Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2009 Vegetation Plot Monitoring Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

March 2010

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Lower Colorado River Multi-Species Conservation Program

2009 Vegetation Plot Monitoring Report

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March 2010

TABLE OF CONTENTS

INTRODUCTION 1

FIELD METHODS 1
Monitoring 4
Overstory Trees 4
Intermediate Story Trees and Shrubs 5
Ground Cover/Herbaceous Layer 5
Crown Closure 5
Foliage Height Diversity 6

RESULTS 6
Overstory Data 6
Intermediate Tree and Shrub Layer Data 8
Ground Cover Data 15
Crown Closure Data 19
Foliage-Height Diversity Data 20

DISCUSSION 26
Restoration Site Conditions 26
Wildlife 27
Weed Disturbance 28
Problems 31

APPENDIX A: FIGURES

List of Tables

Table 1. Number of plots monitored per habitat type within a given restoration area. 2

Table 2. Overstory layer average tree density (number of trees per acre). 6

Table 3. Total overstory layer trees measured per site. 7

Table 4. Average overstory tree height in meters (m) per site. 8

Table 5. Average overstory tree diameter breast height (DBH) in centimeters (cm) per site. 8

Table 6. Average density of trees < 4.5 feet high (trees per acre). 9

Table 7. Average density of trees for DBH Class 1 (< 0.4 inch/<1.0 centimeter) (trees per acre). 10

Table 8. Average density of trees for DBH Class 2 (0.4–1.0 inch/1–2.5 centimeter[s]) (trees per acre). 11

Table 9. Average density of trees for DBH Class 3 (1.1–2.2 inches/2.6–5.5 centimeters) (trees per acre). 12

Table 10. Average density of trees for DBH Class 4 (1.1–2.2 inches/2.6–5.5 centimeters) (trees per acre). 13

Table 11. Intermediate and shrub layer tree densities (trees per acre). 14

Table 12. Intermediate and shrub layer average tree height in meters (m). 15

Table 13. Intermediate and shrub layer average tree diameter breast height (DBH) in centimeters (cm). 16

Table 14. Average ground cover in meters (m). 16

Table 15. Average ground cover observed for each species by site in meters (m). 17

Table 16. Average crown closure. 20

Table 17. Foliage height diversity percent total vegetation per meter layer. 21

Table 18. Foliage height diversity percent species composition by site. 23

Table 19. Species and location of birds observed within or near restoration sites. 28

List of Figures

Figure 1. Vegetation monitoring plot diagram. 4

List of Photos

Photo 1. Sandhill cranes in an agriculture field at Cibola National Wildlife Refuge. 29

Photo 2. Mourning dove nest in a cottonwood at Cibola Valley Conservation Area Phase 3. 29

Photo 3. Dense arrowweed in mesquite plot at Beal Lake. 30

Photo 4. Johnsongrass at the Cibola National Wildlife Refuge Nature Trail. 30

Photo 5. West side of Palo Verde Ecological Reserve Phase 4 with dense Palmer amaranth. 32

Photos 6, 7. Cottonwood re-establishing central leader through dead morning glory at Cibola Valley Conservation Area Phase 2. 32

Photo 8. Continued morning glory-control issues in Cibola Valley Conservation Area Phase 1. 33

Photo 9. Morning glory infestation on cottonwood in Cibola Valley Conservation Area Phase 1. 33

INTRODUCTION

In 2008 BIO-WEST, Inc. (BIO-WEST) was contracted by the U.S. Bureau of Reclamation (Reclamation) to set up and monitor permanent vegetation plots within the Lower Colorado Multi-Species Conservation Program (LCR-MSCP) habitat creation demonstration areas. The LCR-MSCP was designed to create habitat supporting the conservation of target fish and wildlife species important to the Lower Colorado River ecosystem. According to the Lower Colorado River Habitat Conservation Plan (HCP), approximately 8,100 acres (3,278 hectares) of habitats will be created in order to reach this goal. Included in the HCP is a long-term monitoring strategy designed to follow the progression of each LCR-MSCP habitat creation goal over time and ensure that these goals are reached.

Data collected by BIO-WEST during annual monitoring events can be used to characterize habitat composition, structure, and functionality. The information can also be used to identify any potential problems within the habitat creation sites, such as weed infestation and plant stress. The data obtained through the current monitoring year can be compared with previous years' data in order to detect changes in vegetation community structure and provide annual benchmark levels with which to determine the progression of each target habitat creation demonstration area and restoration site.

Using several components of common forestry and vegetation monitoring protocols, data are collected within several parameters and strata to capture a "complete picture" (from ground cover to canopy) of the vegetation composition within each habitat type and at each restoration site. Trends observed following multiple years of data collection will be used to formulate an adaptive management strategy for the restoration sites and demonstration areas.

FIELD METHODS

The 2009 Lower Colorado River vegetation monitoring occurred at five different demonstration areas and was performed in two stages of work. The Beal Lake Riparian Restoration Demonstration project area (Beal Lake) (Appendix A, Figure 1) and Colorado River Indian Tribe (CRIT) Riparian Restoration Demonstration project area (CRIT9) (Appendix A, Figure 2) were monitored beginning September 28, 2009, and completed October 2, 2009. Palo Verde Ecological Reserve Phases 2–4 (PVER) (Appendix A, Figures 3, 4, and 5), Cibola Valley Conservation Area Phases 1–4 (CVCA) (Appendix A, Figures 5, 6, 7, 8, 9, and 10), and Cibola National Wildlife Refuge Unit #1 (CNWR) (Appendix A, Figure 11) were completed between October 12–23, 2009. Two teams of two field biologists each performed field work based on the methodology outlined in the statement of work.

In 2009 167 vegetation plots were monitored by BIO-WEST. Of these plots 50 were established in newly planted demonstration areas within PVER and CVCA. In addition to the newly planted 2009 plots, two new plots were established in CVCA3, and six new plots were established in

PVER3. These fields were planted in late 2008 after vegetation monitoring had taken place and were, therefore, established and monitored in 2009. The number of plots at each location are shown in Table 1.

Table 1. Number of plots monitored per habitat type within a given restoration area.

BEAL LAKE		
	Habitat Type	**Number of Plots**
	mesquite	3
	cottonwood-willow (3 X/week)	4
	cottonwood-willow (1 X/month)	4
	cottonwood-willow (2 X/month)	4
CIBOLA NATIONAL WILDLIFE REFUGE		
	Habitat Type	**Number of Plots**
	cottonwood-willow II	2
	mesquite	4
	cottonwood-willow III	4
	mass transplanting site	4
COLORADO RIVER INDIAN TRIBE		
Section	**Habitat Type**	**Number of Plots**
1	mesquite	2
1	cottonwood-willow	2
2	cottonwood-willow	2
3	mesquite	2
3	cottonwood-willow	2
4	cottonwood-willow	2
CIBOLA VALLEY CONSERVATION AREA PHASE 1		
	Habitat Type	**Number of Plots**
	Goodding's willow	2
	coyote willow	2
	cottonwood	2
	morning glory treatment	2
CIBOLA VALLEY CONSERVATION AREA PHASE 2		
Section	**Habitat Type**	**Number of Plots**
1	atriplex-mesquite	2
2	cottonwood-Goodding's willow	2
3	coyote willow	2
4	cottonwood-coyote willow-Goodding's willow	2
5	coyote willow	2
6	cottonwood-Goodding's willow	2
7	coyote willow-Goodding's willow	2
8	coyote willow	2
9	cottonwood-coyote willow-Goodding's willow	2
10	Goodding's willow	2

CIBOLA VALLEY CONSERVATION AREA PHASE 3		
Fields	**Habitat Type**	**Number of Plots**
1	cottonwood	2
2	Goodding's willow	2
3	coyote willow	1
4	cottonwood-Goodding's willow	1
5	coyote willow	1
6	cottonwood-Goodding's willow	1
7	baccharis	2
8	cottonwood-coyote willow	2
9	atriplex-mesquite	2

CIBOLA VALLEY CONSERVATION AREA PHASE 4		
Section	**Field**	**Number of Plots**
Eastern	A	4
Eastern	B	4
Eastern	C	4
Eastern	D	4
Western	1	2
Western	2	2
Western	3	2
Western	4	2
Western	5	2
Western	6	1
Western	7	1

PALO VERDE ECOLOGICAL RESERVE PHASE 2		
	Habitat Type	**Number of Plots**
	mesquite	2
	coyote willow	4
	Goodding's willow	4
	cottonwood	4

PALO VERDE ECOLOGICAL RESERVE PHASE 3		
Fields	**Habitat Type**	**Number of Plots**
1–3	mesquite	6
4–5	coyote willow-Goodding's willow	4
6–8	cottonwood-coyote willow	6
9–10	grasses-alfalfa	4

PALO VERDE ECOLOGICAL RESERVE PHASE 4		
Fields	**Habitat Type**	**Number of Plots**
1–6	coyote willow-Goodding's willow	8
7–14	baccharis-cottonwood-Goodding's willow	10
Not applicable	coyote willow	not applicable
15–16	atriplex-mesquite	4

Plots center points were randomly preselected within habitat strata as indicated by the statement of work. Rebar was installed at each plot center point along with an aluminum survey cap stamped with the date, plot number, and UTM coordinates. Once a plot has been established it represents a permanent location that will be monitored annually to determine changes within the vegetation community over time. Primary and sub plots with a common center point were marked with flagging at an 8.00-meter (m) (26.25-foot [ft]) radius and 5.00-m (16.40-ft) radius, respectively. Transect ends in all cardinal directions, 10.00 m (32.81 ft) from the center point, were also marked with rebar. Plots established in 2008 were inspected, and any missing markers within the plot were replaced.

Monitoring

Overstory Trees

Within the primary plot radius (26.25 ft [8.00 m]), overstory trees with a diameter breast height (DBH) equal to or greater than 5.00 inches (in) (12.70 centimeters [cm]) were monitored. Species, height, and DBH of trees were recorded in metric with tree height collected in tenths of a meter and DBH collected in tenths of a centimeter. Tree height was measured with a 7.5-m survey rod and height for all trees taller than 7.5 m were estimated. A tree near the boundary of the primary plot would be monitored if more than half the trunk fell within the plot radius and the tree had a DBH equal to or greater than 5.00 in (12.70 cm) (Figure 1).

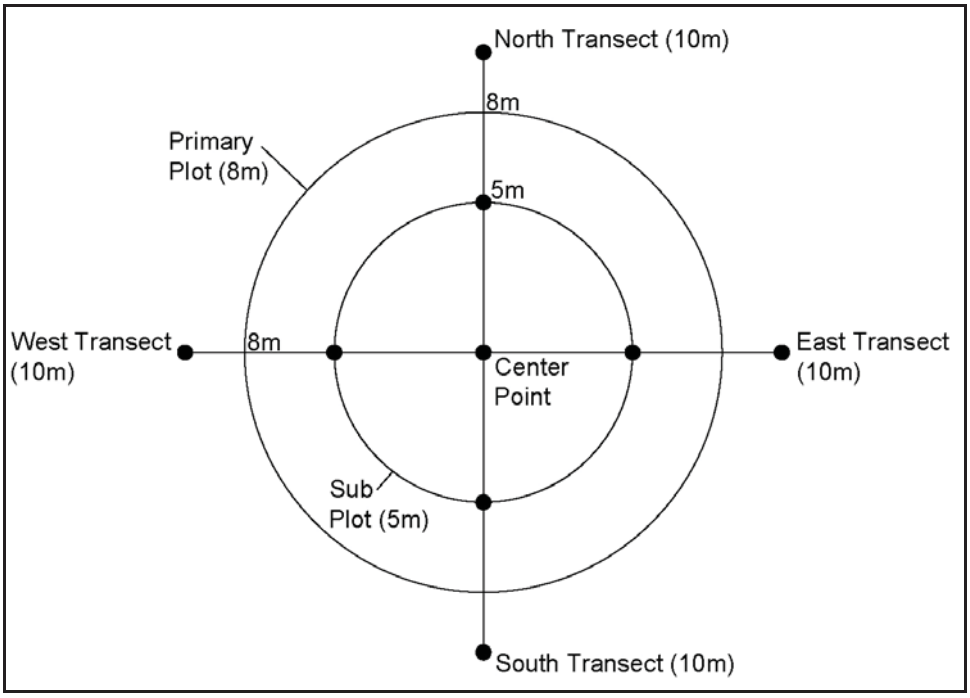


Figure 1. Vegetation monitoring plot diagram.

The protocol for monitoring mesquite (*Prosopis* spp.) was different than that outlined above. Diameter was measured at the root collar (in tenths of a centimeter), and number of stems greater than 1.00 in (2.54 cm) at breast height were estimated and recorded. Height data were also collected in tenths of a meter. All mesquite in the primary plot were monitored if they were above 4.50 ft (1.37 m) in height and if root collar diameter was equal to or greater than 5.00 in (12.70 cm).

Intermediate Story Trees and Shrubs

Within the sub-plot radius (16.40 ft [5.00 m]), all woody trees were monitored based on DBH. If a tree's DBH was equal to or greater than 3.10 in (7.87 cm), then species, height and DBH data were recorded. Measurements were collected in tenths of a metric unit. All tree species with a DBH of less than 3.10 in (7.87 cm) were placed into one of four DBH classes. The number of each species in each class was recorded. The four DBH classes are; <0.40 in (<1.02 cm); 0.40–1.00 in (1.02–2.54 cm); 1.10–2.20 in (2.79–5.59 cm); 2.30–3.10 in (5.84–7.87 cm). The number of tree species with height of <4.50 ft (1.37 m) was also tallied. Desert broom (*Baccharis sarothroides*) shrubs were assigned a DBH class based on the DBH of the largest stem. Saltbush (*Atriplex* spp.) species above 4.50 ft (1.37 m) were measured for height, and those below this height were tallied.

Ground Cover/Herbaceous Layer

Ground cover data were collected along 32.81-ft (10.00-m) transects extending from the center point in all four cardinal directions. A measuring tape was laid out as close to ground level as possible and data were collected using the line intercept method. Linear distribution of herbaceous cover along the length of the transect was recorded. All herbaceously vegetated ground cover and unvegetated ground cover along the four transects were collected including bare ground and leaf litter.

Crown Closure

The percent canopy closure was measured at nine different locations within the plot. Data were taken using a spherical densiometer at the center point and at the 16.40-ft (5.00 m) and 32.81-ft 10.00-m) point along the transects established for ground cover estimation. The densiometer was held at elbow height above position, and number of dots covered by canopy and open sky were recorded. In this case dots were considered intersections of lines on the densitometer. Using a methodology similar to a sighting tube there are a total of 37 intersections. Sighting canopy closure over cross hairs (or line intersections) can be more precise than sighting canopy over imagined dots within each square on the densiometer. The total number of intersections covered by canopy is multiplied by a factor of 2.702 to obtain the percent crown closure.

Foliage Height Diversity

Vegetation density from canopy top to ground level was monitored along the cardinal transects established for ground cover at the 16.40-ft (5.00-m) and 32.81-ft (10.00-m) locations. Data were also collected at the center point. At each position a 7.5-m survey rod was extended through the canopy and data were recorded based on all vegetation that came within a tenth of a meter to the survey rod. At every tenth of a meter section, a "hit" was recorded when a species fell within that proximity of the rod. A maximum of 10 "hits" per meter was collected. If more than one species was present within proximity to the rod, "hits" were assigned based on percent composition (visual estimation) of each species present so as to never exceed the 10 hits per meter maximum. The 2008 data were collected by BIO-WEST using a vertical line-intercept method. Before field work began in 2009, the foliage height diversity protocol was clarified and the correct methods were implemented for all plots during data collection.

