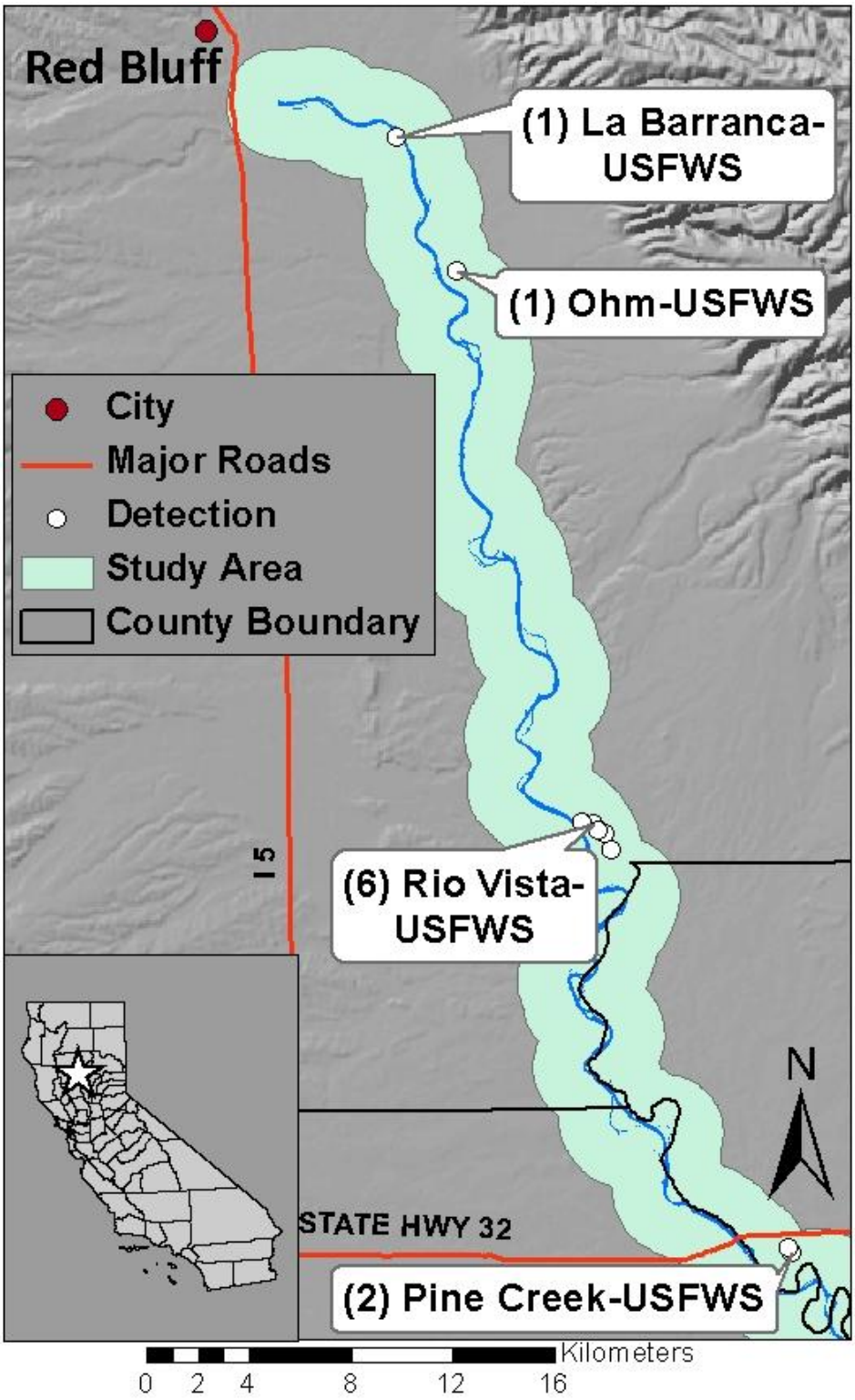


Figure 2a. Yellow-billed Cuckoo detection site names, owners and number of detections (in parentheses) from Red Bluff to Highway 32 (USFWS-US Fish and Wildlife Service). Due to the scale of the map some of the detections made in the same general area appear as one point.

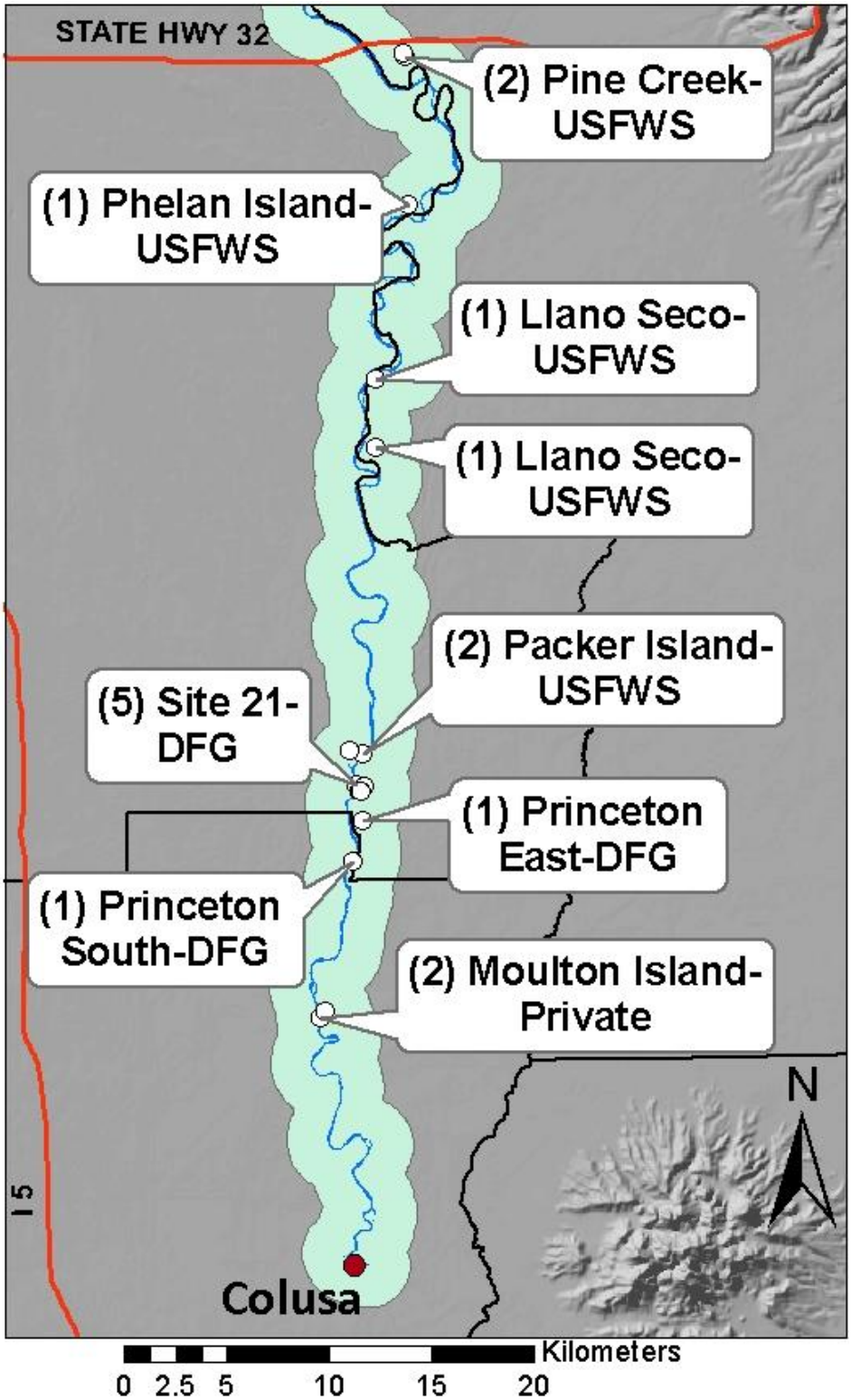


Figure 2b. Yellow-billed Cuckoo detection site names, owners and number of detections (in parentheses) from Highway 32 to Colusa. USFWS-US Fish and Wildlife Service, DFG-Department of Fish and Game. Due to the scale of the map some of the detections made in the same general area appear as one point.

