RECLAMATION

Managing Water in the West

Bosque del Apache Sediment Plug Baseline Studies

Annual Report 2011

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Fisheries and Wildlife Resources
Denver, CO

March 2012

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Bosque del Apache Sediment Plug Baseline Studies

Annual Report 2011

prepared by

Technical Service Center

Rebecca Siegle, Natural Resource Specialist

Darrell Ahlers, Wildlife Biologist

Gregory Reed, Natural Resource Specialist

Dave Moore, Wildlife Biologist

prepared for

Albuquerque Area Office

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Introduction

The Rio Grande is a dynamic river system that experiences high sediment loads which have historically led to points of aggradation and degradation in the river (Earick 1999). Over the last two decades, several sediment plugs have formed on the Middle Rio Grande in various locations (Lai 2009). It can be difficult to determine the dominant process responsible for plug formation, but there are certain conditions that are known to be factors (Boroughs 2005 as cited in Lai 2009). Sediment plugs occur in alluvial rivers where a constriction causes significant overbank flow. As flows are transferred overbank and away from the river, the sediment transport capacity in the main channel decreases while the total sediment load isn't reduced at the same proportion. This results in sediment deposition in the main channel. If overbank flows continue for weeks, deposition eventually completely clogs the main channel of the river. Other factors may also contribute to sediment plug formation. A combination of processes – including river geometry, flow, and sediment factors – may work together to form a plug when certain conditions are met (Lai 2009).

A sediment plug formed in May 2008 within the Bosque del Apache National Wildlife Refuge (BDANWR) on the Middle Rio Grande near San Antonio in central New Mexico (Figure 1). This reach of the river is generally aggraded. Bureau of Reclamation (Reclamation) is using a two-dimensional model to study plug formation in the BDANWR area (Lai 2009). Model predictions were compared to cross section data measured in 2009. The study found that, as of July 2009, the portion upstream of the reach (i.e. North Boundary of the BDANWR to Range Line SO-1520.8) was degrading, the middle reach (from Range Lines SO-1525 to SO-1550, which includes the location of plug formation and where a pilot channel was excavated in October 2008) was also degrading, and the downstream reach (from Range Lines SO-1554 to 1562.9) was aggrading.

Albuquerque Area Office (AAO) has expressed concern that the plug could lead to problems by affecting water deliveries to downstream users and threatening levee integrity. A number of options are being considered to address the situation at the BDANWR that include:

- Realigning the river channel
- Excavating main river channel
- Improving levees with no plug removal
- Levee setback
- No action

If the river naturally altered its course into a lower elevational portion of the valley due to blockage by the sediment plug, the water table could potentially be naturally lowered. However, other alternatives such as channel realignment and channel excavation could

Figure 1.—Sediment plug formed in BDANWR looking downstream from above at minimal flows (top) and looking across the river at flows of approximately 1500 cfs (bottom). Top photo from Lai 2009.

also lower the adjacent water table. AAO is concerned that any of these scenarios could have a negative effect on endangered Southwestern willow flycatcher (SWFL) habitat by drying currently occupied areas (Reclamation 2007). One of the most important characteristics of SWFL habitat is the presence of dense vegetation; therefore sites must have a high enough water table to support riparian vegetation (USGS 2011). Nests are usually within close proximity (less than 50 m) of water or saturated soil, and SWFLs show a strong affinity for the presence of surface water during the early breeding season (Moore and Ahlers 2010). In the case at BDANWR, the sediment plug resulted in an elevated water table and overbank flooding which has improved habitat for the SWFL. From 2002 to 2008, an average of 3 territories per year (ranging from 0 to 7) were established in the active flood plain of the BDANWR. After formation of the sediment plug, the number of territories increased to 20 in 2009, 34 in 2010, and 49 in 2011, which was likely correlated with an elevated water table, overbank flooding, and improved SWFL habitat. This scenario is consistent with historical conditions on the Rio Grande (Ahlers and White 1999). Generally, areas of suitable SWFL breeding habitat are a result of recent sediment deposition (aggradation), which leads to the establishment and growth of willow-dominated vegetation as well as the presence of surface water and increased ground water levels.

In 2008, Reclamation mapped riparian areas along the Middle Rio Grande and these vegetation maps were used to identify vegetation types that provided suitable SWFL habitat (Ahlers, *et. al* 2010). Of the 3,247 acres mapped within the BDANWR river reach, 26 acres were classified as suitable habitat and 513 acres were classified as moderately suitable. At the time of mapping (which was the same year the sediment plug at BDANWR formed), the dominant vegetation types were primarily understory communities, but within treed communities the dominant vegetation types were Native canopy/exotic understory (460 acres); Exotic canopy/exotic understory (325 acres); and Native canopy/mixed understory (310 acres).

Reclamation's Technical Service Center (TSC) initiated baseline studies in April 2010 to examine effects that proposed management alternatives might have on the quality of SWFL habitat that currently exists within the floodplain of the BDANWR. This information can be used in making future management decisions regarding potential impacts to existing SWFL habitat. Hydrologic and vegetation baseline data are being collected in order to identify key habitat parameters, evaluate alternatives, and compare hydrologic and habitat conditions pre- and post-project.

Methods

This comprehensive study is comprised of various types of monitoring which include ground water monitoring wells, vegetation transects associated with wells, vegetation quantification plots associated with SWFL nests, hemispheric photo stations, and SWFL surveys and nest monitoring. The map in Figure 2 shows the study area and includes