RESULTS

The following data were summarized for each restoration site. The requested analyses include standard deviation where applicable. Summary statistics are tabulated and discussed below.

Overstory Data

The average overstory tree density (Table 2) was calculated by totaling the number of trees in each plot (Table 3) and dividing by 0.05 (the overstory plot size=0.05 acre [0.02 hectare]) to obtain the average density per plot. The per-plot density was then extrapolated to obtain a per-acre average density.

Table 2. Overstory layer average tree density (number of trees per acre).

SITE	N	NUMBER OF PLOTS WITH OVERSTORY TREES	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	15	5	0.00	160.00	26.67	51.08
CRIT9	12	10	0.00	160.00	65.00	50.54
CVCA1	8	4	0.00	140.00	47.50	63.19
CVCA2 [a]	20	0	0.00	0.00	0.00	0.00
CVCA3	14	2	0.00	80.00	10.00	25.72
CVCA4 [a]	28	0	0.00	0.00	0.00	0.00
CNWR	14	8	0.00	180.00	61.43	69.93
PVER2	14	0	0.00	0.00	0.00	0.00
PVER3 [a]	20	0	0.00	0.00	0.00	0.00
PVER4 [a]	22	0	0.00	0.00	0.00	0.00

[a] Denotes sites with no trees meeting the overstory size requirement (5.0 in DBH (12.7 cm) or greater).

Table 3. Total overstory layer trees measured per site.

SITE	NUMBER OF OVERSTORY TREES MEASURED
Beal Lake	25
CRIT9	39
CVCA1	19
CVCA2 [a]	0
CVCA3	7
CVCA4 [a]	0
CNWR	43
PVER2	0
PVER3 [a]	0
PVER4 [a]	0

[a] Denotes sites with no trees meeting the overstory size requirement (5.0 in DBH (12.7 cm) or greater).

The average density is reported in terms of the average number of trees per acre for each restoration site. The high standard deviation values for the average overstory tree density are a result of the variation of average densities per plot.

The restoration site with the highest overstory tree density is CRIT9, closely followed by the CNWR site. The restoration sites located within the nature-trail portion of the CNWR site contain a high number of very large, mature cottonwood trees. The CVCA3 restoration site has the lowest average density of overstory trees of all restoration sites; only seven trees meet the overstory tree-size requirement (Table 3). Several sites (CVCA2, CVCA3, PVER2, PVER3, and PVER4), lack trees large enough to meet the size requirement.

The Beal Lake and CVCA3 sites have the smallest average overstory tree height (Table 4) with means of 1.97 m and 1.47 m, respectively. The CRIT9, CVCA1, and CNWR sites have relatively similar average overstory tree heights. Of these sites the tallest average height is at CVCA1.

Because the DBH of a tree determines its inclusion in the overstory tree category, the average overstory DBH of all trees (Table 5) is an excellent overall representation of overstory tree composition within each restoration site. The average DBH for the CRIT9 site is highest of all restoration sites containing qualifying trees. The DBH averages for the four other restoration sites with qualifying trees range from 2.13 cm to 11.76 cm.

Table 4. Average overstory tree height in meters (m) per site.

SITE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	15.00	0.00	8.45	1.97	3.01
CRIT9	12.00	0.00	14.29	6.92	4.21
CVCA1	8.00	0.00	13.49	5.45	6.10
CVCA2 [a]	20.00	0.00	0.00	0.00	0.00
CVCA3	14.00	0.00	10.67	1.47	3.95
CVCA4	28.00	0.00	0.00	0.00	0.00
CNWR	14.00	0.00	13.94	5.41	5.87
PVER2 [a]	14.00	0.00	0.00	0.00	0.00
PVER3 [a]	20.00	0.00	0.00	0.00	0.00
PVER4 [a]	22.00	0.00	0.00	0.00	0.00

[a] Denotes sites with no trees meeting the overstory size requirement (5.0 in DBH (12.7 cm) or greater).

Table 5. Average overstory tree diameter breast height (DBH) in centimeters (cm) per site.

SITE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	15.00	0.00	17.25	5.14	7.56
CRIT9	12.00	0.00	28.00	14.34	7.69
CVCA1	8.00	0.00	16.43	7.49	8.06
CVCA2	20.00	0.00	0.00	0.00	0.00
CVCA3	14.00	0.00	15.63	2.13	5.43
CVCA4	28.00	0.00	0.00	0.00	0.00
CNWR	14.00	0.00	33.13	11.76	11.62
PVER2 [a]	14.00	0.00	0.00	0.00	0.00
PVER3 [a]	20.00	0.00	0.00	0.00	0.00
PVER4 [a]	22.00	0.00	0.00	0.00	0.00

[a] Denotes sites with no trees meeting the overstory size requirement (5.0 in DBH (12.7 cm) or greater).

Intermediate Tree and Shrub Layer Data

The average densities for each intermediate tree and shrub DBH class (Tables 6, 7, 8, 9, and 10) were calculated in the same manner as the overstory tree data. After calculating the average density per plot (intermediate tree and shrub sub plot size= 0.019 acre), the data were extrapolated and reported as the average number of trees and shrubs per acre.

Table 6. Average density of trees < 4.5 feet high (trees per acre).

SITE	SPECIES NAME	6-LETTER SPECIES CODE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	*Populus fremontii*	POPFRE	6.00	0.00	157.89	26.32	64.46
Beal Lake	*Prosopis glandulosa*	PROGLA	2.00	0.00	842.11	421.05	595.46
Beal Lake	*Prosopis pubescens*	PROPUB	10.00	0.00	263.16	26.32	83.22
Beal Lake	*Salix gooddingii*	SALGOO	4.00	0.00	52.63	26.32	30.39
Beal Lake	*Pluchea sericea*	PLUSER	14.00	947.37	16105.26	5210.53	4756.06
Beal Lake	*Tamarisk* spp.	TAMARIX	5.00	0.00	3894.74	957.89	1650.32
CRIT9		NONE					
CVCA1	*Populus fremontii*	POPFRE	3.00	0.00	52.63	17.54	30.39
CVCA1	*Salix exigua*	SALEXI	3.00	105.26	578.95	280.70	259.63
CVCA2	*Salix gooddingii*	SALGOO	10.00	0.00	105.26	10.53	33.29
CVCA2	*Tamarisk* spp.	TAMARIX	16.00	0.00	526.32	151.32	198.68
CVCA3	*Prosopis glandulosa*	PROGLA	2.00	0.00	52.63	26.32	37.22
CVCA3	*Salix exigua*	SALEXI	5.00	0.00	11000.00	2336.84	4847.62
CVCA3	*Baccharis sarothroides*	BACSAR	2.00	0.00	52.63	26.32	37.22
CVCA3	*Tamarisk* spp.	TAMARIX	7.00	0.00	1578.95	556.39	660.77
CVCA4	*Prosopis glandulosa*	PROGLA	28.00	0.00	263.16	54.51	75.09
CVCA4	*Atriplex lentiformis*	ATRLEN	11.00	52.63	157.89	86.12	35.48
CVCA4	*Tamarisk* spp.	TAMARIX	1.00	105.26	105.26	105.26	N/A
CNWR	*Populus fremontii*	POPFRE	3.00	52.63	105.26	70.18	30.39
CNWR	*Prosopis glandulosa*	PROGLA	1.00	315.79	315.79	315.79	N/A
CNWR	*Salix exigua*	SALEXI	1.00	315.79	315.79	315.79	N/A
CNWR	*Salix gooddingii*	SALGOO	3.00	0.00	52.63	17.54	30.39
CNWR	*Baccharis sarothroides*	BACSAR	6.00	0.00	105.26	17.54	42.97
PVER2	*Populus fremontii*	POPFRE	4.00	0.00	157.89	52.63	74.43
PVER2	*Salix exigua*	SALEXI	5.00	0.00	263.16	63.16	114.10
PVER3	*Populus fremontii*	POPFRE	13.00	0.00	52.63	4.05	14.60
PVER3	*Prosopis glandulosa*	PROGLA	1.00	52.63	52.63	52.63	N/A
PVER3	*Prosopis pubescens*	PROPUB	2.00	0.00	105.26	52.63	74.43
PVER3	*Salix exigua*	SALEXI	12.00	0.00	210.53	52.63	77.74
PVER3	*Salix gooddingii*	SALGOO	7.00	0.00	210.53	60.15	88.22
PVER4	*Populus fremontii*	POPFRE	8.00	0.00	52.63	13.16	24.36
PVER4	*Prosopis pubescens*	PROPUB	4.00	0.00	52.63	13.16	26.32
PVER4	*Salix exigua*	SALEXI	18.00	0.00	473.68	204.68	148.74
PVER4	*Salix gooddingii*	SALGOO	15.00	0.00	1473.68	168.42	387.89
PVER4	*Atriplex lentiformis*	ATRLEN	2.00	52.63	105.26	78.95	37.22

Table 7. Average density of trees for DBH Class 1 (< 0.4 inch/<1.0 centimeter) (trees per acre).

SITE	SPECIES NAME	6-LETTER SPECIES CODE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	*Populus fremontii*	POPFRE	6.00	0.00	473.68	78.95	193.38
Beal Lake	*Prosopis glandulosa*	PROGLA	2.00	157.89	368.42	263.16	148.86
Beal Lake	*Prosopis pubescens*	PROPUB	10.00	0.00	105.26	15.79	35.52
Beal Lake	*Salix exigua*	SALEXI	2.00	0.00	2736.84	1368.42	1935.24
Beal Lake	*Salix gooddingii*	SALGOO	4.00	0.00	210.53	65.79	99.63
Beal Lake	*Pluchea sericea*	PLUSER	14.00	1210.53	18000.00	5278.20	4394.48
Beal Lake	*Tamarisk* spp.	TAMARIX	5.00	0.00	315.79	126.32	137.25
CRIT9	*Populus fremontii*	POPFRE	3.00	0.00	421.05	140.35	243.09
CRIT9	*Prosopis glandulosa*	PROGLA	2.00	0.00	52.63	26.32	37.22
CRIT9	*Salix gooddingii*	SALGOO	2.00	105.26	157.89	131.58	37.22
CVCA1	*Populus fremontii*	POPFRE	3.00	0.00	52.63	17.54	30.39
CVCA1	*Salix exigua*	SALEXI	3.00	578.95	5894.74	3543.86	2710.57
CVCA2	*Salix exigua*	SALEXI	13.00	0.00	2210.53	647.77	683.33
CVCA2	*Salix gooddingii*	SALGOO	10.00	0.00	368.42	131.58	122.18
CVCA2	*Tamarisk* spp.	TAMARIX	16.00	0.00	842.11	266.45	212.68
CVCA3	*Populus fremontii*	POPFRE	5.00	0.00	105.26	21.05	47.08
CVCA3	*Prosopis glandulosa*	PROGLA	2.00	52.63	368.42	210.53	223.30
CVCA3	*Salix exigua*	SALEXI	5.00	0.00	14105.26	3810.53	5799.35
CVCA3	*Salix gooddingii*	SALGOO	5.00	0.00	210.53	42.11	94.15
CVCA3	*Baccharis sarothroides*	BACSAR	2.00	210.53	421.05	315.79	148.86
CVCA3	*Tamarisk* spp.	TAMARIX	7.00	0.00	2105.26	563.91	825.33
CVCA4	*Prosopis glandulosa*	PROGLA	28.00	0.00	263.16	50.75	72.31
CVCA4	*Tamarisk* spp.	TAMARIX	1.00	52.63	52.63	52.63	N/A
CNWR	*Populus fremontii*	POPFRE	3.00	105.26	157.89	122.81	30.39
CNWR	*Prosopis glandulosa*	PROGLA	1.00	105.26	105.26	105.26	N/A
CNWR	*Salix exigua*	SALEXI	4.00	0.00	157.89	52.63	74.43
CNWR	*Salix gooddingii*	SALGOO	3.00	52.63	315.79	157.89	139.25
CNWR	*Baccharis sarothroides*	BACSAR	6.00	0.00	52.63	17.54	27.18
CNWR	*Tamarisk* spp.	TAMARIX	1.00	52.63	52.63	52.63	N/A
PVER2	*Populus fremontii*	POPFRE	4.00	0.00	157.89	65.79	66.23
PVER2	*Prosopis glandulosa*	PROGLA	2.00	52.63	210.53	131.58	111.65
PVER2	*Salix exigua*	SALEXI	5.00	105.26	2684.21	1421.05	1085.67
PVER3	*Populus fremontii*	POPFRE	13.00	0.00	315.79	40.49	101.13
PVER3	*Salix exigua*	SALEXI	12.00	0.00	1052.63	425.44	326.35
PVER3	*Salix gooddingii*	SALGOO	7.00	0.00	789.47	353.38	307.96
PVER4	*Populus fremontii*	POPFRE	8.00	0.00	526.32	118.42	175.13
PVER4	*Prosopis pubescens*	PROPUB	4.00	52.63	105.26	65.79	26.32
PVER4	*Salix exigua*	SALEXI	18.00	0.00	842.11	432.75	267.49
PVER4	*Salix gooddingii*	SALGOO	15.00	0.00	1473.68	242.11	374.18

Table 8. Average density of trees for DBH Class 2 (0.4–1.0 inch/1–2.5 centimeter[s]) (trees per acre).

SITE	SPECIES NAME	6-LETTER SPECIES CODE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	*Populus fremontii*	POPFRE	6.00	0.00	842.11	192.98	342.17
Beal Lake	*Prosopis glandulosa*	PROGLA	2.00	105.26	210.53	157.89	74.43
Beal Lake	*Prosopis pubescens*	PROPUB	10.00	0.00	684.21	126.32	220.80
Beal Lake	*Salix exigua*	SALEXI	2.00	52.63	1684.21	868.42	1153.70
Beal Lake	*Salix gooddingii*	SALGOO	4.00	52.63	210.53	131.58	91.16
Beal Lake	*Baccharis sarothroides*	BACSAR	1.00	526.32	526.32	526.32	N/A
Beal Lake	*Pluchea sericea*	PLUSER	14.00	0.00	8052.63	1045.11	2271.84
Beal Lake	*Tamarisk* spp.	TAMARIX	5.00	0.00	52.63	21.05	28.83
CRIT9	*Populus fremontii*	POPFRE	3.00	0.00	789.47	280.70	441.39
CRIT9	*Prosopis glandulosa*	PROGLA	2.00	0.00	105.26	52.63	74.43
CVCA1	*Populus fremontii*	POPFRE	3.00	0.00	157.89	52.63	91.16
CVCA1	*Salix exigua*	SALEXI	3.00	105.26	2684.21	1508.77	1304.51
CVCA1	*Salix gooddingii*	SALGOO	1.00	52.63	52.63	52.63	N/A
CVCA2	*Populus fremontii*	POPFRE	13.00	0.00	210.53	40.49	68.47
CVCA2	*Salix exigua*	SALEXI	13.00	0.00	2473.68	854.25	644.30
CVCA2	*Salix gooddingii*	SALGOO	10.00	0.00	789.47	310.53	283.38
CVCA2	*Tamarisk* spp.	TAMARIX	16.00	0.00	263.16	62.50	90.59
CVCA3	*Populus fremontii*	POPFRE	5.00	0.00	894.74	305.26	349.91
CVCA3	*Salix exigua*	SALEXI	5.00	0.00	1684.21	1042.11	798.54
CVCA3	*Salix gooddingii*	SALGOO	5.00	0.00	421.05	231.58	172.97
CVCA3	*Baccharis sarothroides*	BACSAR	2.00	0.00	368.42	184.21	260.51
CVCA3	*Tamarisk* spp.	TAMARIX	7.00	0.00	1052.63	172.93	392.35
CVCA4		NONE	0.00	0.00	0.00	0.00	0.00
CNWR	*Populus fremontii*	POPFRE	3.00	105.26	210.53	140.35	60.77
CNWR	*Salix exigua*	SALEXI	4.00	0.00	157.89	52.63	74.43
CNWR	*Salix gooddingii*	SALGOO	3.00	157.89	263.16	210.53	52.63
CNWR	*Baccharis sarothroides*	BACSAR	6.00	0.00	210.53	87.72	85.95
PVER2	*Populus fremontii*	POPFRE	4.00	0.00	1157.89	447.37	525.44
PVER2	*Prosopis glandulosa*	PROGLA	2.00	0.00	52.63	26.32	37.22
PVER2	*Salix exigua*	SALEXI	5.00	0.00	3052.63	1200.00	1122.92
PVER2	*Salix gooddingii*	SALGOO	4.00	52.63	315.79	144.74	124.36
PVER3	*Populus fremontii*	POPFRE	13.00	0.00	1578.95	157.89	429.20
PVER3	*Prosopis pubescens*	PROPUB	2.00	0.00	52.63	26.32	37.22
PVER3	*Salix exigua*	SALEXI	12.00	0.00	1263.16	504.39	474.19
PVER3	*Salix gooddingii*	SALGOO	7.00	0.00	631.58	150.38	236.21
PVER4	*Populus fremontii*	POPFRE	8	105.2632	578.9474	348.6842	151.3362
PVER4	*Salix exigua*	SALEXI	18	0	526.3158	35.08772	123.7616
PVER4	*Salix gooddingii*	SALGOO	15	0	1157.895	273.6842	366.3746

Table 9. Average density of trees for DBH Class 3 (1.1–2.2 inches/2.6–5.5 centimeters) (trees per acre).