Table 1. Yellow-billed Cuckoo detections during 2010 survey listed by round, then from north to south. The last detection was during vegetation surveys. Coordinates are NAD83 Zone 10. Method describes if the detection was directly following a playback or if the bird was detected before the playback was started.

| Location Name | UTM Coordinates | Date | Method | County | Landowner |
|---|---|---|---|---|---|
| Llano Seco | 586680, 4380969 | 29-Jun | Playback | Butte | USFWS |
| LaBarranca | 572627, 4443718 | 30-Jun | Playback | Tehama | USFWS |
| Pine Creek | 588102, 4400094 | 2-Jul | Playback | Butte | USFWS |
| Packer Island | 586053, 4366064 | 15-Jul | Playback | Glenn | USFWS |
| Site 21 | 585719, 4364538 | 15-Jul | Playback | Glenn | DFG |
| Site 21 | 586085, 4364430 | 15-Jul | Playback | Glenn | DFG |
| Site 21 | 586085, 4364430 | 15-Jul | Spontaneous | Glenn | DFG |
| Site 21 | 585908, 4364198 | 15-Jul | Playback | Glenn | DFG |
| Princeton South | 585551, 4360755 | 15-Jul | Playback | Colusa | DFG |
| Moulton Island | 583999, 4353151 | 15-Jul | Playback | Colusa | Private |
| East Ohm | 574982, 4438507 | 26-Jul | Playback | Tehama | USFWS |
| Rio Vista | 580346, 4416851 | 17-Jul | Playback | Tehama | USFWS |
| Rio Vista | 580346, 4416851 | 17-Jul | Spontaneous | Tehama | USFWS |
| Rio Vista | 580771, 4416516 | 19-Jul | Playback | Tehama | USFWS |
| Rio Vista | 581030, 4415883 | 19-Jul | Playback | Tehama | USFWS |
| Pine Creek | 588015, 4400259 | 17-Jul | Playback | Butte | USFWS |
| Phelan Island | 588222, 4392860 | 21-Jul | Playback | Glenn | USFWS |
| Moulton Island | 584180, 4353478 | 29-Jul | Playback | Colusa | Private |
| Rio Vista | 579906, 4416936 | 4-Aug | Playback | Tehama | USFWS |
| Llano Seco | 586637, 4384315 | 13-Aug | Playback | Butte | USFWS |
| Packer Island | 585408, 4366164 | 6-Aug | Playback | Glenn | USFWS |
| Site 21 | 585950, 4364208 | 17-Aug | Playback | Glenn | DFG |
| Princeton East | 586001, 4362725 | 5-Aug | Playback | Glenn | DFG |
| Rio Vista | 580527, 4416596 | 20-Aug | Spontaneous | Tehama | USFWS |

The number of detections can overestimate the number of individuals because the same individual may be encountered on multiple survey rounds. We estimated the number of individuals encountered throughout the season by examining each detection in relation to those in close proximity. Individuals detected on the same day were separated by the surveyor, who kept track of the cuckoo's movements to ensure that it was not double counted. Differentiating individuals among rounds is more difficult, but generally detections greater than 500 m apart are likely different birds and detections within 300 m

are likely the same individual (Halterman et al 2001). Using these criteria we determined that we encountered 18 unique individuals. An alternate approach is to consider a bird breeding if it is detected during two of the four survey periods (Henneman 2009). If we use this approach then there were 5 breeding birds detected in our survey efforts.

After each cuckoo was detected, the surveyor attempted to locate the bird and observe any breeding behavior. On average, the surveyor spent 30 minutes searching or watching the individual, though the amount of time ranged from 6 to 70 minutes. No explicit breeding activity (e. g. nest material carry) was noted during these observations. In fact, most detections (17 of 24) were of birds that were only heard and not seen. Although we did not confirm breeding by direct observation, we are fairly confident that most of our detections were of breeding individuals since they were detected during the height of breeding season (July to early August, Table 1).

## Occupancy Analysis

Occupancy analysis requires repeated presence/absence surveys at a single location in order to determine the occupancy at that location. We wanted to define the occupancy in terms of the territory, but cuckoo territory size is not well known. Therefore we selected a range of cuckoo territory size areas varying from 15 to 75 ha. These correspond to ranges for western cuckoo territory size from telemetry data. A territory was considered occupied if a cuckoo was detected during at least one round. A naïve estimate (i.e. an estimate that does not account for detectability and therefore assumes a 100% detection rate) of occupancy was calculated directly from our results (Table 2).

Although we detected 18 individuals using the protocol, when using the larger territory sizes of 60 and 75 ha, some observations that we considered "separate individuals" had to be combined into one territory due to the proximity of the detections, so the number of occupied territories became 16 instead of 18 under these scenarios (Table 2).

Table 2. Cuckoo occupancy estimates for the Sacramento River during 2010 based on a range of potential territory sizes. Using the total amount of riparian habitat surveyed, we calculated the number of potential territories, the number of occupied territories, and the number of empty territories. These were used as inputs to determine the occupancy estimate (%) for each territory size. We multiplied the number of potential territories times the occupancy estimate (%) to determine the estimated number of occupied territories. The radius length of a circle for each territory size is shown for comparative purposes since that metric is often used by other researchers.

| Terr. size (ha) | Terr. radius (m) | # Potential terr. | Naïve # Occupied territories | # Empty territories | Occupancy estimate % | Occupancy estimate # terr. |
|---|---|---|---|---|---|---|
| 15 | 218.6 | 371 | 18 | 353 | 10.3 | 38.2 |
| 30 | 309.1 | 185 | 18 | 167 | 20.6 | 38.1 |
| 45 | 378.6 | 124 | 18 | 106 | 30.7 | 38.1 |
| 60 | 437.1 | 93 | 16 | 77 | 34.0 | 31.6 |
| 75 | 488.7 | 74 | 16 | 58 | 42.8 | 31.7 |

Occupancy estimates were lowest when the territory size was the smallest, and highest with the largest territory size (Table 2, Figure 3). As the territory size increases, there was a corresponding decrease in the number of potential territories. Our observed occupied territories were widely spread geographically and therefore their number changes very little as the territory size increases. The expected result would then be increasing occupancy with increasing territory size, which was what our results show.

The occupancy analysis suggests that with a territory size of 15 ha, approximately 10.3% of the 371 potential territories (or about 38 territories) are occupied by cuckoos (Table 2); 38 territories are also estimated at territory sizes of 30-45 ha. This is more than double the number of territories we actually observed occupied; this result occurs because

cuckoo detection probability was estimated at less than 0.25 per survey round, so the analysis projects undetected territories. At territory sizes of 60 or 75 ha, the occupancy estimated number of territories drops to approximately 32.

When the probability of detection is considered constant throughout the survey, its estimated value only varies slightly as the territory size increases (Figure 4). Allowing the estimated probability of detection to vary among rounds, we see that it is highest in rounds 2 and 3, followed by round 4, and lastly by round 1. This pattern holds as territory size increases. We used AIC values to choose which model had the most support to estimate occupancy (Burnham and Anderson 2002). Using AIC values is a method for comparing a number of models to assess which of them is the best supported by the data. We considered a model in which the probability of detectability was constant among survey rounds, as well as a model in which detectability varied among survey rounds. The model in which the probability of detection varied among rounds had the most support for each of the territory sizes we considered (Appendix 2).

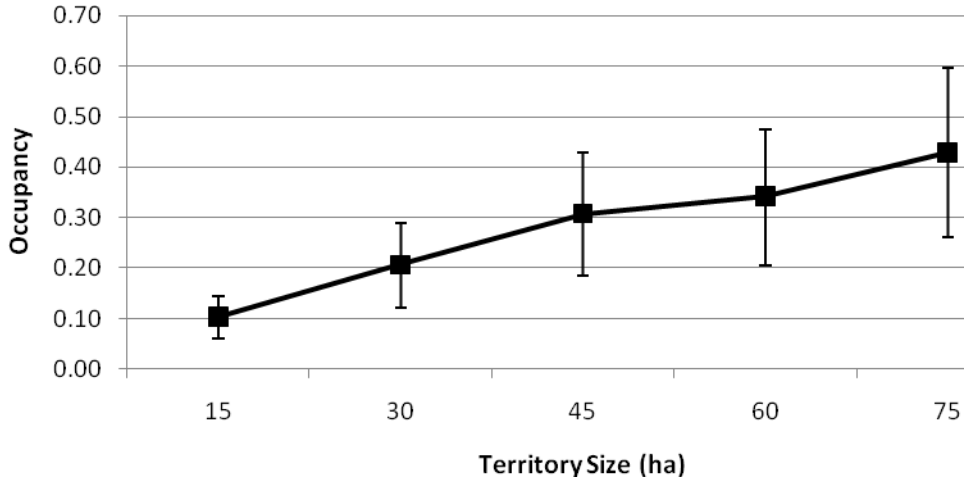


Figure 3. Estimates of the proportion of occupied Yellow-billed Cuckoo territories along the Sacramento River. Estimates generated with probability of detection allowed to vary among survey rounds. Error bars represent one standard error.