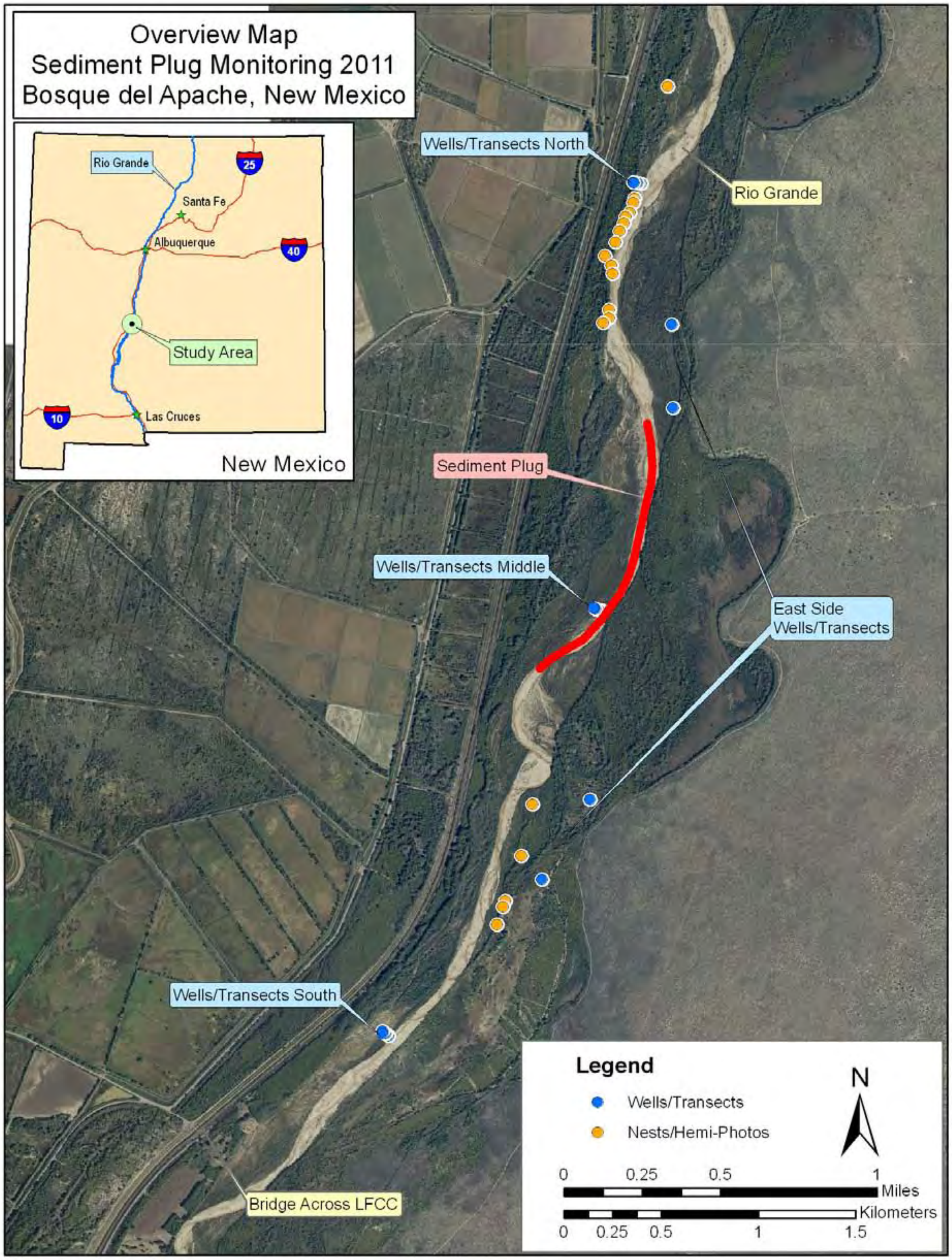


Figure 2.—Study area and general locations of the ground water wells, vegetation transects, and vegetation plots.

general locations of groundwater wells, vegetation transects, and vegetation plots. The following are descriptions of, and methodologies used for monitoring.

Ground Water Wells

Shallow ground water wells were installed in April 2010 along three Range Lines (referred to as North, Middle, and South Range Lines) within the BDANWR. Range Lines are survey transects cleared and maintained by Reclamation to access the river for monitoring aggradation and degradation of the active flood plain. Wells along the North, Middle, and South Range Lines are located upstream of, downstream of, and adjacent to the sediment plug (Figure 2). In association with each of the Range Lines, 3 wells were positioned along a transect perpendicular to the river at 10, 30, and 50 meters (m) from the existing river bank on the west side, for a total of 9 wells. In August 2011, 4 more wells were installed on the east side of the river. Two North wells are located just upstream of the sediment plug and between the North and Middle Range Lines on the east side of the river (Figure 2). Two South wells are located just downstream of the sediment plug and between the Middle and South Range Lines on the east side of the river.

Maps with well locations are shown in Figures A-1 to A-5 in Appendix A. All wells were installed using the Army Corps of Engineers (2000) methodology. When initially installed, wells on the west side ranged between 2.7 and 4.3 feet (ft) in depth, with the ground water depth averaging between 1.5 to 3.5 ft below the surface at the time of installation (except one well which was dry at 4.3 ft depth). At these depths, wells were often dry, making it difficult to detect relationships between ground water and river levels at lower surface flows typical of the Rio Grande. Therefore, all wells were deepened by an average of 2 ft in May 2011 in an effort to improve the data collected. The limited data set from wells installed in August 2011 on the east side were not included in this report.

A HOBO Water Level Logger was inserted into each well and attached to the well cap via a braided stainless steel wire. Loggers were programmed to collect readings every six hours. Data were periodically downloaded from the loggers by Reclamation staff and correlated to surface flows from the nearest USGS gauging station at “Hwy 380.”

Ground water data will be used to monitor water table levels and associated habitat/ vegetation data. These data will also be used to evaluate project alternatives and potential impacts to the existing habitat.

Vegetation Transects

Two permanent 25-meter (m) vegetation transects were established in association with each of the 13 ground water monitoring wells, for a total of 26 transects. Each transect was generally situated parallel to the river, with one transect running north (0°) of the well and the other running south (180°; Figures A-1 to A-5 in Appendix A). These transects were established to acquire vegetation data that was closely associated with hydrologic data collected at the well site, which would support correlation analysis.

For understory measurements, cover and species composition were measured every 0.5 m along the 25-m transect. The point-intercept method was used, which entailed recording the first "hit" for herbaceous plant species and for woody species less than 1 m tall. If a plant was not intercepted, then bare soil or litter was recorded. The line-intercept method was used for measuring overstory cover. Overstory cover was quantified along each transect by noting the point along the tape where the canopy began and the point at which it ended for each woody species over a meter tall. Because species overlapped in some cases, the sum of the cover for each species did not necessarily reflect the actual percentage of overstory cover along the tape. The percentage of the tape covered by overstory was also calculated. The height of the tallest vegetation within each stretch per species was recorded as well.

Canopy cover was also collected using a densiometer and through hemispheric photographs (see Hemispheric Photo Station section below). Estimates with a densiometer were gathered by taking four readings at the end point of each transect — two at each direction parallel to the transect and two at each direction perpendicular to the transect. These four readings were averaged to get one value for each point, or two values per transect, which were then averaged to get a canopy cover estimate for each transect. To avoid confusion, in this report "canopy cover" will be used to refer to percent canopy cover as measured with a densiometer at each end of transects and "overstory cover" will be used to describe the total percent cover of woody species measured using the line-intercept method, as described above.

Data from each sampling period was compared to evaluate any statistically significant changes in vegetation over time. The paired t-test was used to statistically compare normally distributed data, and the signed rank nonparametric test was used to compare data that were not normally distributed. Because this was the first year of monitoring the East side transects, no statistical comparisons were made for these transects. Total percent cover (*i.e.* actual cover estimate) was used for understory and overstory cover estimates and for statistical analysis. Relative percent cover was used for life-forms and proportion of native versus introduced species. Relative cover is cover of a species or life-form relative to the cover of all species combined (i.e. total vegetation). It is calculated as follows:

Relative cover of species or lifeform = % species or lifeform / % total vegetation cover * 100

Digital photos were taken from each end of vegetation transects to visually document changes in the vegetation over time and in response to management activities. Transect endpoints are mapped and waypoints listed in Figures A-1 to A-5 in Appendix A.

Vegetation Quantification Plots

Vegetation quantification plots were established in association with 20 SWFL nests that were active in 2010. These are permanent plots and will be monitored throughout the study regardless of whether SWFLs occupy the same territory in the future. Monitoring plot locations are shown in Figure A-1 to A-5 in Appendix A, most of which are nearest to the North Range Line upstream from the sediment plug. These plots were established to examine direct effects to SWFL nesting habitat. Methods were adapted from BBIRD protocol (Martin et al. 1997), similar studies conducted by the New Mexico Natural Heritage Program along the Rio Grande (DeRagon et al. 1995, Ahlers and White 1997, Stoleson and Finch 1999), and University of New Mexico (Peter Stacey, pers. comm.).

Vegetation and habitat data were collected within an 11.35-meter radius plot (0.04 hectare BBIRD-type plot) centered below the selected nests (Figure 3). All trees within the center plot were tallied by species. Diameter at breast height (DBH) class, densities, species composition, and percentage of dead trees were computed for these plots. Stems were considered trees when DBH was greater than 5 centimeters (cm). Trees were divided into three DBH classes: Class I consisted of trees greater than 5 cm to 10 cm DBH, Class II consisted of trees greater than 10 cm to 20 cm, and Class III consisted of trees greater than 20 cm.