SITE	SPECIES NAME	6-LETTER SPECIES CODE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	*Populus fremontii*	POPFRE	6.00	0.00	736.84	307.02	341.77
Beal Lake	*Prosopis glandulosa*	PROGLA	2.00	0.00	105.26	52.63	74.43
Beal Lake	*Prosopis pubescens*	PROPUB	10.00	0.00	947.37	126.32	291.67
Beal Lake	*Salix exigua*	SALEXI	2.00	0.00	52.63	26.32	37.22
Beal Lake	*Salix gooddingii*	SALGOO	4.00	0.00	105.26	26.32	52.63
Beal Lake	*Baccharis sarothroides*	BACSAR	1.00	210.53	210.53	210.53	N/A
Beal Lake	*Tamarisk* spp.	TAMARIX	5.00	0.00	52.63	10.53	23.54
CRIT9	*Populus fremontii*	POPFRE	3.00	52.63	1052.63	385.96	577.35
CRIT9	*Prosopis glandulosa*	PROGLA	2.00	0.00	52.63	26.32	37.22
CVCA1	*Populus fremontii*	POPFRE	3.00	0.00	105.26	35.09	60.77
CVCA1	*Salix exigua*	SALEXI	3.00	52.63	1473.68	543.86	805.68
CVCA1	*Salix gooddingii*	SALGOO	1.00	263.16	263.16	263.16	N/A
CVCA2	*Populus fremontii*	POPFRE	13.00	52.63	842.11	206.48	217.50
CVCA2	*Salix exigua*	SALEXI	13.00	0.00	526.32	133.60	189.30
CVCA2	*Salix gooddingii*	SALGOO	10.00	52.63	578.95	273.68	146.36
CVCA2	*Tamarisk* spp.	TAMARIX	16.00	0.00	157.89	32.89	53.93
CVCA3	*Populus fremontii*	POPFRE	5.00	0.00	1368.42	726.32	492.89
CVCA3	*Salix exigua*	SALEXI	5.00	0.00	842.11	178.95	371.42
CVCA3	*Salix gooddingii*	SALGOO	5.00	0.00	1684.21	768.42	808.20
CVCA4	*Prosopis glandulosa*	PROGLA	28.00	0.00	105.26	3.76	19.89
CNWR	*Populus fremontii*	POPFRE	3.00	421.05	684.21	508.77	151.93
CNWR	*Salix exigua*	SALEXI	4.00	0.00	578.95	210.53	275.16
CNWR	*Salix gooddingii*	SALGOO	3.00	0.00	157.89	87.72	80.40
CNWR	*Baccharis sarothroides*	BACSAR	6.00	0.00	315.79	140.35	123.06
PVER2	*Populus fremontii*	POPFRE	4.00	0.00	210.53	65.79	99.63
PVER2	*Prosopis glandulosa*	PROGLA	2.00	52.63	105.26	78.95	37.22
PVER2	*Salix exigua*	SALEXI	5.00	0.00	1631.58	536.84	698.63
PVER2	*Salix gooddingii*	SALGOO	4.00	0.00	631.58	302.63	298.89
PVER3	*Populus fremontii*	POPFRE	13.00	0.00	842.11	234.82	235.00
PVER4	*Salix gooddingii*	SALGOO	15.00	0.00	52.63	3.51	13.59

Table 10. Average density of trees for DBH Class 4 (1.1–2.2 inches/2.6–5.5 centimeters) (trees per acre).

SITE	SPECIES NAME	6-LETTER SPECIES CODE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	*Populus fremontii*	POPFRE	6.00	0.00	263.16	87.72	92.17
Beal Lake	*Prosopis pubescens*	PROPUB	10.00	0.00	263.16	94.74	95.45
Beal Lake	*Baccharis sarothroides*	BACSAR	1.00	52.63	52.63	52.63	N/A
CRIT9	*Populus fremontii*	POPFRE	3.00	0.00	368.42	122.81	212.71
CRIT9	*Prosopis pubescens*	PROPUB	1.00	52.63	52.63	52.63	N/A
CVCA1	*Populus fremontii*	POPFRE	3.00	0.00	1052.63	368.42	593.13
CVCA1	*Salix gooddingii*	SALGOO	1.00	631.58	631.58	631.58	N/A
CVCA2	*Populus fremontii*	POPFRE	13.00	0.00	894.74	230.77	248.30
CVCA2	*Salix exigua*	SALEXI	13.00	0.00	52.63	4.05	14.60
CVCA2	*Salix gooddingii*	SALGOO	10.00	0.00	105.26	31.58	44.38
CVCA2	*Tamarisk* spp.	TAMARIX	16.00	0.00	105.26	13.16	35.95
CVCA3	*Salix gooddingii*	SALGOO	5.00	0.00	263.16	94.74	114.10
CVCA4		NONE	0.00	0.00	0.00	0.00	0.00
CNWR	*Salix gooddingii*	SALGOO	3.00	0.00	105.26	35.09	60.77
PVER2	*Populus fremontii*	POPFRE	4.00	0.00	421.05	171.05	207.77
PVER2	*Salix gooddingii*	SALGOO	4.00	52.63	263.16	184.21	91.16
PVER3	N/A	NONE	0.00	0.00	0.00	0.00	0.00
PVER4	N/A	NONE	0.00	0.00	0.00	0.00	0.00

The growth habit of big saltbush (*Atriplex lentiformis*) does not allow for a central stem DBH measurement; therefore, the species is only represented in the total count of trees and shrubs less than 4.5 ft (1.40 m) tall. Big saltbush will also be represented in the average intermediate tree and shrub height calculations but not the average DBH calculations.

The species with the highest density is arrowweed (*Pluchea sericea*), represented in the smaller DBH classes as well as the < 4.5 ft (1.40 m) size category. Arrowweed typically branches below the soil surface, sending up several stems approximately the same size, making it difficult to determine a central stem. Difficulties with arrowweed and big saltbush measurement are addressed in the discussion. Average densities are extremely high (1,000–5,000 on average) for arrowweed, which is indicative of the dense thickets observed in many plots at the Beal Lake site. The complete absence of arrowweed in the larger DBH classes may be more a function of DBH determination problems than lack of presence. Arrowweed was not found at any of the remaining nine restoration sites.

Coyote willow is the second most dense species less than 4.50 ft (1.40 m) tall as well as DBH classes one and two. This may be representative of the coyote willow growth habit. A shift in the species with the highest average density occurs in the larger DBH classes (3 and 4), moving from arrowweed and coyote willow to Goodding's willow, desert broom, and Fremont's cottonwood (*Populus freemontii*). Tamarix (*Tamarisk* spp.) is present in all size categories (primarily at Beal Lake and CVCA 1, 2, and 3) with the highest densities less than 4.50 ft (1.40 m) high and DBH class one categories. This can have important implications for tamarix control.

As with the overstory tree standard deviation values, high standard deviation values in the intermediate tree and shrub layer data are representative of a high degree of variation in the density averages per monitoring plot.

The intermediate tree-layer average densities (Table 11) represent all trees located within the sub plot that have a DBH between 3.10 in (8.0 cm) and 5.00 in (12.70 cm). The general growth habit of coyote willow may have some affect on its high average densities in the larger intermediate tree and shrub DBH size categories. The restoration site with the highest average intermediate tree density is PVER2. The restoration site with the lowest average intermediate tree density is CVCA4. This site was planted this year exclusively with a mesquite habitat type containing big saltbush. The mesquite trees are likely not mature enough to meet the size requirements for intermediate trees and shrubs. The problems with measuring DBH on big saltbush may have an affect on the average density calculations at this restoration site. The repetitive minimum values evident in Table 11 are the result of a minimum value of one tree/shrub per plot extrapolated for the entire site. Density is the number of trees divided by unit (plot) area. The average height of all intermediate trees was calculated for each restoration site (Table 12).

Table 11. Intermediate and shrub layer tree densities (trees per acre).

SITE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	8.00	52.63	842.11	203.95	263.06
CRIT9	6.00	52.63	263.16	114.04	84.32
CVCA1	4.00	52.63	368.42	236.84	139.25
CVCA2	10.00	52.63	368.42	163.16	112.20
CVCA3	5.00	52.63	315.79	147.37	114.10
CVCA4	5.00	52.63	52.63	52.63	0.00
CNWR	7.00	52.63	368.42	150.38	111.35
PVER2	6.00	105.26	894.74	456.14	304.48
PVER3	2.00	52.63	157.89	105.26	74.43
PVER4*	0.00	0.00	0.00	0.00	0.00

[a] Denotes sites with no shrubs meeting the 3.1 inch (8.0 centimeter) or greater diameter breast height requirement.

Table 12. Intermediate and shrub layer average tree height in meters (m).

SITE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	31.00	4.30	8.50	6.50	1.31
CRIT9	13.00	3.30	9.40	5.65	1.98
CVCA1	18.00	8.70	13.00	10.43	1.52
CVCA2	31.00	1.60	10.50	6.69	3.00
CVCA3	14.00	1.70	10.10	6.64	3.63
CVCA4	5.00	1.40	1.80	1.60	0.16
CNWR	20.00	2.90	11.20	8.22	2.53
PVER2	52.00	6.20	16.00	10.94	2.18
PVER3	4.00	6.90	7.30	7.10	0.18
PVER4 [a]	0.00	0.00	0.00	0.00	0.00

[a] Denotes sites with no shrubs meeting the 3.1 in (7.9 cm) or greater diameter breast height requirement.

The CVCA4 site has the smallest average tree height of 5.25 ft (1.60 m). As previously mentioned, this site was newly planted with honey mesquite. The two restoration sites with the largest average intermediate tree height are CVCA1 and PVER2. At CVCA1 the tallest trees were at 42.65 ft (13.00 m) and at PVER2 they were 52.49 ft (16.00 m).

The average DBH values for intermediate trees are listed in Table 13. The average DBH per restoration site differ by just 0.51 in (1.30 cm) between the highest and lowest values. The restoration site with the highest average DBH is CNWR. The restoration site with the lowest average is PVER3, a primarily cottonwood/willow site of which half was planted this year.

Ground Cover Data

The total average ground cover (Table 14) was calculated by summing the length of ground cover along each transect in a plot. The lengths were first averaged for each plot, then for each restoration site as a whole.

The restoration site with the lowest average ground cover is Beal Lake with an average of 37.30 ft (11.37 m). There are several restoration sites with an average cover exceeding 328.08 ft (100.00 m), the highest being PVER4. The PVER3 site has a high average ground cover of 1,044.78 ft (318.45 m).

Table 13. Intermediate and shrub layer average tree diameter breast height (DBH) in centimeters (cm).

SITE	N	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
Beal Lake	31.00	7.90	12.00	9.48	1.40
CRIT9	12.00	8.00	11.00	9.67	1.07
CVCA1	18.00	8.10	12.50	9.59	1.40
CVCA2	22.00	8.00	12.25	9.16	1.04
CVCA3	9.00	8.10	10.00	9.09	0.67
CVCA4 [a]	0.00	0.00	0.00	0.00	0.00
CNWR	20.00	8.00	12.50	9.99	1.09
PVER2	52.00	8.00	12.25	9.92	1.30
PVER3	4.00	8.00	9.50	8.69	0.63
PVER4 [b]	0.00	0.00	0.00	0.00	0.00

[a] Shrub layer vegetation at CVCA4 was limited to big saltbush. Due to the growth habit, no DBH data were collected.
[b] Denotes sites with no shrubs meeting the 3.1 in (7.9 cm) or greater diameter breast height requirement.

Table 14. Average ground cover in meters (m).

SITE	AVERAGE LENGTH OF GROUND COVER [a]	STANDARD DEVIATION
Beal Lake	11.37	5.28
CRIT9	24.78	2.58
CVCA1	68.89	7.09
CVCA2	108.60	11.56
CVCA3	136.65	14.78
CVCA4	187.07	9.37
CNWR	92.90	11.41
PVER2	157.60	9.52
PVER3	318.45	8.48
PVER4	365.00	15.78

[a] Averages were calculated by first summing the length of all species within each transect and then averaging the length across the four transects.

The average length of each species within each restoration site/demonstration area is reported in Table 15. The most common species at each restoration site are similar to the common species in each habitat type. Bermudagrass is the species with the greatest total length at Beal Lake, CRIT9, CVCA1, CVCA4, and PVER2. The two species with the highest average length at CVCA2 are horseweed (*Conyza canadensis*) and morning glory. Horseweed was observed at several restoration sites forming thickets within planting areas and monitoring plots. At CVCA3 purple nutsedge (*Cyperus rotundus*) has the highest average ground cover length with other species appearing to be only minor components of the ground cover at that site. Johnsongrass (*Sorghum halepense*) is the species with the highest average ground cover length at CNWR. At both PVER3 and PVER4, alfalfa is the species with the highest average; Bermudagrass is a close second.

Table 15. Average ground cover observed for each species by site in meters (m).