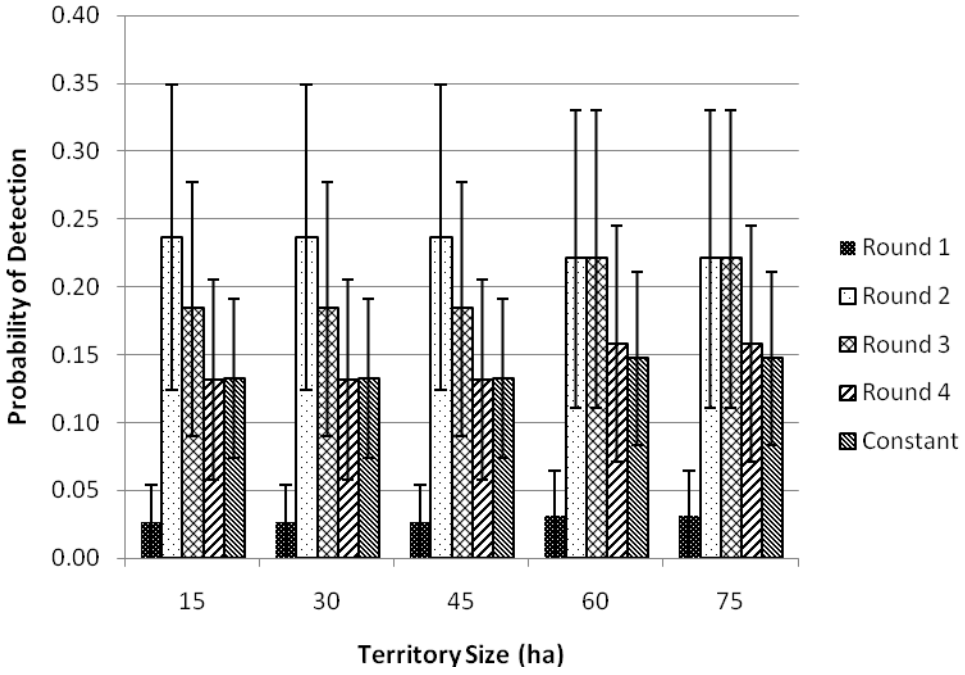


Figure 4. Probability of detection estimates for Yellow-billed Cuckoo along the Sacramento River when allowed to vary among survey rounds or held constant throughout the survey period. Estimates were calculated for each territory size. Error bars represent one standard error.

## GIS Analysis

The study area was calculated to be 58,894 ha, most of which is privately owned (Table 3). Federal and state agencies, along with non-governmental organizations (NGOs), own a combined 18.6% of the study area, with the remainder as private lands. With the riparian vegetation layer we can narrow the scope to habitats that may support Yellow-billed Cuckoos. For this analysis, we restricted the habitat types to those consisting of forests and scrub, excluding wetlands, grasslands, open water, and gravel bars. Of the total study area, only 13.5% (7,925 ha) consists of this forested riparian habitat. When evaluating the ownership of the riparian habitat, the majority (71.8%) is owned by federal and state agencies, and NGOs (Table 3).

Table 3. Study area ownership analysis.

| Owner | Total Area (ha) | % of Total | Riparian Habitat (ha) | % of Riparian Habitat |
|---|---|---|---|---|
| Bureau of Land Management | 158 | 0.3% | 140 | 1.8% |
| US Fish and Wildlife Service | 4345 | 7.4% | 2636 | 33.3% |
| Other Federal Agencies | 165 | 0.3% | 15 | 0.2% |
| **Federal** | **4668** | **7.9%** | **2791** | **35.2%** |
| Department of Fish and Game | 1721 | 2.9% | 1377 | 17.4% |
| Department of Parks and Recreation | 408 | 0.7% | 295 | 3.7% |
| Department of Water Resources | 843 | 1.4% | 591 | 7.5% |
| Other State and Local | 298 | 0.5% | 179 | 2.3% |
| **State and Local** | **3270** | **5.6%** | **2442** | **30.8%** |
| River Partners | 55 | 0.1% | 15 | 0.2% |
| The Nature Conservancy | 1902 | 3.2% | 348 | 4.4% |
| Northern California Regional Land Trust | 1018 | 1.7% | 93 | 1.2% |
| **NGOs** | **2975** | **5.1%** | **456** | **5.8%** |
| **Private** | **47981** | **81.5%** | **2236** | **28.2%** |
| ***Total*** | ***58894*** | | ***7925*** | |

## Vegetation Analysis

Vegetation surveys were conducted along the survey routes and at cuckoo detection locations to characterize the habitat (although in many cases we only heard the cuckoo and had to estimate its location for the vegetation survey). We used ArcGIS to determine all vegetation survey points within 300 m of a positive cuckoo detection (n=39 vegetation survey locations) and all vegetation survey points greater that 600 m from a positive cuckoo detection (n=403 points). In our vegetation analyses we refer to these two groups as cuckoos present (Y) and absent (N). We used logistic regression to determine if vegetation variables were significant predictors of cuckoo presence and absence. In all cases the slope of the vegetation variable was not significant (likely due to the low number of cuckoos we detected, see Discussion) indicating that it was not a significant

predictor of cuckoo presences; therefore we show boxplots for relevant variables to show how the distributions of vegetation variables varied. In the box and whisker plots, the bottom and top of the box are always the 25th and 75th percentile (the lower and upper quartiles, respectively), and the band near the middle of the box is always the 50th percentile (the median). The whiskers extend to maximum and minimum values excluding outliers. Outliers are shown as dots and are values more than 3/2 times the upper quartile or more than 3/2 times the lower quartile.

*Overstory measurements*

We estimated overall canopy cover using a densiometer (Figure 5). Canopy cover was similar between the two groups, although there was greater range and variance at the lower tail for sites without cuckoos.

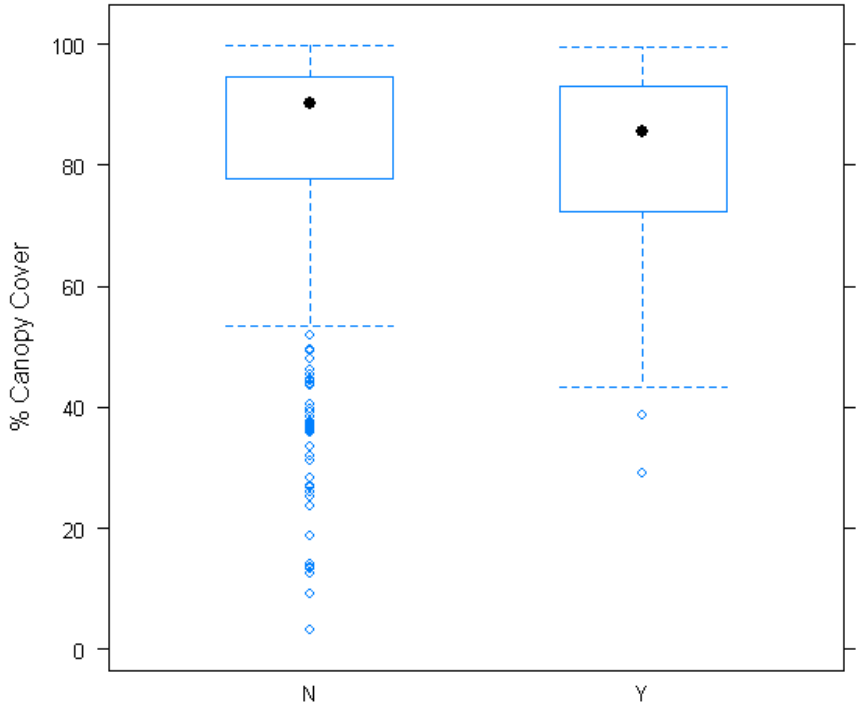


Figure 5. Canopy cover (derived from the average of four densiometer readings) for areas with (Y; n=39) and without (N; n=403) Yellow-billed Cuckoo detections.