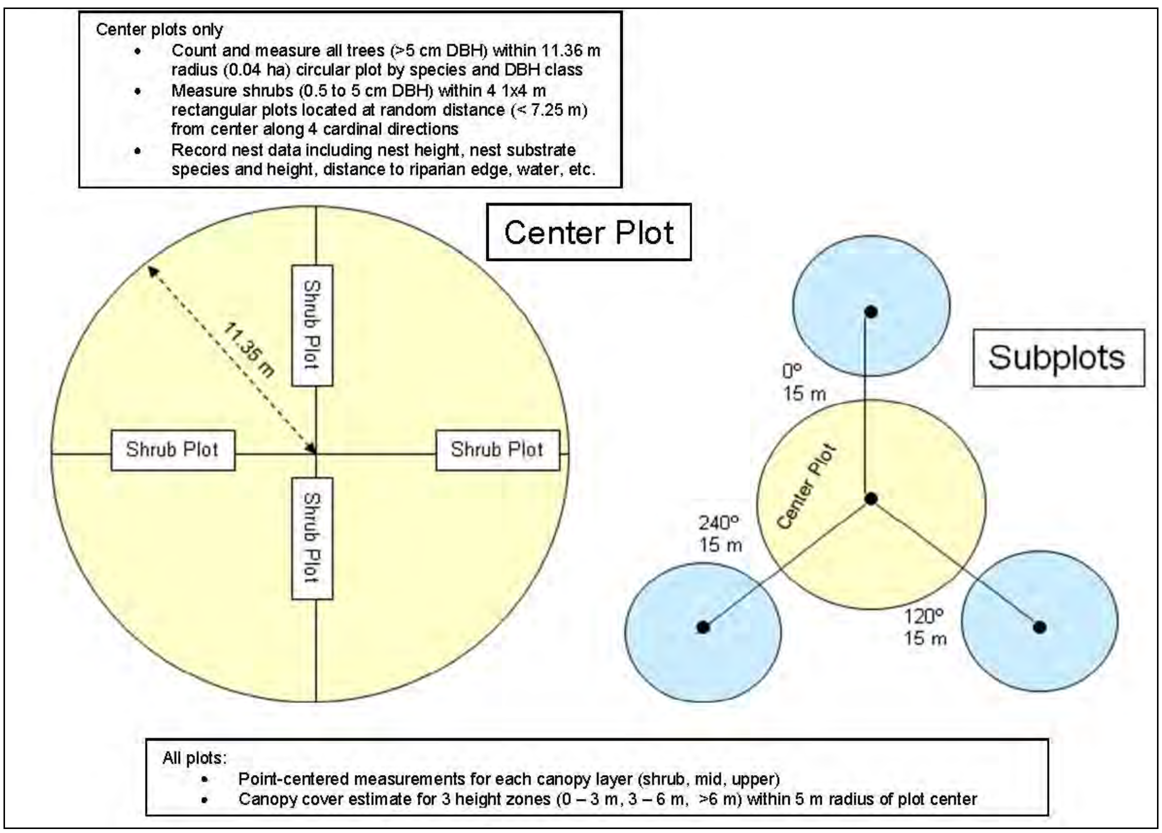


Figure 3.—Vegetation quantification plot layout.

Shrubs were measured in four 1 x 4 m shrub plots located at random distances less than 7.35 m from the plot center along each of four radii in cardinal directions. Shrub stems were defined as having a DBH between 0.5 cm and 5 cm. All shrub stems within each shrub plot were counted by species. Densities, species composition, and percentage of dead were computed. In cases with exceptional stem densities, shrub stems where measured in four 1 x 2 m subplots.

To collect data for canopy cover and plant densities by canopy layer, three additional subplots, each with a 5 m radius, were established adjacent to each center plot (Figure 3). From the center point of the center plot and of the three smaller subplots, point-centered quarter measurements were taken for plants in three canopy classes (shrub, mid-canopy, and upper canopy). Canopy layers were classified beginning with the lowest. Thus, some sites had all three layers (Figure 4) but most only had a shrub and mid-canopy layer (Figure 5). From these data, stem densities were calculated for the respective canopy layers and canopy cover visual estimates were made within each of three canopy layers (0 to 3 m, 3 to 6 m, and >6 m). Estimates were made using a Daubenmire ranking of 0 to 6 where 0 = 0 percent cover, 1 = 1 to 10 percent, 2 = 11 to 25 percent, 3 = 26 to 50 percent, 4 = 51 to 75 percent, 5 = 76 to 90 percent, and 6 = greater than 90 percent cover.

If a subplot fell partially or entirely within an area of non-habitat (in this case the river channel), it was excluded from measurements. For center plots, the quarter of the plot (as measured from each cardinal direction) that fell in non-habitat was excluded from data collection. Because most nests in the BDANWR were located close to the river, it was not uncommon for all or part of plots to be positioned in open water.

Data from each sampling period were compared to evaluate any statistically significant changes in SWFL habitat over time. The paired t-test was used to statistically compare normally distributed data for vegetation variables, and the signed rank nonparametric test was used to compare data that are not normally distributed.

Hemispheric Photo Stations

A hemispheric camera was used to take photographs at one end of each transect (nearest the ground water well) facing upward into the plant canopy. Hemispheric photos were also taken from beneath each nest tree used in 2010 in the vegetation quantification plots (Figures A-1 to A-5 in Appendix A). All photostations were permanently marked with a metal “T” post. Hemispherical (fisheye) canopy photography is a technique for characterizing plant canopies using photographs taken through an extreme wide-angle lens with a viewing angle of 180°. Each digital photograph was analyzed using Hemiview software to determine total cover. The objectives in using this camera were to gather permanent and more precise records of the geometry of canopy openings and of changes in the amount of canopy over time. Cover data was compared to detect any changes in canopy cover over time.

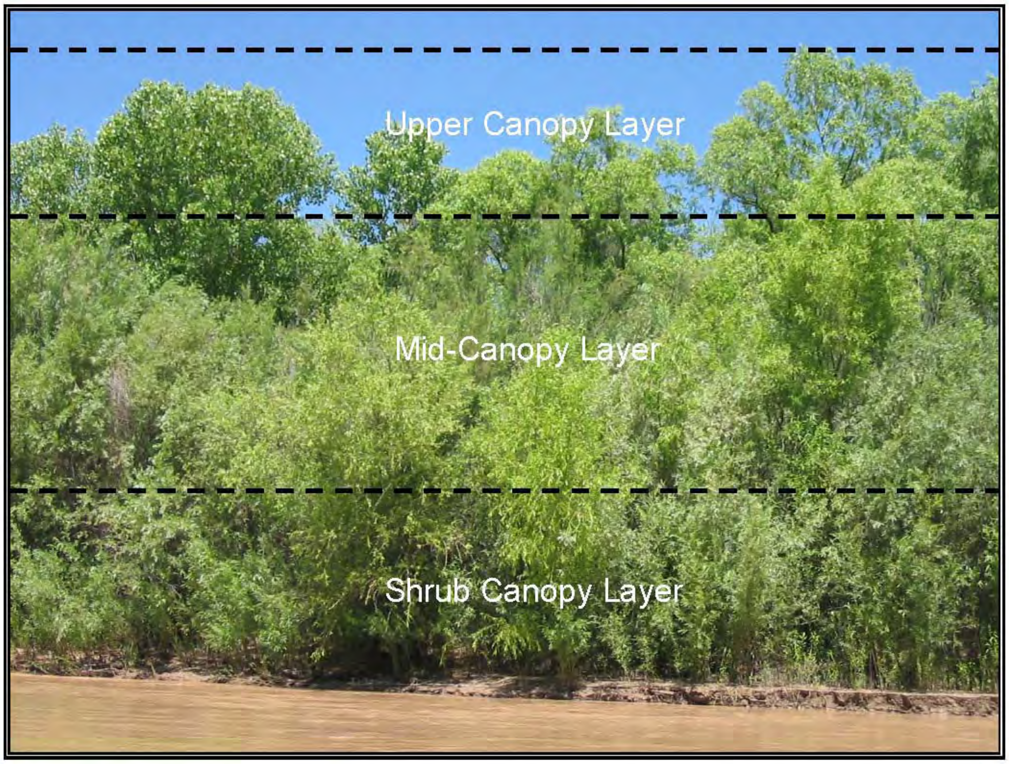


Figure 4.—Riparian habitat showing three different canopy layers.

