LOWER SANTA CRUZ RIVER
RIPARIAN VEGETATION 2013 SURVEY REPORT

FINAL

SUBMITTED TO:
PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TUCSON, ARIZONA 85701

SUBMITTED BY:
HARRIS ENVIRONMENTAL GROUP, INC.
SEPTEMBER 2013

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97 EAST CONGRESS, 3RD FLOOR
TUCSON, ARIZONA 85701

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SEPTEMBER 2013

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ACRONYMS

DBH: Diameter at Breast Height
FAC: Facultative
FACU: Facultative Upland
FACW: Facultative Wetland
GIS: Geographic Information Systems
GPS: Global Positioning System
HEG: Harris Environmental Group, Inc.
NITRO#: Nitrogen Affinity Score
OBL: Obligate (wetland)
PCRFCD: Pima County Regional Flood Control District
SEINet: Southwest Environmental Information Network
SOW: Statement of Work
UPL: Upland
WIS#: Wetland Indicator Score
WRF: Wastewater Reclamation Facility

INTRODUCTION

Harris Environmental Group, Inc. (HEG), under contract with Pima County Regional Flood Control District (PCRFCD), conducted vegetation surveys along the Santa Cruz River to determine baseline conditions prior to sewage treatment improvements. A new sewage treatment facility is being constructed just north of the Roger outfall to replace the 60-yr old Roger Road Wastewater Reclamation Facility (WRF). While the new facility will improve the quality of water discharged at the Roger outfall in the future, the total discharge may decrease from its current volume due to less overall water being treated as well as increased use of recycled water for municipal purposes. The Ina Road WRF is also being improved and will handle more total metropolitan sewage, which will likely increase the treated discharge upstream from the Ina outfall. Because maintaining riparian vegetation is a priority for Pima County, they wish to monitor the effects of the changes in discharge on woody and herbaceous riparian vegetation. These surveys and analyses serve as a preliminary assessment of the herbaceous and woody vegetation present along the Santa Cruz River and, coupled with post-construction surveys, will enable Pima County to assess the impacts of the sewage treatment project on riparian vegetation. A secondary goal is to compare results with research along other riparian reaches across the region. Surveys were conducted during the last two weeks of May 2013 after spring leaf out, but before summer monsoon rainfall. Streamside herbaceous surveys will continue annually after the improvements are completed, whereas woody vegetation will be reassessed in three years.

PROJECT LOCATION

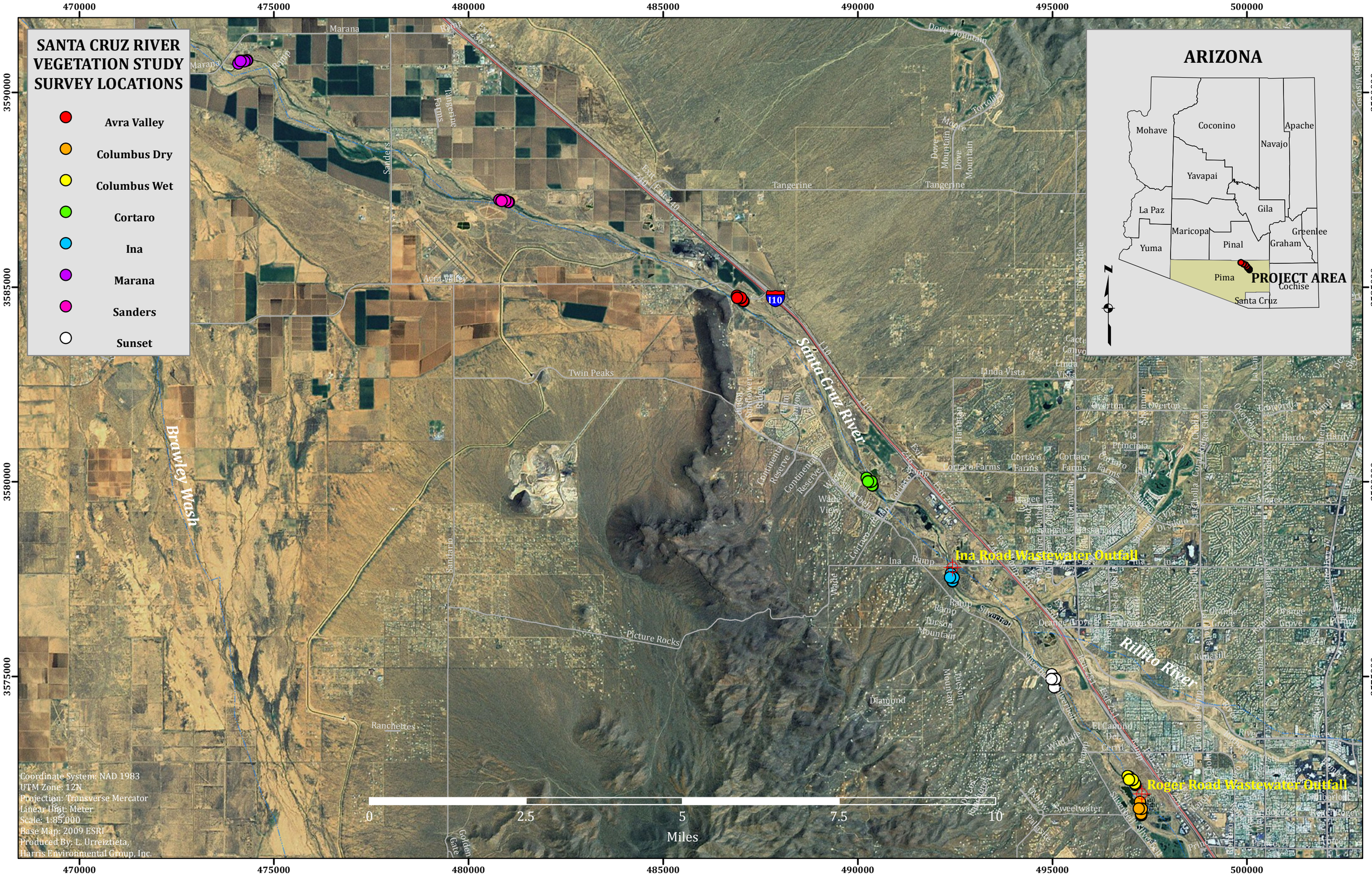
Surveys were conducted along the lower Santa Cruz River from the city of Tucson to the town of Marana in Pima County, AZ (Figure 1). Specifically, we examined a 40-kilometer [km] (25-mile [mi]) stretch of the lower Santa Cruz River spanning from a reach adjacent to Columbus Park (12S 0497161 m E, 3571679 m N) to a reach downstream, just south and east of Trico-Marana Rd (12S 0473698 m E, 3590743 m N).Within the project area, the width of the main channel ranges from 8-20 m (26-66 ft) with a floodplain anywhere from 80-500+ m (262-1640+ ft) wide. Stabilized embankments, typically consisting of man-made soil cement, are common along this stretch of the lower Santa Cruz River and often constrain the width of the floodplain to ~100 m. The channel is free to meander independently throughout many river miles; however, an edge of the main channel's low-flow often abuts these stabilized banks. Therefore, herbaceous surveys were only conducted along natural streamsides and woody vegetation surveys were constrained within the man-made stabilized banks when present. In this manner, upland and landscape vegetation common along these disturbed terraces was avoided. However, vegetation on floodplain terraces was included in surveys if stabilized banks were a result of channel incision resulting from natural bank erosion.

ENVIRONMENTAL SETTING

The lower Santa Cruz River is within the basin and range topography typical of southern Arizona within the Arizona Upland subdivision of the Sonoran Desertscrub biotic community with a few areas characteristic of vegetative zones of the Lower Colorado River subdivision (Brown, 1994). Historically, perennial stretches were more common in the 19thcentury; however, shallow groundwater and seasonal rainfall often produced baseflow for many weeks of the year until the mid-20th century (Wood et al., 1999). In the mid-1900s, factors such as groundwater and surface water pumping, excessive wood-cutting, and overgrazing drastically impacted dense riparian gallery forests of cottonwood (*Populus* spp.), willow (*Salix* spp.), and mesquite(*Prosopis* spp.)(Rea, 1983; Bahr, 1991). Today, native vegetation along the Santa Cruz River includes abundant velvet mesquite (*Prosopis velutina*) and Goodding's willow (*Salix gooddingii*) while non-native species include two tamarisk species (*Tamarix ramosissima* and *T. aphylla*). Streamside herbaceous vegetation consists of obligate and facultative wetland plants, including mixed native and non-native grasses, and encroaching upland vegetation. Current river conditions and associated vegetation communities reflect current management strategies including flood control and prevention, and an altered hydrological regime consisting of treated wastewater discharge at varying volumes throughout the day and year.

SURVEY SITES

Eight survey sites were selected using information provided by the PCRFCD (Figure 1). Before significant monsoon rains, 100% of the baseflows within the Santa Cruz River are supported by two outfalls that discharge treated wastewater from the Roger Road and Ina Road WRFs. The Roger outfall provides baseflows to the entire river reach from Columbus Park to its confluence with the Ina outfall just south of Ina Rd. One survey site (Veg_1), not influenced by reclaimed water, was located upstream from the Roger outfall and served as the control site; three sites were located downstream from the Roger outfall, but upstream from the Ina outfall (Veg_2, Veg_3, Veg_4); and the remaining four locations were downstream from the Ina outfall and were influenced by both Roger and Ina outfalls (Veg_5, Veg_6, Veg_7, Veg_8; Figure 1).


SANTA CRUZ RIVER VEGETATION STUDY SURVEY LOCATIONS
Avra Valley
Columbus Dry
Columbus Wet
Cortaro
Ina
Marana
Sanders
Sunset
ARIZONA
Mohave
Coconino
Apache
Navajo
Yavapai
La Paz
Gila
Maricopa
Greenlee
Yuma
Pinal
Graham
Pima
PROJECT AREA
Cochise
Santa Cruz
Ina Road Wastewater Outfall
Roger Road Wastewater Outfall
Santa Cruz River
Brawley Wash
Rillito River
Coordinate System: NAD 1983
UTM Zone: 12N
Projection: Transverse Mercator
Linear Unit: Meter
Scale: 1:85,000
Base Map: 2009 ESRI
Produced By: L. Urreiztieta,
Harris Environmental Group, Inc.
0
2.5
5
7.5
10
Miles
470000
475000
480000
485000
490000
495000
500000
3590000
3585000
3580000
3575000

Site 1 (Veg_1), Columbus Park Dry

The first survey site serves as the overall control site. It is the only location that is not influenced by treated wastewater. This site is located Southeast of Columbus Park and the nearest transect is just less than 200 m from the Roger outfall to the north. This reach has stabilized banks to the east and the west of the main channel and the width from bank to bank is less than 100 m. Singlewhorl burrobrush (*Hymenoclea monogyra*) is the most abundant species at this site and upland vegetation dominates the landscape.

Site 2 (Veg_2), Columbus Park Wet

The second survey site is located northeast of Columbus Park with the nearest transect beginning approximately 250 m north of the Roger outfall. The eastern edge of the main channel abuts a stabilized soil cement embankment. This is the first site downstream from the Roger outfall that supports larger, facultative phreatophytic trees (i.e., trees using both groundwater and the unsaturated zone for growth and survival) such as *S. gooddingii* and *Tamarix* spp., but soil cement along the eastern border limits growth to the west side of the main channel.

Site 3 (Veg_3), Sunset Rd.

The third survey site lies parallel to Silverbell Rd. and just north of the east-west plane of Sunset Rd. A gravel pit borders the site to the east and power lines cross the river in three separate areas. Vegetation is mainly a mix of native species such as *S. gooddingii* and Mexican paloverde(aka. Jerusalem thorn, *Parkinsonia aculeata*), and a high terrace above the eroded western bank includes upland species such as wolfberry (*Lycium* spp.), creosotebush (*Larrea tridentada*), and cattle saltbush (*Atriplex polycarpa*).

Site 4 (Veg_4), Ina Rd.

The fourth survey site is over 200 m south of Ina Rd. and just over 100 m south of the Ina outfall. This is the furthest site downstream that receives water discharge from the Roger outfall alone. Depending on the management of the newly constructed WRF upstream, baseflows could be greatly reduced and may not reach this site in the future. Small to very large trees are prevalent at this site and include *Tamarix* spp. and *S. gooddingii*.

Site 5 (Veg_5), Cortaro Rd.

The fifth survey site is located just west of Marana Golf Continental Ranch and is over 600 m northwest of Cortaro Rd. This site is relatively open and is the first site to receive treated wastewater from the Ina WRF. A small sandbar is present at the first transect upstream, a large channel bar encompasses most of the middle transect, and an embankment impacts the third

transect downstream. Few trees exist at this site and shrubs such as *H. monogyra* and *Baccharis* spp. dominate the landscape.

Site 6 (Veg_6), Avra Valley Rd.

The sixth survey site lies parallel to Avra Valley Rd. and has a stabilized eastern bank made of soil cement. This site is unique in that the main channel is incised with steep slopes or banks on both sides ranging from three to eight meters. Thick stands of non-native, shrubby *T. ramosissima* dominate this site with *B. salicifolia* common in the understory.

Site 7 (Veg_7), Tangerine Rd.

The seventh site, also referred to as "Sanders" (located upstream from and east of Sanders Rd) is located south and west of Tangerine Rd. This site also has an eastern bank stabilized with soil cement. Channel bars and sand bars are common at this site and also of note is a large drainage to the east of the middle transect which likely introduces high volume runoff through a culvert during large storm events. The main channel runs roughly east-south-east to west-north-west with the most common woody species being *Tamarix* spp. This site also has a host of aquatic plants including floating mats and grasses.

Site 8 (Veg_8), Marana-Trico Rd.

The eighth survey site is located south and east of Trico-Marana Rd. The main channel is sinuous along this reach heading east to west then meandering southwest. Large *T. aphylla* dominate the site, but *T. ramosissima* and *S. gooddingii* are also common. This particular site is very remote and it is evident that cattle grazing and associated erosion is common in the area.

METHODS

The PCFCD provided site maps with GPS coordinates and restrictions (e.g., jurisdiction/right of entry) to eight survey areas (Appendix A). A GPS and aerial imagery (e.g., GoogleEarth and supplied maps) were used to find the survey area and then the placement of transects were selected subjectively to capture vegetation representative of each site. Each site included three streamside herbaceous transects and one woody vegetation belt-transect. A GPS was used to document the beginning and ending coordinates of each herbaceous transect as well as each corner (i.e., northwest, southwest, northeast, and southeast, Appendix B) of each woody transect. The woody transects are permanent and rebar and flagging were used to mark the south west and southeast corners of each transect. In addition, a digital camera was used to aid in finding transects three years hence. Photograph documentation included pictures taken from the southwest and southeast corners facing inward toward the extended transect line, outward away from the transect, and north downstream (Appendix C).