Canopy structure was measured by estimating the bottom height, median height (50% of the canopy above and below this height), top height, and range in canopy height (Figure 6). When comparing sites with and without cuckoos there is a broad overlap in values. None of these variables were significant predictors for the presence of cuckoos.

We further broke down canopy structure by individual tree species to examine differences in associations. We included the nine most common species in our analyses: boxelder, Oregon ash, California black walnut, California sycamore, Fremont cottonwood, valley oak, sandbar willow, Goodding's black willow, and arroyo willow (see Figure 7 for scientific names). Sites with cuckoos present had similar maximum tree heights for the nine most frequently encountered tree species (Figure 7). The variables were not significant predictors of cuckoo presence.

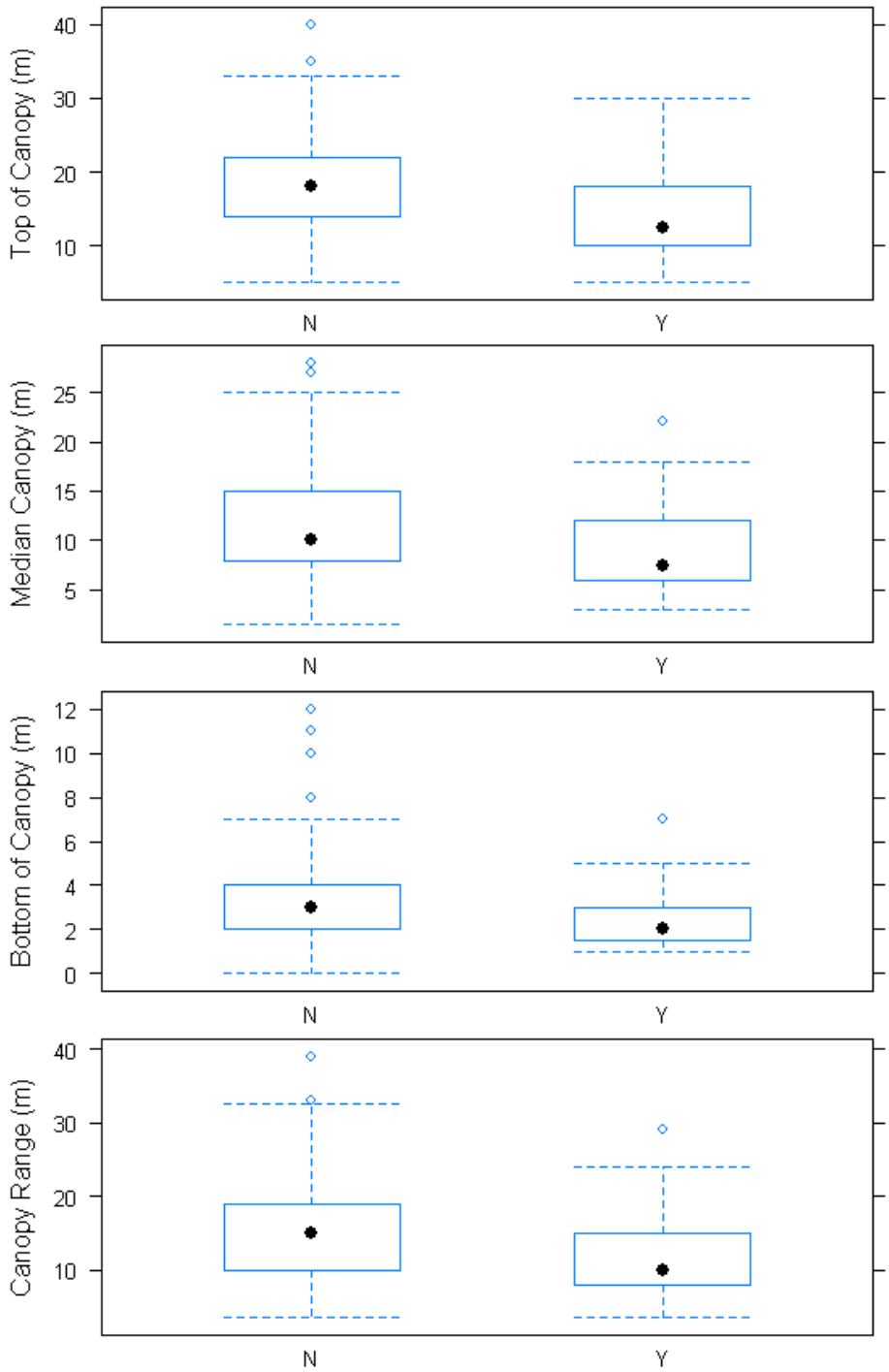


Figure 6. Canopy heights, in meters, for the top (tallest tree), median (50% of canopy is above this height), and bottom (lowest live branch) for areas with (Y; n=39) and without (N; n=403) Yellow-billed Cuckoo detections. Canopy Range is the distance between the top and bottom of the canopy.

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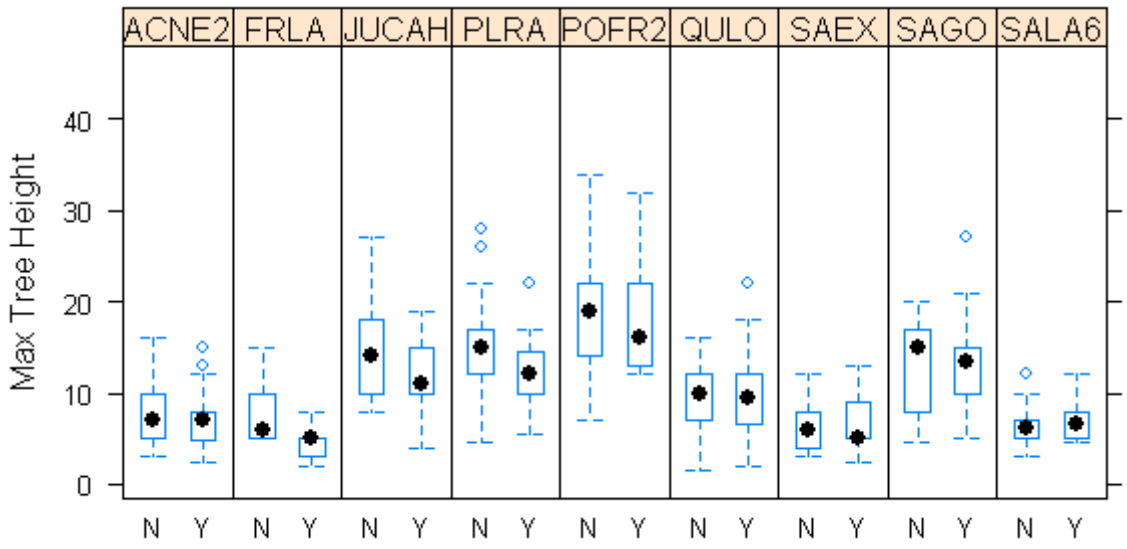


Figure 7. Maximum tree height for the nine most frequent tree species at sites with (Y; n=39) and without (N; n=403) cuckoos. Tree species included boxelder (*Acer negundo*, ACNE2); Oregon ash (*Fraxinus latifolia*, FRLA); California black walnut (*Juglans californica*, JUCAH); California sycamore (*Platanus racemosa*, PLRA); Fremont cottonwood (*Populus fremontii*, POFR2); valley oak (*Quercus lobata*, QULO); sandbar willow (*Salix exigua*, SAEX); Goodding's black willow (*Salix gooddingii*, SAGO); arroyo willow (*Salix lasiolepis*, SALA6).

We also calculated the vegetation profiles for all trees as well as the nine most frequently occurring species (Figure 8). The amount of cover provided by each species within four height ranges was recorded in order to characterize the structure of the forest. The cover provided by all species shows that the highest percent cover is from 1.4 to 15 m, with a modest amount from 15 to 30 m, and a very small amount above 30 m (Figure 8). In the lowest height range, boxelder, arroyo willow, and Fremont cottonwood are common. Above 5 m, Fremont cottonwood provides much of the cover.