SITE	SCIENTIFIC NAME	COMMON NAME	6-LETTER SPECIES CODE	AVERAGE LENGTH OF GROUND COVER	STANDARD DEVIATION
Beal Lake	*Bouteloua gracilis*	blue grama	BOUGRA	6.38	2.30
Beal Lake	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	6.61	7.41
Beal Lake	*Tiquilia plicata*	fanleaf crinklemat	TIQPLI	0.08	0.05
CRIT9	*Ambrosia dumosa*	burrobush	AMBDUM	0.20	N/A
CRIT9	*Symphyotrichum falcatum*	white prairie aster	ASTFAL	0.65	0.53
CRIT9	*Cenchrus longispinus*[a]	longspine sandbur	CENLON	1.70	0.62
CRIT9	*Conyza canadensis*[a]	horseweed	CONCAN	5.71	5.69
CRIT9	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	12.96	5.64
CRIT9	*Echinochloa colona*[a]	junglerice	ECHCOL	0.86	0.31
CRIT9	*Heterotheca subaxilaris*[a]	camphorweed	HETSUB	1.89	1.13
CRIT9	*Sorghum halepense*[a]	Johnsongrass	SORHAL	0.40	NA
CRIT9	*Sporobolus airoides*	alkali sacaton	SPOAIR	0.20	NA
CRIT9	*Tiquilia plicata*	fanleaf crinklemat	TIQPLI	1.15	0.68
CRIT9		unknown herb	UN_HERB	0.30	NA
CVCA1	*Conyza canadensis*[a]	horseweed	CONCAN	1.10	N/A
CVCA1	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	34.21	1.50
CVCA1	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	0.70	N/A
CVCA1	*Ipomea hederocea*[a]	ivy-leafed morning glory	IPOHED	0.20	N/A
CVCA1	*Ipomea purpurea*[a]	morning glory	IPOPUR	21.35	5.20
CVCA1	*Medicago sativa*[a]	alfalfa	MEDSAT	12.83	5.62
CVCA2	*Amaranthus palmeri*[a]	Palmer amaranth	AMAPAL	0.20	N/A
CVCA2	*Conyza canadensis*[a]	horseweed	CONCAN	33.08	9.77
CVCA2	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	20.70	12.66
CVCA2	*Cyperus esculentus*[a]	yellow nutsedge	CYPESC	1.13	1.19

SITE	SCIENTIFIC NAME	COMMON NAME	6-LETTER SPECIES CODE	AVERAGE LENGTH OF GROUND COVER	STANDARD DEVIATION
CVCA2	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	1.10	0.99
CVCA2	*Echinochloa colona*[a]	junglerice	ECHCOL	8.98	3.34
CVCA2	*Ipomea hederocea*[a]	ivy-leafed morning glory	IPOHED	0.10	N/A
CVCA2	*Ipomea purpurea*[a]	morning glory	IPOPUR	32.65	5.91
CVCA2	*Leptochloa uninervia*[a]	Mexican sprangletop	LEPUNI	0.40	N/A
CVCA2	*Medicago sativa*[a]	alfalfa	MEDSAT	3.78	1.55
CVCA3	*Conyza canadensis*[a]	horseweed	CONCAN	4.98	3.72
CVCA3	*Cynodon dactylon*[a]	purple nutsedge	CYNDAC	11.29	3.39
CVCA3	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	116.58	4.53
CVCA3	*Echinochloa colona*[a]	junglerice	ECHCOL	8.60	NA
CVCA3	*Ipomea purpurea*[a]	morning glory	IPOPUR	8.80	4.20
CVCA3	*Leptochloa uninervia*[a]	Mexican sprangletop	LEPUNI	0.45	0.21
CVCA4	*Amaranthus palmeri*[a]	Palmer amaranth	AMAPAL	2.10	2.12
CVCA4	*Bouteloua barbata*[a]	sixweeks grama	BOUBAR	3.80	1.42
CVCA4	*Conyza canadensis*[a]	horseweed	CONCAN	0.40	0.42
CVCA4	*Gossypium* spp.[a]	cotton	N/A	0.70	0.89
CVCA4	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	61.18	6.01
CVCA4	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	42.15	8.54
CVCA4	*Echinochloa colona*[a]	junglerice	ECHCOL	22.73	3.80
CVCA4	*Heliotropium curassavicum*	salt heliotrope	HELCUR	1.98	0.60
CVCA4	*Helianthus annuus*[a]	common sunflower	HELANN	1.00	N/A
CVCA4	*Ipomea purpurea*[a]	morning glory	IPOPUR	6.80	1.51
CVCA4	*Kochia scoparia*[a]	kochia	KOCSOC	0.40	0.26
CVCA4	*Leptochloa uninervia*[a]	Mexican sprangletop	LEPUNI	22.73	5.00
CVCA4	*Medicago sativa*[a]	alfalfa	MEDSAT	0.20	N/A
CVCA4		unknown succulent	UNK_SUC	0.10	N/A
CNWR	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	24.23	7.36
CNWR	*Medicago sativa*[a]	alfalfa	MEDSAT	0.20	N/A
CNWR	*Sorghum halepense*[a]	Johnsongrass	SORHAL	68.08	8.73
PVER2	*Conyza canadensis*[a]	horseweed	CONCAN	5.68	3.68
PVER2	*Cuscuta* sp.[a]	dodder	CUSCU	1.93	2.40
PVER2	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	100.33	7.04
PVER2	*Cyperus esculentus*[a]	yellow nutsedge	CYPESC	0.50	0.71

SITE	SCIENTIFIC NAME	COMMON NAME	6-LETTER SPECIES CODE	AVERAGE LENGTH OF GROUND COVER	STANDARD DEVIATION
PVER2	*Heleanthus annuus*[a]	common sunflower	HELANN	0.00	N/A
PVER2	*Medicago sativa*[a]	alfalfa	MEDSAT	49.40	9.71
PVER3	*Amaranthus palmeri*[a]	Palmer amaranth	AMAPAL	0.90	1.13
PVER3	*Conyza canadensis*[a]	horseweed	CONCAN	21.50	4.81
PVER3	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	106.48	10.29
PVER3	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	2.70	1.13
PVER3	*Echinochloa colona*[a]	junglerice	ECHCOL	1.13	0.64
PVER3	*Leptochloa uninervia*[a]	Mexican sprangletop	LEPUNI	0.10	N/A
PVER3	*Medicago sativa*[a]	alfalfa	MEDSAT	187.80	5.34
PVER4	*Amaranthus palmeri*[a]	Palmer amaranth	AMAPAL	27.50	7.99
PVER4	*Cynodon dactylon*[a]	Bermudagrass	CYNDAC	114.88	9.04
PVER4	*Cyperus esculentus*[a]	yellow nutsedge	CYPESC	6.25	6.79
PVER4	*Cyperus rotundus*[a]	purple nutsedge	CYPROT	21.85	3.91
PVER4	*Echinochloa colona*[a]	junglerice	ECHCOL	43.70	2.07
PVER4	*Leptochloa uninervia*[a]	Mexican sprangletop	LEPUNI	8.40	6.66
PVER4		unknown mallow	MALLOW	0.90	N/A
PVER4	*Medicago sativa*[a]	alfalfa	MEDSAT	136.03	6.62
PVER4	*Panicum species*[a]	panic grass	PANICUM	2.00	1.41
PVER4	*Sorghum halepense*[a]	Johnsongrass	SORHAL	1.00	N/A
PVER4	*Thinopyrum intermedium*	intermediate wheatgrass	THYINT	2.55	1.57

[a] Denotes non-native, invasive, and weedy species.

Crown Closure Data

The average percent crown closure (Table 16) was calculated by averaging crown closure readings for each transect in a plot; the readings were then averaged for each plot and restoration site . The number of observations for each site refers to the number of readings at each plot across the entire site. For example, there are 15 plots at Beal Lake with 9 readings at each plot for a total number of observations of 135. Results are reported as the percentage of canopy closure. High percentages indicate closed canopy, lower percentages indicate a more open canopy. The restoration site with the highest canopy closure is CVCA1. This is an established site with large, mature cottonwood trees. The restoration site with the lowest percent closure is CVCA4 with 0.00% canopy cover. This newly planted site does not contain material large enough to provide any canopy cover at this time. The PVER4 site also has a low crown closure of only 7.67% cover.

Table 16. Average crown closure.

SITE	NUMBER OF OBSERVATIONS	MEAN PERCENTAGE OF CROWN CLOSURE	STANDARD DEVIATION
Beal Lake	135	51.75	40.30
CRIT9	108	77.28	26.67
CVCA1	72	88.87	27.12
CVCA2	180	80.67	31.60
CVCA3	126	70.81	38.83
CVCA4	252	0.00	0.00
CNWR	126	78.74	34.69
PVER2	126	68.71	40.61
PVER3	180	33.62	37.89
PVER4	198	8.57	17.74

Foliage-Height Diversity Data

The total percentage of vegetation in each meter section for foliage-height diversity is listed in Table 17 for each restoration site. With the exception of the CNWR site, vegetation composition decreases as height increases. Aside from outliers at the 2-m and 6-m layers at CNWR, foliage height diversity follows the decreasing trend. The high vegetation percentage within the first meter layer at each restoration site is reflective of ground cover at foliage height diversity survey points shared with ground cover transects.

Within the Beal Lake site, arrowweed, Fremont's cottonwood, and screwbean mesquite have the highest percent vegetation composition (Table 18). At CRIT9 Fremont's cottonwood is the dominant species with screwbean mesquite at 32.92% of the total vegetation composition. The three species with the highest percent composition at CVCA1, CVCA2, and CVCA3 are Fremont's cottonwood, Goodding's willow, and coyote willow. Bermudagrass and purple nutsedge have the highest percent composition at CVCA4. However, big saltbush does compose 14.80% of the vegetation at the site. Within CNWR, Fremont's cottonwood composes 52.29% of the vegetation. Desert broom also composes 14.47% of the vegetation at the site. The two species with the highest percent composition at PVER2 are Fremont's cottonwood and coyote willow.. At the PVER3 site, alfalfa has the highest percent composition at 38.74%. However, Fremont's cottonwood composes 28.12% of the vegetation at the site. The two species with the highest percent composition at PVER4 are Bermudagrass and alfalfa. Goodding's willow does compose 14.57% of the vegetation at the site. The high percentage of herbaceous vegetation at each restoration site is reflective of the ground cover at the foliage height diversity sampling points.

Table 17. Foliage height diversity percent total vegetation per meter layer.

SITE	METER SECTION	PERCENTAGE	STANDARD DEVIATION
Beal Lake	0_1	27.57	0.04
Beal Lake	1_2	27.03	0.02
Beal Lake	2_3	18.13	0.02
Beal Lake	3_4	13.15	0.01
Beal Lake	4_5	7.33	0.02
Beal Lake	5_6	4.79	0.01
Beal Lake	6_7	1.81	0.02
Beal Lake	7_8	0.58	N/A
CRIT9	0_1	9.95	0.03
CRIT9	1_2	11.18	0.02
CRIT9	2_3	19.71	0.01
CRIT9	3_4	17.95	0.03
CRIT9	4_5	12.58	0.05
CRIT9	5_6	9.41	0.02
CRIT9	6_7	4.61	0.03
CRIT9	7_8	2.51	0.01
CRIT9	8_9	3.73	0.04
CRIT9	9_10	4.79	0.05
CRIT9	10_11	3.61	0.03
CRIT9	11_12	0.93	0.00
CRIT9	12_13	0.28	0.00
CVCA1	0_1	16.17	0.13
CVCA1	1_2	5.57	0.01
CVCA1	2_3	8.48	0.03
CVCA1	3_4	11.45	0.05
CVCA1	4_5	11.89	0.06
CVCA1	5_6	14.05	0.01
CVCA1	6_7	13.55	0.01
CVCA1	7_8	8.00	0.04
CVCA1	8_9	5.94	0.01
CVCA1	9_10	1.64	0.01
CVCA1	10_11	4.13	0.04
CVCA1	11_12	4.53	0.06
CVCA1	12_13	2.80	0.03

SITE	METER SECTION	PERCENTAGE	STANDARD DEVIATION
CVCA2	0_1	18.00	0.09
CVCA2	1_2	15.17	0.01
CVCA2	2_3	18.94	0.02
CVCA2	3_4	18.05	0.01
CVCA2	4_5	11.07	0.03
CVCA2	5_6	8.87	0.02
CVCA2	6_7	6.42	0.01
CVCA2	7_8	2.69	0.01
CVCA2	8_9	0.99	0.01
CVCA2	9_10	0.37	N/A
CVCA3	0_1	23.75	0.06
CVCA3	1_2	13.32	0.01
CVCA3	2_3	17.89	0.01
CVCA3	3_4	18.58	0.04
CVCA3	4_5	12.52	0.02
CVCA3	5_6	9.33	0.04
CVCA3	6_7	5.20	0.04
CVCA3	7_8	1.72	0.00
CVCA4	0_1	99.24	0.01
CVCA4	1_2	2.27	N/A
CNWR	0_1	18.03	0.01
CNWR	1_2	6.38	0.04
CNWR	2_3	10.26	0.05
CNWR	3_4	9.73	0.02
CNWR	4_5	8.21	0.01
CNWR	5_6	8.16	0.02
CNWR	6_7	10.97	0.06
CNWR	7_8	5.67	0.00
CNWR	8_9	5.47	0.01
CNWR	9_10	3.37	0.00
CNWR	10_11	3.26	0.01
CNWR	11_12	3.10	0.01
CNWR	12_13	2.94	0.01
CNWR	13_14	2.30	0.02
CNWR	14_15	1.03	0.00
CNWR	15_16	0.80	N/A
CNWR	16_17	1.13	0.01
CNWR	17_18	0.94	0.01
CNWR	18_19	1.39	N/A
CNWR	19_20	0.40	N/A

SITE	METER SECTION	PERCENTAGE	STANDARD DEVIATION
PVER2	0_1	15.39	0.01
PVER2	1_2	8.03	0.00
PVER2	2_3	13.15	0.01
PVER2	3_4	13.75	0.01
PVER2	4_5	10.40	0.02
PVER2	5_6	10.91	0.01
PVER2	6_7	9.64	0.02
PVER2	7_8	8.87	0.01
PVER2	8_9	5.83	0.01
PVER2	9_10	2.73	0.01
PVER2	10_11	1.96	0.02
PVER3	0_1	65.82	0.05
PVER3	1_2	9.11	0.01
PVER3	2_3	7.41	0.04
PVER3	3_4	8.26	0.01
PVER3	4_5	7.62	0.03
PVER3	5_6	1.39	0.01
PVER3	6_7	0.59	0.00
PVER4	0_1	85.42	0.07
PVER4	1_2	12.87	0.05
PVER4	2_3	2.56	0.01

Table 18. Foliage height diversity percent species composition by site.