The surveys were conducted following methods detailed in the statement of work (SOW; Appendix D). Surveys and analyses were adapted from protocols implemented by the Stromberg Research Group, Arizona State University. The metrics and indices used are amenable to other sites, thus a secondary goal was to be able to compare results with research along other riparian reaches across the region.

Streamside Herbaceous Surveys

Streamside herbaceous vegetation was surveyed using three, 20-m transects spaced approximately 100-m apart and parallel to the streambank. We estimated percent cover of vegetation in gridded, 1-m x 1-m sampling frames (i.e., quadrats). A stopwatch was used to randomize three locations along each transect by separating the hundredths into five, 20-interval categories to match 1-m intervals of a 20-m transect. For example; .05, .25, .45, .65, and .85 sec all represent a quadrat to be randomized at the 5-m position, whereas .17, .37, etc represent a randomized placement of 17 m. We also implemented a stratified random rule such that at least one quadrat would land in each of the two, 10-m halves of each transect (i.e., no three randomized quadrats could land in the first 10 m or second 10 m of the transect). On each side of the main channel, streamside vegetation was surveyed along the margin of low-flow perpendicular to the randomized transect locations. As suggested by PCRFC staff, the river was assumed to be near its low-flow during our early morning surveys (e.g., between 5a-11a); however, margins of low-flow were chosen to the best of our ability during late morning to afternoon surveys. Because placement was inherently subjective, the front edge (i.e., the edge closest to the main channel) of each quadrat was placed at the front edge of the first patch of vegetation influenced by channel moisture. We categorized the moisture at this interface as dry, moist, <3 cm, or >10 cm deep. This strategy allowed for obligate wetland plants to be included in the surveys when present, but also assessed vegetation reaching one meter onto a sandbar, channel bar, or the channel's edge. If an edge of the low-flow channel abutted a stabilized embankment, then a total of six randomized quadrats were placed along two, 20-m transects on the opposite bank. A standard cover-abundance class approach was used to estimate cover of each species (FGDC 2008). Specifically, a modified Braun-Blanquet approach was used to assign a cover percentage to each species identified within each quadrat. Herbaceous or woody species not originating in the quadrat but overhanging were included in the survey. A table was used to express each cover estimate as a midpoint following in one of five possible cover classes (Table 1). For example, if a species covered approximately 30% of the quadrat, then the species was given a value of 37.5, which represents the mid-point between the 25-50% cover class category.

Table 1. Modified Braun-Blanquet classes used for data analyses.

Cover Class Range	Midpoint
76-100	87.5
51-75	62.5
26-50	37.5
6-25	15.0
1-5	3.0
<1	0.5
0	0.0

Floodplain Woody Vegetation Surveys

We measured woody vegetation, which includes small to large shrubs and all trees at each site using a 100-m x 5-m belt transect with 10-m intervals (Figure 2). Each belt-transect perpendicularly bisected the mid-point of the middle herbaceous transect and was oriented across the floodplain spanning from due west to due east. When possible, the center of the belt-transect (i.e., 50-m point) was placed in the middle of the main channel to allow the survey to extend 50 m onto the floodplain on each side. All measurements were conducted within 10-m x 5-m subplots spanning from west to east with summary statistics being compiled during the analyses for a total of 10 subplots. If bank protection was located within 50 m of the main channel, such that it would interfere with the belt-transect, we imposed the following decision rule to maintain the 100-m length required for the belt transect: The end of the transect (i.e., the 100-m mark) would begin at the immediate edge of the bank protection and extend west across the main channel until the zero point is reached. In other words, the majority of the belt-transect would reside on the west side of the channel. This occurred during the woody vegetation surveys at the Columbus Wet (Veg_2) and Avra Valley (Veg_6) sites. Note that there were no occurrences where bank protection impacted surveys on the west end of the transect. One exception occurred at the Columbus Dry (Veg_1) site where the width of the floodplain was 80 m and constrained within bank protection on both sides. As a result; eight, 10-m intervals were surveyed and analyzed at this particular belt-transect instead of 10.

We used a spherical concave densiometer to measure canopy cover (i.e., canopy closure) for each woody species. We held the densiometer at 1.25-m above ground surface in the middle of each subplot, and counted vegetation "hits" if plant leaves or stems were present within any of four imaginary, equidistant dots within each of the 24 squares. A total of 96 hits were possible and canopy closure was post-processed. In addition, for each subplot, we estimated vegetation cover within each of three stratified layers: 1) ground (<1 m); 2) mid-canopy (1-5 m); and 3) canopy (>5 m) for all woody species combined as well as each individual species.

Like streamside herbaceous cover, woody cover was visually estimated and documented using the midpoints of each cover class (Table 1). For each woody species present, stem diameters were measured at six inches above ground surface using either calipers or diameter at breast height (DBH) tape to the nearest mm (e.g., 5.8 cm). Multiple stems were measured per tree if stems branched out below six inches from its base. If a woody species was small, shrubby, and many-branched; size class categories (e.g., <1 m, 1-2 cm) were used to document all stems. If it was not practical or feasible to measure or count all the stems for certain shrubby species, then an individual plant count was taken instead (See Table 2). Notes were taken in the field to document whether stems represented new saplings versus being a small stem, ramet, or clonal extension from a mature tree.

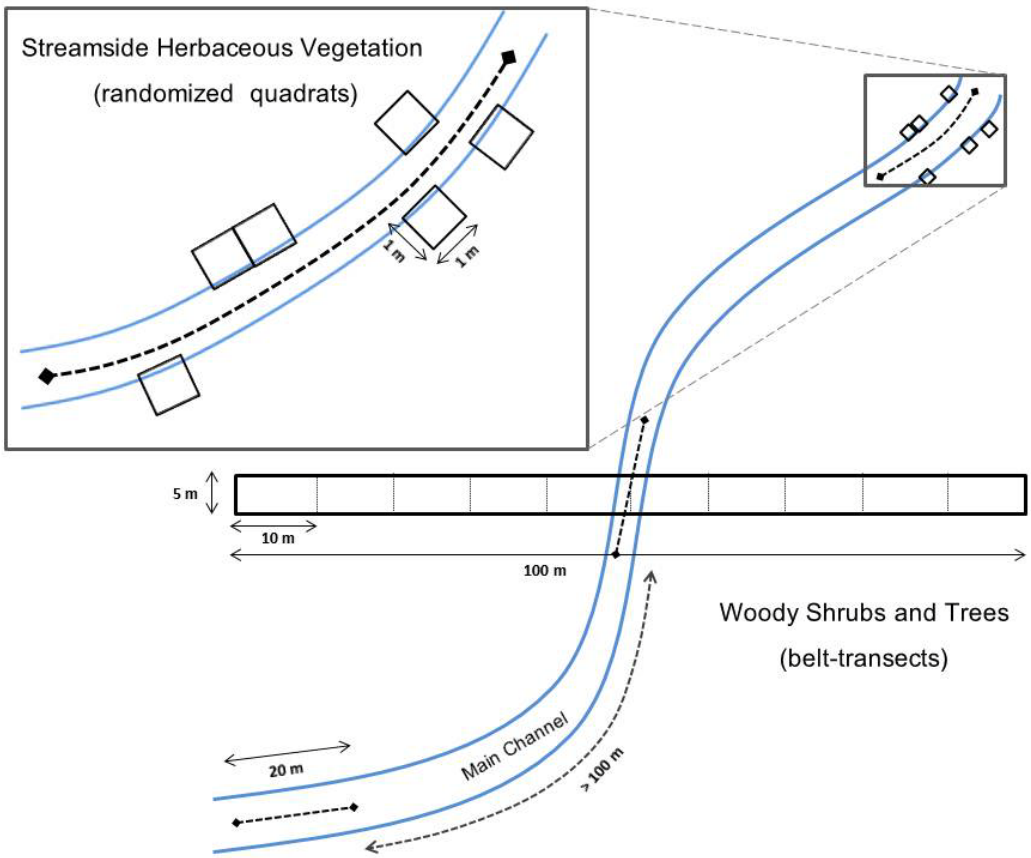


Figure 2. Schematic of 100-m x 5-m woody belt-transects at 10-m intervals across main channel and example of randomized quadrats within 20-m transects (inset; not to scale).

Table 2. Definition of target species versus non-target species within the belt-transects for analysis purposes.

Measured Species		Estimated Species
Trees[1]	**Shrubs[2]**	**Shrubs[3]**
Populus fremontii	*Baccharis salicifolia*	*Atriplex elegans*
Salix gooddingii	*Baccharis sarathroides*	*Atriplex polycarpa*
Tamarix aphylla		*Hymenoclea monogyra*
Tamarix ramosissima		*Larrea tridentata*
Parkinsonia aculeata		*Lycium fremontii*
Prosopis velutina		

[1]All stems diameters were systematically measured at 6" above ground surface for all targeted trees

[2]All stem diameters >2 cm were measured while small stems were estimated within two small classes (i.e., <1 cm and 1-2 cm) for targeted shrubs

[3]Only individual plant counts were documented for non-target shrubs due to the impracticality of measuring individual stems for each plant

ANALYSIS

Species Identification and Richness

All plants surveyed were identified to species using the USA Plants Database treatment (USDA 2013). Other resources used included SEINet (Southwest Environmental Information Network,http://swbiodiversity.org/portal/index.php), the University of Arizona Herbarium, and relevant regional plant identification books. All species were given a unique four-letter code using the first two letters of the genus and species. When necessary, some coded species were assigned a number to differentiate them from other similarly names species (e.g., *Baccharis salicifolia*and *B. sarathroides* were assigned BASA and BASA2, respectively). Species richness, the total number of individual species observed, was analyzed by quadrat, transect (i.e., three quadrats), and site (18 quadrats) as well as cumulatively for the entire project.

Wetland Indicator Status

A wetland indicator status (WIS) number was computed for each site. Using a list provided by Pima County and adapted from the National Wetland Plant List (Appendix E; USACE 2012), each species documented was assigned to one of five functional groups: 1) “1” obligate wetland species (OBL); 2) “2” facultative wetland (FACW); 3) “3” facultative (FAC); 4) “4” facultative upland (FACU); and 5) “5” upland (UPL). A WIS number was computed by weighting each species by their overall cover percentage and then using the functional group number as the multiplier. The WIS number is an index ranging from 1-5 with lower numbers representing sites with prevalent wetland species and higher numbers representing sites more characteristic of upland vegetation.

Nitrogen Affinity

Sites were also analyzed using a nitrogen score index. Each species was assigned a nitrogen number ranging from 0-9 representing low to high affinity to nitrogen. Similar to the WIS number analysis, the nitrogen score was weighted by cover percentages of species found at each site. Lower nitrogen numbers represented sites characteristic of species with low nitrogen affinity while higher scores represented sites with species having high tolerance to high nitrogen concentrations.

Woody Species Plant Density, Stem Density, Basal Area, and Recruitment

Stem density of each woody species was analyzed across the entire 100-m x 5-m belt-transect as well as within each subplot. Stem density was reported as stems per hectare after excluding the area represented by the main channel. Similarly, basal area for each woody species was analyzed across the entire belt-transect and within each subplot. Basal area was reported as square meters per hectare excluding the area represented by the main channel. Stem density

and basal area could not be analyzed for species in which it was not practical to measure each stem (e.g., *H. monogyra*, *L. tridentata*); however, plant density is reported for these species. Saplings, defined as plants that likely germinated within the last year and determined *in situ* to the best of our ability, were counted across the entire belt-transect. These counts were assessed by using a combination of quantitative information (i.e., stems that were <1.0 cm) and qualitative information (i.e. field notes that established whether a small stem was a sapling or an extension from an existing mature shrub or tree) taken in the field.

Vegetation Canopy Closure, Cover Percentage, and Structure

Multiple methods were used to analyze vegetation cover. Canopy closure was estimated using densiometer readings with the following equation:

$$\text{Canopy Closure} = 100-((96-x)*1.04) \qquad 1)$$

where x is total hits and canopy closure is expressed as a percentage. At each site, individual species cover percentage was analyzed within three stratified layers (described in the methods) by averaging cover estimates across all 10 subplots. Cover percentage was also analyzed within functional groups across the 10 subplots. Using a table provided by Pima County (Table 3), canopy cover by strata data was also used to classify each subplot into one of five structure types: 1) forest; 2) woodland; 3) shrubland; 4) grassland; or 5) open. The percent cover for each structure type was reported for each site using the average across the 10 subplots.

RESULTS

Species Identification and Richness

A total of 51 individual plant species were identified during the streamside herbaceous surveys (Appendix F). The average number of species documented was 18.88 per site, 10.96 per transect, and 3.49 per quadrat. Species richness varied greatly across the eight survey sites with the least number of species observed at the Columbus Dry site (Veg_1, 11) and the most at observed at the Sunset Rd site (Veg_3, 24) (Table 4). A total of 13 species were documented in the woody belt-transect, including five additional species not observed in the streamside surveys (Appendix F).

Wetland Indicator Status

The average WIS# for all survey sites combined was 3.38. The Tangerine Rd site south of SandersRd had the lowest WIS# at 2.67, representing the site with the most wetland species observed, while the Columbus Park Dry site (Veg_1) had a WIS# of 4.93, indicating the site with the most upland species present (Figure 3).

Table 3. Metrics used to classify subplots within each belt-transect into structure types.

	Ground	Mid-canopy	Canopy
forest			>60%
woodland			25-60%
shrubland		>25%	<25%
grassland	>25%		
open	<25%		

Table 4. Species richness documented across each survey site. Summary statistics by column include: 1) average species richness per quadrat and average of all three quadrats combined (bold, left); 2) species richness within each transect as well as average per transect (bold, center); and 3) total number of species identified per site.

	Species Richness		
	Quadrat	**Transect**	**Site**
Veg_1	2.33	9	
	1.17	4	
	1.67	4	
	1.72	***5.67***	***11***
Veg_2	3.00	11	
	4.17	15	
	2.83	8	
	3.33	***11.33***	***20***
Veg_3	4.83	15	
	4.33	12	
	3.17	9	
	4.11	***12.00***	***24***
Veg_4	2.50	6	
	3.67	12	
	5.17	18	
	3.78	***12.00***	***20***
Veg_5	1.67	6	
	4.00	12	
	4.17	15	
	3.28	***11.00***	***20***
Veg_6	3.00	10	
	3.17	10	
	3.50	13	
	3.22	***11.00***	***15***
Veg_7	1.83	8	
	4.50	14	
	4.50	14	
	3.61	***12.00***	***21***
Veg_8	3.83	10	
	5.83	13	
	5.00	15	
	4.89	***12.67***	***20***

Nitrogen Affinity

The average NITRO# for all survey sites combined was 4.71. The lowest two NITRO#s were 3.14 and 3.15, computed for the Sanders site (Veg_7) near Tangerine Rd and the Columbus Park Dry site (Veg_1), respectively (Figure 3). The highest NITRO#, 6.69, was computed at the Ina Rd site (Veg_4).