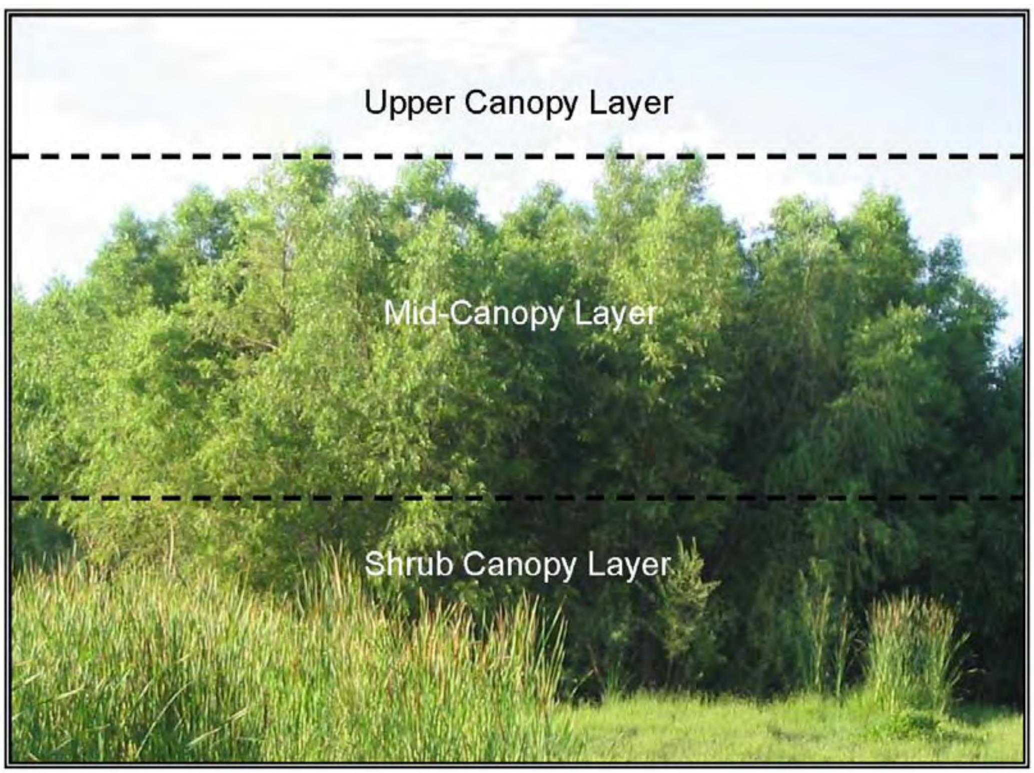


Figure 5.—Typical SWFL habitat showing lack of upper canopy layer.

Photos were taken in summer and winter. The purpose for two photo sessions was to compare cover between the two seasons to calculate the amount of canopy covered by foliage. That is, the difference between cover in summer, when trees had foliage, and cover in winter, when trees were mostly defoliated and only stems were measured, determines how much canopy is occupied by foliar cover. Potential effects to vegetation from changing hydrology are expected to be detected in foliage earlier than in stems, which could remain standing even if dead.

Southwestern Willow Flycatcher Surveys/Nest Monitoring

Presence/absence surveys were conducted for the endangered SWFL in accordance with Sogge et al. (2010). Five SWFL presence/absence surveys were conducted each year within the BDANWR from 2002 through 2011. These surveys were part of Reclamation's annual SWFL monitoring program conducted at selected sites along the Rio Grande from Bandelier National Monument to Elephant Butte Reservoir (Moore and Ahlers 2011). Once detected, nests were monitored until the outcome (i.e. success in producing fledglings) was determined.

Results and Discussion

Ground Water Wells

Ground water data from the west side wells were collected and analyzed from May 12, 2010 through August 17, 2011. Water table levels and river flows are graphed by well and presented in Appendix B. Daily mean flow data was measured by a flow gauge located at Hwy 380 in San Antonia, NM, approximately 5 mi upstream of the North Range Line.

River flows peaked in May 2010 at around 3000 cfs when overbank flooding occurred and monitoring showed the water table near, at, or above ground surface level along all Range Lines. Low summer flows followed, with a temporary increase in late July/early August associated with the monsoonal season. Increases in the water table during monsoons were only detected along the Middle Range Line. River flows began to pick up again in November, with water loggers detecting an increasing water table beginning in December at the Middle and South Range Lines. River discharge levels were extremely low in 2011, with peak flows of around 500 cfs in the early part of June and briefly in early August. The river was essentially dry during the remainder of the monitoring period. Wells were deepened June 4, 2011 and groundwater was detected in all wells in early June but wells were dry from mid June through August.

Ground water levels generally correlated closely with river flows, indicating a hydrologic regime influenced by the riverine system at the project site. There was occasionally a lag in the rise of the water table following high river discharge, with the length of time it took for response in ground water levels dependent on soil texture at the well site. Smaller clay pores take longer to absorb water – as well as holding water longer – than pores of more coarse soils, in which water table response will be observed more quickly. This phenomenon was also observed following a drop in discharge when the water table sometimes remained high despite decreasing flows. Figure 6 shows an example of this trend with ground water levels trailing the pattern of discharge in May and June 2010 and taking around 4 weeks to show increases following higher discharge in November 2010. Lag time should be less apparent with the deeper wells.

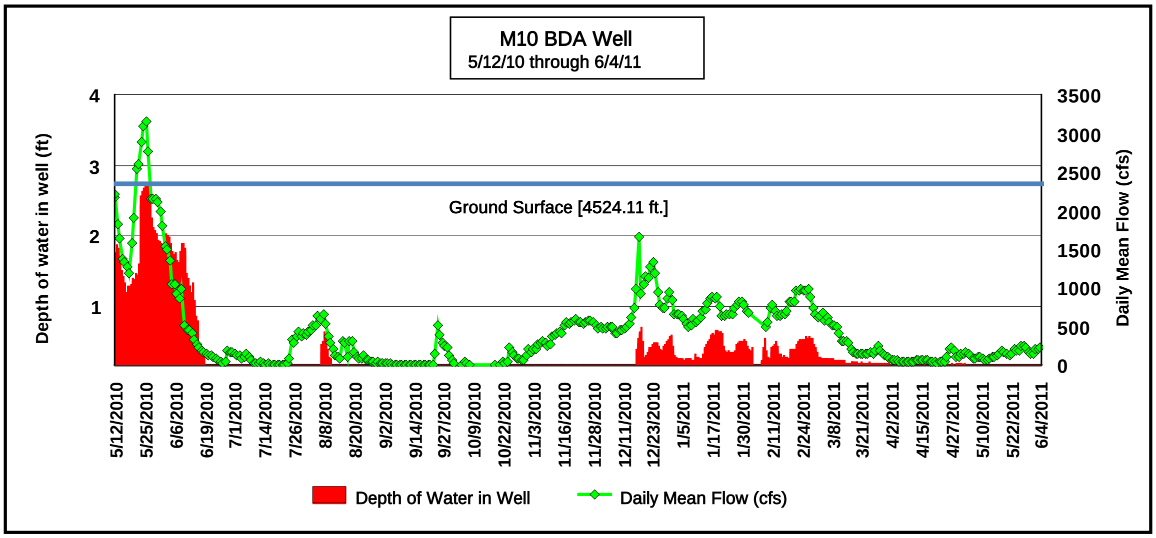


Figure 6.—An example of lag time between increases in discharge and responses in water table levels, as observed in May and June 2010 and November 2010.