SPECIES NAME	COMMON NAME	6-LETTER SPECIES CODE	SITE	TOTAL NUMBER OF HITS FOR EACH SPECIES IN EACH SITE	TOTAL NUMBER OF HITS FOR THE SITE	SPECIES COMPOSITION
Pluchea sericea	arroweed	PLUSER	Beal Lake	666	1538	43.30%
Prosopis pubescens	screwbean mesquite	PROPUB	Beal Lake	382	1538	24.84%
Populus freemontii	Fremont cottonwood	POPFRE	Beal Lake	339	1538	22.04%
Salix exigua	coyote willow	SALEXI	Beal Lake	51	1538	3.32%
Prosopis glandulosa	honey mesquite	PROGLA	Beal Lake	42	1538	2.73%
Baccharis sarothroides	desert broom	BACSAR	Beal Lake	25	1538	1.63%
Salix gooddingii	Goodding's willow	SALGOO	Beal Lake	12	1538	0.78%
Bouteloua gracilis	blue grama	BOUGRA	Beal Lake	10	1538	0.65%
Echinochloa colona	junglerice	ECHCOL	Beal Lake	5	1538	0.33%
Cynodon dactylon	Bermudagrass	CYNDAC	Beal Lake	3	1538	0.20%
Tamarix spp.	tamarisk species	TAMARIX	Beal Lake	3	1538	0.20%

SPECIES NAME	COMMON NAME	6-LETTER SPECIES CODE	SITE	TOTAL NUMBER OF HITS FOR EACH SPECIES IN EACH SITE	TOTAL NUMBER OF HITS FOR THE SITE	SPECIES COMPOSITION
Symphyotrichum falcatum	white prairie aster	ASTFAL	CRIT9	2	1139	0.18%
Heterotheca subaxilaris	camphorweed	HETSUB	CRIT9	2	1139	0.18%
Tiquilia plicata	fanleaf crinklemat	TIQPLI	CRIT9	2	1139	0.18%
Conyza canadensis	horseweed	CONCAN	CRIT9	3	1139	0.26%
Cenchrus longispinus	longspine sandbur	CENLON	CRIT9	8	1139	0.70%
Salix gooddingii	Goodding's Willow	SALGOO	CRIT9	15	1139	1.32%
Salix exigua	Coyote willow	SALEXI	CRIT9	29	1139	2.55%
Cynodon dactylon	Bermudagrass	CYNDAC	CRIT9	31	1139	2.72%
Prosopis glandulosa	honey mesquite	PROGLA	CRIT9	145	1139	12.73%
Prosopis pubescens	screwbean mesquite	PROPUB	CRIT9	375	1139	32.92%
Populus freemontii	Fremont cottonwood	POPFRE	CRIT9	527	1139	46.27%
Populus freemontii	Fremont cottonwood	POPFRE	CVCA1	515	1409	36.55%
Salix gooddingii	Goodding's willow	SALGOO	CVCA1	463	1409	32.86%
Salix exigua	coyote willow	SALEXI	CVCA1	302	1409	21.43%
Cynodon dactylon	Bermudagrass	CYNDAC	CVCA1	51	1409	3.62%
Ipomea purpurea	morning glory	IPOPUR	CVCA1	43	1409	3.05%
Medicago sativa	alfalfa	MEDSAT	CVCA1	32	1409	2.27%
Tamarix spp.	tamarisk species	TAMARIX	CVCA1	3	1409	0.21%
Populus freemontii	Fremont cottonwood	POPFRE	CVCA2	1339	3503	38.22%
Salix exigua	coyote willow	SALEXI	CVCA2	780	3503	22.27%
Salix gooddingii	Goodding's willow	SALGOO	CVCA2	752	3503	21.47%
Conyza canadensis	horseweed	CONCAN	CVCA2	259	3503	7.39%
Ipomea purpurea	morning glory	IPOPUR	CVCA2	166	3503	4.74%
Tamarix species	tamarisk species	TAMARIX	CVCA2	114	3503	3.25%
Atriplex lentiformis	big saltbush	ATRLEN	CVCA2	43	3503	1.23%
Echinochloa colona	junglerice	ECHCOL	CVCA2	17	3503	0.49%
Cynodon dactylon	Bermudagrass	CYNDAC	CVCA2	16	3503	0.46%
Medicago sativa	alfalfa	MEDSAT	CVCA2	12	3503	0.34%
Cyperus rotundus	purple nutsedge	CYPROT	CVCA2	3	3503	0.09%
Cyperus esculentus	yellow nutsedge	CYPESC	CVCA2	1	3503	0.03%
Ipomea hederacea	ivy-leafed morning glory	IPOHED	CVCA2	1	3503	0.03%
Populus freemontii	Fremont cottonwood	POPFRE	CVCA3	505	1386	36.44%

SPECIES NAME	COMMON NAME	6-LETTER SPECIES CODE	SITE	TOTAL NUMBER OF HITS FOR EACH SPECIES IN EACH SITE	TOTAL NUMBER OF HITS FOR THE SITE	SPECIES COMPOSITION
Salix gooddingii	Goodding's willow	SALGOO	CVCA3	283	1386	20.42%
Salix exigua	coyote willow	SALEXI	CVCA3	235	1386	16.96%
Cyperus rotundus	purple nutsedge	CYPROT	CVCA3	206	1386	14.86%
Ipomea purpurea	morning glory	IPOPUR	CVCA3	61	1386	4.40%
Baccharis sarothroides	desert broom	BACSAR	CVCA3	36	1386	2.60%
Tamarix species	tamarisk species	TAMARIX	CVCA3	31	1386	2.24%
Conyza canadensis	horseweed	CONCAN	CVCA3	16	1386	1.15%
Atriplex lentiformis	big saltbush	ATRLEN	CVCA3	7	1386	0.51%
Cynodon dactylon	Bermudagrass	CYNDAC	CVCA3	6	1386	0.43%
Cynodon dactylon	Bermudagrass	CYNDAC	CVCA4	167	446	37.44%
Cyperus rotundus	purple nutsedge	CYPROT	CVCA4	84	446	18.83%
Atriplex lentiformis	big saltbush	ATRLEN	CVCA4	66	446	14.80%
Echinochloa colona	junglerice	ECHCOL	CVCA4	59	446	13.23%
Leptochloa uninervia	Mexican sprangletop	LEPUNI	CVCA4	37	446	8.30%
Ipomea purpurea	morning glory	IPOPUR	CVCA4	12	446	2.69%
Amaranthus palmeri	Palmer amaranth	AMAPAL	CVCA4	6	446	1.35%
Helianthus annuus	common sunflower	HENANN	CVCA4	5	446	1.12%
Bouteloua barbata	sixweeks grama	BOUBAR	CVCA4	3	446	0.67%
Tamarix spp.	tamarisk species	TAMARIX	CVCA4	3	446	0.67%
Kochia scoparia	kochia	KOCSOC	CVCA4	2	446	0.45%
Prosopis glandulosa	honey mesquite	PROGLA	CVCA4	2	446	0.45%
Populus freemontii	Fremont cottonwood	POPFRE	CNWR	1189	2274	52.29%
Sorghum halepense	Johnsongrass	SORHAL	CNWR	355	2274	15.61%
Baccharis sarothroides	desert broom	BACSAR	CNWR	329	2274	14.47%
Prosopis glandulosa	honey mesquite	PROGLA	CNWR	190	2274	8.36%
Salix gooddingii	Goodding's willow	SALGOO	CNWR	111	2274	4.88%
Prosopis pubescens	screwbean mesquite	PROPUB	CNWR	35	2274	1.54%
Cynodon dactylon	Bermudagrass	CYNDAC	CNWR	33	2274	1.45%
Atriplex lentiformis	big saltbush	ATRLEN	CNWR	31	2274	1.36%
Cyperus rotundus	purple nutsedge	CYPROT	CNWR	1	2274	0.04%
Populus freemontii	Fremont cottonwood	POPFRE	PVER2	1723	3093	55.71%
Salix exigua	coyote willow	SALEXI	PVER2	503	3093	16.26%
Salix gooddingii	Goodding's willow	SALGOO	PVER2	422	3093	13.64%

SPECIES NAME	COMMON NAME	6-LETTER SPECIES CODE	SITE	TOTAL NUMBER OF HITS FOR EACH SPECIES IN EACH SITE	TOTAL NUMBER OF HITS FOR THE SITE	SPECIES COMPOSITION
Cynodon dactylon	Bermudagrass	CYNDAC	PVER2	262	3093	8.47%
Medicago sativa	alfalfa	MEDSAT	PVER2	137	3093	4.43%
Conyza canadensis	horseweed	CONCAN	PVER2	37	3093	1.20%
Cyperus esculentus	yellow nutsedge	CYPESC	PVER2	7	3093	0.23%
Echinochloa colona	junglerice	ECHCOL	PVER2	2	3093	0.06%
Medicago sativa	alfalfa	MEDSAT	PVER3	631	1629	38.74%
Populus freemontii	Fremont cottonwood	POPFRE	PVER3	458	1629	28.12%
Cynodon dactylon	Bermudagrass	CYNDAC	PVER3	291	1629	17.86%
Salix exigua	coyote willow	SALEXI	PVER3	151	1629	9.27%
Conyza canadensis	horseweed	CONCAN	PVER3	83	1629	5.10%
Salix gooddingii	Goodding's willow	SALGOO	PVER3	11	1629	0.68%
Cyperus rotundus	purple nutsedge	CYPROT	PVER3	2	1629	0.12%
Echinochloa colona	junglerice	ECHCOL	PVER3	2	1629	0.12%
Cynodon dactylon	Bermudagrass	CYNDAC	PVER4	313	913	34.28%
Medicago sativa	alfalfa	MEDSAT	PVER4	229	913	25.08%
Salix gooddingii	Goodding's willow	SALGOO	PVER4	133	913	14.57%
Echinochloa colona	junglerice	ECHCOL	PVER4	57	913	6.24%
Cyperus rotundus	purple nutsedge	CYPROT	PVER4	53	913	5.81%
Amaranthus palmeri	Palmer amaranth	AMAPAL	PVER4	41	913	4.49%
Populus freemontii	Fremont cottonwood	POPFRE	PVER4	32	913	3.50%
Salix exigua	coyote willow	SALEXI	PVER4	31	913	3.40%
Cyperus esculentus	yellow nutsedge	CYPESC	PVER4	14	913	1.53%
Leptochloa uninervia	Mexican sprangletop	LEPUNI	PVER4	10	913	1.10%

DISCUSSION

Restoration Site Conditions

Plots monitored within each restoration site show an increase in tree density and height, as well as overall habitat quality from conditions observed during the 2008 field season. Plot access is generally good and permanent locations of plots will continue to be monitored annually. Portions of Beal Lake (Plot ID abbreviated BL) restoration site are thick with arrowweed, which makes access difficult, though not impossible, in the most dense plots. Future monitoring will

determine continued accessibility to these plots. The west portion of CVCA2 also presents a possible access issue if horseweed or coyote willow continue to become more dense. Disturbance is low and none of the plots monitored appeared to have been tampered with.

Trees in all plots appear to have grown considerably since the 2008 monitoring season. Understory vegetation of Bermudagrass and alfalfa is beginning to be shaded out in the fields with greatest canopy closure, such as CVCA1 and the south portion of PVER2. As of 2009 no other ground cover has moved in to replace the alfalfa and Bermudagrass in these locations. General health of trees within plots appears good, with a few instances of diseased cottonwood in plots PVER4-09 and PVER3-15. Plots in CVCA4-EAST (planted in 2009) showed some honey mesquite mortality due to being overgrown by other native and non-native species within the planting trenches. Other dead species within the restoration sites include mesquite in plot CNWR-9, willows in plot BL-1, and willow in plot PVER4-6. All other dead species within the plots monitored were scattered and regarded as incidental die back.

Wildlife

Within all restoration site plots, wildlife activity data were recorded with focus on bird presence and nesting activity, grazing evidence, non-native species, and large mammal presence. An increase in overall wildlife activity was observed during the 2009 field season compared to the 2008 field season. While each restoration site showed an increase in wildlife activity, data collected from CVCA showed the highest diversity and abundance of wildlife.

Mammal activity observed was restricted to the CVCA, CRIT and Beal Lake sites. Throughout the Beal Lake restoration site non-native wild pig (*Sus* spp.) tracks, as well as soil and tree and shrub root disturbance, was observed. Pig carcasses were seen along access roads within the site due to control methods and active hunting in the demonstration area. Although activity was noted throughout the monitored plots, disturbance was considered low. Moderate disturbance was found only in plot BL.06 (Appendix A, Figure 1). Mule deer (*Odocoileus hemionus*) individuals were observed several times at CVCA and CRIT entering or leaving restoration fields. Deer tracks, scat, and grazing evidence were observed in CVCA1 and CVCA2 but especially in plots with a more open canopy and understory. Raccoon (*Procyon lotor*) and coyote (*Canis latrans*) tracks were also found within plots at CVCA.

Birds were observed or heard within all of the restoration sites but were especially abundant at CVCA and CNWR sites. Unidentified swallow species activity was mainly restricted to cotton or other agricultural fields near the demonstration area. Sandhill cranes (*Grus canadensis*) were observed in flight and in agricultural fields in numbers ranging from 1 to over 40 individuals. The highest numbers were found at the CNWR (see Photo 1). All other species observed and their locations can be found in Table 19. Bird nests were found at CVCA2 and CVCA3 as well as Beal Lake (see Photo 2); however, species were not identified. In CVCA the birds appeared to prefer to nest in tamarix rather than cottonwoods and willow within the same plots. This was most evident in CVCA3-12.

Table 19. Species and location of birds observed within or near restoration sites.

SPECIES		RESTORATION SITES				
Scientific Name	**Common Name**	**Beal Lake**	**CNWF**	**CRIT**	**CVCA**	**PVER**
Zonotrichia leucophrys	white-crowned sparrow	X	X	X	X	X
Corvus corax	common raven	X	X	X	X	X
Sayornis nigricans	black phoebe				X	
Circus cyaneus	northern harrier				X	X
Falco sparverius	American kestrel		X		X	
Grus canadensis	sandhill crane		X		X	X
Petrochelidon pyrrhonota	cliff swallow	X	X	X	X	X
Hirundo rustica	barn swallow	X	X	X	X	X
Buteo jamaicensis	red-tailed hawk				X	X
Catharte aura	turkey vulture		X			X
Geococcyx californianus	greater roadrunner	X	X	X	X	X
Zenaida macroura	mourning dove	X			X	

Weed Disturbance

Non-native species appear in all restoration sites at varying levels of proliferation and aggression. Although many of the plots have a strong non-native ground cover component, not all sites are of concern. Increased canopy cover and closure may shade out low-to-moderate infestations of undesirable non-natives species. Throughout all restoration plots, scattered tamarix were recorded with infestation considered low in most cases. Other common non-native species not considered to be of concern are Bermudagrass, alfalfa, jungle rice (*Echinochloa colona*), and Mexican spanglegrass (*Leptochloa uninerva*).

Beal Lake, CRIT, and CNWR restoration sites showed the lowest incidence of weedy species. Arrowweed, while a native species, shows aggressive recruitment within many plots at Beal Lake, often dominating planted willow and cottonwood (see Photo 3). Longspine sandbur (*Cenchrus longispinus*) was found scattered throughout CRIT but disturbance was considered low. Johnson grass (*Sorghum halepense*) infestation within CNWR is moderate and concentrated mainly within the central portion of the nature trail (see Photo 4). Minimal control techniques have been applied to areas with Johnson grass infestation due to the habitat it provides for LCR MSCP target rodent species.

Photo 1. **Sandhill cranes in an agriculture field at Cibola National Wildlife Refuge.**

Photo 2. **Mourning dove nest in a cottonwood at Cibola Valley Conservation Area Phase 3.**

Photo 3. Dense arrowweed in mesquite plot at Beal Lake.

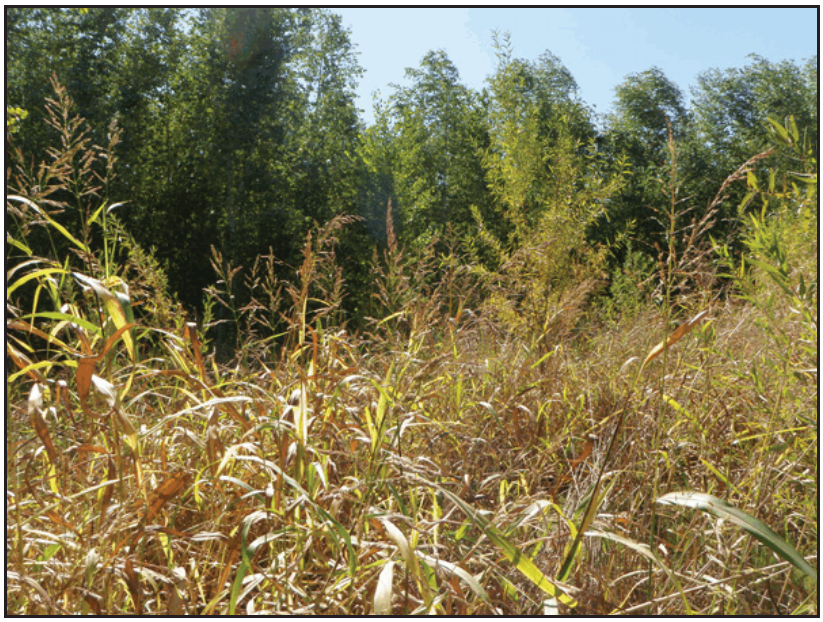


Photo 4. Johnsongrass at the Cibola National Wildlife Refuge Nature Trail.