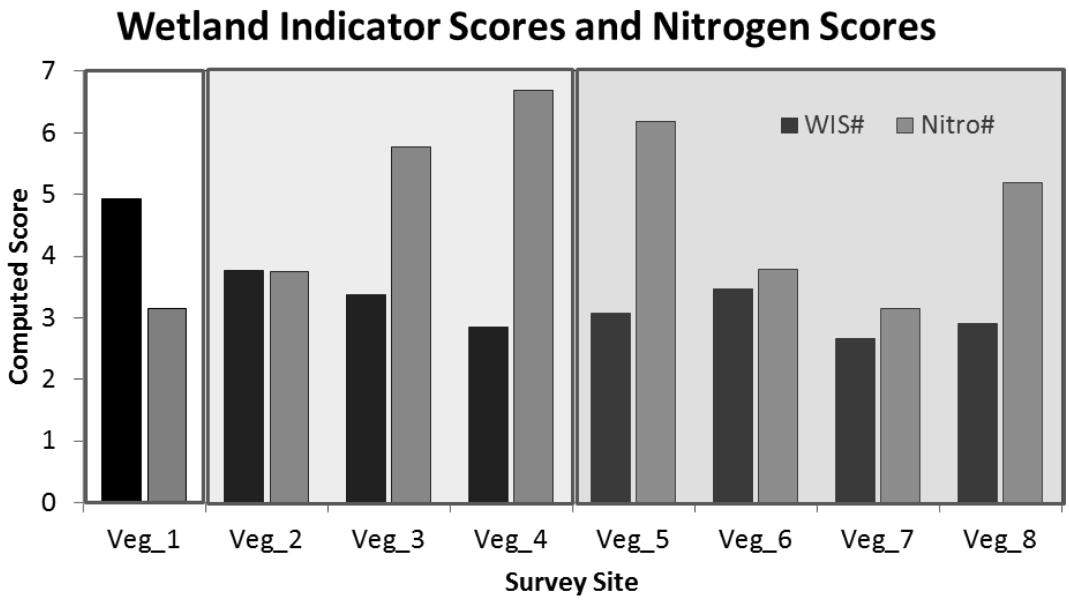


Figure 3. Computed wetland indicator scores (WIS#) and nitrogen affinity scores (NITRO#) for each survey site. Wetland Indicator Scores range from 1-5 with lower scores representing sites with more wetland species. Nitrogen affinity scores range from 1-9 with higher numbers indicating higher tolerance to nitrogen concentrations. Color gradients from left to right depict the influence of the Roger Rd and Ina Rd outfalls, respectively.

Woody Species Plant Density, Stem Density, Basal Area, and Recruitment

The highest average plant and stem density of all species across all sites was *S. gooddingii*with estimates ofjust under 5,000 plants/ha and just over 5,000 stems/ha (Table 5.1). This was a result of hundreds of approximately 6”-tall single-stemmed saplingsdocumented within the belt-transect at the Sunset Rd site (Veg_3; Table 5.1). The second highest woody species density observed was *T. ramosissima* with estimates of ~300 plants/ha and >1000 stems/ha. The highest shrubby plant density was *H. monogyra* with estimates of 825 plants/ha (Table 5.1).The highest dead plant density and stem density were *T. ramosissima*with estimates of90 dead plants/ha and over 150 dead stems/ha (Table 5.2). When analyzed within functional

groups, the highest plant density observed was by upland and facultative wetland species with estimates of 1473 and 1426 plants/ha, respectively. Analyzed by stem density, however, facultative wetland species had the highest density with 1550 stems/ha followed by upland species with 1250 stems/ha (Table 5.2).

The greatest species basal area observed across sites was by *S. gooddingii* estimated at 3.7 m^2/ha followed by *T. ramosissima* with 1.2 m^2/ha. The greatest dead species basal area observed across sites was *T. ramosissima* with 0.04 m^2/ha followed by *S. gooddingii* with 0.03 m^2/ha. When analyzed by functional group, facultative wetland species had the greatest basal area with 3.9 m2/ha while the least basal area was represented by facultative upland species with 0.9 m^2/ha (Table 5.2). *S. gooddingii* had the highest recruitment observed with an average of 66 new saplings counted per site (Table 5.2). Other notable volunteers were *B. sarathroides*, *H. monogyra*, and *B. salicifolia* with averages of 21.3, 14.5, and 14.1 saplings/site, respectively. As requested in the SOW, summary statistics were also computed by subplot within each belt-transect and include standard deviation from the mean (Appendix G)

Vegetation Canopy Closure, Cover Percentage, and Structure

The highest average percentage of canopy closure (i.e., computed densiometer measurements) observed across all sites was *T. aphylla* with 6.1% followed by *S. gooddingii* with 4.04% and *T. ramosissima* with 3.69% (Table 6).Averaging cover by strata data across all sites, open areas made up 68.4% of the total survey area within the belt-transects. Shrublands had the highest vegetation coverwith 17.5% followed by grasslands with 9.1%. Woodland and forest covered 3.8% and 1.3% of the survey area, respectively. Open areas were present at all sites while forest, defined by >60% cover, 5 m above ground surface, was only encountered at the Ina Rd site (Veg_4; Figure 4).

Table 5.1. Plant density, stem density, basal area, and sapling recruitment statistics from woody belt-transect surveys for live plant species.

	Vegetation	ACGR	BASA	BASA2	PAAC	POFR	PRVE	SAGO	TAAP	TARA	ATEL	ATPO	HYMO	LATR	LYFR
	plants/site	*	*	8	*	*	5	*	*	*	3	*	60	3	*
	plants/ha	*	*	222.2	*	*	138.9	*	*	*	83.3	*	1666.7	83.3	*
	stems/site	*	*	105	*	*	9	*	*	*	*	*	*	*	*
Veg_1	stems/ha	*	*	2916.7	*	*	250.0	*	*	*	*	*	*	*	*
	basal area (cm^2)	*	*	431.7	*	*	8.7	*	*	*	*	*	*	*	*
	basal area (m^2/ha)	*	*	1.2	*	*	0.02	*	*	*	*	*	*	*	*
	saplings	*	*	74	*	*	3	*	*	*	*	*	30	3	*
	plants/site	3	*	10	2	1	4	2	*	14	*	*	76	*	*
	plants/ha	67.4	*	224.7	44.9	22.5	89.9	44.9	*	314.6	*	*	1707.9	*	*
	stems/site	14	*	113	3	1	12	30	*	91	*	*	*	*	*
Veg_2	stems/ha	314.6	*	2539.3	67.4	22.5	269.7	674.2	*	2044.9	*	*	*	*	*
	basal area (cm^2)	2.3	*	126.3	333.8	0.5	161.1	3958.3	*	520.1	*	*	*	*	*
	basal area (m^2/ha)	0.01	*	0.3	0.8	0.0	0.4	8.9	*	1.2	*	*	*	*	*
	saplings	0	*	51	0	1	2	27	*	13	*	*	25	*	*
	plants/site	*	5	13	2	*	4	500	*	*	5	56	4	1	10
	plants/ha	*	111.1	288.9	44.4	*	88.9	11111.1	*	*	111.1	1244.4	88.9	22.2	222.2
	stems/site	*	49	45	6	*	8	500	*	*	*	*	*	*	*
Veg_3	stems/ha	*	1088.9	1000.0	133.3	*	177.8	11111.1	*	*	*	*	*	*	*
	basal area (cm^2)	*	91.4	129.6	163.3	*	2760.4	250.0	*	*	*	*	*	*	*
	basal area (m^2/ha)	*	0.2	0.3	0.4	*	6.1	0.6	*	*	*	*	*	*	*
	saplings	*	32	27	0	*	1	500	*	*	*	*	*	*	*
	plants/site	*	1	1	4	*	*	3	1	5	*	*	3	*	*
	plants/ha	*	24.4	24.4	97.6	*	*	73.2	24.4	122.0	*	*	73.2	*	*
	stems/site	*	3	10	4	*	*	9	5	17	*	*	*	*	*
Veg_4	stems/ha	*	73.2	243.9	97.6	*	*	219.5	122.0	414.6	*	*	*	*	*
	basal area (cm^2)	*	4.5	6.0	12.1	*	*	4271.7	256.2	329.4	*	*	*	*	*
	basal area (m^2/ha)	*	0.01	0.01	0.03	*	*	10.4	0.6	0.8	*	*	*	*	*
	saplings	*	0	9	1	*	*	0	0	0	*	*	*	*	*

cont.	Vegetation	ACGR	BASA	BASA2	PAAC	POFR	PRVE	SAGO	TAAP	TARA	ATEL	ATPO	HYMO	LATR	LYFR
	plants/site	*	1	3	*	*	*	*	*	6	3	*	123	*	*
	plants/ha	*	22.0	65.9	*	*	*	*	*	131.9	65.9	*	2703.3	*	*
	stems/site	*	9	9	*	*	*	*	*	40	*	*	*	*	*
Veg_5	stems/ha	*	197.8	197.8	*	*	*	*	*	879.1	*	*	*	*	*
	basal area (cm^2)	*	4.5	4.5	*	*	*	*	*	16.1	*	*	*	*	*
	basal area (m^2/ha)	*	0.01	0.01	*	*	*	*	*	0.04	*	*	*	*	*
	saplings	*	9	9	*	*	*	*	*	2	*	*	61	*	*
	plants/site	*	6	*	*	*	*	*	1	80	*	*	*	*	*
	plants/ha	*	134.8	*	*	*	*	*	22.5	1797.8	*	*	*	*	*
	stems/site	*	38	*	*	*	*	*	4	214	*	*	*	*	*
Veg_6	stems/ha	*	853.9	*	*	*	*	*	89.9	4809.0	*	*	*	*	*
	basal area (cm^2)	*	220.2	*	*	*	*	*	62.2	3292.0	*	*	*	*	*
	basal area (m^2/ha)	*	0.5	*	*	*	*	*	0.1	7.4	*	*	*	*	*
	saplings	*	13	*	*	*	*	*	0	0	*	*	*	*	*
	plants/site	*	6	*	*	*	*	1	1	*	6	*	3	*	*
	plants/ha	*	144.6	*	*	*	*	24.1	24.1	*	144.6	*	72.3	*	*
	stems/site	*	51	*	*	*	*	1	12	*	*	*	*	*	*
Veg_7	stems/ha	*	1228.9	*	*	*	*	24.1	289.2	*	*	*	*	*	*
	basal area (cm^2)	*	26.5	*	*	*	*	1.0	271.7	*	*	*	*	*	*
	basal area (m^2/ha)	*	0.1	*	*	*	*	0.002	0.7	*	*	*	*	*	*
	saplings	*	50	*	*	*	*	0	0	*	*	*	*	*	*
	plants/site	*	1	*	*	*	*	4	4	1	*	*	9	*	*
	plants/ha	*	32.3	*	*	*	*	129.0	129.0	32.3	*	*	290.3	*	*
	stems/site	*	11	*	*	*	*	8	11	5	*	*	*	*	*
Veg_8	stems/ha	*	354.8	*	*	*	*	258.1	354.8	161.3	*	*	*	*	*
	basal area (cm^2)	*	7.5	*	*	*	*	3001.9	1713.4	40.9	*	*	*	*	*
	basal area (m^2/ha)	*	0.02	*	*	*	*	9.7	5.5	0.1	*	*	*	*	*
	saplings	*	9	*	*	*	*	0	0	0	*	*	*	*	*
	plants/site	0.4	2.5	4.4	1.0	0.1	1.6	63.8	0.9	13.3	2.1	7.0	34.8	0.5	1.3
	plants/ha	8.4	58.6	103.3	23.4	2.8	39.7	1422.8	25.0	299.8	50.6	155.6	825.3	13.2	27.8
	stems/site	1.8	20.1	35.3	1.6	0.1	3.6	68.5	4.0	45.9	0.0	0.0	0.0	0.0	0.0
Average	stems/ha	39.3	474.7	862.2	37.3	2.8	87.2	1535.9	107.0	1038.6	0.0	0.0	0.0	0.0	0.0
	basal area (cm^2)	0.3	44.3	87.3	63.6	0.1	366.3	1435.3	287.9	524.8	0.0	0.0	0.0	0.0	0.0
	basal area (m^2/ha)	0.001	0.1	0.2	0.1	0.0001	0.8	3.7	0.9	1.2	0.0	0.0	0.0	0.0	0.0
	saplings	0.0	14.1	21.3	0.1	0.1	0.8	65.9	0.0	1.9	0.0	0.0	14.5	0.4	0.0

Table 5.2. Plant density, stem density, and basal areastatistics from woody belt-transect surveys for dead speciesand as analyzed by live species within functional group.

	Vegetation	BASA2d	PAACd	PRVEd	SAGOd	TAAPd	TARAd	BASAd	FAC	FACU	FACW	UPL
Veg_1	plants/site	1	*	1	*	*	*	*	15	*	*	66
	plants/ha	27.8	*	27.8	*	*	*	*	416.7	*	*	1833.3
	stems/site	2	*	8	*	*	*	*	124	*	*	*
	stems/ha	55.6	*	222.2	*	*	*	*	3444.4	*	*	*
	basal area (cm^2)	6.0	*	35.3	*	*	*	*	481.7	*	*	*
	basal area (m^2/ha)	0.02	*	0.1	*	*	*	*	1.3	*	*	*
Veg_2	plants/site	*	*	*	*	*	7	*	2	14	2	101
	plants/ha	*	*	*	*	*	157.3	*	44.9	314.6	44.9	2269.7
	stems/site	*	*	*	*	*	16	*	3	125	30	122
	stems/ha	*	*	*	*	*	359.6	*	67.4	2809.0	674.2	2741.6
	basal area (cm^2)	*	*	*	*	*	98.4	*	333.8	287.4	3958.3	621.3
	basal area (m^2/ha)	*	*	*	*	*	0.2	*	0.8	0.6	8.9	1.4
Veg_3	plants/site	*	*	*	*	*	*	*	7	17	500	76
	plants/ha	*	*	*	*	*	*	*	155.6	377.8	11111.1	1688.9
	stems/site	*	*	*	*	*	*	*	55	53	500	*
	stems/ha	*	*	*	*	*	*	*	1222.2	1177.8	11111.1	*
	basal area (cm^2)	*	*	*	*	*	*	*	231.2	2889.8	250.0	*
	basal area (m^2/ha)	*	*	*	*	*	*	*	0.5	6.4	0.6	*
Veg_4	plants/site	*	1	*	*	1	1	*	8	1	3	9
	plants/ha	*	24.4	*	*	24.4	24.4	*	195.1	24.4	73.2	219.5
	stems/site	*	1	*	*	5	1	*	18	10	9	18
	stems/ha	*	24.4	*	*	122.0	24.4	*	439.0	243.9	219.5	439.0
	basal area (cm^2)	*	1.3	*	*	11.4	0.4	*	245.3	6.0	4831.5	510.3
	basal area (m^2/ha)	*	0.003	*	*	0.03	0.001	*	0.6	0.01	11.8	1.2