Associations between water table and river discharge rates were especially pronounced along the Middle Range Line and somewhat so along the South Range Line before wells were deepened. Relationships between ground water levels and river discharge became apparent in all wells after further excavation. Ground water was shallowest along the Middle Range Line, with the water table averaging around 2 ft. below the surface when flows were approximately 1000 cfs. After deepening, water table levels around 35 in from the surface were detected when discharge rates remained near 500 cfs. The water table along the South Range Line ranged between 30 and 40 in. below the surface when flows were around 1000 cfs, although when wells were shallower, ground water levels were barely detected at these flows. Once wells were deepened, the water table was found to range from about 41 in (S10) to 52 in (S50) from the surface at river discharge around 500 cfs.

The water table was deepest along the North Range Lines at lower flows. Prior to deepening, the wells along this Range line were 43 to 52 in. deep and very little to no water was detected in the wells at flows as high as 1500 cfs. When deepened, ground water levels ranging from 41 in to 68 in were detected when discharge levels remained around 500 cfs. These results indicate that deepening the wells improved the data collected, allowing water loggers to better detect variations in the water table and relationships between ground water and river levels at minimal flows typical of the Rio Grande. These data will also provide a better opportunity to identify correlations between ground water levels and the condition of vegetation, which in turn will offer insight into the potential effects of various project alternatives.

Vegetation Transects

Vegetation transects along the North, Middle, and South Range Lines were measured in August 2010 and 2011. Vegetation transects on the east side were established and measured in 2011. The average total percent cover of individual plant species, life-forms, and cover types in the understory layer by area is shown for the west side in Tables C-1 and C-2 in Appendix C. Twenty-three species were detected in the understory in all areas during the first 2 years of monitoring. Average relative percent cover of life-forms is graphed by Range Line on the West side in Figure 7 and by North and South transects on the East side in Figure 8.

All areas had rather low total understory plant cover, particularly in 2011, which was a relatively dry year (Tables C-1 and C-2). The Middle Range Line had the highest total cover in both years at 22.8 percent in 2010 and 12.2 percent in 2011. The decrease in total plant cover from 2010 to 2011 was statistically significant (alpha=0.05; see Table 1 for P-values). Concurrently, litter cover increased in 2011. Vegetative cover at this site was primarily composed of native shrubs (woody species under 1 m in height) and introduced forbs (Figure 7). The comparatively high plant cover along this Range Line was in large part due to the relatively high percentage of yellow sweet clover (introduced forb) and coyote willow (native shrub). Total understory cover along the South Range Line was 18.3 percent in 2010 with the dominant life-forms being native grasses and native forbs and 8.0 percent in 2011, shifting to native and introduced shrubs as the dominant life-forms. The decrease in total plant cover was also significant along this Range Line and was associated with a statistical increase in litter (Table 1). Finally, the North Range Line had only 6 percent total understory cover in 2010 made up of predominantly native grasses and native forbs. Total understory cover was a mere 0.9 percent in 2011, which was composed entirely of native shrubs (coyote willow and seep willow).

In 2011, total understory cover on the East side was 9.0 percent in the North transects and 10.5 percent in the South transects, with vegetation dominated by native shrubs and introduced forbs in the North transects and by native shrubs and grasses in the South transects (Figure 7). The predominance of shrub species in the understory layer of all vegetation transects in 2011 was undoubtedly related to the dry conditions. Deeper root systems in woody species were able to withstand the deeper water tables associated with lower precipitation and subsequently lower river flows.

Within all areas, native species were more abundant relative to introduced species in the understory layer (Table 2), although total cover of native species did decrease

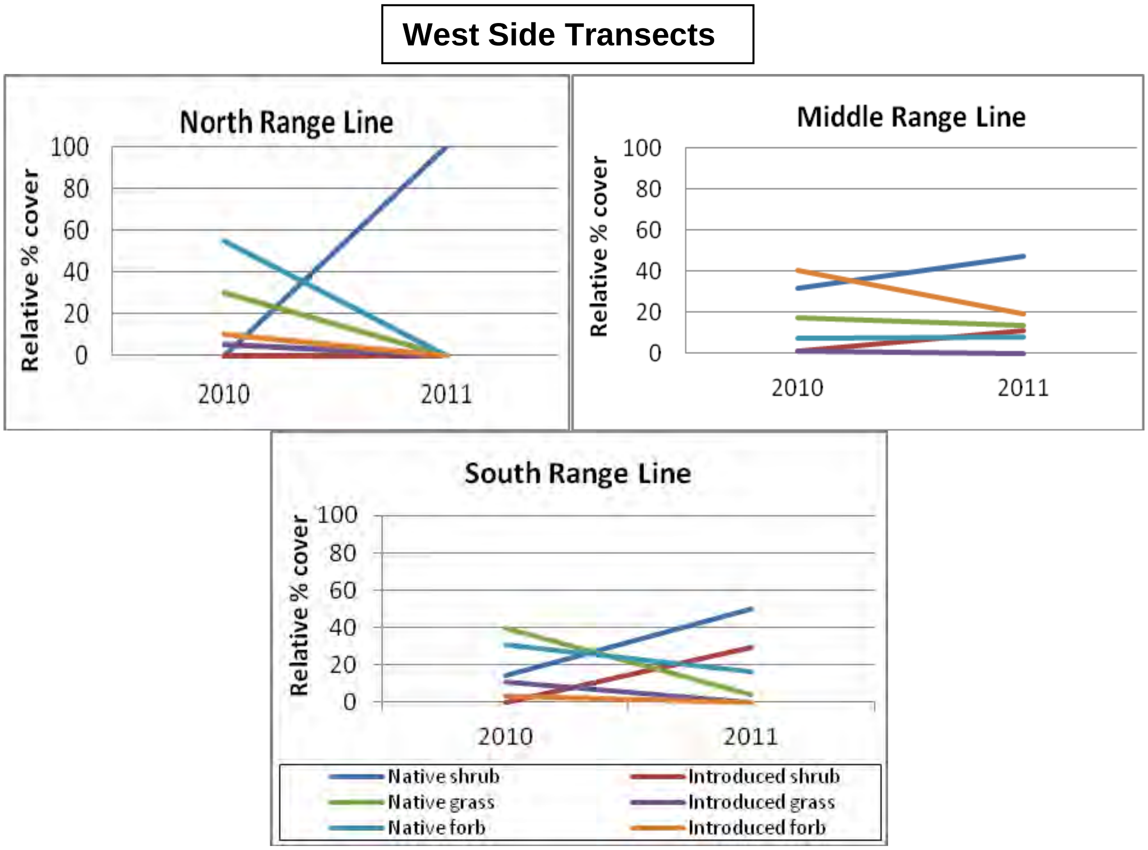
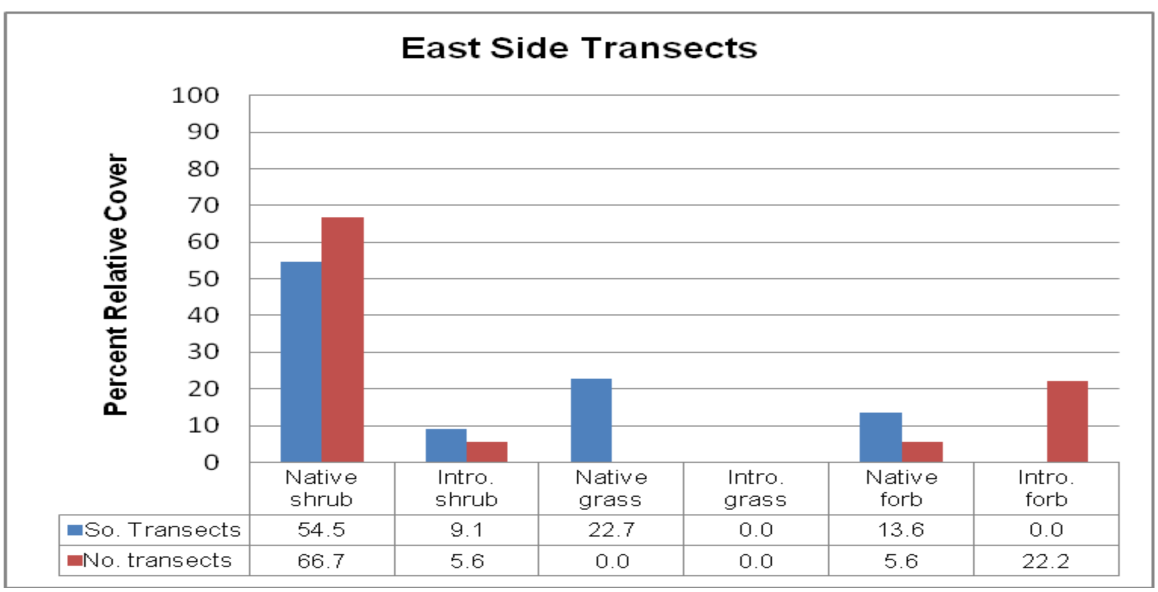