Plots monitored within the PVER restoration site showed low-to-moderate weed disturbance. The northwest corner of PVER3 has a moderate amount of horseweed infestation, and in plots PVER3-1 and PVER3-4 was a dominant portion of the herbaceous layer. Palmer amaranth (*Amaranthus palmeri*) is a non-native annual scattered along access roads and edges of restoration fields, but it was observed at a higher concentration on the east end of PVER4 (planted in 2009) (see Photo 5).

Weed infestation was the highest at CVCA, especially in the western portion of CVCA2 where horseweed dominates the plots. Drastic improvements have been made in regards to morning glory infestation in CVCA2 from the 2008 field conditions. Larger trees are shading out the majority of morning glory, and previously overwhelmed planted trees are establishing new central leaders (see Photo 6 and Photo 7). Morning glory-treated areas within CVCA1 are improved; however, some plots (CVCA1-1) are an ongoing management issue (see Photo 8 and Photo 9). The northern portion of CVCA3 has a moderate infestation of purple nutsedge, which in some plots comprises the large majority of the ground cover layer. Within these plots purple nutsedge is tolerating a fairly closed canopy and seems resistant to being shaded out. Weed issues in CVCA4 (planted in 2009) are concentrated in fields A and D. All ground between planting trenches is heavily dominated by Bermudagrass, while the southwest portion of field D has a moderate tamarix and Palmer amaranth component within the growing trenches.

Problems

Monitoring of plots was performed based on the protocol outlined in the statement of work. During the 2009 field season some problems were encountered that needed clarification in regards to monitoring shrub species, in particular big saltbush and arrowweed. The current protocol is written to monitor shrubs based on branching patterns and number of stems at point of branching. Due to the growth pattern of both big saltbush and arrowweed, the current protocol is unclear and was found to be unrepresentative of size and success of intermediate shrubs. Both shrubs have multiple stems branching at or near the soil level with no clear central stem. Based on the current protocol, measuring DBH from the root collar, large and small individuals may be placed in the same DBH class since many shrubs of varying sizes may exhibit a similar diameter root collar at soil level. Measurements of width and height of individual shrubs may be more appropriate for monitoring shrub growth and health. Desert broom sometimes exhibits a central stem that may be monitored based on the current protocol, but this growth form is not consistent and varies from individual to individual. For the 2009 field season, height data were collected for big saltbush with a height of >4.50 ft (1.37 m). Big saltbush with a height <4.50 ft (1.37 m) were tallied. Desert broom was put into a DBH class based on DBH of the most central stem, as well as overall height and width of the shrub. Changes or clarifications in protocol are suggested for the continued monitoring of shrubs to better represent overall status and health of shrub species within the restoration sites.

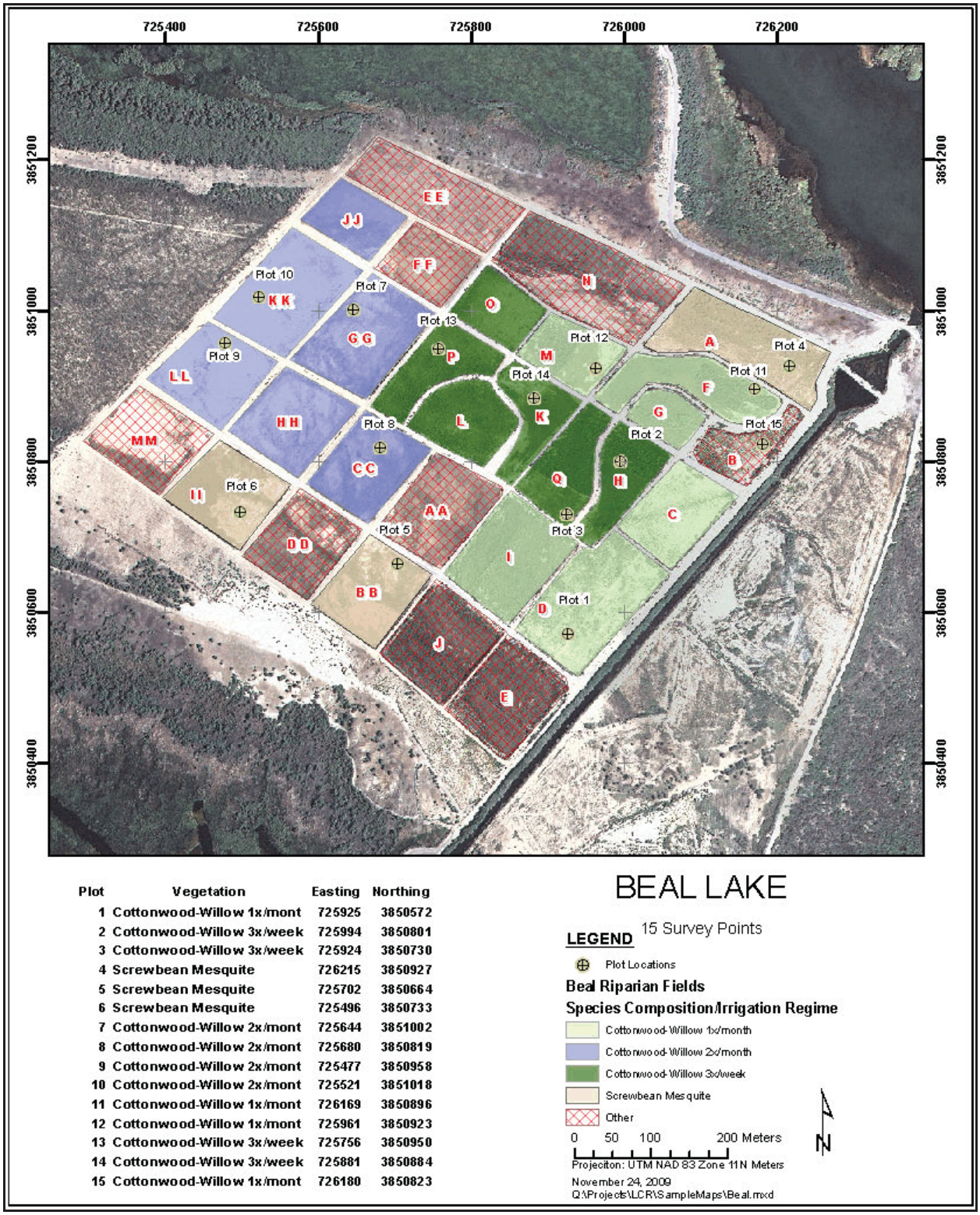
Photo 5. **West side of Palo Verde Ecological Reserve Phase 4 with dense Palmer amaranth.**

Photos 6 and 7. **Cottonwood re-establishing central leader through dead morning glory at Cibola Valley Conservation Area Phase 2.**

Photo 8. **Continued morning glory-control issues in Cibola Valley Conservation Area Phase 1.**

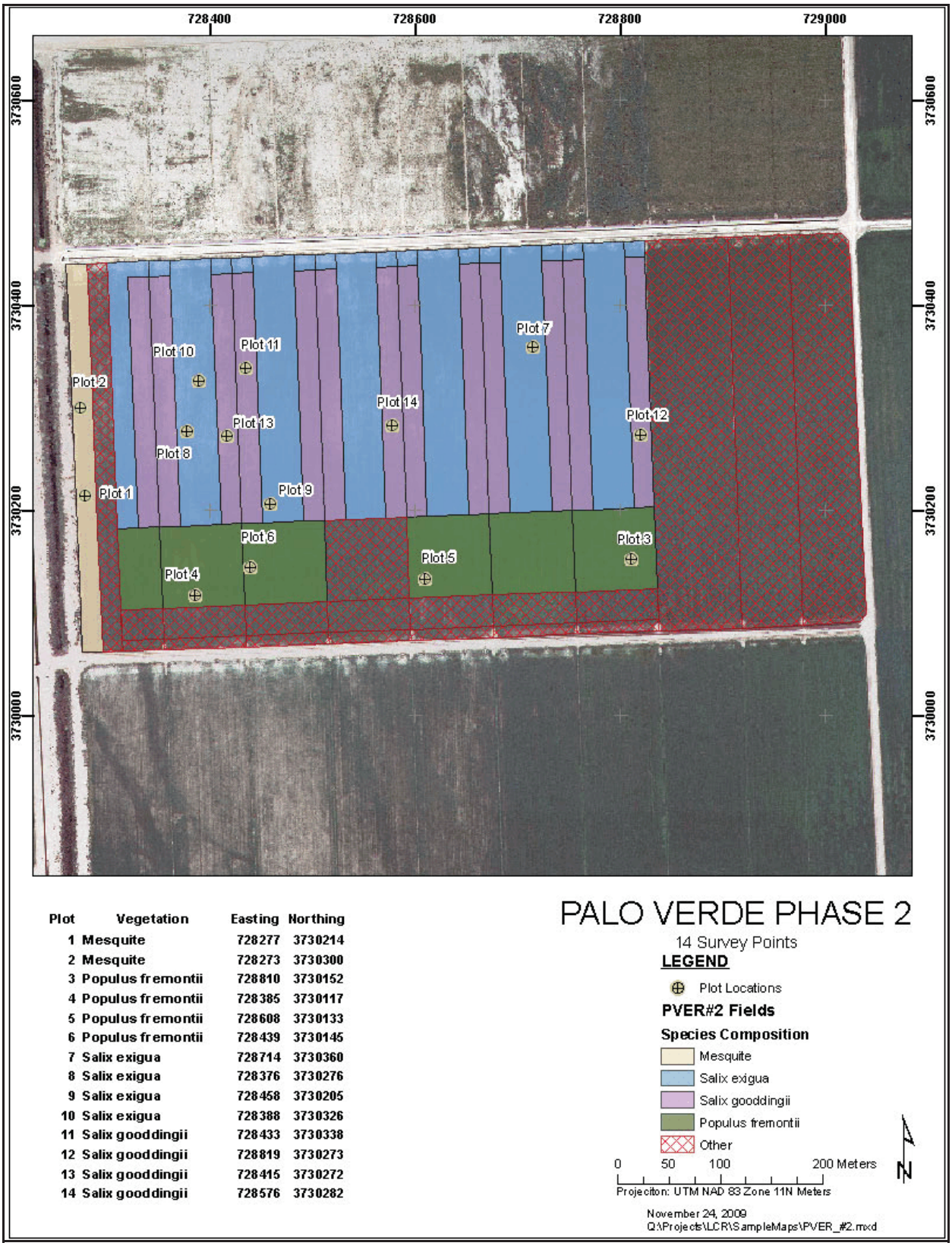
Photo 9. **Morning glory infestation on cottonwood in Cibola Valley Conservation Area Phase 1.**

APPENDIX A: FIGURES



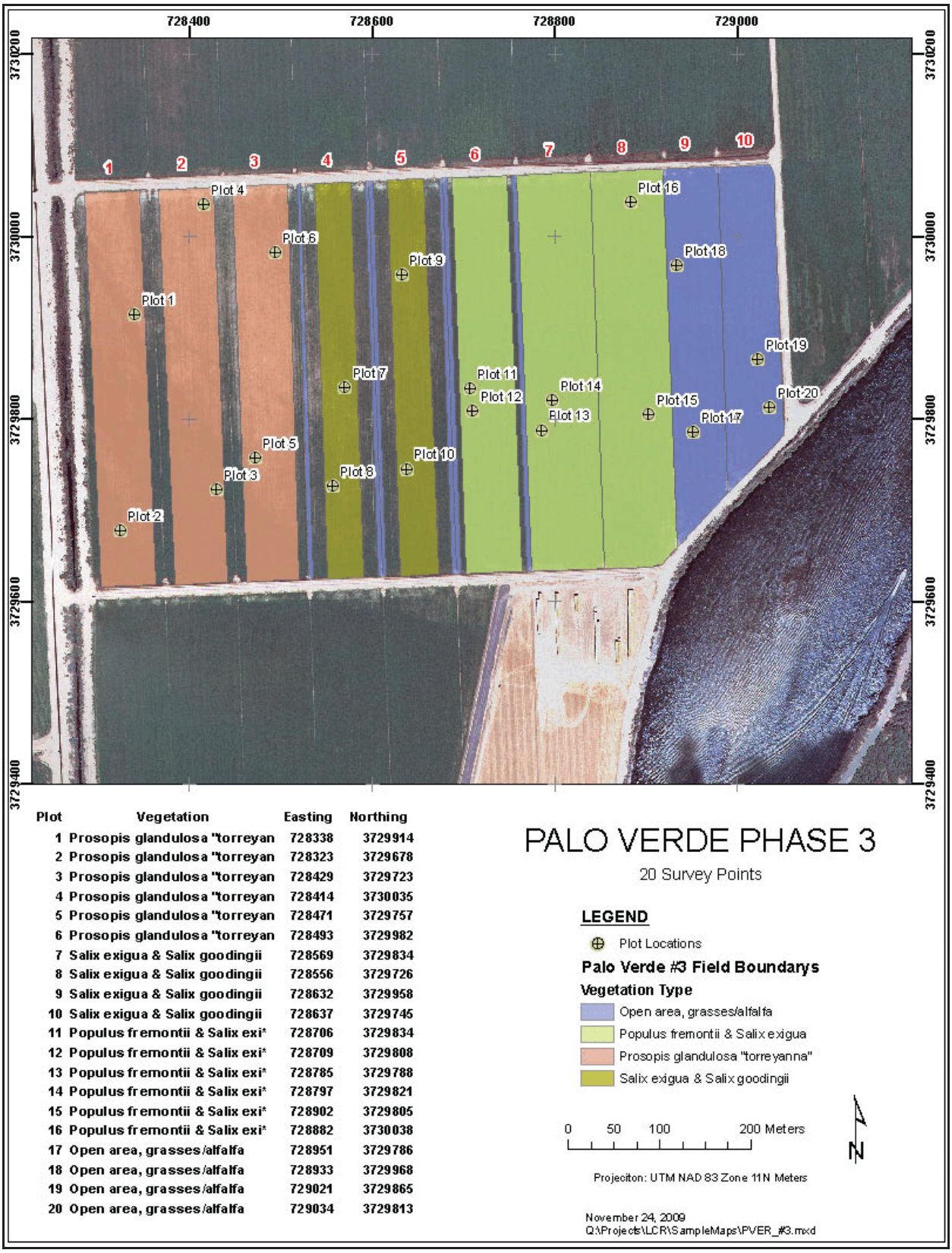
Plot	Vegetation	Easting	Northing
1	Cottonwood-Willow 1x/mont	725925	3850572
2	Cottonwood-Willow 3x/week	725994	3850801
3	Cottonwood-Willow 3x/week	725924	3850730
4	Screwbean Mesquite	726215	3850927
5	Screwbean Mesquite	725702	3850664
6	Screwbean Mesquite	725496	3850733
7	Cottonwood-Willow 2x/mont	725644	3851002
8	Cottonwood-Willow 2x/mont	725680	3850819
9	Cottonwood-Willow 2x/mont	725477	3850958
10	Cottonwood-Willow 2x/mont	725521	3851018
11	Cottonwood-Willow 1x/mont	726169	3850896
12	Cottonwood-Willow 1x/mont	725961	3850923
13	Cottonwood-Willow 3x/week	725756	3850950
14	Cottonwood-Willow 3x/week	725881	3850884
15	Cottonwood-Willow 1x/mont	726180	3850823

Figure 2. Beal Lake Riparian Restoration Demonstration project area.