cont.	Vegetation	BASA2d	PAACd	PRVEd	SAGOd	TAAPd	TARAd	BASAd	FAC	FACU	FACW	UPL
Veg_5	plants/site	*	*	*	*	*	*	*	1	3	*	132
	plants/ha	*	*	*	*	*	*	*	22.0	65.9	*	2901.1
	stems/site	*	*	*	*	*	*	*	9	9	*	40
	stems/ha	*	*	*	*	*	*	*	197.8	197.8	*	879.1
	basal area (cm^2)	*	*	*	*	*	*	*	4.5	4.5	*	15.8
	basal area (m^2/ha)	*	*	*	*	*	*	*	0.01	0.01	*	0.03
Veg_6	plants/site	*	*	*	*	*	24	1	8	*	*	104
	plants/ha	*	*	*	*	*	539.3	22.5	179.8	*	*	2337.1
	stems/site	*	*	*	*	*	43	9	51	*	*	257
	stems/ha	*	*	*	*	*	966.3	202.2	1146.1	*	*	5775.3
	basal area (cm^2)	*	*	*	*	*	60.2	13.5	297.2	*	*	3299.2
	basal area (m^2/ha)	*	*	*	*	*	0.1	0.03	0.7	*	*	7.4
Veg_7	plants/site	*	*	*	*	*	*	*	7	*	1	9
	plants/ha	*	*	*	*	*	*	*	168.7	*	24.1	216.9
	stems/site	*	*	*	*	*	*	*	63	*	1	*
	stems/ha	*	*	*	*	*	*	*	1518.1	*	24.1	*
	basal area (cm^2)	*	*	*	*	*	*	*	298.2	*	1.0	*
	basal area (m^2/ha)	*	*	*	*	*	*	*	0.7	*	0.002	*
Veg_8	plants/site	*	*	*	1	2	*	*	7	*	5	10
	plants/ha	*	*	*	32.3	64.5	*	*	225.8	*	161.3	322.6
	stems/site	*	*	*	3	4	*	*	26	*	11	5
	stems/ha	*	*	*	96.8	129.0	*	*	838.7	*	354.8	161.3
	basal area (cm^2)	*	*	*	67.6	13.5	*	*	1730.4	*	3069.4	36.3
	basal area (m^2/ha)	*	*	*	0.2	0.04	*	*	5.6	*	9.9	0.1
Average	plants/site	0.1	0.1	0.1	0.1	0.4	4.0	0.1	6.9	4.4	63.9	63.4
	plants/ha	3.5	3.0	3.5	4.0	11.1	90.1	2.8	176.1	97.8	1426.8	1473.6
	stems/site	0.3	0.1	1.0	0.4	1.1	7.5	1.1	43.6	24.6	68.9	55.3
	stems/ha	6.9	3.0	27.8	12.1	31.4	168.8	25.3	1109.2	553.6	1548.0	1249.5
	basal area (cm^2)	0.8	0.2	4.4	8.4	3.1	19.9	1.7	452.8	398.5	1513.8	560.4
	basal area (m^2/ha)	0.002	0.0004	0.01	0.03	0.009	0.04	0.004	1.3	0.9	3.9	1.3

Table 6. Canopy closure across survey sites expressed as a percentage as computed from densiometer readings for individual species as well as functional group.

	HYMO	PRVE	SAGO	TAAP	TARA	FAC	FACU	FACW	UPL
1	0	0	0	0	0	0	0	0	0
2	3.05	0	8.54	4.82	0	0	8.75	8.54	7.86
3	0.54	19.62	2.53	0	0	0	19.62	2.53	0.54
4	0	0	13.60	0	2.72	0	0	13.60	2.72
5	0	0	0	0	0	0	0	0	0
6	0	0	0	3.03	26.81	0	0	3.03	26.81
7	0	0	0	15.96	0	15.96	0	0	0
8	0	0	7.64	25.02	0	25.02	0	7.64	0
Average	*0.45*	*2.45*	*4.04*	*6.10*	*3.69*	*5.12*	*3.55*	*4.42*	*4.74*

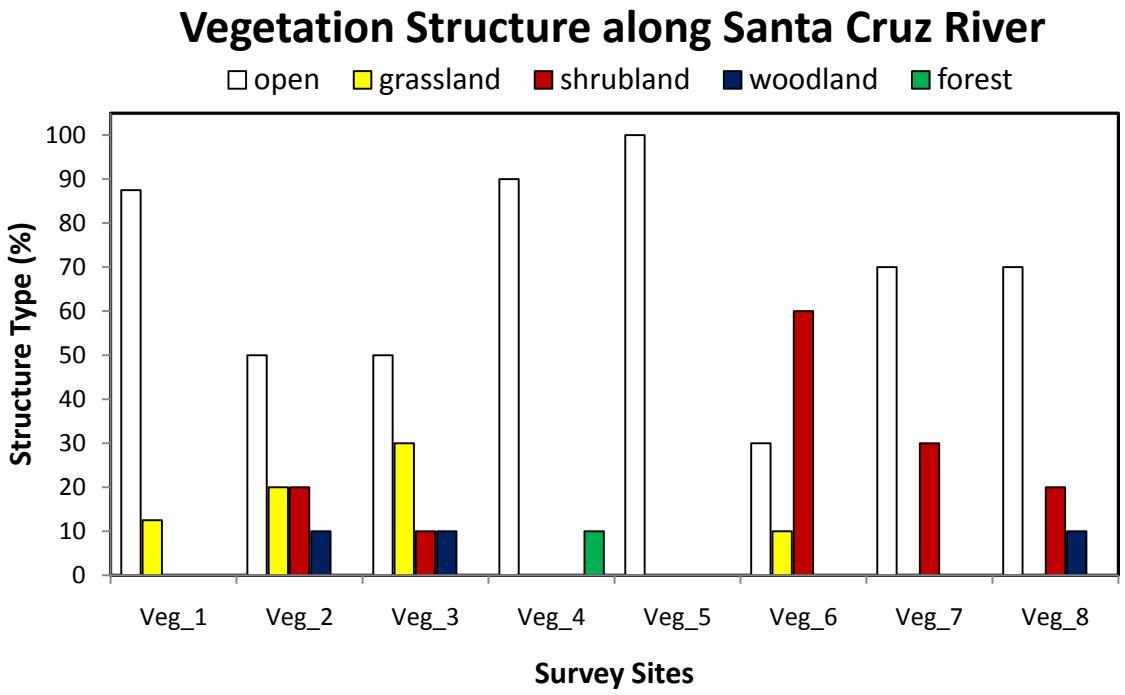


Figure 4. Structure types found along the Santa Cruz River surveying woody vegetation using belt-transects.

DISCUSSION

Streamside Herbaceous Vegetation

The most species observed by site was at Sunset Rd (Veg_3) where 24 total species were identified. Excluding the Columbus Dry site (Veg_1), species richness was similar across all sites ranging from 11 to 12.67 species per transect. The Columbus Dry site (5.67 species per transect) was dominated by upland vegetation which was also indicated by the highest WIS# of all sites.

The Tangerine Rd site (Veg_7) had the lowest WIS# which was the only site where large mats of aquatic plants were observed during the surveys. These aquatic plants included marsh seedbox (*Ludwigia palustris*) and floating marsh pennywort (*Hydrocotyle ranunculoides*), the latter of which was not included in the species list given prior to the surveys. The only unknown observed was a bunchgrass at the Cortaro Rd site (Veg_5);which was not mature enough to be identified via dichotomous keys, the University of Arizona herbarium, or by a botanist.

As expected, lower WIS#s were associated with higher NITRO#s. The highest NITRO# was computed at the Ina Rd site (Veg_4) and was due to the large cover percentages of *Typha domingensis* and *Polygonum lapathifolium* in the surveys. The lowest NITRO#s were computed for the Tangerine Rd site (Veg_7) and the Columbus Park Dry site (Veg_1), and were due to the high cover percentage of *H. monogyra* and *Tamarix* spp., respectively.

In general, streamside quadrats were surveyed rapidly and efficiently. It is recommended to increase the sampling number of transects, and therefore quadrats, for future surveys when woody vegetation is not concurrently surveyed. This will increase sampling power and improve the overall analyses.

Woody Vegetation

When analyzing stem density and recruitment, it is important to consider how saplings affect analyses. For instance, the highest stem and plant density was observed for *S. gooddingii*, however, this could be misleading because this was a direct result of hundreds of 6” saplings falling into the woody survey. While this is valid data, it may be beneficial to analyze data for mature trees separately depending on what information is deemed most important. Saplings were also counted along the stabilized streambank during woody surveys, which also may misconstrue the information being presented. Although they successfully germinated, these saplings will not grow into mature trees because roots will not be able to penetrate the compact soil cement. Because saplings, or recruitment, can be sampled or analyzed separately, it is recommended to compute summary statistics (e.g., densities, basal area) for mature trees separately in the future.

It was not feasible to measure every stem of all woody vegetation and as a result some upland species were given an individual count. These trees could not be included in the basal area analysis due to the lack of diameter measurements (see Table 2). There were two cases in which it was not feasible to

measure every stem of a multiple-stemmed *Tamarix* spp. tree due to litter and scour material hindering the ability to reach basal stems. In these two special cases; the smallest and largest diameters were measured, the total stem count was estimated, and the average of all diameters combined was estimated to obtain summary statistics.

The width of the main channel varied and the east-west orientation of the woody transect resulted in a different amount of total area surveyed at each site. While the area represented by the water was excluded from the analysis, it may be beneficial in the future to omit the main channel during the survey such that two, 50-m transects begin at the edge of the stream and extend into the floodplain on each side. Although the current method does not affect the results, which are expressed per hectare, this would allow for each survey to always have an area of 100 m x 5 m (500 m^2).

In general; plant density, stem density, and basal area were highly variable across all sites. As such, some data is best interpreted on a site-specific basis when comparing species. When comparing across sites, the computed averages will likely be more meaningful.

Notes Specific to Surveys

Streamside herbaceous surveys were impacted by soil cement at both Columbus sites (Veg_1 and Veg_2) and the Cortaro Rd site (Veg_5). When this occurred, little to no herbaceous vegetation was present along the stabilized embankment. To avoid areas of soil cement, an additional 20-m transect was extended from the original transect such that a total of six randomized quadrats could be conducted on one side of the stream edge. In these cases, three GPS coordinates were taken, with the middle coordinate representing where the two, 20-m transects adjoined.

Both Columbus sites and the Avra Valley Rd (Veg_6) site had belt-transects in which the eastern edge was bordered by soil cement resulting in the majority of the transect extending into the western floodplain. While the majority of the Santa Cruz River flowed northwest to north-northwest, some stretches existed in which it meandered due west and in some cases south before turning back northwest. This impacted the belt-transects at the Tangerine Rd site (Veg_7) and the Marana Rd site (Veg_8) where the east-to-west orientation rule resulted in the inclusion of large stretches of the main channel in the woody surveys. Also, depending on the orientation, the belt-transect could fall ontoa channel bar with no large trees present (e.g., Tangerine Rd site, Veg_7) or into a thick ribbon of trees along the main channel (Marana Rd site, Veg_8). While these are permanent transects, it may be beneficial to relocate woody surveys such that the flanks extend in a perpendicular direction from the main channel. Although the river may alter its course in the future as discussed prior to initiating surveys, this strategy would capture more data that could be compared across sites because each belt-transect would capture both the ribbon of phreatophytic trees immediately adjacent to the river and the upland vegetation extending away from the main channel. In addition, after completing the first round of surveys, we feel that the river is not likely to drastically change courses during large flood events.

Notes Specific to Sites

Wildlife was common during the surveys. Of particular interest were a water turtle species and a snake (likely a king snake) observed during the site visit near the Roger outfall. A person walking the river path also mentioned that he sees big water turtles regularly near the Roger outfall. Small fish (unidentifiable) were common throughout the surveys. The Sunset Rd site (Veg_3) has a large power line very close to an incised, eroded bank and may be compromised in future run-off events. The belt-transect at this location was unique in that it spanned from a terrace dominated with upland vegetation to the west, then crossed over the main channel with common riparian vegetation, and then ended in an area disturbed by off-road trails and garbage near the gravel pit. This could not be avoided unless the belt-transect was placed much further north. Although garbage and disturbance was common on the floodplain, the main channel was relatively isolated and killdeer (*Charadrius vociferus*) were observed nesting in the area. The Ina Rd site (Veg_4), in particular, had a range of tree species representing many sizes. This site may produce an interesting dataset considering potential decreases in effluent reaching this stretch in the future. The Avra Valley site (Veg_6) is unique in that the main channel is incised with steep slopes or banks on both sides ranging from three to eight meters. This results in a faster streamflows and water is not likely to inundate the floodplain unless large monsoon events occur. Dense stands of tamarisk were observed at this site. The Marana Rd site (Veg_8) was clearly impacted by cattle grazing and a cow was observed near the river during these surveys.