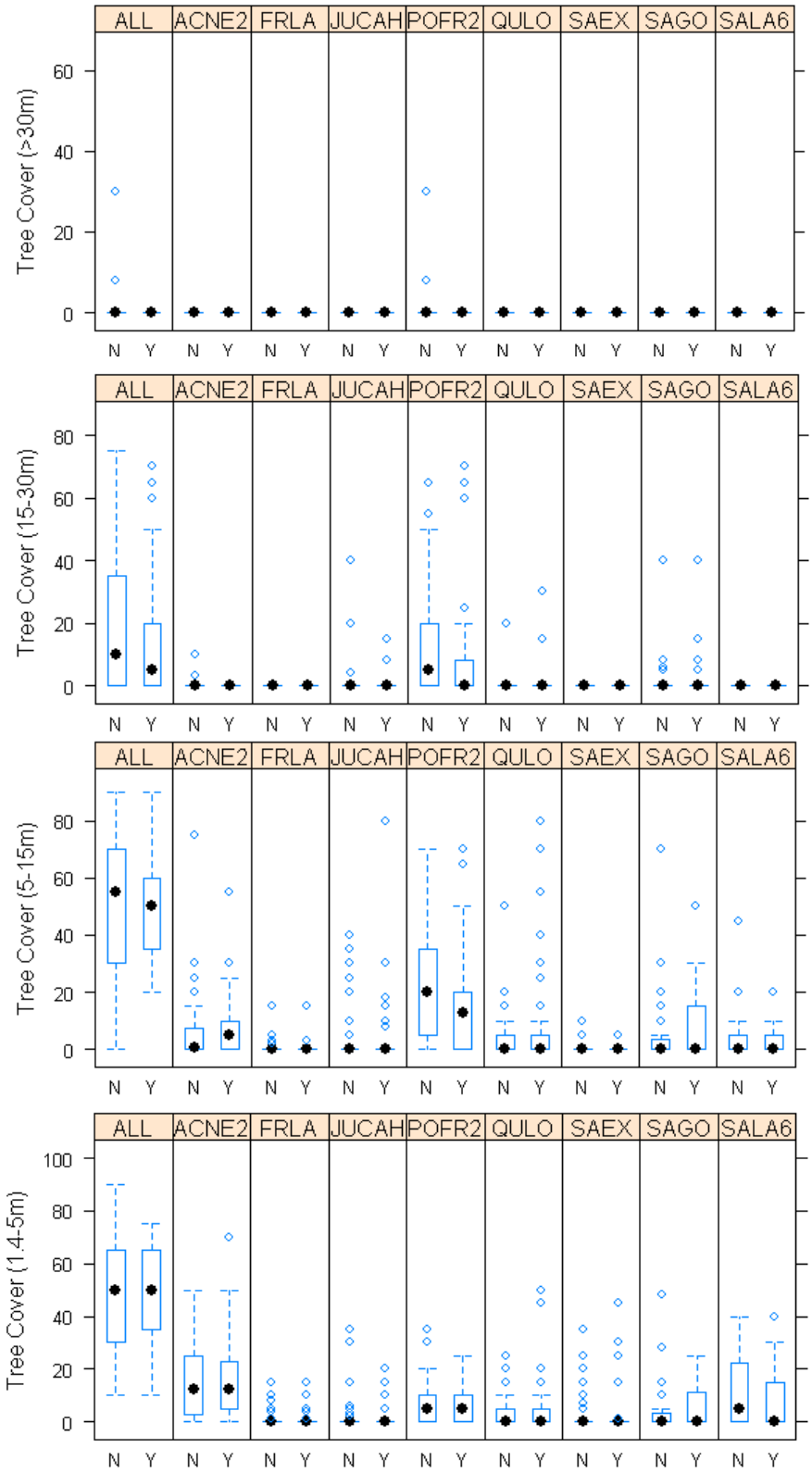


Figure 8. Vegetation profiles at sites with (Y; n=39) and without (N; n=403) for all trees and for 9 frequently occurring tree species. Tree cover is broken into four intervals. See Figure 7 for species codes.

*Understory measurements*

We also examined the shrub layer between 0.5 and 1.4 m to examine differences in sites with and without cuckoos. The amounts of cover provided by shrubs (live woody plants) and brush (dead woody plants) were similar in areas with or without cuckoo detections. Shrubs tended to provide between 0 and 20% of the cover in this low height range. Brush made up a smaller amount of cover. The high shrub height was also similar between areas (Figure 9).

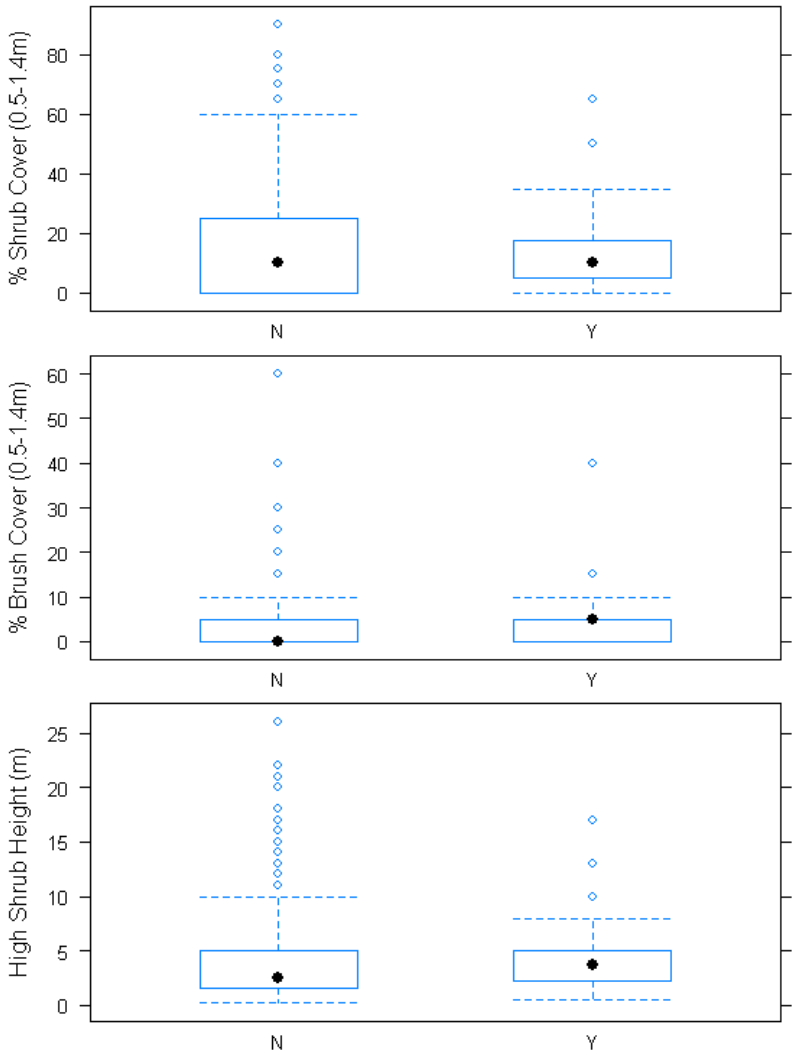


Figure 9. Measures of understory. Shrub and brush (dead woody debris) cover for areas with (Y; n=39) and without (N; n=403) Yellow-billed Cuckoo detections. Height of tallest shrub includes

wild grape (*Vitis californica*) and poison oak (*Toxicodendron diversilobum*) that can climb high up into trees.

## DISSCUSSION

During the 2010 survey of the Sacramento River, we surveyed approximately 1500 call points over 1191 hours within riparian habitat on federal, state, NGO, and private lands. Collectively we estimate that we surveyed 5560 ha. We encountered 18 individual cuckoos on state (n=6), federal (n=11), and private lands (n=1). These cuckoos were observed at the following sites: LaBarranca (1), Ohm (1), Rio Vista (3), Pine Creek (1), Phelan Island (1), Llano Seco (2), Packer Island (2), Site 21 (4), Princeton East (1), Princeton South (1), and Moulton Island (1). Cuckoos were mostly detected during the second, third, and fourth survey rounds during the time period of 30 June to 17 August, which is the time period that is thought to correspond with the peak of their breeding activity in the Sacramento Valley (Halterman 1991).