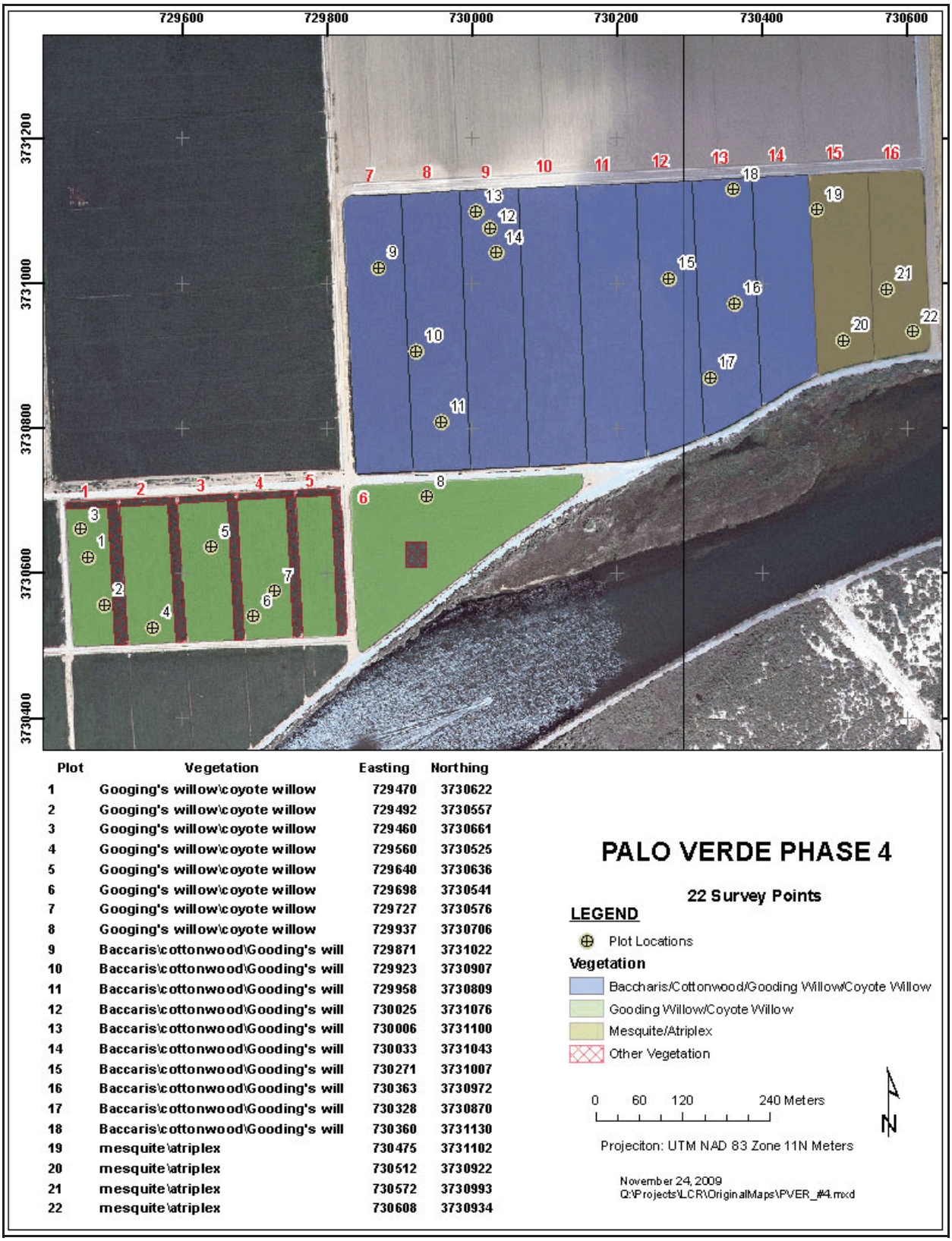
Plot	Vegetation	Easting	Northing
1	Mesquite	728277	3730214
2	Mesquite	728273	3730300
3	Populus fremontii	728810	3730152
4	Populus fremontii	728385	3730117
5	Populus fremontii	728608	3730133
6	Populus fremontii	728439	3730145
7	Salix exigua	728714	3730360
8	Salix exigua	728376	3730276
9	Salix exigua	728458	3730205
10	Salix exigua	728388	3730326
11	Salix gooddingii	728433	3730338
12	Salix gooddingii	728819	3730273
13	Salix gooddingii	728415	3730272
14	Salix gooddingii	728576	3730282

Figure 3. Palo Verde Ecological Phase 2 project area.



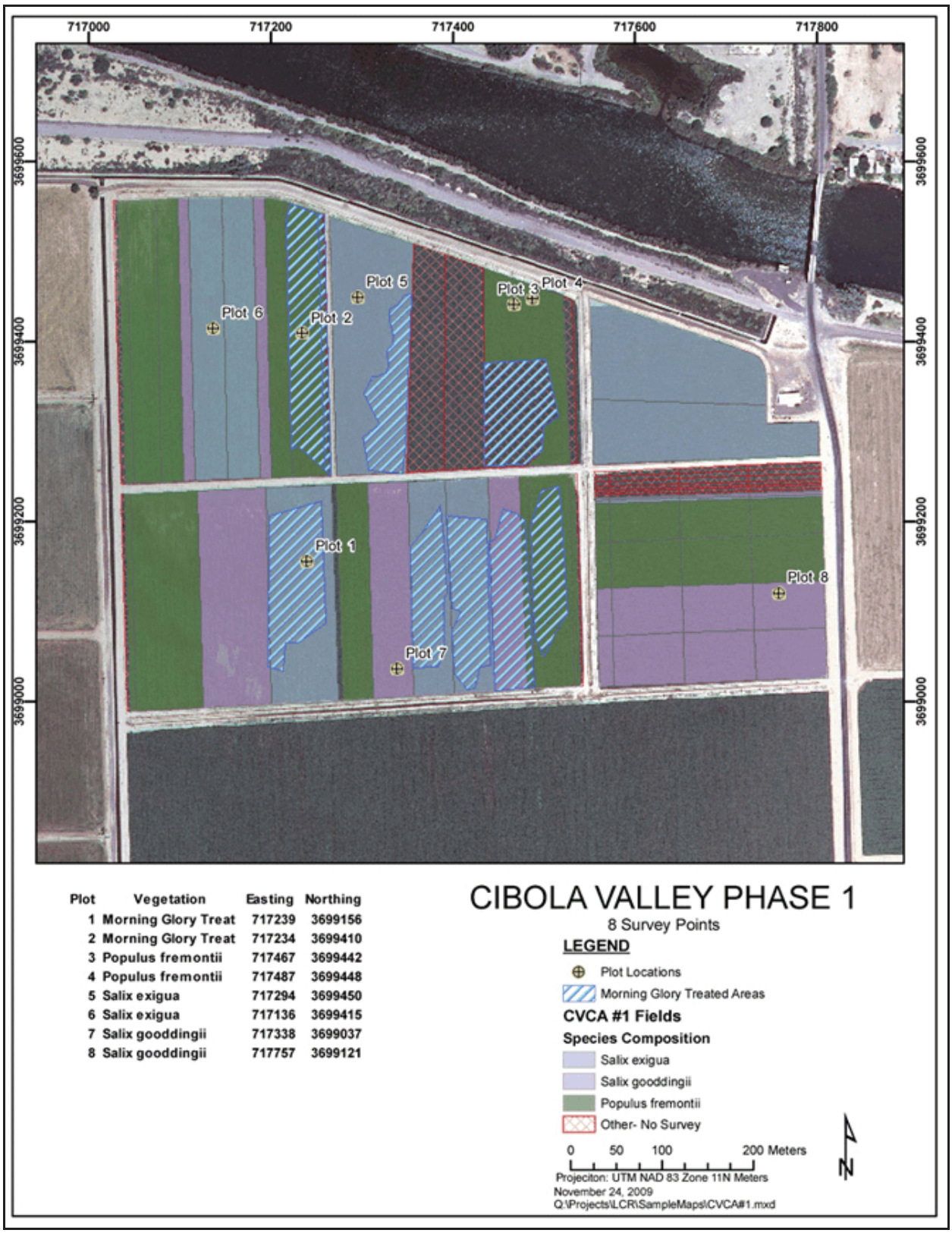
Plot	Vegetation	Easting	Northing
1	Prosopis glandulosa "torreyan	728338	3729914
2	Prosopis glandulosa "torreyan	728323	3729678
3	Prosopis glandulosa "torreyan	728429	3729723
4	Prosopis glandulosa "torreyan	728414	3730035
5	Prosopis glandulosa "torreyan	728471	3729757
6	Prosopis glandulosa "torreyan	728493	3729982
7	Salix exigua & Salix goodingii	728569	3729834
8	Salix exigua & Salix goodingii	728556	3729726
9	Salix exigua & Salix goodingii	728632	3729958
10	Salix exigua & Salix goodingii	728637	3729745
11	Populus fremontii & Salix exi*	728706	3729834
12	Populus fremontii & Salix exi*	728709	3729808
13	Populus fremontii & Salix exi*	728785	3729788
14	Populus fremontii & Salix exi*	728797	3729821
15	Populus fremontii & Salix exi*	728902	3729805
16	Populus fremontii & Salix exi*	728882	3730038
17	Open area, grasses/alfalfa	728951	3729786
18	Open area, grasses/alfalfa	728933	3729968
19	Open area, grasses/alfalfa	729021	3729865
20	Open area, grasses/alfalfa	729034	3729813

Figure 4. Palo Verde Ecological Reserve Phase 3 project area.



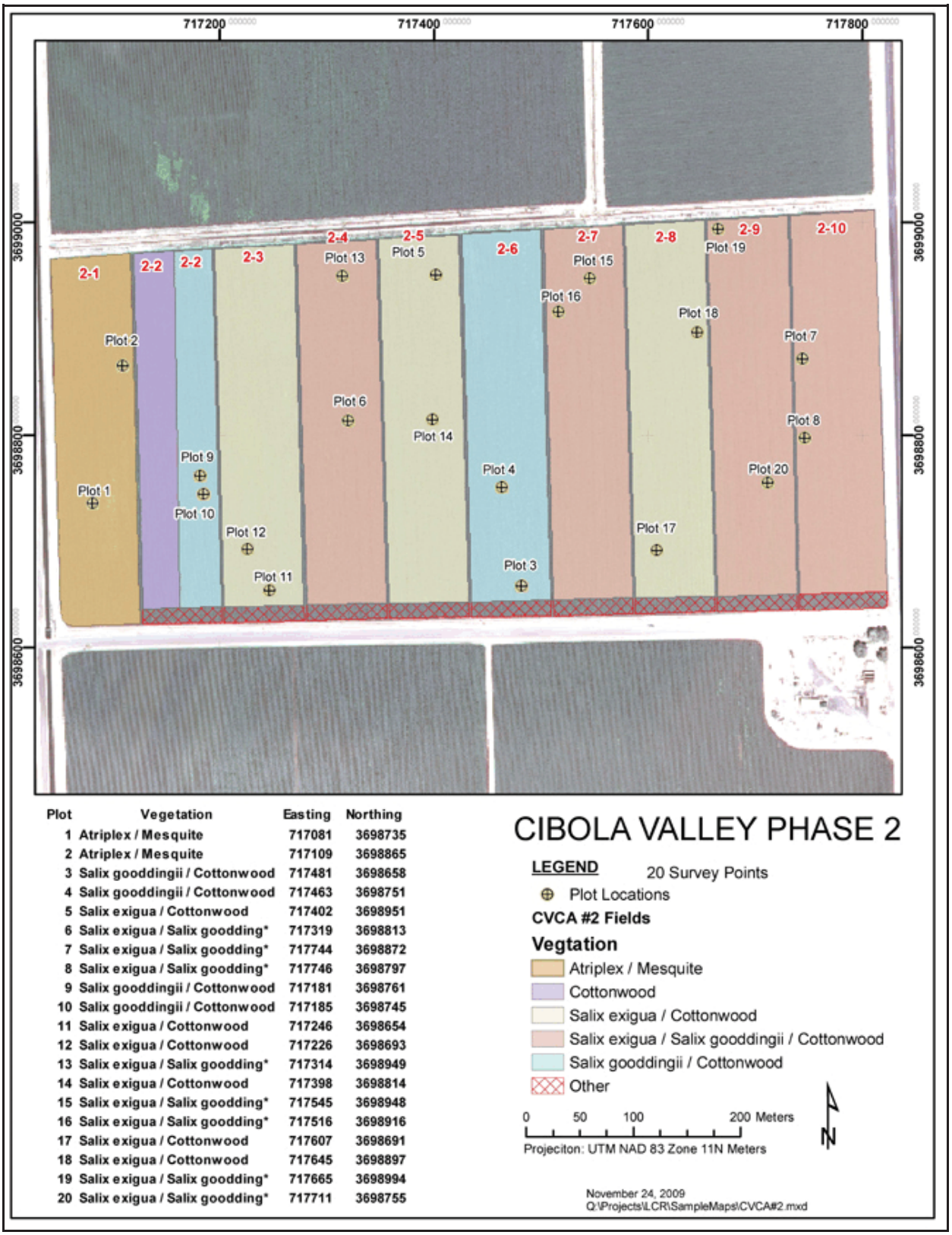
Plot	Vegetation	Easting	Northing
1	Googing's willow\coyote willow	729470	3730622
2	Googing's willow\coyote willow	729492	3730557
3	Googing's willow\coyote willow	729460	3730661
4	Googing's willow\coyote willow	729560	3730525
5	Googing's willow\coyote willow	729640	3730636
6	Googing's willow\coyote willow	729698	3730541
7	Googing's willow\coyote willow	729727	3730576
8	Googing's willow\coyote willow	729937	3730706
9	Baccaris\cottonwood\Gooding's will	729871	3731022
10	Baccaris\cottonwood\Gooding's will	729923	3730907
11	Baccaris\cottonwood\Gooding's will	729958	3730809
12	Baccaris\cottonwood\Gooding's will	730025	3731076
13	Baccaris\cottonwood\Gooding's will	730006	3731100
14	Baccaris\cottonwood\Gooding's will	730033	3731043
15	Baccaris\cottonwood\Gooding's will	730271	3731007
16	Baccaris\cottonwood\Gooding's will	730363	3730972
17	Baccaris\cottonwood\Gooding's will	730328	3730870
18	Baccaris\cottonwood\Gooding's will	730360	3731130
19	mesquite\atriplex	730475	3731102
20	mesquite\atriplex	730512	3730922
21	mesquite\atriplex	730572	3730993
22	mesquite\atriplex	730608	3730934

Figure 5. Palo Verde Ecological Reserve Phase 4 project area.