LITERATURE CITED

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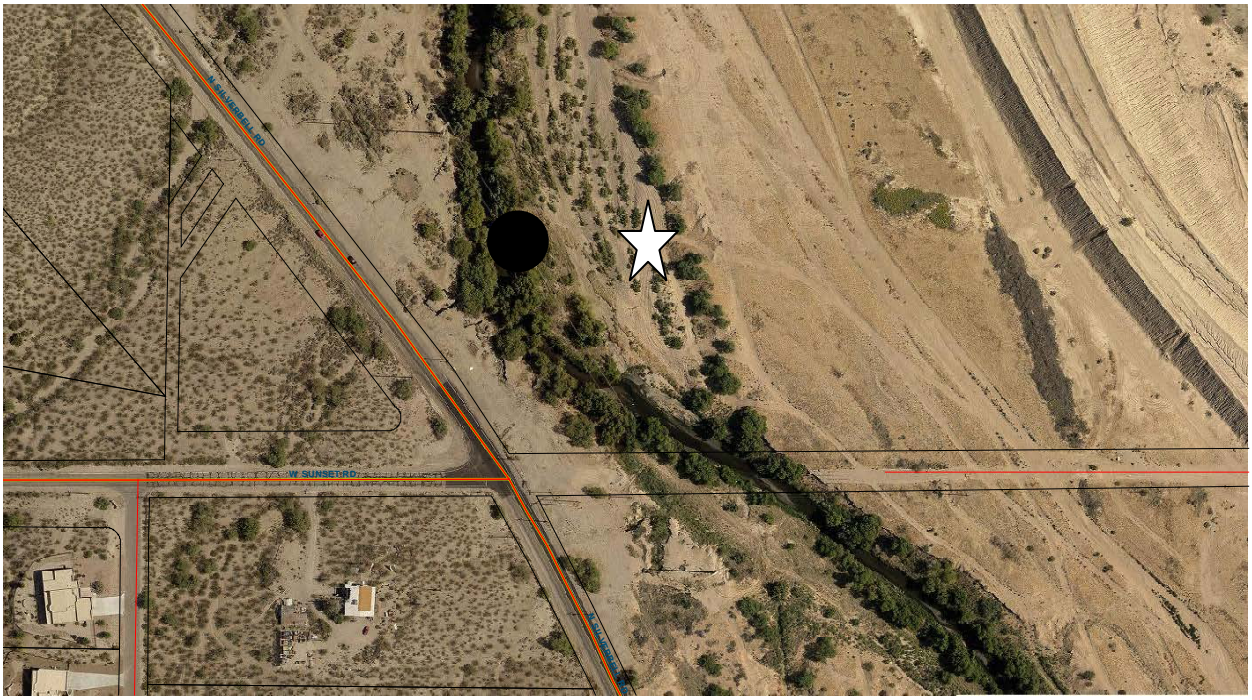
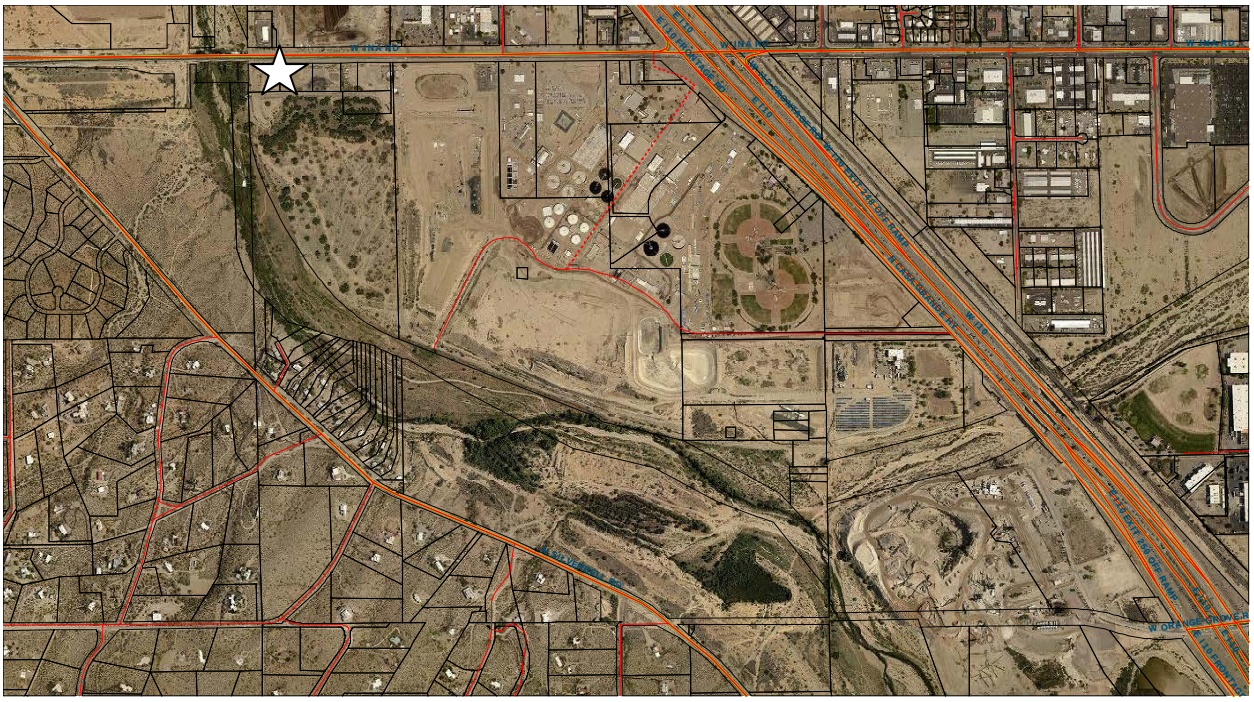
Appendix A – Survey Site Information Provided by Pima County

Map 1: Veg sites 1 and 2 at the black dots are on City land, upstream and downstream of Roger outfall. The upstream site is the "control"; be sure you are not in the reach with both sides of soil-cement. 32.285944, -110,030420; 32.282573, -110.02475, -111,029475. Access via Columbus Park, park at star shape.

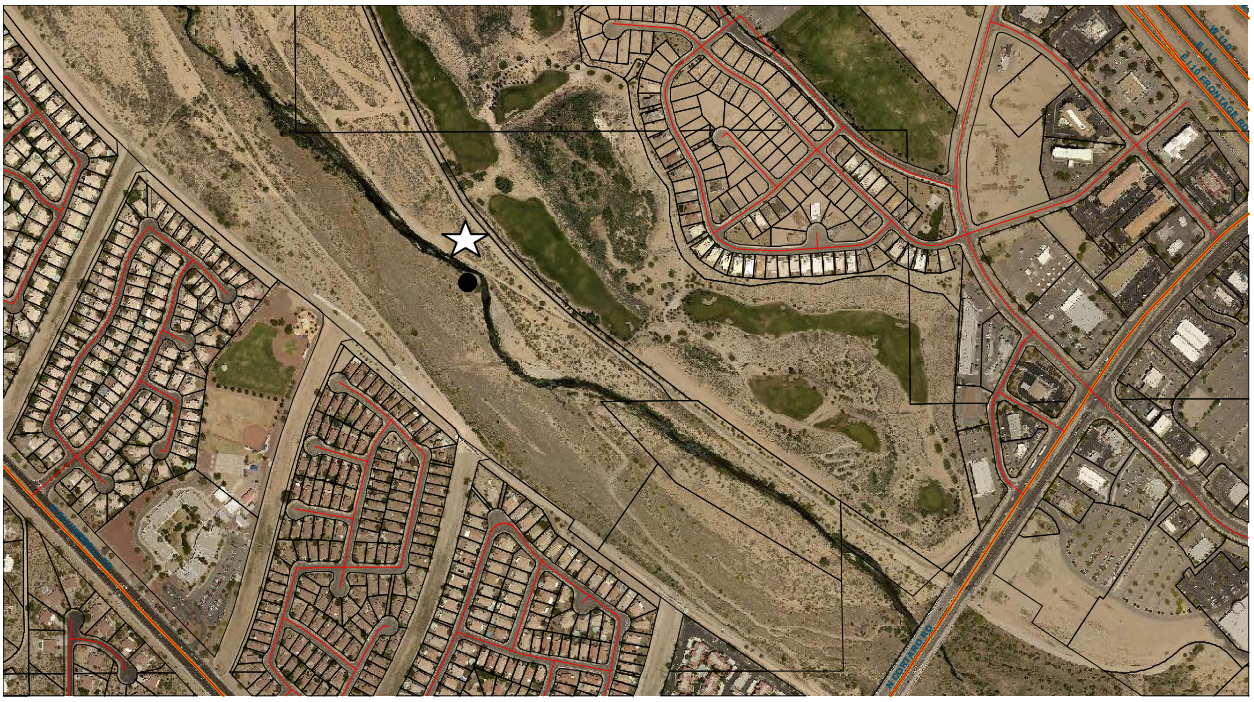
Map 2. Sunset Road vicinity, veg site 3 located at Latitude 32.310461 N, Longitude -110.052698 West. Note this is under a powerline (see faint white lines). I would suggest using the reach slightly downstream to get out from under this facility because TEP may artificially "clear" the vegetation over the years. This is a MI site as well. RFCD ownership, access via keyed entrance at Sunset Road off freeway frontage rd. Park at star if soil condition permits, or higher up.



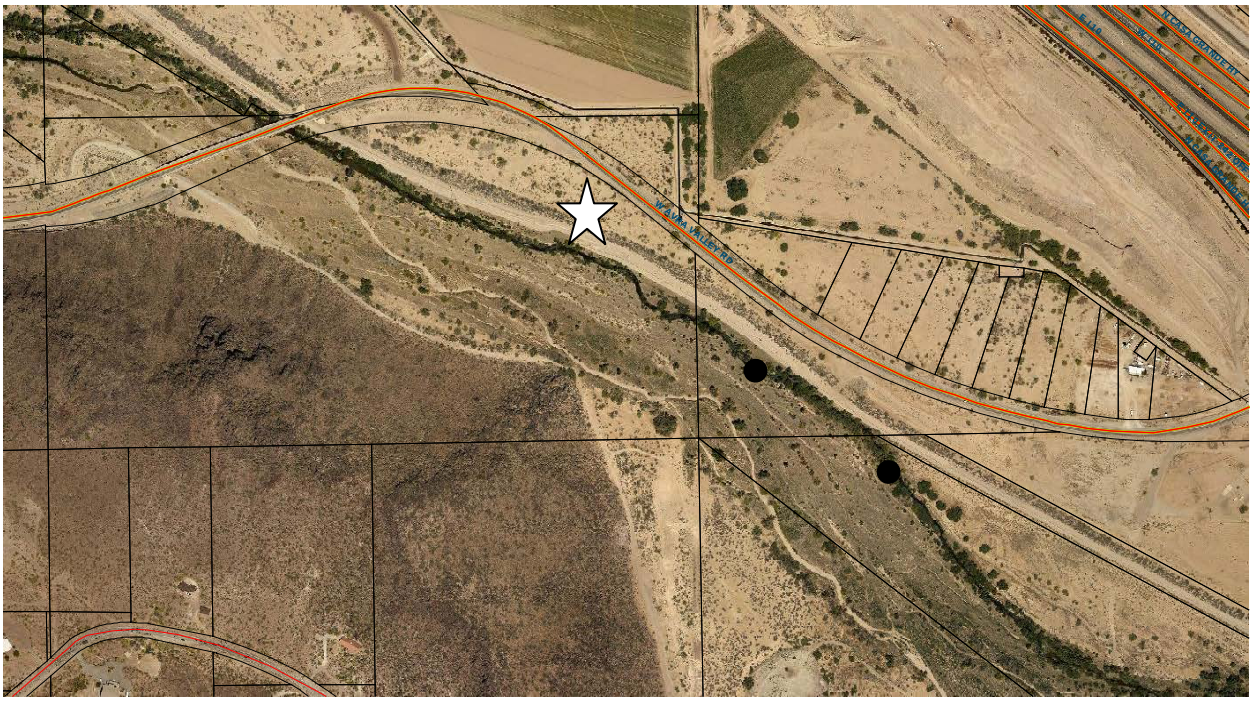
Map 3. Ina and upstream—Veg site #4 just upstream of the Ina outfall, same location as Meg White's. Access is via Ina Road. Ina should always flow, but Roger Road effluent may not always reach this site. No MI study here. Park on side of road, not bridge.



Map 4. Cortaro veg site #5 owned by Pima County RFCD, co-located with MI site. Access is via Cortaro Road, pull up bollards and drive on riverpark to the site, drive down embankment to first terrace next to well (star shape). 32.357062, -110.102815.



Map 5. Avra Valley parcels with black dots are owned by Pima County. Veg site #6 can be in between the dots. Meg White's site was on a parcel downstream, owned by CalPortland Cement. This reach is unsuitable for MI. Access via Avra Valley Road on existing dirt road to top of bank by ramp, or walk along old road from west side of SCR.



Map 6. Veg site #7. Upstream of Sanders. Co-located with MI site. Anywhere between the dots is on County land, note there is State Trust land upstream or downstream, constraining site selection:

Map 7. Upstream of Trico-Marana Rd. Veg site #8 is near black dot on land owned by RFCD. Mid-channel bars with a little gravel. Latitude 32.4533337 North, Longitude -111.2757639 South.

APPENDIX B – GPS Coordinates for all Transects

FID	SiteName	Site #	Subsite	Info	UTM (NAD 83)	Latitude	Longitude
1	Columbus Dry	Veg_1	1E1	start	12S 0497291 3571431	-111.028768	32.279624
2	Columbus Dry	Veg_1	1E1	end	12S 0497286 3571451	-111.028821	32.279805
3	Columbus Dry	Veg_1	1E2	start	12S 0497286 3571451	-111.028821	32.279805
4	Columbus Dry	Veg_1	1E2	end	12S 0497282 3571470	-111.028864	32.279976
5	Columbus Dry	Veg_1	2	start	12S 0497276 3571594	-111.028928	32.281095
6	Columbus Dry	Veg_1	2	end	12S 0497274 3571612	-111.028949	32.281257
7	Columbus Dry	Veg_1	3W1	start	12S 0497265 3571736	-111.029045	32.282376
8	Columbus Dry	Veg_1	3W1	end	12S 0497261 3571756	-111.029087	32.282556
9	Columbus Dry	Veg_1	3W2	start	12S 0497261 3571756	-111.029087	32.282556
10	Columbus Dry	Veg_1	3W2	end	12S 0497258 3571778	-111.029119	32.282755
11	Columbus Dry	Veg_1	2	NE	12S 0497308 3571601	-111.028588	32.281158
12	Columbus Dry	Veg_1	2	NW	12S 0497229 3571607	-111.029427	32.281212
13	Columbus Dry	Veg_1	2	SE	12S 0497307 3571599	-111.028598	32.281140
14	Columbus Dry	Veg_1	2	SW	12S 0497229 3571604	-111.029427	32.281185
15	Columbus Wet	Veg_2	1W1	start	12S 0497142 3572206	-111.030352	32.286616
16	Columbus Wet	Veg_2	1W1	end	12S 0497134 3572224	-111.030437	32.286778
17	Columbus Wet	Veg_2	1W2	start	12S 0497134 3572224	-111.030437	32.286778
18	Columbus Wet	Veg_2	1W2	end	12S 0497125 3572245	-111.030533	32.286967
19	Columbus Wet	Veg_2	2W1	start	12S 0497065 3572332	-111.031171	32.287752
20	Columbus Wet	Veg_2	2W1	end	12S 0497051 3572346	-111.031319	32.287878
21	Columbus Wet	Veg_2	2W2	start	12S 0497051 3572346	-111.031319	32.287878
22	Columbus Wet	Veg_2	2W2	end	12S 0497038 3572360	-111.031457	32.288005
23	Columbus Wet	Veg_2	3W1	start	12S 0496972 3572424	-111.032159	32.288582
24	Columbus Wet	Veg_2	3W1	end	12S 0496954 3572432	-111.032350	32.288654
25	Columbus Wet	Veg_2	3W2	start	12S 0496964 3572427	-111.032244	32.288609
26	Columbus Wet	Veg_2	3W2	end	12S 0496936 3572439	-111.032541	32.288717
27	Columbus Wet	Veg_2	2	NE	12S 0497071 3572345	-111.031107	32.287869
28	Columbus Wet	Veg_2	2	NW	12S 0496975 3572352	-111.032127	32.287932
29	Columbus Wet	Veg_2	2	SE	12S 0497073 3572342	-111.031086	32.287842
30	Columbus Wet	Veg_2	2	SW	12S 0496972 3572346	-111.032158	32.287878
31	Sunset	Veg_3	1	start	12S 0495066 3574710	-111.052413	32.309198
32	Sunset	Veg_3	1	end	12S 0495047 3574723	-111.052615	32.309315
33	Sunset	Veg_3	2	start	12S 0495032 3574918	-111.052775	32.311074
34	Sunset	Veg_3	2	end	12S 0495033 3574938	-111.052765	32.311255
35	Sunset	Veg_3	3	start	12S 0494996 3575033	-111.053158	32.312112
36	Sunset	Veg_3	3	end	12S 0494986 3575050	-111.053265	32.312265
37	Sunset	Veg_3	2	NE	12S 0495080 3574936	-111.052265	32.311237
38	Sunset	Veg_3	2	NW	12S 0494982 3574931	-111.053306	32.311191
39	Sunset	Veg_3	2	SE	12S 0495081 3574930	-111.052255	32.311183
40	Sunset	Veg_3	2	SW	12S 0494982 3574928	-111.053306	32.311164
41	Ina	Veg_4	1	start	12S 0492444 3577432	-111.080288	32.333739
42	Ina	Veg_4	1	end	12S 0492438 3577451	-111.080352	32.333911
43	Ina	Veg_4	2	start	12S 0492431 3577525	-111.080427	32.334578
44	Ina	Veg_4	2	end	12S 0492431 3577546	-111.080427	32.334768
45	Ina	Veg_4	3	start	12S 0492408 3577613	-111.080672	32.335372

cont.