Figure 7.—Relative percent cover of life-forms in the understory layer of transects for North, Middle, and South Range Lines on the West side in 2010 and 2011.



	Native shrub	Intro. shrub	Native grass	Intro. grass	Native forb	Intro. forb
So. Transects	54.5	9.1	22.7	0.0	13.6	0.0
No. transects	66.7	5.6	0.0	0.0	5.6	22.2

Figure 8.—Relative percent cover of life-forms in the understory layer of North and South transects on the East side in 2011.

Table 1— Statistical comparisons of paired samples between 2010 and 2011 for transects along the North, Middle, and South Range Lines on the West side. Alpha = 0.05.

West side transects	**2010 vs 2011**		
Total percent cover	**North Range Line**	**Middle Range Line**	**South Range Line**
Understory (woody spp. < 1m, grasses, forbs)			
Plant	2010=2011 P=0.269[2]	2010>2011 P=0.024[1]	2010>2011 P=0.003[1]
Bare	2010=2011 P=0.196[1]	2010=2011 P=0.394[1]	2010=2011 P=0.133[1]
Litter	2010=2011 P=0.198[1]	2010<2011 P=0.025[1]	2010<2011 P=0.009[1]
Native understory species	2010=2011 P=0.657[1]	2010=2011 P=0.175[1]	2010>2011 P=0.010[1]
Introduced understory species	2010=2011 P=0.158[1]	2010=2011 P=0.146[1]	2010=2011 P=0.895[1]
Overstory (woody spp. > 1m)			
Native overstory species	2010>2011 P=0.022[1]	2010>2011 P=0.016[1]	2010>2011 P=0.004[1]
Introduced overstory overstory species	2010=2011 P=0.103[1]	2010=2011 P=0.111[1]	2010=2011 P=0.619[1]
Total transect overstory	2010=2011 P=0.911[1]	2010>2011 P=0.012[1]	2010>2011 P=0.011[1]

Table 2.—Relative percent cover of native vs. introduced species in the understory and overstory layers of transects for the North, Middle, and South Range Lines in 2010 and 2011 and for the North and South transects on the East side in 2011.

Average Relative Percent Cover								
	Herbaceous Layer				**Overstory Layer**			
	2010		**2011**		**2010**		**2011**	
	Native	**Intro**	**Native**	**Intro**	**Native**	**Intro**	**Native**	**Intro**
West side - North Range Line	85.0	15.0	100.0	0.0	71.9	28.1	77.2	22.8
West side - Middle Range Line	56.5	43.5	69.4	30.6	94.9	5.1	93.0	7.0
West side - South Range Line	85.5	14.5	70.8	29.2	83.4	16.6	75.8	24.2
East side - North transects	NA	NA	72.2	27.8	NA	NA	92.5	7.5
East side - South transects	NA	NA	90.9	9.1	NA	NA	87.3	12.7

significantly from 15.6 percent in 2010 to 5.7 percent in 2011 along the South Range Line (Tables 1 and C-1) .

Total percent cover and average height of overstory species are shown in Table 3 for the West side and in Table 4 for the East side. Six woody plant species were detected in the overstory layer in all areas combined. Based on total overstory cover estimates, the North Range Line was characterized by a tall canopy of cottonwood with predominantly

Table 3.—Average total percent cover and height of plant species detected within the overstory layer of transects along North, Middle, and South Range Lines on the West side in 2010 and 2011.

Average Total Percent Cover - West Side Overstory Layer												
	North Range Line				Middle Range Line				South Range Line			
Species	2010		2011		2010		2011		2010		2011	
	% cover	Height (m)	% cover	Height (m)	% cover	Height (m)	% cover	Height (m)	% cover	Height (m)	% cover	Height (m)
Cottonwood (*Populus deltoides*)	77.1	13.1	68.6	11.2	54.8	3.5	51.7	3.7	16.5	4.4	12.3	4.3
Coyote willow (*Salix exigua*)	7.6	3.3	4.7	3.7	63.5	3.4	32.7	2.9	45.5	2.9	32.4	2.8
Goodding's willow (*Salix gooddingii*)	7.4	7.4	5.5	9.0	1.9	6.0	0.0	0.0	0.0	0.0	0.0	0.0
Seep willow (*Baccharis salicifolia*)	0.1	1.7	0.0	0.0	4.1	1.9	2.6	1.6	11.2	2.2	4.2	2.0
Saltcedar (*Tamarix ramosissima*)	25.4	3.8	19.8	4.0	4.5	2.0	3.5	2.1	14.5	1.9	15.7	1.9
Russian olive (*Eleagnus angustifolia*)	10.7	3.7	3.5	2.9	2.1	5.1	3.1	3.6	0.1	2.5	0.0	0.0
% TOTAL TRANSECT COVER*	**92.9**		**93.5**		**92.1**		**74.8**		**73.9**		**57.6**	

*Due to overlap of some species, total is not equal to the sum of all species.

Table 4.—Average total percent cover and height of plant species detected within the overstory layer of North and South transects on the East side in 2011.