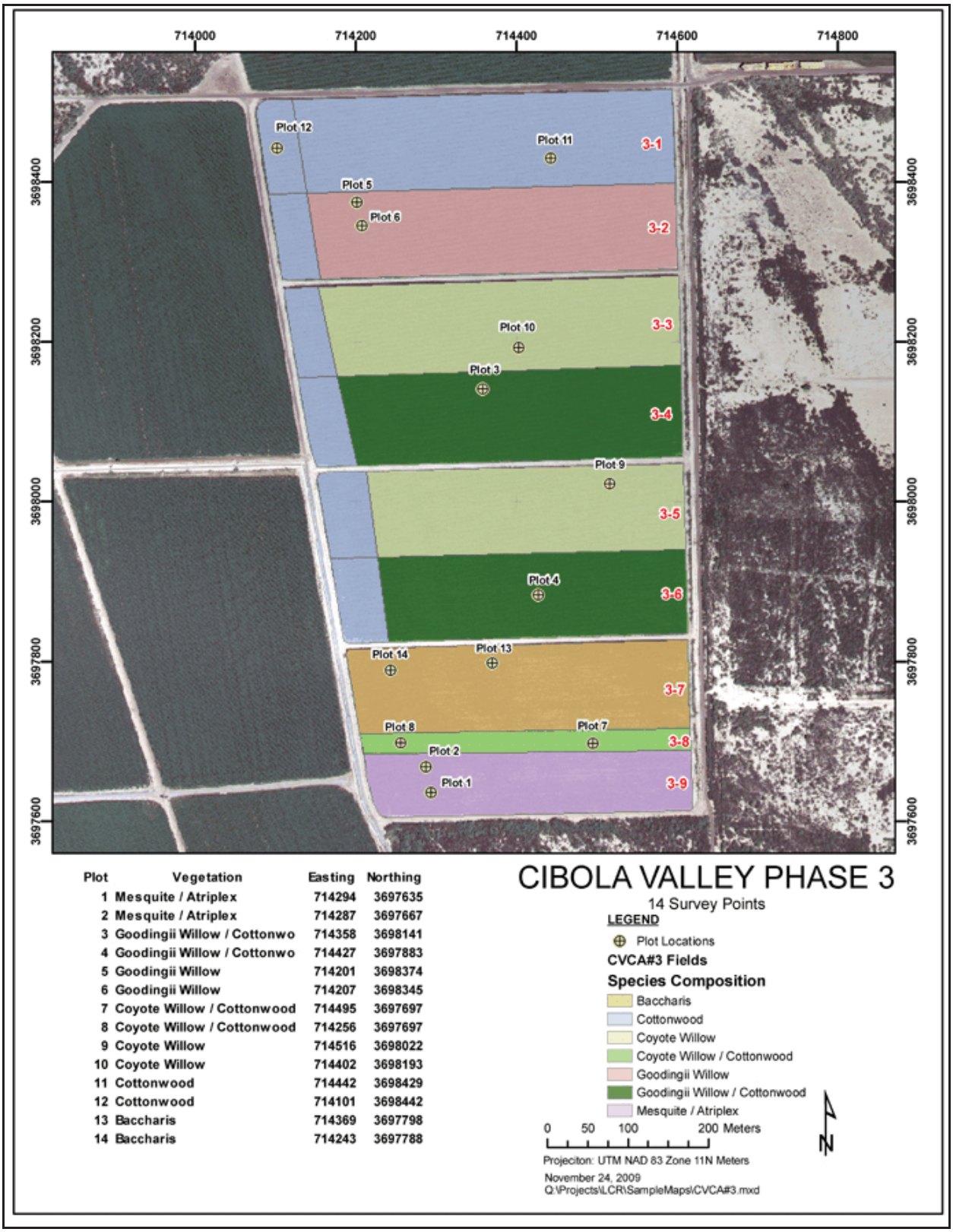
Plot	Vegetation	Easting	Northing
1	Morning Glory Treat	717239	3699156
2	Morning Glory Treat	717234	3699410
3	Populus fremontii	717467	3699442
4	Populus fremontii	717487	3699448
5	Salix exigua	717294	3699450
6	Salix exigua	717136	3699415
7	Salix gooddingii	717338	3699037
8	Salix gooddingii	717757	3699121

Figure 6. Cibola Valley Conservation Area Phase 1 project area.



Plot	Vegetation	Easting	Northing
1	Atriplex / Mesquite	717081	3698735
2	Atriplex / Mesquite	717109	3698865
3	Salix gooddingii / Cottonwood	717481	3698658
4	Salix gooddingii / Cottonwood	717463	3698751
5	Salix exigua / Cottonwood	717402	3698951
6	Salix exigua / Salix goodding*	717319	3698813
7	Salix exigua / Salix goodding*	717744	3698872
8	Salix exigua / Salix goodding*	717746	3698797
9	Salix gooddingii / Cottonwood	717181	3698761
10	Salix gooddingii / Cottonwood	717185	3698745
11	Salix exigua / Cottonwood	717246	3698654
12	Salix exigua / Cottonwood	717226	3698693
13	Salix exigua / Salix goodding*	717314	3698949
14	Salix exigua / Cottonwood	717398	3698814
15	Salix exigua / Salix goodding*	717545	3698948
16	Salix exigua / Salix goodding*	717516	3698916
17	Salix exigua / Cottonwood	717607	3698691
18	Salix exigua / Cottonwood	717645	3698897
19	Salix exigua / Salix goodding*	717665	3698994
20	Salix exigua / Salix goodding*	717711	3698755

Figure 7. Cibola Valley Conservation Area Phase 2 project area.



Plot	Vegetation	Easting	Northing
1	Mesquite / Atriplex	714294	3697635
2	Mesquite / Atriplex	714287	3697667
3	Goodingii Willow / Cottonwo	714358	3698141
4	Goodingii Willow / Cottonwo	714427	3697883
5	Goodingii Willow	714201	3698374
6	Goodingii Willow	714207	3698345
7	Coyote Willow / Cottonwood	714495	3697697
8	Coyote Willow / Cottonwood	714256	3697697
9	Coyote Willow	714516	3698022
10	Coyote Willow	714402	3698193
11	Cottonwood	714442	3698429
12	Cottonwood	714101	3698442
13	Baccharis	714369	3697798
14	Baccharis	714243	3697788

Figure 8. **Cibola Valley Conservation Area Phase 3 project area.**

Plot	Vegtation	Easting	Northing
1	mesquite/atriple	716935	3699381
2	mesquite/atriple	716884	3699559
3	mesquite/atriple	716772	3699438
4	mesquite/atriple	716655	3699434
5	mesquite/atriple	716846	3699320
6	mesquite/atriple	716909	3699151
7	mesquite/atriple	716763	3699315
8	mesquite/atriple	716993	3699197
9	mesquite/atriple	716705	3698989
10	mesquite/atriple	716936	3698992
11	mesquite/atriple	716895	3699011
12	mesquite/atriple	716704	3698945
13	mesquite/atriple	716957	3698824
14	mesquite/atriple	716923	3698806
15	mesquite/atriple	716739	3698658
16	mesquite/atriple	716696	3698629

CVCA PHASE 4 EAST

16 Survey Points

LEGEND

⊕ CVCA4East_Pts_Nov2009

CVCA #4 Fields

Vegetation

Mesquite/Atriplex mix

Other

0 100 200 Meters

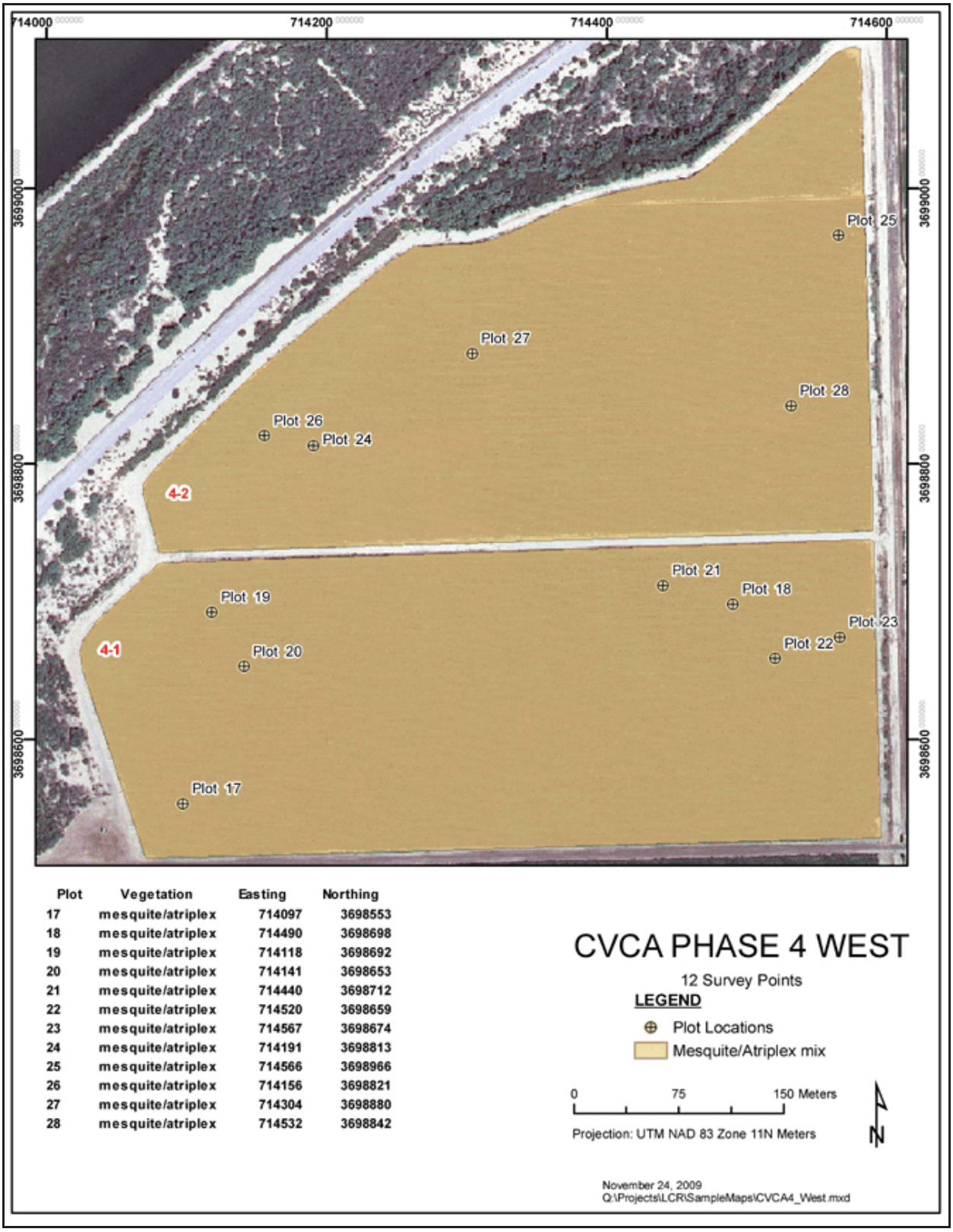
N

Projection: UTM NAD 83 Zone 11N Meters

November 24, 2009

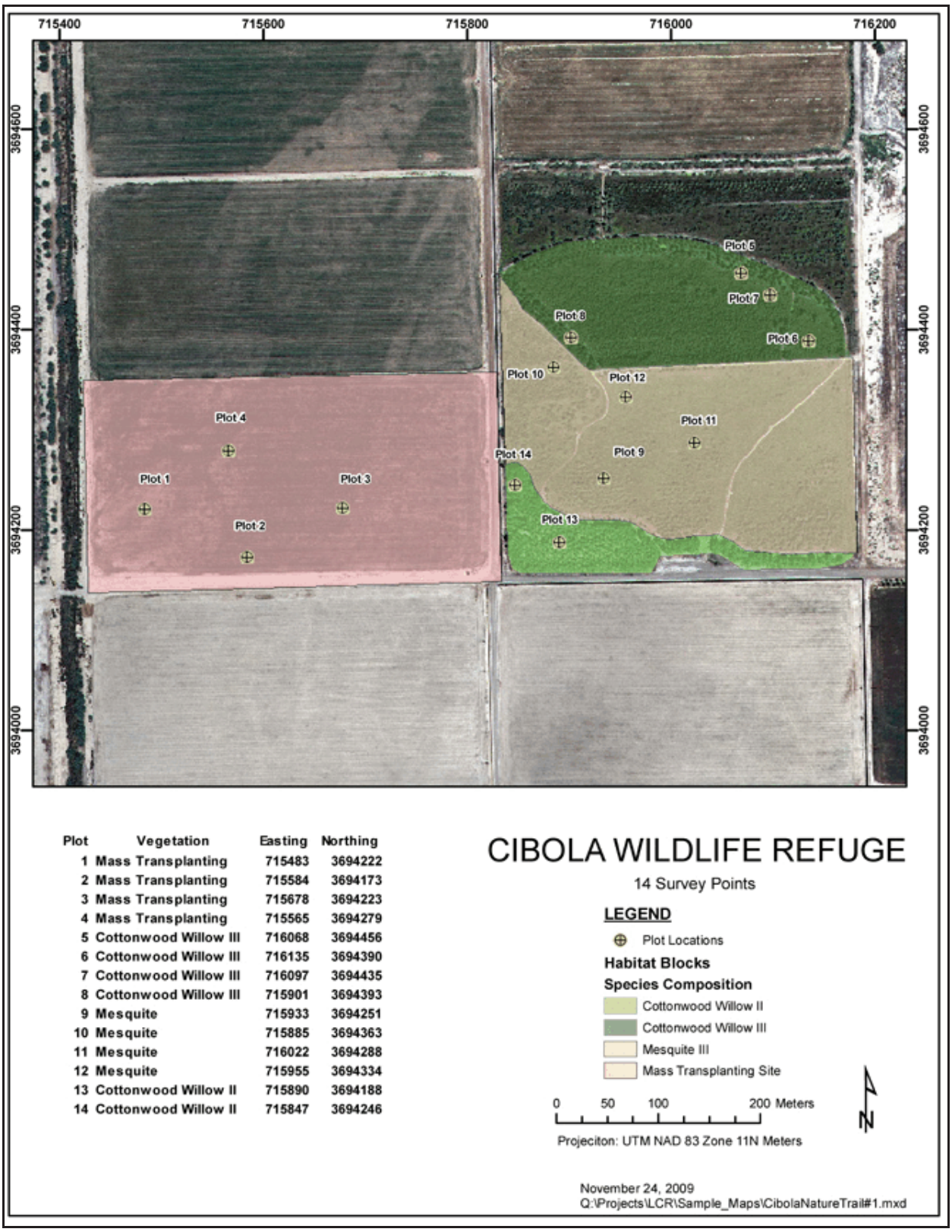
Q:\Projects\LCR\SampleMaps\CVCA4_East.mxd

Figure 9. Cibola Valley Conservation Area Phase 4 project area.



Plot	Vegetation	Easting	Northing
17	mesquite/atriplex	714097	3698553
18	mesquite/atriplex	714490	3698698
19	mesquite/atriplex	714118	3698692
20	mesquite/atriplex	714141	3698653
21	mesquite/atriplex	714440	3698712
22	mesquite/atriplex	714520	3698659
23	mesquite/atriplex	714567	3698674
24	mesquite/atriplex	714191	3698813
25	mesquite/atriplex	714566	3698966
26	mesquite/atriplex	714156	3698821
27	mesquite/atriplex	714304	3698880
28	mesquite/atriplex	714532	3698842

Figure 10. Cibola Valley Conservation Area Phase 4 project area.



Plot	Vegetation	Easting	Northing
1	Mass Transplanting	715483	3694222
2	Mass Transplanting	715584	3694173
3	Mass Transplanting	715678	3694223
4	Mass Transplanting	715565	3694279
5	Cottonwood Willow III	716068	3694456
6	Cottonwood Willow III	716135	3694390
7	Cottonwood Willow III	716097	3694435
8	Cottonwood Willow III	715901	3694393
9	Mesquite	715933	3694251
10	Mesquite	715885	3694363
11	Mesquite	716022	3694288
12	Mesquite	715955	3694334
13	Cottonwood Willow II	715890	3694188
14	Cottonwood Willow II	715847	3694246

Figure 11. Cibola National Wildlife Refuge Unit #1 project area.