FID	SiteName	Site #	Subsite	Info	UTM (NAD 83)	Latitude	Longitude
46	Ina	Veg_4	3	end	12S 0492398 3577633	-111.080778	32.335552
47	Ina	Veg_4	2	NE	12S 0492472 3577544	-111.079991	32.334750
48	Ina	Veg_4	2	NW	12S 0492376 3577541	-111.081011	32.334722
49	Ina	Veg_4	2	SE	12S 0492473 3577537	-111.079980	32.334687
50	Ina	Veg_4	2	SW	12S 0492377 3577539	-111.081000	32.334704
51	Cortaro	Veg_5	1	start	12S 0490393 3579896	-111.102106	32.355952
52	Cortaro	Veg_5	1	end	12S 0490376 3579905	-111.102287	32.356033
53	Cortaro	Veg_5	2	start	12S 0490324 3579988	-111.102840	32.356782
54	Cortaro	Veg_5	2	end	12S 0490316 3580007	-111.102925	32.356953
55	Cortaro	Veg_5	3	start	12S 0490249 3580091	-111.103638	32.357710
56	Cortaro	Veg_5	3	end	12S 0490231 3580099	-111.103830	32.357782
57	Cortaro	Veg_5	2	NE	12S 0490364 3580005	-111.102415	32.356935
58	Cortaro	Veg_5	2	NW	12S 0490265 3580006	-111.103467	32.356943
59	Cortaro	Veg_5	2	SE	12S 0490365 3580000	-111.102404	32.356890
60	Cortaro	Veg_5	2	SW	12S 0490266 3580002	-111.103457	32.356907
61	Avra Valley	Veg_6	1	start	12S 0487071 3584629	-111.137478	32.398616
62	Avra Valley	Veg_6	1	end	12S 0487057 3584644	-111.137627	32.398751
63	Avra Valley	Veg_6	2	start	12S 0487000 3584712	-111.138234	32.399364
64	Avra Valley	Veg_6	2	end	12S 0486983 3584722	-111.138415	32.399454
65	Avra Valley	Veg_6	3	start	12S 0486919 3584769	-111.139096	32.399877
66	Avra Valley	Veg_6	3	end	12S 0486899 3584771	-111.139308	32.399895
67	Avra Valley	Veg_6	2	NE	12S 0487004 3584722	-111.138191	32.399454
68	Avra Valley	Veg_6	2	NW	12S 0486906 3584722	-111.139233	32.399453
69	Avra Valley	Veg_6	2	SE	12S 0487005 3584721	-111.138181	32.399445
70	Avra Valley	Veg_6	2	SW	12S 0486906 3584718	-111.139233	32.399417
71	Sanders	Veg_7	1	start	12S 0481040 3587174	-111.201658	32.421489
72	Sanders	Veg_7	1	end	12S 0481017 3587178	-111.201902	32.421525
73	Sanders	Veg_7	2	start	12S 0480915 3587214	-111.202988	32.421848
74	Sanders	Veg_7	2	end	12S 0480898 3587223	-111.203169	32.421928
75	Sanders	Veg_7	3	start	12S 0480818 3587235	-111.204020	32.422035
76	Sanders	Veg_7	3	end	12S 0480800 3587236	-111.204211	32.422044
77	Sanders	Veg_7	2	NE	12S 0480950 3587217	-111.202616	32.421875
78	Sanders	Veg_7	2	NW	12S 0480850 3587213	-111.203679	32.421837
79	Sanders	Veg_7	2	SE	12S 0480951 3587212	-111.202605	32.421830
80	Sanders	Veg_7	2	SW	12S 0480852 3587209	-111.203658	32.421801
81	Marana	Veg_8	1	start	12S 0474100 3590746	-111.275568	32.453572
82	Marana	Veg_8	1	end	12S 0474088 3590735	-111.275696	32.453473
83	Marana	Veg_8	2	start	12S 0474215 3590802	-111.274346	32.454080
84	Marana	Veg_8	2	end	12S 0474199 3590798	-111.274516	32.454044
85	Marana	Veg_8	3	start	12S 0474323 3590819	-111.273198	32.454236
86	Marana	Veg_8	3	end	12S 0474303 3590814	-111.273410	32.454191
87	Marana	Veg_8	2	NE	12S 0474249 3590797	-111.273984	32.454036
88	Marana	Veg_8	2	NW	12S 0474149 3590805	-111.275049	32.454106
89	Marana	Veg_8	2	SE	12S 0474249 3590793	-111.273984	32.454000
90	Marana	Veg_8	2	SW	12S 0474149 3590800	-111.275049	32.454061

APPENDIX C – Belt-transect Photographs

SiteName	Site	Corner	Direction	Pictures	File Name
Columbus Dry	Veg_1	SE	W (twd)	127-0055	Veg_1_SE_Wt
Columbus Dry	Veg_1	SE	E (away)	127-0056	Veg_1_SE_Ea
Columbus Dry	Veg_1	SE	N (dwnstrm)	127-0057	Veg_1_SE_Nd
Columbus Dry	Veg_1	SW	E (twd)	127-0052	Veg_1_SW_Et
Columbus Dry	Veg_1	SW	W (away)	127-0053	Veg_1_SW_Wa
Columbus Dry	Veg_1	SW	N (dwnstrm)	127-0054	Veg_1_SW_Nd
Columbus Wet	Veg_2	SE	W (twd)	127-0063	Veg_2_SE_Wt
Columbus Wet	Veg_2	SE	E (away)	127-0064	Veg_2_SE_Ea
Columbus Wet	Veg_2	SE	N (dwnstrm)	127-0065	Veg_2_SE_Nd
Columbus Wet	Veg_2	SE	W (twd)	127-0066	Veg_2_SE_Wt2
Columbus Wet	Veg_2	SW	E (twd)	127-0058	Veg_2_SW_Et
Columbus Wet	Veg_2	SW	W (away)	127-0059	Veg_2_SW_Wa
Columbus Wet	Veg_2	SW	N (dwnstrm)	127-0060	Veg_2_SW_Nd
Sunset	Veg_3	SE	W (twd)	127-0067	Veg_3_SE_Wt
Sunset	Veg_3	SE	E (away)	127-0068	Veg_3_SE_Ea
Sunset	Veg_3	SE	N (dwnstrm)	127-0069	Veg_3_SE_Nd
Sunset	Veg_3	SE	E (away)	127-0070	Veg_3_SE_Ea2
Sunset	Veg_3	SW	E (twd)	127-0071	Veg_3_SW_Et
Sunset	Veg_3	SW	W (away)	127-0072	Veg_3_SW_Wa
Sunset	Veg_3	SW	N (dwnstrm)	127-0073	Veg_3_SW_Nd
Ina	Veg_4	SE	W (twd)	127-0024	Veg_4_SE_Wt
Ina	Veg_4	SE	E (away)	127-0025	Veg_4_SE_Ea
Ina	Veg_4	SE	N (dwnstrm)	127-0029	Veg_4_SE_Nd
Ina	Veg_4	SW	E (twd)	127-0026	Veg_4_SW_Et
Ina	Veg_4	SW	W (away)	127-0027	Veg_4_SW_Wa
Ina	Veg_4	SW	N (dwnstrm)	127-0028	Veg_4_SW_Nd
Cortaro	Veg_5	SE	W (twd)	127-0095	Veg_5_SE_Wt
Cortaro	Veg_5	SE	E (away)	127-0096	Veg_5_SE_Ea
Cortaro	Veg_5	SE	N (dwnstrm)	127-0097	Veg_5_SE_Nd
Cortaro	Veg_5	SW	E (twd)	127-0092	Veg_5_SW_Et
Cortaro	Veg_5	SW	W (away)	127-0093	Veg_5_SW_Wa
Cortaro	Veg_5	SW	N (dwnstrm)	127-0094	Veg_5_SW_Nd
Avra Valley	Veg_6	SE	W (twd)	127-0083	Veg_6_SE_Wt
Avra Valley	Veg_6	SE	E (away)	127-0084	Veg_6_SE_Ea
Avra Valley	Veg_6	SE	N (dwnstrm)	127-0085	Veg_6_SE_Nd
Avra Valley	Veg_6	SW	E (twd)	127-0080	Veg_6_SW_Et
Avra Valley	Veg_6	SW	W (away)	127-0081	Veg_6_SW_Wa
Avra Valley	Veg_6	SW	N (dwnstrm)	127-0082	Veg_6_SW_Nd
Sanders	Veg_7	NE	W (twd)	127-0074	Veg_7_NE_Wt
Sanders	Veg_7	NE	E (away)	127-0075	Veg_7_NE_Ea
Sanders	Veg_7	NE	S (upstream)	127-0076	Veg_7_NE_Su
Sanders	Veg_7	NW	E (twd)	127-0077	Veg_7_NW_Et
Sanders	Veg_7	NW	W (away)	127-0078	Veg_7_NW_Wa
Sanders	Veg_7	NW	S (upstream)	127-0079	Veg_7_NW_Su
Marana	Veg_8	NE	W (twd)	127-0031	Veg_8_NE_Wt
Marana	Veg_8	NE	E (away)	127-0032	Veg_8_NE_Ea
Marana	Veg_8	NE	S (dwnstrm)	127-0033	Veg_8_NE_Su
Marana	Veg_8	NW	E (twd)	127-0036	Veg_8_NW_Et
Marana	Veg_8	NW	W (away)	127-0037	Veg_8_NW_Wa
Marana	Veg_8	NW	S (dwnstrm)	127-0038	Veg_8_NW_Su
Marana	Veg_8	NE	W	127-0041	Veg_8_NE_W
Marana	Veg_8	NE	W	127-0042	Veg_8_NE_W2

Columbus Dry (Veg_1)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Columbus Wet (Veg_2)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Sunset (Veg_3)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Ina (Veg_4)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Cortaro (Veg_5)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Avra Valley (Veg_6)

SE corner toward

SW corner toward

SE corner away

SW corner away

SE corner downstream

SW corner downstream

Tangerine/Sanders (Veg_7)

NE corner toward

NW corner toward

NE corner away

NW corner away

NE corner upstream

NW corner upstream

Marana (Veg_8)

NE corner toward

NW corner toward

NE corner away

NW corner away

NE corner downstream

NW corner downstream

Extra Pictures

Columbus Wet (looking east toward SE corner)

Marana (looking toward water to west)

Sunset (looking downhill from SE corner)

Marana (closer, looking across water to west)

Gridded Quadrat (herbaceous surveys)

Common Bank Stabillization (soil cement)

Working Pictures

Gridded Quadrat along Streamside

GPS Measurements

Densiometer Measurements

Incised Channel at Avra Valley Site

DBH Measurements

Crossing Main Channel at Marana

APPENDIX D – Statement of Work Provided by Pima County

DRAFT SCOPE OF WORK FOR VEGETATION STUDY, EPA WETLAND GRANT

Contract length: This is a one-year contract, renewable for up to three additional years at the discretion of the project manager.

Project manager: The project manager is Evan Canfield, RFCD. The project manager is responsible for obtaining permissions from land owners to work at the specified locations, reviewing invoices, getting the contract renewals, etc.

Funding: Funding identified covers the first three years and is reimbursed from the EPA Wetland Grant. Additional funding for the fourth year is not necessarily secure.

Locations of work: All work is located along the effluent-dependent Santa Cruz River in Pima County.

The contractor shall work at eight of the following study sites, which are located within the wetland grant project study area. The number of study sites will not change, but variation in locations is possible with project manager approval.

1. Downstream of Roger outfall near SC-1 (City of Tucson park land, see map 1)
2. Sunset water quality sampling and MI sampling site at 32.310461 N, -111.052698 W. (RFCD land, see map 2)
3. A site that would be downstream of CDO-Rillito confluence, upstream of Ina outfall?—why is this needed, in addition to #4 below? (let's ditch this and get a control site upstream of Roger)
4. Just upstream of Ina outfall, upstream of the "Falls" at approximately latitude 32.226229 N, longitude -111.080780 W similar to Meg White's. (Pima County, see map 3)
5. Cortaro MI and water quality sampling site at 32.357062 N, -111.102815 W. (RFCD land, see map 4)
6. Avra Valley Road site at 32.400252 N, -111.139836 W. (RFCD land or get Calportland permission for a location closer to the bridge or go slightly upstream?, see map 5)
7. Sanders area site (see map of possible sites, may not be located on State Trust land, see map 6)
8. Upstream of Trico Road (see map 8 of upstream of Trico and map 7 upstream of Trico-Marana Road; select one site with MI group)
9. What about a control just upstream of Roger? (City of Tucson park land, see map 1)

Methods of Data Collection and Analysis:

Herbaceous Cover, Calendar Years 2013, 2014, 2015, 2016.

Field data collection: Detailed field methods can be found in the main body of the report.

Data summary and reporting: Each species shall also be coded using the 2012 National Wetland Plant List indicator status codes 1 through 5 (USACE, 2012) and for annual/perennial status using the USA Plants Database (USDA, 2013) in conjunction with SEINet to provide regional refinement if necessary (SEINet, 2013). For each site, the contractor shall calculate the weighted average of cover in each of the five wetland classes. The contractor shall determine mean species richness per plot and cumulative richness for the eighteen plots. Each species will be classified according to Ellenberg N scale (Ellenberg et al., 1991; White and Stromberg, in prep) using a Table supplied to the contractor. The contractor shall determine a weighted-average N-score (range from 1 to 9, with 9 indicting highest affinity for high nitrogen sites) for each site, using the species cover values and species N-scores. These data, along with all datasheets, will be provided to the contract manager within 2 months of completing the field work.

Woody Vegetation in the Floodplain, Calendar Years 2013 and 2016

Field data collection: Detailed field methods can be found in the main body of the report.