Average Total Percent Cover - East Side Overstory Layer				
	North transects		South transects	
Species	Total % cover	Height	Total % cover	Height
Cottonwood (*Populus deltoides*)	33.8	6.0	44.1	6.0
Coyote willow (*Salix exigua*)	38.5	2.4	22.5	2.3
Goodding's willow (*Salix gooddingii*)	2.8	7.2	0.6	2.0
Seep willow (*Baccharis salicifolia*)	0.3	1.6	2.2	1.8
Saltcedar (*Tamarix ramosissima*)	3.8	3.0	8.0	2.4
Russian olive (*Eleagnus angustifolia*)	2.3	9.0	2.1	2.2
% TOTAL TRANSECT COVER*	**67.1**		**63.1**	

*Due to overlap of some species, total is not equal to the sum of all species.

saltcedar beneath. The Middle Range Line was characterized by developing cottonwood and coyote willow of the same size-class and the South Range Line was dominated by coyote willow followed by cottonwood and saltcedar in somewhat equal proportions. Both East side transects had an overstory canopy of cottonwood with coyote willow dominant in the lower canopy.

In 2010, total overstory cover along the West side transects (accounting for overlap) was approximately 92 percent along the North and Middle Range Lines and near 75 percent along the South Range Line (Table 3). In 2011, overstory cover stayed about the same along the North Range Line, but decreased by around 17 percent along the Middle and South Range Lines, which was a significant change in both (Table 1). The total cover of native overstory species decreased significantly along all Range Lines in 2011.

Values for canopy cover as measured with the densitometer were similar to overstory cover measured using the line-intercept, at approximately 98 percent canopy cover along the North Line, 92 percent along the Middle Range Line, and 85 percent along the South Range Line in 2010 (Table 5). In 2011, canopy cover values remained relatively close along the North Range Line, but decreased by about 8 percent in the Middle Range Line and by about 18 percent in the South Range Line. These values were higher than overstory cover values by 10 percent or so in the Middle and South Range Lines.

Total overstory cover along the East transects (accounting for overlap) was 67.1 percent in the North transects and 63.1 in the South transects in 2011 (Table 3). These values averaged around 10 percent lower than canopy cover measured with the densitometer, which were 73.6 percent for the North transects and 77.4 percent for the South transects (Table 6).

Native plant species were far more abundant than introduced species in the overstory in all areas for both years as determined by relative percent cover (Table 2). The only introduced species detected in the overstory were saltcedar and Russian olive. The highest cover of both introduced species was along the North Range Line (Table 3), although coverage was still moderate compared to native species. In 2011, total cover of saltcedar increased slightly along the South Range Line while total cover of native species decreased.

Table 5.—Average percent canopy cover as measured with a densitometer by transect for the North, Middle, and South Range Lines on the West side in 2010 and 2011.

West Side Percent Canopy Cover						
	2010			2011		
Transect	Point A	Point B	Total Avg. % Canopy Cover	Point A	Point B	Total Avg. % Canopy Cover
N10S	100.0	100.0	100.0	98.7	100.0	99.4
N10N	93.5	82.6	88.0	70.1	71.4	70.8
N30S	100.0	100.0	100.0	100.0	96.9	98.4
N30N	99.0	100.0	99.5	98.2	99.0	98.6
N50S	100.0	100.0	100.0	100.0	99.0	99.5
N50N	99.7	100.0	99.9	100.0	97.4	98.7
Avg North Range Line			**97.9**			**94.2**
M10S	95.3	97.1	96.2	89.3	78.4	83.9
M10N	93.0	95.1	94.0	90.6	88.3	89.5
M30S	94.0	96.4	95.2	84.7	91.9	88.3
M30N	90.4	89.3	89.9	no reading	73.0	73.0
M50S	83.4	99.5	91.4	76.3	95.8	86.1
M50N	100.0	75.0	87.5	71.9	100.0	86.0
Avg Middle Range Line			**92.4**			**84.4**
S10S	100.0	99.5	99.7	80.5	94.3	87.4
S10N	95.3	93.8	94.5	81.5	76.6	79.1
S30S	73.2	94.3	83.8	51.4	76.6	64.0
S30N	97.9	91.9	94.9	70.7	65.2	68.0
S50S	71.1	40.7	55.9	57.1	4.8	31.0
S50N	88.8	69.8	79.3	65.9	79.7	72.8
Avg South Range Line			**84.7**			**67.0**

Table 6.—Average percent canopy cover as measured with a densitometer for the North and South transects on the East side in 2011.

East Side Percent Canopy Cover			
Transect	**Point A**	**Point B**	**Average**
E1S	87.5	82.3	84.9
E1N	90.4	93.2	91.8
E2N	24.1	88.3	56.2
E2S	67.0	56.3	61.7
		Avg North Transects	**73.6**
E3S	40.5	87.3	63.9
E3N	51.1	48.8	50.0
E4S	100.0	100.0	100.0
E4N	91.4	100.0	95.7
		Avg South Transects	**77.4**

Both the amount of understory vegetation and the composition of the overstory appeared to be associated with ground water depths. When flows were high (e.g. around 3000 cfs in the spring of 2010), the water table was at or near the surface along all Range Lines (see graphs in Appendix B). Ground water was deepest along the North Range Lines at lower flows. When the wells along this Range Line were 43 to 52 in. deep, no water was detected in the wells at flows as high as 1500 cfs. Once deepened, ground water levels ranged from 41 to 68 in from the surface when discharge levels remained around 500 cfs. Vegetation transects along the North Line also had the lowest percentage of ground cover. Ground water was shallowest along the Middle Range Line, with the water table averaging around 2 ft. below the surface when flows were approximately 1000 cfs and about 35 in from the surface when discharge rates remained near 500 cfs. Understory vegetation along the Middle Range Line had the highest percentage of cover. Finally, the water table along the South Range Line ranged between 30 and 40 in. below the surface when flows were around 1000 and ranged from about 41 in (S10) to 52 in (S50) from the surface at river discharge around 500 cfs. The South Range Line fell between the other two in both ground water depth and vegetation coverage. Of course, the amount and type of overstory also influences the abundance of understory vegetation. The tall, dense canopy of older age-class cottonwood and Goodding's willow along the North Range Line may have been a larger factor in the low percent cover of herbaceous species. Overstory cover was also quite dense (though not as tall) along the Middle Range Line (Tables 3 and 4), however, which had the highest understory cover.

Tree growth and maintenance in the Middle Rio Grande bosque depend on groundwater remaining above a depth of about 10 ft (Cartron et al 2008). Ground water wells used in this study do not go to this depth, which limits the ability to make correlations between the water table and vegetation cover. However, general trends in ground water depths can be detected and compared to vegetation conditions and trends. Along the North Range Line, the tall cottonwood upper canopy with saltcedar mid-canopy associates well with a lower water table which is available to the deep roots of mature cottonwoods and phreatophytic saltcedar. It is also logical that the younger age-class of cottonwood and coyote willow growing along the Middle Range Line are associated with a shallower water table.

Digital photographs taken in association with vegetation transects are shown in Appendix D. The decrease in vegetative cover in 2011 is evident in photos from all transects. Photos from 2010 and 2011 will serve as baseline with which to visually compare future conditions.

Vegetation Quantification Plots

Vegetation quantification plot data were collected in August of 2010 and 2011 following the SWFL breeding season. Data from 17 of 60 in 2010 and 13 of 60 subplots in 2011 were excluded from analysis due to their position in the river (*i.e.* non-habitat). Within the 20 center plots, 12 were partially in the river in 2010 and 11 were partially in the river in 2011, which resulted in data from 24 and 22, respectively, of 80 quarter plots being excluded from analysis.