### Comparison to Previous Years

We interpret that our 2010 results represent a decline from the previous 40 years (Table 4). Direct comparison of the 2010 and previous surveys is complicated by the different way in which the cuckoo responses were interpreted. Several past surveys have focused on evaluating the number of breeding pairs (Laymon and Halterman 1989, Halterman et al 2001). Pair status was determined by observation of two birds in close proximity or the type of call response given (Halterman et al 2001). With the recent finding that using the call type to determine the breeding status is unreliable (Halterman 2009), the previous survey results become more difficult to interpret.

Adding to the difficulty in comparing results from different surveys are the varying amounts of effort and area covered from survey to survey. In the earliest surveys (1972-73, 1977), the sites were surveyed only once during the breeding season, while in later surveys (1999-2000, 2010) sites were visited three or four times. There are also differences in effort between the 2010 and 1999-2000 surveys, with 312 points surveyed over 255 hrs in 1999 (Halterman et al. 2001) and about 1500 points surveyed over 1191 hrs in 2010.

Table 4. Yellow-billed Cuckoo surveys of the Sacramento River and the reported results (cuckoos detected; these results did not correct for probability of undetected cuckoos).

| Year | Reported Results | # Survey Rounds | Citation |
|---|---|---|---|
| 1972 | 28 individuals | 1 | Gaines 1974 |
| 1973 | 29 individuals | 1 | Gaines and Laymon 1984 |
| 1972-73 | 44 individuals | 1 | Gaines and Laymon 1984 |
| 1977 | 44 individuals | 1 | Gaines and Laymon 1984 |
| 1977 | 29-60 pairs | 1 | Halterman et al. 2001 |
| 1987 | 18 pairs, 19 unmated | 3 | Laymon and Halterman 1989 |
| 1987 | 18 pairs, 23 unmated | 3 | Halterman 1991 |
| 1988 | 35 pairs, 31 unmated | 3 | Halterman 1991 |
| 1989 | 26 pairs, 19 unmated | 3 | Halterman 1991 |
| 1990 | 23 pairs, 25 unmated | 3 | Halterman 1991 |
| 1999 | 28-32 pairs, 26 unmated | 3 | Halterman et al. 2001 |
| 2000 | 35-40 pairs, 38-42 unmated | 3 | Halterman et al. 2001 |
| 2010 | 18 individuals | 4 | Dettling and Howell 2011 |

The extensive effort and coverage in 2010 produced the fewest number of individuals over surveys from the past 40 years, not accounting for the differences in effort and interpretation noted above. We assume that if the amount of effort and area covered of past surveys were increased to the 2010 level, the number of cuckoos detected would have been even higher during those previous years. Even if we take the most conservative interpretation of previous data (i.e. birds counted as a pair are actually just

one individual), the 2010 results indicate a decline in Yellow-billed Cuckoo numbers along the Sacramento River.

In 2010 cuckoos were detected at multiple sites along the stretch of river we surveyed, from river mile 240 to river mile 157. Halterman et al. (2001) primarily made surveys from the river and report the number of detections by river mile allowing us to compare whether river miles we found individuals in 2010 were also occupied in 1999-2000 (Table 5). One limitation is that we do not know where exactly along that river mile the 1999-2000 detections were. We detected cuckoos at three separate river mile locations where cuckoos were not detected in 1999-2000. These included the La Barranca Unit and two locations at the Rio Vista Unit (one restored in 1994-95 and one restored in 1998-99) which are both at the north end of the study area. Girvetz and Greco (2009) found that cuckoos occupied more patches south of Highway 32 than north, a pattern which held in our data in 2010 (Figure 2).

Table 5. Yellow-billed Cuckoo detection river miles (RM) for 2010 (including management unit from Appendix 1) in comparison to the 1999-2000 survey (Halterman et al 2001). For the 1999-2000 data we do not know what side of the river birds were detected on, so we cannot assume that they were in the same management unit as the 2010 surveys.

| 2010 Detection approx. RM | Unit or Area Name | Side of River for 2010 Detection | 1999 or 2000 Detection at a nearby RM? (approx. RM) |
|---|---|---|---|
| 240 | La Barranca | West | N |
| 235 | Ohm | East | Y (234) |
| 217 | Rio Vista | East | N |
| 216 | Rio Vista | East | N |
| 198.5 | Pine Creek | East | Y (197) |
| 191.5 | Phelan Island | West | Y (191.5) |
| 182 | Llano Seco | East | Y (182.5, 181.5) |
| 179 | Llano Seco | East | Y (179) |
| 167 | Packer | West | Y (167) |
| 165 | Site 21 | West | Y (165.5, 166) |
| 164 | Princeton East | East | Y (163) |

| | | | |
|---|---|---|---|
| 163 | Princeton South | West | Y (163) |
| 157 | Moulton Island | East | Y (157, 156.5) |

We did not encounter any breeding activity, such as birds carrying nesting material or food. Yellow-billed Cuckoos are very secretive in general and especially around their nests, so breeding behavior can be difficult to observe. We did not have time to follow up detections with intensive nest searching, because the large amount of area we were covering and the short two weeks we had to cover it during a survey round. The timing of our detections, between early July and early August, was during the cuckoo breeding season. There are no known major breeding populations further north, so it is unlikely that the birds we detected were migrating through.

## Implications of Occupancy Analyses

We applied recently developed statistical methods to the 2010 survey data to calculate occupancy (MacKenzie et al 2005). We did this at multiple scales because the scale chosen can greatly affect the rate of occupancy (in our case the rate ranges from 10% to 42%). When using occupancy analysis to aid in estimating a population size, the scale that is most appropriate would correspond to the territory size for the study species. If the scale chosen is smaller than the actual territory size then the estimate of occupied territories may be an overestimate (i.e. two occupied territories might be occupied by one pair instead of two). If the scale chosen is larger than the actual territory size then the estimate of occupied territories may be an underestimate (i.e. one occupied territory might be occupied by more than one pair).

With the reported territory sizes for Yellow-billed Cuckoos varying (Johanson et al. 2007, Halterman 2009, Henneman 2009), we felt it appropriate to report a range of

occupancy estimates. Based on our experiences on the ground, we estimate that cuckoo territory size is less than 60 ha along the Sacramento River. If territory size was 60 ha (or greater) we would not have had as many detections as we did within the existing spatial configuration of the habitat. Additional research efforts, including telemetry studies, are needed to determine territory size for Sacramento Valley cuckoos.

At all territory sizes we considered, detection probabilities are lower than those calculated for the Kern River (0.35-0.83, Henneman 2009) and the Lower Colorado River (0.19-0.84, McNeil et al. 2010). The probability of detection of each survey period varied in our study, with the second (early to mid-July) and third (mid to late July) periods having the greatest probability. This pattern is also evident in the Kern and Lower Colorado River studies (Henneman 2009, McNeil et al. 2010). Though scales of other studies may not exactly match ours in terms of what size was used to delineate a territory, our range of territory sizes span those used in other studies. If cuckoos in northern California are not more secretive than those at the Kern or Lower Colorado rivers, the low detection probability indicates that population density is lower in the north.

Our occupancy analyses predict that between 32 and 38 cuckoo territories were occupied in the study region along the Sacramento River (Table 2). Given our knowledge about the spatial configuration of the cuckoos we observed, we believe the estimate of 38 better corresponds to our data. These estimates do not indicate how many of the territories are occupied by pairs or only an individual, so the estimate of total population size potentially ranges from 38 to 76 individuals. We do not have occupancy estimates from the 1999-2000 surveys of the Sacramento River, therefore we cannot make direct comparisons. Even with the difficulties in comparing our results with past results and

unknowns about territory size in this region, our results indicate low population sizes which are a cause for conservation concern.

## Vegetation Structure

We found no differences in vegetation structure between sites with and without Yellow-billed Cuckoo detections. This is likely because areas we considered as not having cuckoos were actually suitable cuckoo habitat, but lacking in cuckoos during this year of surveys. Some of these sites may have been occupied in recent years by cuckoos. Previous studies along the Sacramento River have found cuckoos positively associated with low woody vegetation (Halterman 1991, Hammond personal communication), the presence of willows and cottonwood (Gaines 1974, Halterman et al. 2001), and a taller canopy that provides more cover (Halterman et al. 2001). We suspect that the small number of cuckoo detections we had also made such associations difficult to detect.