Data summary and reporting. For each site, the contractor shall calculate mean stem density, by species (live and dead), as stems per ha. Additional calculations will include the summary statistics (total across plot, mean for each subplot $\pm$ SD) for basal area for each species encountered. The <1 cm class will capture newly established tree saplings and will be reported as total number of individuals in this category. Mean canopy cover will be calculated, by species, as percent canopy cover.

Plants will be placed into functional groups that take into account the plants drought sensitivity and tolerance of flood disturbance, using a Table supplied to the contractor. Density, basal area, and canopy cover then will be calculated, by functional group, per site.

Each of the 50m^2 subplots (20 per site) will be assigned to one of five structure types (forest, woodland, shrubland, grassland/marshland, and bare ground) using the canopy cover by strata data (ground cover of 0-1 m, mid-story of 1-5 m, and canopy cover of >5 m in height) in conjunction with criteria given in Grossman et al. (1998). A plot shall be classified as forest if cover in the canopy layer is >60%; as a woodland if cover in the canopy layer is 25-60%; as a shrubland if canopy is <25% and mid-stratum cover is >25%, as a grassland if ground cover is >25%; and as open if ground cover is <25%) (Grossman et al. 1998). The percent cover of forest, woodland, shrubland, grassland/marshland and open will be calculated per site. These data, along with all datasheets, will be provided to the contract manager within 2 months of completing the field work.

Table 1. Modified Braun-Blanquet Cover Classes

Percent cover class range	Midpoint*
76-100	87.5
51-75	62.5
26-50	37.5
5-25	15
1-5	3
<1	0.5
0	0

Safety and Other Requirements:

The contractor shall be responsible for the following:

1) Transportation to and from sites
2) Notifying the project manager at least 3 days prior to each field visit
3) Following common-sense safety procedures, including having a minimum of two field personnel working on field-based aspects of the project at all times. The contractor should be aware of the inherent risks of working on the field site in May and June, most notably the potential for acute, heat-related stress and illness. Also, the contractor will take precautions related to working in and around effluent water.
4) All field equipment necessary to achieve the work
5) Understanding that the data for the project is owned by the funder and that any and all data (including original datasheets) will be provided to the funder at the end of the contract.

Qualifications:

The contractor is required to identify (on site and with little or no training) most or all plant species that could be encountered within the study area.

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APPENDIX E – Species List Provided by Pima County

Genus species	Family	ABBR	Wetland	Pre-2012 WIS	2012 AW List	Numerical WIS*
Acalyphaneomexicana	Euphorbiaceae	ACNE	N/A	5	*UPL*	*5*
Acalyphaostryifolia	Euphorbiaceae	ACOS	N/A	5	*UPL*	*5*
Amaranthusfimbriatus	Amaranthaceae	AMFI	N/A	4	*UPL*	*5*
Amaranthuspalmeri	Amaranthaceae	AMPA	FACU	4	*FACU*	*4*
Ambrosia ambrosioides	Asteraceae	AMAM	N/A	4	*UPL*	*5*
Ambrosia artemisiifolia	Asteraceae	AMAR	FACU	4	*FACU*	*4*
Ambrosia deltoidea	Asteraceae	AM_DE	N/A	4	*UPL*	*5*
Ambrosia psilostachya	Asteraceae	AMPS	FAC	3	*FACU*	*4*
Ambrosia trifida	Asteraceae	AMTR	FACW-	2	*FAC*	*3*
Androsaceoccidentalis	Primulaceae	ANOC2	FACU	4	*FACU*	*4*
Anodacristata	Malvaceae	ANCR2	FAC	3	*FAC*	*3*
Apodantheraundulata	Cucurbitaceae	APUN	NI	5	*UPL*	*5*
Argemonepleiacantha	Papaveraceae	ARPL3	NI	5	*UPL*	*5*
Aristidaadscensionis	Poaceae	ARAD	N/A	5	*UPL*	*5*
Arundodonax	Poaceae	ARDO	FACW	2	*FACW*	*2*
Astragalusthurberi	Fabaceae	ASTH	N/A	5	*UPL*	*5*
Baccharis salicifolia	Asteraceae	BASA	FACW	2	*FAC*	*2*
Baccharis sarothroides	Asteraceae	BASA2	FAC-	3	*FACU*	*4*
Bidensleptocephala	Asteraceae	BILE	FAC	3	*FAC*	*3*
Boerhaviacoccinea	Nyctaginaceae	BOCO	N/A	5	*UPL*	*5*
Boerhaviacoulteri	Nyctaginaceae	BOCO2	N/A	5	*UPL*	*5*
Boutelouaaristidoides	Poaceae	BOAR	N/A	5	*UPL*	*5*
Boutelouarothrockii	Poaceae	BORO	N/A	5	*UPL*	*5*
Bowlesiaincana	Apiaceae	BOIN	UPL	5	*FACU*	*4*
Bromuscatharticus	Poaceae	BRCA	N/A	5	*UPL*	*5*
Calibrachoaparviflora	Solanaceae	CAPA	FACW	2	*FACW*	*2*
Celtislaevigata var. reticulata	Ulmaceae	CELAR	FACU	4	*FAC*	*3*
Cenchrusspinifex	Poaceae	CESP	NI	4	*UPL*	*5*
Chamaecristanictitans	Fabaceae	CHNI	NO	4	*UPL*	*5*
Chamaesycecapitellata	Euphorbiaceae	CHCA	N/A	5	*UPL*	*5*
Chamaesyceflorida	Euphorbiaceae	CHFL	N/A	5	*UPL*	*5*
Chamaesycehyssopifolia	Euphorbiaceae	CHHY	NI	3	*FACU*	*4*
Chamaesycesetiloba	Euphorbiaceae	CHSE	N/A	5	*UPL*	*5*
Chenopodiumambrosioides	Chenopodiaceae	CHAM	FAC	3	*UPL*	*5*
Chenopodiumberlandieri	Chenopodiaceae	CHBE	N/A	4	*UPL*	*5*
Chenopodiumfremontii	Chenopodiaceae	CHFR	UPL	5	*UPL*	*5*
Chlorisvirgata	Poaceae	CHVI	N/A	5	*FACU*	*4*
Cirsiumvulgare	Asteraceae	CIVU	FACU	4	*FACU*	*4*
Clematis drummondii	Ranunculaceae	CLDR	N/A	4	*UPL*	*5*
Clematis hirsutissima	Ranunculaceae	CLHI		4	*UPL*	*5*
Conium maculatum	Apiaceae	COMA	OBL	1	*FACW*	*2*
Conyzacanadensis	Asteraceae	COCA	FACU	4	*UPL*	*5*
Crotalaria pumila	Fabaceae	CRPU	N/A	5	*UPL*	*5*
Croton pottsii	Euphorbiaceae	CRPO	N/A	5	*UPL*	*5*
Cryptanthaangustifolia	Boraginaceae	CRAN	N/A	5	*UPL*	*5*
Cryptanthamicrantha	Boraginaceae	CRMI	N/A	5	*UPL*	*5*

cont. ***Genus species***	**Family**	**ABBR**	**Wetland**	**Pre-2012 WIS**	**2012 AW List**	**Numerical WIS***
Cyclospermumleptophyllum	Apiaceae	CYLE	UPL	5	*FACU*	*4*
Cynodondactylon	Poaceae	CYDA	FACU	4	*FACU*	*4*
Cyperusesculentus	Cyperaceae	CYES	FACW	2	*FACW*	*2*
Cyperusinvolucratus	Cyperaceae	CYIN	NO	2	*FACW*	*2*
Cyperusodoratus	Cyperaceae	CYOD	FACW+	2	*FACW*	*2*
Cyperusstrigosus	Cyperaceae	CYST	FACW	2	*FACW*	*2*
Dactylocteniumaegyptium	Poaceae	DAAE	N/A	5	*UPL*	*5*
Daturawrightii	Solanaceae	DAWR	N/A	5	*UPL*	*5*
Daucuscarota	Apiaceae	DACA	N/A	3	*UPL*	*5*
Descurainiapinnata	Brassicaceae	DEPI	N/A	5	*UPL*	*5*
Diclipteraresupinata	Acanthaceae	DIRE	N/A	5	*UPL*	*5*
Digitariasanguinalis	Poaceae	DISA	FACU	4	*FACU*	*4*
Distichlisspicata	Poaceae	DISP	FACW	2	*FAC*	*3*
Dysphaniaambrosioides	Chenopodiaceae	DYAM	FAC	3	*FAC*	*3*
Echinochloacolona	Poaceae	ECCO	FACW	2	*FAC*	*2*
Echinochloa crus-galli	Poaceae	ECCR	FACW-	2	*FACW*	*2*
Ecliptaprostrata	Asteraceae	ECPR	FAC	3	*FAC*	*3*
Equisetum laevigatum	Equisetaceae	EQLA	FACW	2	*FACW*	*2*
Eragrostiscilianensis	Poaceae	ERCI	FACU+	4	*FACU*	*4*
Eragrostislehmanniana	Poaceae	ERLE	N/A	5	*UPL*	*5*
Eragrostispectinacea	Poaceae	ERPE	FAC	3	*FAC*	*3*
Erigeron divergens	Poaceae	ERDI	N/A	5	*UPL*	*5*
Eriochloaacuminata	Poaceae	ERAC	FACW	2	*FACW*	*2*
Eriochloaaristata	Poaceae	ERAR	FACW	2	*FACW*	*2*
Eriogonumpolycladon	Polygonaceae	ERPO	N/A	5	*UPL*	*5*
Erodiumcicutarium	Geraniaceae	ERCI2	N/A	5	*UPL*	*5*
Eschscholziacalifornica	Papaveraceae	ESCAM	N/A	5	*UPL*	*5*
Euphorbia heterophylla	Euphorbiaceae	EUHE	UPL	5	*UPL*	*5*
Euphorbia micromera	Euphorbiaceae	CHMI	N/A	5	*UPL*	*5*
Gauramollis	Onagraceae	GAMO	NI	4	*UPL*	*5*
Helianthus annuus	Asteraceae	HEAN	FAC-	3	*FACU*	*4*
Heliotropiumcurassavicum	Boraginaceae	HECU	FACW	2	*FACU*	*4*
Heterothecasubaxillaris	Asteraceae	HESU	UPL	5	*UPL*	*5*
Hydrocotyleverticillata	Apiaceae	HYVE	OBL	1	*OBL*	*1*
Hymenoclea monogyra	Asteraceae	HYMO	N/A	5	*UPL*	*5*
Ipomoea barbatisepala	Convovulaceae	IPBA	N/A	4	*UPL*	*5*
Ipomoea cristulata	Convovulaceae	IPCR	N/A	4	*UPL*	*5*
Ipomoea hederacea	Convovulaceae	IPHE	FACU*	4	*FACU*	*4*
Ipomoea purpurea	Convovulaceae	IPPU	UPL	5	*UPL*	*5*
Ipomoea ternifolia	Convovulaceae	IPTE	N/A	4	*UPL*	*5*
Isocomatenuisecta	Asteraceae	ISTE	N/A	5	*UPL*	*5*
Kallstroemiaparviflora	Zygophyllaceae	KAPA	N/A	5	*UPL*	*5*
Lepidiumthurberi	Brassicaceae	LETH	N/A	4	*FACU*	*4*
Ludwigia palustris	Onagraceae	LUPA	OBL	1	*OBL*	*1*
Lupinusconcinnus	Fabaceae	LUCO	N/A	5	*UPL*	*5*
Machaerantheracanescens	Asteraceae	MACA	UPL	5	*UPL*	*5*
Malacothrixglabrata	Asteraceae	MAGL	N/A	5	*UPL*	*5*

cont. ***Genus species***	**Family**	**ABBR**	**Wetland**	**Pre-2012 WIS**	**2012 AW List**	**Numerical WIS***
Malvaparviflora	Malvaceae	MAPA	N/A	5	*UPL*	*5*
Melilotus alba	Fabaceae	MEAL	FACU+	4	*FACU*	*4*
Melilotusindicus	Fabaceae	MEIN	FACU+	4	*FACU*	*4*
Melilotusofficinalis	Fabaceae	MEOF	FACU+	4	*UPL*	*4*
Mentzeliamultiflora	Loasaceae	MEMU	N/A	5	*UPL*	*5*
Mimulusguttatus	Scrophulariaceae	MIGU	OBL	1	*OBL*	*1*
Mirabilis longiflora	Nyctaginaceae	MILO	N/A	4	*UPL*	*5*
Myosuruscupulatus	Ranunculaceae	MYCO			*FAC*	*3*
Namahispidum	Hydrophyllaceae	NAHI	N/A	5	*UPL*	*5*
Nasturtium officinale	Brassicaceae	NAOF	OBL	1	*OBL*	*1*
Nicotianaglauca	Solanaceae	NIGL	FAC	3	*FAC*	*3*
Nicotianaobtusifolia	Solanaceae	NIOB	FACU	4	*FACU*	*4*
Panicumantidotale	Poaceae	PAAN	N/A	5	*UPL*	*5*
Parkinsonia aculeata	Fabaceae	PAAC			*FAC*	*4*
Parkinsoniaflorida	Fabaceae	PASP	N/A		*FAC*	*5*
Paspalumdilatatum	Poaceae	PADI	FAC	3	*FAC*	*3*
Pectispapposa	Asteraceae	PEPA	N/A	5	*UPL*	*5*
Pectisprostrata	Asteraceae	PEPR	N/A	5	*UPL*	*5*
Phaceliaarizonica	Solanaceae	PHAR	N/A	5	*UPL*	*5*
Physalisacutifolia	Solanaceae	PHAC	N/A	5	*UPL*	*5*
Polygonum lapathifolium	Polygonaceae	POLA	OBL	1	*UPL*	*2*
Polypogonmonspeliensis	Poaceae	POMO	FACW+	2	*FACW*	*2*
Populus fremontii	Salicaceae	POFR	FACW	2	*UPL*	*2*
Portulacahalimoides	Portulaceae	POHA	NO	4	*FAC*	*3*
Portulacaoleracea	Portulaceae	POOL	FAC	3	*FAC*	*3*
Portulacasuffrutescens	Portulaceae	POSU	N/A	4	*UPL*	*5*
Proboscideaparviflora	Pedaliaceae	PRPA	N/A	5	*UPL*	*5*
Prosopis velutina	Fabaceae	PRVE	N/A		*FACU*	*4*
Pseudognaphaliumcanescens	Asteraceae	PSCA	UPL	5	*FACU*	*4*
Ranunculus sceleratus	Ranunculaceae	RASC	OBL	1	*OBL*	*1*
Rumexdentatus	Polygonaceae	RUDE	NO	1	*FACW*	*2*
Rumexobtusifolius	Polygonaceae	RUOB	FACW	2	*FAC*	*3*
Salix gooddingii	Salicaceae	SAGO	OBL	1	*FACW*	*2*
Salsola tragus	Chenopodiaceae	SATR	FACU	4	*FACU*	*4*
Schismusarabicus	Poaceae	SCAR	N/A	5	*UPL*	*5*
Schismusbarbatus	Poaceae	SCBA	N/A	5	*UPL*	*5*
Schoenoplectusamericanus	Cyperaceae	SCAM	OBL	1	*OBL*	*1*
Setariagrisebachii	Poaceae	SEGR	N/A	4	*UPL*	*5*
Sidaspinosa	Malvaceae	SISP	UPL	5	*UPL*	*5*
Sisymbriumirio	Brassicaceae	SIIR	N/A	5	*UPL*	*5*
Solanumamericanum	Solanaceae	SOAM	FAC	3	*FACU*	*4*
Solanumelaeagnifolium	Solanaceae	SOEL	N/A	5	*UPL*	*5*
Solanumlycopersicum	Solanaceae	SOLY	N/A	5	*UPL*	*5*
Sonchusasper	Asteraceae	SOAS	FACW	2	*FAC*	*3*