## Habitat Availability

Only 13.5% of the land within 2 km of the Sacramento River exists as riparian habitat, but the majority of that (71.8%) is in public ownership. Prior to the 1849 gold rush, most of this land was riparian forest, though portions were also grassland, wetland, and gravel bar habitats (Gibson 1975). Since 1989, federal and state agencies and NGOs have restored nearly 2,500 ha of riparian forest along the Sacramento River (Golet et al. 2008). Much of this work was done after 1996, so it either did not exist or was likely too young to provide cuckoo habitat during previous surveys in 1999-2000. Those same organizations continue to acquire and restore habitat along the river, steadily increasing the amount of habitat for cuckoos and other species such as migratory songbirds and the valley elderberry longhorn beetle. A large impact could be made by partnering with

private landowners, who own the majority of the land, to encourage and assist in restoration projects. This could be especially effective in locations that would increase the size of existing riparian forest or connect remnant patches.

Our calculations of the extent of riparian habitat rely on the accuracy of the vegetation data layer we used (Geographical Information Center, California State University, Chico). The vegetation data has been shown to contain some inaccuracies in the spatial position of polygons as well as the vegetation classes assigned to the polygons (Viers et al. 2009). The data layer classified polygons by the dominant tree species, and in some cases were shown to have been misclassified (e.g. Fremont cottonwood as valley oak) a significant number of times (Viers et al. 2009). While misclassifications of forest type occurred, it was rare for a non-forest class to be misclassified as one type of forest and vice versa, so we believe our calculations of riparian habitat are fairly accurate.

While it is relatively straightforward to determine the amount of riparian habitat based on GIS data, additional information and research is needed to calculate the amount of riparian habitat suitable for cuckoos along the Sacramento River. While the GIS data indicate the types of vegetation present, especially the dominant tree species, cuckoos may key in on other attributes such as plant or tree height which is not currently readily available through GIS. The amount of suitable cuckoo breeding habitat is also affected by the misclassifications of dominant tree species in the GIS database. Cottonwood forests were sometimes classified as valley oak, and Goodding's black willow forests as black walnut, mixed willow, or valley oak (PRBO unpublished data, Viers et al. 2009). If we were to restrict the forest type to cottonwood and willow, the preferred habitat for cuckoos, in order to calculate the amount of cuckoo habitat, those misclassifications

would introduce error. Suitable cuckoo breeding habitat also includes a well developed understory, which the vegetation classifications do not address somewhat limiting their usefulness to identifying cuckoo habitat.

Aside from the presence of "suitable" cuckoo habitat, the configuration of that habitat within the landscape is likely important. Girvetz and Greco (2009) used data collected by Halterman et al. (2001) and earlier cuckoo surveys to evaluate spatial occupancy of riparian forest patches. While the cuckoo data inputs for their modeling exercise were based on the old interpretation of cuckoo playback surveys (in which pair status was considered determinable from the response data), they nonetheless showed that cuckoos responded to the amount of riparian habitat in the landscape. This analysis should be re-run in the future with updated data inputs to match current interpretations of cuckoo playback data.

## Conservation Implications and Future Research Needs

Potential factors leading to low cuckoo numbers in the Sacramento Valley include problems on the wintering grounds, problems during migration, food limitation in the Sacramento Valley, habitat quality, or cuckoos choosing other breeding locations. Cuckoos numbers are known to fluctuate among years at the same site, even in suitable habitat (Halterman 2009). If there were problems on the wintering grounds we might expect equally poor results in other regions, however numbers on the Lower Colorado River were above average in 2010 (Halterman personal communication).

With such a small population, continued monitoring is recommended in addition to more focused studies on cuckoo biology in the region. Compiling historic data and "cross-walking" among different survey protocols would be very helpful in understanding

cuckoo population trends in the Sacramento Valley over the past 40 years. Recently developed statistical techniques (occupancy analysis) may allow us to use these data to make population estimates that account for the difficulty in detecting the species.

Since occupancy estimates rely on defining the correct scale for the analyses, obtaining telemetry data on territory size would be very useful for calculating more accurate population assessments. In this 2010 study there were few areas in which we detected multiple individuals or territories within the same relative area, so differences in potential territory size did not have a large effect on our results. However, in previous surveys of the area in 2007-2008 there were multiple detections within an area (Hammond, personal communication), as well as in the 1999-2000 surveys, so it would be prudent to determine territory size for cuckoos on the Sacramento River. Knowing territory size would also allow us to determine the potential maximum population size for this area.

The protocol we used was developed by groups in California and Arizona (Halterman et al. 2001, Johnson et al. 2006, Halterman 2009, McNeil et al. 2010) to standardize data collection. Standardized protocols ensure that adequate data is taken by each surveyor and that results can be compared across the entire range of the species. While the collection of the data has been standardized, there has not been standardization regarding the interpretation and analysis of cuckoo play back survey data. Moreover, additional refinement and updating of the survey protocol may be warranted for the Sacramento River population since it is further north than other populations. We only detected one individual during the first survey round and future Sacramento surveys might consider dropping the first round or starting it later. Another potential refinement

to the protocol could be to increase the number of survey rounds within the time period of highest activity as well as add confirmation follow-up visits.

It is imperative that the Sacramento Valley population remain viable if the Yellow-billed Cuckoo population in California is to recover and avoid extirpation. The factors under the most direct control of land managers in the Sacramento Valley are the amount and quality of riparian habitat available to breeding cuckoos. The impressive amount of restoration that has taken place over the last 20 years in the Sacramento Valley is a great conservation success story (Golet et al. 2008). However, even with recent increases in riparian habitat and potential cuckoo habitat, these efforts represent only a fraction of the historic riparian extent. Continued efforts to restore riparian habitat, and the river processes which maintain them, are needed to aid cuckoo recovery. Additional research is needed on cuckoo habitat selection cues, territory size, and overall habitat requirements in the Sacramento Valley.

## ACKNOWLEDGEMENTS

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# APPENDICES

Appendix 1. 2010 Yellow-billed Cuckoo survey routes, the range of survey points over all rounds, and the dates of each survey round. *Surveys only partially completed due to mechanical issues. +Surveys not completed due to mechanical issues.