cont. ***Genus species***	**Family**	**ABBR**	**Wetland**	**Pre-2012 WIS**	**2012 AW List**	**Numerical WIS***
Sorghum halepense	Poaceae	SOHA	FACU+	4	*FACU*	*4*
Sphaeralcealaxa	Malvaceae	SPLA	NI	5	*UPL*	*5*
Sporoboluscontractus	Poaceae	SPCO	N/A	4	*UPL*	*5*
Sporoboluscryptandrus	Poaceae	SPCR	FACU-	4	*FACU*	*4*
Stemodiadurantifolia	Scrophulariaceae	STDU	OBL	1	*OBL*	*1*
Symphyotrichumascendens	Asteraceae	SYAS	N/A	5	*FAC*	*3*
Tamarix aphylla	Tamaricaceae	TAAP	FAC	3	*FAC*	*3*
Tamarix ramosissima	Tamaricaceae	TARA	NI		*UPL*	*4*
Tidestromialanuginosa	Amaranthaceae	TILA	N/A	5	*UPL*	*5*
Trianthemaportulacastrum	Aizoaceae	TRPO	NI	2	*FAC*	*3*
Typha domingensis	Typhaceae	TYDO	OBL	1	*OBL*	*1*
Urochloaarizonica	Poaceae	URAR	N/A	5	*UPL*	*5*
Verbesinaencelioides	Asteraceae	VEEN	FAC	3	*FACU*	*4*
Veronica anagallis-aquatica	Scrophulariaceae	VEAN	OBL	1	*OBL*	*2*
Vulpiaoctoflora	Poaceae	VUOC	NI	5	*UPL*	*5*
Xanthium strumarium	Asteraceae	XAST	NI	4	*FAC*	*3*

APPENDIX F – Species Observed during Surveys

Family	*Genus species*	Code	Common Names
Amaranthaceae	*Amaranthuspalmeri*	AMPA	careless weed
Apiaceae	*Conium maculatum*	COMA	poison hemlock
Apiaceae	*Hydrocotyle ranunculoides*	HYRA	floating marsh pennywort
Asteraceae	*Baccharis salicifolia*	BASA	mule fat, seep willow
Asteraceae	*Baccharis sarothroides*	BASA2	desert broom
Asteraceae	*Conyzacanadensis*	COCA	Canadian horseweed
Asteraceae	*Helianthus annuus*	HEAN	common sunflower
Asteraceae	*Hymenoclea monogyra*	HYMO	singlewhorlburrobrush
Asteraceae	*Pseudognaphaliumcanescens*	PSCA	Wright's cudweed
Asteraceae	*Sonchusasper*	SOAS	spiny sowthistle
Asteraceae	*Xanthium strumarium*	XAST	rough cocklebur
Boraginaceae	*Amsinckiaintermedia*	AMIN	common fiddleneck
Boraginaceae	*Pectocaryarecurvata*	PERE	curvenutcombseed
Brassicaceae	*Descurainiapinnata*	DEPI	western tansymustard
Brassicaceae	*Lepidiumthurberi*	LETH	Thurber's pepperweed
Brassicaceae	*Nasturtium officinale*	NAOF	watercress
Brassicaceae	*Sisymbriumirio*	SIIR	London rocket
Chenopodiaceae	*Atriplex elegans*	ATEL*	wheelscale saltbush
Chenopodiaceae	*Atriplex polycarpa*	ATPO*	cattle saltbush
Chenopodiaceae	*Chenopodiumambrosioides*	CHAM	Mexican tea
Chenopodiaceae	*Chenopodiumberlandieri*	CHBE	pitseed goosefoot
Chenopodiaceae	*Salsola tragus*	SATR	prickly Russian thistle
Cyperaceae	*Cyperusesculentus*	CYES	yellow nutsedge
Cyperaceae	*Cyperusinvolucratus*	CYIN	umbrella sedge
Cyperaceae	*Schoenoplectusamericanus*	SCAM	chairmaker's bulrush
Fabaceae	*Lycium fremontii*	LYFR*	Fremont's desert thorn
Fabaceae	*Melilotusindicus*	MEIN	annual yellow sweetclover
Fabaceae	*Parkinsonia aculeata*	PAAC	MX palo verde, Jerusalem thorn
Fabaceae	*Prosopisglandulosa*	PRGL	honey mesquite
Fabaceae	*Prosopis velutina*	PRVE	velvet mesquite
Juncaceae	*Juncusbufonius*	JUBU	toad rush
Loasaceae	*Mentzeliamultiflora*	MEMU	Adona's blazing star, stickleaf
Onagraceae	*Ludwigia palustris*	LUPA	marsh seedbox

cont.

Family	*Genus species*	Code	Common Names
Poaceae	*Bromuscatharticus*	BRCA	rescue grass
Poaceae	*Bromusrubens*	BRRU	red brome
Poaceae	*Cynodondactylon*	CYDA	Bermuda grass
Poaceae	*Echinochloa crus-galli*	ECCR	barnyard grass
Poaceae	*Hordeummurinam*	HOMU	mouse barley
Poaceae	*Paspalumdilatatum*	PADI	dallisgrass
Poaceae	*Pennisetumciliare*	PECI	buffelgrass
Poaceae	*Polypogonmonspeliensis*	POMO	annual rabbitsfoot grass
Poaceae	*Schismusbarbatus*	SCBA	common Mediterranean grass
Poaceae	*Sorghum halepense*	SOHA	Johnsongrass
Poaceae		UNK1	
Polygonaceae	*Polygonum lapathifolium*	POLA	curlytop knotweed
Polygonaceae	*Rumexobtusifolius*	RUOB	bitter dock
Ranunculaceae	*Ranunculus sceleratus*	RASC	cursed buttercup
Salicaceae	*Salix gooddingii*	SAGO	Goodding's willow
Scrophulariaceae	*Veronica anagallis-aquatica*	VEAN	water speedwell
Solanaceae	*Nicotianaobtusifolia*	NIOB	desert tabacco
Salicaceae	*Populus fremontii*	POFR*	Fremont cottonwood
Solanaceae	*Solanumamericanum*	SOAM	American black nightshade
Tamaricaceae	*Tamarix aphylla*	TAAP	Athel tamarisk
Tamaricaceae	*Tamarix ramosissima*	TARA	saltcedar
Typhaceae	*Typha domingensis*	TYDO	southern cattail
Zygophyllaceae	*Larrea tridentata*	LATR*	creosote bush

*denotes species observed only in the woody belt-transect surveys

APPENDIX G – Summary Statistics for Stem Density and Basal Area by Subplot

		1	2	3	4	5	6	7	8	9	10	StDev
Veg_1 (stems/ha)	BASA2	0	0	0	0	0	6400	0	14600	*	*	5331.78
	BASA2d	0	0	0	0	0	400	0	0	*	*	141.42
	PRVE	0	0	0	600	0	600	0	600	*	*	310.53
	PRVEd	0	0	0	0	0	0	0	1600	*	*	565.69
Veg_1 basal area (m^2/ha)	BASA2	0	0	0	0	0	8.03	0	0.60	*	*	2.82
	BASA2d	0	0	0	0	0	0.12	0	0	*	*	0.04
	PRVE	0	0	0	0.01	0	0.12	0	0.04	*	*	0.04
	PRVEd	0	0	0	0	0	0	0	0.71	*	*	0.25
Veg_2 (stems/ha)	ACGR	800	0	0	2000	0	0	0	0	0	0	654.56
	BASA2	14000	0	0	2400	0	0	800	5400	0	0	4478.14
	PAAC	600	0	0	0	0	0	0	0	0	0	189.74
	POFR	0	0	0	0	0	0	0	0	0	400	126.49
	PRVE	0	0	1400	600	0	0	0	400	0	0	459.95
	SAGO	0	0	0	0	0	0	600	0	0	10800	3399.41
	TARA	0	0	8600	0	3800	0	1400	18800	0	5600	6048.29
	TARAd	0	0	0	0	0	0	0	0	0	0	0.00
Veg_2 basal area (m^2/ha)	ACGR	0.02	0	0	0.02	0	0	0	0	0	0	0.01
	BASA2	1.79	0	0	0.12	0	0	0.08	0.54	0	0	0.56
	PAAC	6.68	0	0	0	0	0	0	0	0	0	2.11
	POFR	0	0	0	0	0	0	0	0	0	0.02	0.01
	PRVE	0	0	0.04	0.09	0	0	0	3.09	0	0	0.97
	SAGO	0	0	0	0	0	0	78.90	0	0	0	24.95
	TARA	0	0	0.46	0	1.56	0	1.76	14.33	0	0.23	4.44
	TARAd	0	0	0.11	0	0.02	0	0.05	1.79	0	0	0.56
Veg_3 (stems/ha)	BASA	0	0	0	0	0	26800	0	0	0	0	8474.90
	BASA2	0	5400	3600	0	0	0	0	0	0	0	1944.22
	PAAC	1000	0	0	0	0	0	0	0	0	200	315.52
	PRVE	0	0	1400	0	0	0	0	0	0	200	440.20
	SAGO	0	0	0	0	200000	0	0	0	0	0	63245.55
Veg_3 basal area (m^2/ha)	BASA	0	0	0	0	0	5.15	0	0	0	0	1.63
	BASA2	0	0.27	2.32	0	0	0	0	0	0	0	0.73
	PAAC	2.74	0	0	0	0	0	0	0	0	0.53	0.86
	PRVE	0	0	28.80	0	0	0	0	0	0	26.41	11.65
	SAGO	0	0	0	0	10.00	0	0	0	0	0	3.16
Veg_4 (stems/ha)	BASA	0	600	0	0	0	0	0	0	0	0	189.74
	BASA2	0	0	0	0	0	0	0	0	2000	0	632.46
	PAAC	0	0	0	0	0	0	0	0	800	0	252.98
	PAACd	0	0	0	0	0	0	0	0	200	0	63.25
	SAGO	200	0	0	0	0	0	0	1600	0	0	502.88
	TAAP	1000	0	0	0	0	0	0	0	0	0	316.23
	TAAPd	1000	0	0	0	0	0	0	0	0	0	316.23
	TARA	600	2800	0	0	0	0	0	0	0	0	884.68
	TARAd	0	200	0	0	0	0	0	0	0	0	63.25

cont.		1	2	3	4	5	6	7	8	9	10	StDev
Veg_4 basal area (m^2/ha)	BASA	0	0.09	0	0	0	0	0	0	0	0	0.03
	BASA2	0	0	0	0	0	0	0	0	0.12	0	0.04
	PAAC	0	0	0	0	0	0	0	0	0.24	0	0.08
	PAACd	0	0	0	0	0	0	0	0	0.03	0	0.01
	SAGO	18.70	0	0	0	0	0	0	66.74	0	0	21.27
	TAAP	5.12	0	0	0	0	0	0	0	0	0	1.62
	TAAPd	0.23	0	0	0	0	0	0	0	0	0	0.07
	TARA	1.73	4.86	0	0	0	0	0	0	0	0	1.57
	TARAd	0	0.01	0	0	0	0	0	0	0	0	0.00
Veg_5 (stems/ha)	BASA	0	0	0	0	0	3000	0	0	0	0	948.68
	BASA2	0	0	0	600	0	0	0	0	0	1200	404.97
	TARA	0	0	0	2000	0	0	0	0	0	7000	2233.58
Veg_5 basal area (m^2/ha)	BASA	0	0	0	0	0	0.15	0	0	0	0	0.05
	BASA2	0	0	0	0.03	0	0	0	0	0	0.06	0.02
	TARA	0	0	0	0.01	0	0	0	0	0	0.37	0.12
Veg_6 (stems/ha)	BASA	2400	0	0	0	0	2000	0	0	4571	0	1584.97
	BASAd	1800	0	0	0	0	0	0	0	0	0	569.21
	TAAP	0	0	0	0	0	800	0	0	0	0	252.98
	TARA	0	0	8000	0	0	5800	10400	0	1714	43000	13261.56
	TARAd	0	0	4400	0	0	0	2800	200	1429	1000	1513.67
Veg_6 basal area (m^2/ha)	BASA	0.22	0	0	0	0	0.18	0	0	5.72	0	1.80
	BASAd	0.27	0	0	0	0	0	0	0	0	0	0.09
	TAAP	0	0	0	0	0	1.24	0	0	0	0	0.39
	TARA	0	0	7.01	0	0	4.86	8.36	26.05	6.34	75.95	23.51
	TARAd	0	0	0.36	0	0	0	0.45	0.02	0.21	1.19	0.38
Veg_7 (stems/ha)	BASA	0	0	0	0	0	0	3400	2600	4200	0	1685.10
	SAGO	0	0	0	0	0	0	0	200	0	0	63.25
	TAAP	0	0	0	0	48000	0	0	0	0	0	15178.93
Veg_7 basal area (m^2/ha)	BASA	0	0	0	0	0	0	0.17	0.15	0	0	0.07
	SAGO	0	0	0	0	0	0	0	0.02	0	0	0.01
	TAAP	0	0	0	0	97.76	0	0	0	0	0	30.91
Veg_8 (stems/ha)	BASA	2200	0	0	0	0	0	0	0	0	0	695.70
	SAGO	0	0	0	1600	0	0	0	0	0	0	505.96
	SAGOd	0	0	0	600	0	0	0	0	0	0	189.74
	TAAP	0	0	0	0	0	0	0	0	1400	800	484.88
	TAAPd	0	0	0	0	0	0	0	0	600	200	193.22
	TARA	0	0	0	1000	0	0	0	0	0	0	316.23
Veg_8 basal area (m^2/ha)	BASA	0.15	0	0	0	0	0	0	0	0	0	0.05
	SAGO	0	0	0	60.04	0	0	0	0	0	0	18.99
	SAGOd	0	0	0	1.35	0	0	0	0	0	0	0.43
	TAAP	0	0	0	0	0	0	0	0	32.36	1.91	10.18
	TAAPd	0	0	0	0	0	0	0	0	0.14	0.13	0.06
	TARA	0	0	0	0.82	0	0	0	0	0	0	0.26