| Name | Number of Points | River Mile | Owner | Round 1 | Round 2 | Round 3 | Round 4 |
|---|---|---|---|---|---|---|---|
| LaBarranca 1 | 28-35 | 240 | USFWS | 15-Jun | 30-Jun | 16-Jul | 31-Jul |
| Blackberry Island | 10 | 239.5 | USFWS | 15-Jun | 30-Jun | 16-Jul | 5-Aug |
| LaBarranca 2 | 22-24 | 239 | USFWS | 15-Jun | 30-Jun | 15-Jul | 2-Aug |
| LaBarranca Stringer | 18-22 | 238 | USFWS | 15-Jun | 30-Jun | 16-Jul | 2-Aug |
| Todd Island | 17-19 | 237 | USFWS | 15-Jun | 30-Jun | 16-Jul | 2-Aug |
| Mooney 1 | 20-25 | 236.5 | USFWS | 15-Jun | 1-Jul | 16-Jul | 3-Aug |
| Mooney 2 | 20-21 | 236 | USFWS | 15-Jun | 1-Jul | 16-Jul | 3-Aug |
| East Ohm 1 | 9-15 | 235 | USFWS | 28-Jun | 12-Jul | 26-Jul | 12-Aug |
| Ohm 1 | 24-25 | 234.5 | USFWS | 14-Jun | 30-Jun | 15-Jul | 2-Aug |
| East Ohm 2 | 10 | 234 | USFWS | 28-Jun | 12-Jul | 26-Jul | 12-Aug |
| Ohm 2 | 30-31 | 233.5 | USFWS | 14-Jun | 30-Jun | 15-Jul | 2-Aug |
| Flynn 1 | 23-28 | 233 | USFWS | 17-Jun | 1-Jul | 17-Jul | 3-Aug |
| Flynn 2 | 16-23 | 232 | USFWS | 17-Jun | 1-Jul | 16-Jul | 3-Aug |
| Flynn 3 | 19-24 | 232 | USFWS | 17-Jun | 1-Jul | 17-Jul | 3-Aug |
| Flynn 4 | 26-32 | 231 | USFWS | 17-Jun | 1-Jul | 17-Jul | 3-Aug |
| Heron Island | 16-17 | 228 | USFWS | 28-Jun | 12-Jul | 26-Jul | 12-Aug |
| Kopta Slough 1 | 25-27 | 221 | TNC | 19-Jun | 6-Jul | 19-Jul | 6-Aug |
| Kopta Slough 2 | 29-30 | 220 | TNC | 19-Jun | 6-Jul | 19-Jul | 6-Aug |
| Woodson Bridge | 28-31 | 219 | CADPR | 19-Jun | 5-Jul | 19-Jul | 6-Aug |
| Woodson Bridge East | 10-11 | 219 | CADPR | 19-Jun | 30-Jun | 16-Jul | 5-Aug |
| Rio Vista 1 | 20 | 218 | USFWS | 18-Jun | 2-Jul | 20-Jul | 4-Aug |
| Rio Vista 2 | 22-31 | 217 | USFWS | 18-Jun | 2-Jul | 17-Jul | 4-Aug |
| Rio Vista 3 | 14-28 | 216 | USFWS | 18-Jun | 2-Jul | 19-Jul | 4-Aug |
| Rio Vista 4 | 12-20 | 216 | USFWS | 18-Jun | 2-Jul | 20-Jul | 4-Aug |
| Merrill's Landing 1 | 25-29 | 214 | DFG | 19-Jun | 6-Jul | 20-Jul | 5-Aug |
| Merrill's Landing 2 | 24 | 214 | DFG | 19-Jun | 6-Jul | 20-Jul | 5-Aug |
| Foster Island 1 | 6-13 | 211 | USFWS | 29-Jun* | 13-Jul | 27-Jul | 13-Aug |
| Foster Island 2 | 8-16 | 211 | USFWS | 29-Jun* | 13-Jul | 27-Jul | 13-Aug |
| Wilson's Landing | 21-22 | 203 | DFG | 29-Jun | 13-Jul | 27-Jul | 13-Aug |
| Pine Creek 1 | 25-27 | 198.5 | USFWS | 18-Jun | 2-Jul | 19-Jul | 4-Aug |
| Pine Creek 2 | 23-34 | 198.5 | USFWS | 18-Jun | 2-Jul | 17-Jul | 4-Aug |
| Pine Creek North 1 | 14-20 | 198 | DFG | 23-Jun | 7-Jul | 21-Jul | 9-Aug |
| Pine Creek North 2 | 22-24 | 197 | DFG | 21-Jun | 7-Jul | 21-Jul | 9-Aug |
| Bidwell-Sacramento River SP | 21-22 | 195 | CADPR | 21-Jun | 6-Jul | 19-Jul | 5-Aug |
| Pine Creek East | 18-21 | 195 | DFG | 25-Jun | 8-Jul | 21-Jul | 5-Aug |
| Pine Creek West | 24-26 | 195 | DFG | 19-Jun | 2-Jul | 18-Jul | 4-Aug |
| Capay | 11 | 194 | USFWS | 22-Jun | 7-Jul | 21-Jul | 6-Aug |
| Phelan Island | 30-33 | 191.5 | USFWS | 22-Jun | 6-Jul | 21-Jul | 7-Aug |
| Shannon Slough | 7 | 187 | DFG | + | 14-Jul | 28-Jul | 16-Aug |
| Jacinto/Shannon Slough | 10-13 | 186.5 | USFWS | 21-Jun | 7-Jul | 21-Jul | 6-Aug |

| Name | Number of Points | River Mile | Owner | Round 1 | Round 2 | Round 3 | Round 4 |
|---|---|---|---|---|---|---|---|
| South Ord 1 | 16 | 183 | USFWS | 22-Jun | 8-Jul | 24-Jul | 7-Aug |
| South Ord 2 | 11-14 | 183 | USFWS | 22-Jun | 8-Jul | 24-Jul | 7-Aug |
| Llano Seco 1 | 27-33 | 182 | USFWS | 25-Jun | 10-Jul | 29-Jul | 13-Aug |
| Jacinto | 30-31 | 181 | DFG | 23-Jun | 8-Jul | 23-Jul | 9-Aug |
| Llano Seco 2 | 28-29 | 181 | USFWS | 22-Jun | 7-Jul | 22-Jul | 7-Aug |
| Llano Seco 3 | 27-31 | 179 | USFWS | 29-Jun | 15-Jul | 28-Jul | 16-Aug |
| Riparian Sanctuary – Llano Seco | 43 | 176 | USFWS | 24-Jun | 9-Jul | 23-Jul | 11-Aug |
| Oxbow | 24-27 | 175 | DFG | 24-Jun | 10-Jul | 23-Jul | 11-Aug |
| Hartley Island | 20-21 | 173 | TNC | 25-Jun | 8-Jul | 23-Jul | 9-Aug |
| Site 78 | 21-25 | 172 | DWR | 22-Jun | 9-Jul | 22-Jul | 10-Aug |
| Beehive 1 | 20-21 | 170 | DFG | 22-Jun | 7-Jul | 20-Jul | 7-Aug |
| Beehive 2 | 22 | 170 | DFG | 22-Jun | 7-Jul | 20-Jul | 7-Aug |
| Sul Norte | 28 | 169 | USFWS | 23-Jun | 9-Jul | 23-Jul | 10-Aug |
| Codora | 18-19 | 168 | USFWS | 23-Jun | 9-Jul | 21-Jul | 6-Aug |
| Packer Island | 25-34 | 167 | USFWS | 24-Jun | 9-Jul | 22-Jul | 6-Aug |
| Afton | 17-18 | 166.5 | USFWS | 23-Jun | 9-Jul | 22-Jul | 10-Aug |
| Princeton North | 12-13 | 166.5 | DFG | 24-Jun | 9-Jul | 21-Jul | 6-Aug |
| Drumheller North | 10-11 | 165 | USFWS | 23-Jun | 7-Jul | 20-Jul | 5-Aug |
| Princeton East | 17-21 | 164 | DFG | 23-Jun | 7-Jul | 20-Jul | 5-Aug |
| Princeton Southeast | 14-15 | 161.5 | DFG | 24-Jun | 9-Jul | 22-Jul | 9-Aug |
| Moulton North | 8 | 157 | DFG | + | 16-Jul | 28-Jul | 14-Aug |
| Boeger | 15-22 | 148 | TNC | 24-Jun | 9-Jul | 24-Jul | 12-Aug |
| Colusa North | 25-26 | 147 | DFG | 24-Jun | 8-Jul | 23-Jul | 9-Aug |
| Colusa-Sacramento River SP | 24 | 145 | CADPR | 24-Jun | 8-Jul | 23-Jul | 9-Aug |
| Boat - Tehama | 30 | 230,232 236-238, 239 | private | 28-Jun | 12-Jul | 26-Jul | 12-Aug |
| Boat - Merrill's Landing | 6-24 | 205.5-207, 211-212.5 | private | 29-Jun* | 13-Jul | 27-Jul | 13-Aug |
| Dicus Slough | | 208-209 | DFG | | | | |
| Boat - Butte City | 51-54 | 187-192.5 | private | + | 14-Jul | 28-Jul | 16-Aug |
| | | 189-190 | DWR | | | | |
| Boat - Colusa | 68-72 | 169.5-171 | private | + | 15-Jul | 29-Jul | 17-Aug |
| Packer Island | | 167 | USFWS | | | | |
| Site 21 | | 165 | DFG | | | | |
| Princeton South | | 161.5-163 | DFG | | | | |
| Stegeman | | 159-160 | DFG | | | | |
| Moulton Island | | 157 | private | | | | |
| Moulton South | | 155-156 | DFG | | | | |

Appendix 2. Occupancy model selection using AIC values for each of the different territory sizes analyized. *This model allowed the probability of detection (p) to vary by survey round. +This model assumed the probability of detection was constant throughout the entire survey period.

| Territory Size (ha) | Model | AIC | ΔAIC | AIC weight |
|---|---|---|---|---|
| 15 | survey specific p* | 218.22 | 0 | 0.81 |
| | constant p+ | 221.11 | 2.89 | 0.19 |
| 30 | survey specific p* | 192.25 | 0 | 0.81 |
| | constant p+ | 195.14 | 2.89 | 0.19 |
| 45 | survey specific p* | 176.90 | 0 | 0.81 |
| | constant p+ | 179.80 | 2.90 | 0.19 |
| 60 | survey specific p* | 154.91 | 0 | 0.63 |
| | constant p+ | 155.96 | 1.05 | 0.37 |
| 75 | survey specific p* | 146.78 | 0 | 0.63 |
| | constant p+ | 147.83 | 1.05 | 0.37 |