Tree data collected in the center plots and subplots is summarized in Table 7, which shows averages and ranges for each parameter measured. Tree data by individual plot is in Table E-1 in Appendix E. Densities were calculated by summing all stems counted by size class within the center plot and varied from 198 to 2990 trees/ha over the 2 years (Table 7).

Table 7.—Average, minimum, and maximum values of each parameter measured for trees within vegetation quantification plots in 2010 and 2011.

Tree Data (n=20)						
	2010			2011		
Parameter	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**
Height (m)	5.8	3.7	7.3	5.4	3.3	7.1
Crown width (m)	1.8	0.6	3.3	2.0	1.0	4.1
DBH (cm)	5.3	1.9	10.2	4.6	2.1	7.5
Cover 0-3 m (%)	67.7	43.7	89.0	51.0	27.0	76.3
Cover 3-6 m (%)	58.8	34.0	83.0	47.4	29.8	69.7
Cover >6 m (%)	25.7	5.0	48.0	17.6	3.8	39.7
Tree stem species composition (%)						
Goodding's willow	10.2	0.0	41.7	10.3	0.0	48.3
Saltcedar	26.8	0.0	86.7	28.3	0.0	91.1
Coyote willow	31.4	0.0	92.9	25.1	0.0	88.9
Cottonwood	24.5	0.0	97.0	28.1	0.0	98.5
Russian olive	7.1	0.0	33.3	8.2	0.0	39.1
Dead trees (%)	11.0	0.0	32.1	12.6	0.0	45.9
Tree stem size-class composition (%)						
Class I (5-10 cm dbh)	81.2	56.3	98.8	73.3	37.9	97.9
Class II (10-20 cm dbh)	15.4	1.2	36.8	21.6	0.0	41.4
Class III (>20cm dbh)	3.4	0.0	16.7	5.1	0.0	20.7
Density - All stem size classes (#/ha)	1641	272	2990	1392	198	2817

Vegetation cover was highest in the layer 0-3 m from the ground, with a mean of 67.7 percent in 2010 and 51.0 percent in 2011. The layer from 3-6 m followed with a mean percent cover of 58.8 percent in 2010 and 47.4 percent in 2011. In statistical comparisons of tree data between 2010 and 2011, cover in all 3 height zones (*i.e.* 0-3 m, 3-6 m, and >6 m) significantly decreased in 2011 (Table 8). The decrease in average cover is most likely due to dry conditions and a lower water table, which would affect the amount of foliage on trees.

Table 8— Statistical comparisons of paired samples between 2010 and 2011 for trees and shrubs in vegetation quantification (i.e. nest) plots. Alpha = 0.05.

2010 vs. 2011		
Variable	**Trees**	**Shrubs**
Height	2010=2011 P=0.094[2]	2010>2011 P=0.002[1]
Crown width	2010=2011 P=0.100[1]	2010=2011 P=0.173[2]
DBH	2010=2011 P=0.267[2]	NA
Cover 0-3m	2010>2011 P<0.001[1]	NA
Cover 3-6m	2010>2011 P=0.003[1]	NA
Cover >6	2010>2011 P<0.001[2]	NA
% Goodding's willow	2010=2011 P=0.851[2]	2010>2011 P=0.033[2]
% Saltcedar	2010=2011 P=0.591[1]	2010=2011P=0.336[1]
% Coyote willow	2010>2011 P=0.038[2]	2010=2011 P=0.377[1]
% Cottonwood	2010<2011 P=0.035[1]	2010>2011 P=0.017[2]
% Russian olive	2010=2011 P=0.513[1]	2010=2011 P=0.183[2]
% Seep willow	NA	2010=2011 P=1.00[2]
% Dead	2010=2011 P=0.637[1]	2010<2011 P=0.001[1]
Size class I	2010>2011 P<0.001[1]	NA
Size class II	2010<2011 P=0.001[1]	NA
Size class III	2010=2011 P=0.053[2]	NA
Stem density	2010>2011 P=0.027[1]	2010<2011 P=0.001[1]

1=Paired t-test; 2=signed rank nonparametric test

Highlighted boxes = significant difference at the 95-percent confidence level

In 2010, the most common tree species detected in vegetation quantification plots, based on stem counts, was coyote willow (31.4 relative percent of the composition), followed closely by saltcedar (26.8 percent) and cottonwood (24.5 percent). In 2011, these 3 species became closer in proportions, with saltcedar making up 28.3 relative percent of the composition, cottonwood 28.1 percent, and coyote willow 25.1 percent. Statistically, the percentage of coyote willow significantly decreased while the percentage of cottonwood significantly increased from 2010 to 2011.

The vast majority of stems (81.2 percent in 2010 and 73.3 percent in 2011) were in the 5 to 10 cm DBH size-class I. The percentage of trees in size class I significantly decreased while the percentage of trees in size classes II significantly increased (from 15.4 to 21.6 percent). The decrease in size class I density correlates with an increase in size class II density, suggesting that trees are growing. Although there appeared to be an increase in stem size based on stem size class measurements, analysis did not indicate there was a significant increase in DBH (and in fact, average DBH decreased slightly; Tables 7 and 8). Overall, stem density of all trees (i.e. all size classes combined) significantly decreased in 2011, which also correlates with an increase in the number of trees with a larger stem size. That is, as trees grow larger, the number of trees in a stand decreases.

Shrub data collected in the center plots and subplots is summarized in Table 9, which shows averages and ranges for each parameter measured. Shrub data by individual plot is shown in Table E-2 in Appendix E. Shrub stem densities ranged from 1.0 to 7.2 stems/m^2 over the 2 years of monitoring. Shrub stem density increased significantly (Table 8), from 2.8 stems/m^2 in 2010 to 4.6 stems/m^2 in 2011 (Table 9).

Table 9.—Average, minimum, and maximum values of each parameter measured for shrubs within vegetation quantification plots in 2010 and 2011.

Shrub Data (n=20)						
	2010			2011		
Parameter	Average	Minimum	Maximum	Average	Minimum	Maximum
Height (m)	1.5	0.9	2.3	1.2	0.7	1.9
Crown width (m)	0.4	0.3	0.7	0.7	0.1	3.2
Shrub stem species composition (%)						
Gooddings willow	8.1	0.0	46.2	2.5	0.0	30.2
Saltcedar	26.4	0.0	75.7	31.5	0.0	95.0
Coyote willow	50.8	0.0	95.7	55.7	0.0	100.0
Cottonwood	8.0	0.0	32.9	3.7	0.0	22.1
Seep willow	1.4	0.0	24.2	2.4	0.0	47.4
Russian olive	4.8	0.0	43.6	4.3	0.0	42.1
Dead shrubs (%)	39.1	15.2	66.7	63.4	36.2	91.0
Shrub stem density (#/m^2)	2.8	1.0	4.9	4.6	2.3	7.2

Coyote willow was the most common shrub species as determined by average stem counts, with a relative percent cover of 50.8 percent in 2010 and 55.7 percent in 2011. Saltcedar was the next most common with a relative percent cover of 26.4 percent in 2010 and 31.5 percent in 2011. Relative percent cover of both Goodding's willow and cottonwood decreased significantly in 2011. The average percentage of dead shrub stems increased significantly from 39.1 percent in 2010 to 63.4 percent in 2011. The large increase in dead shrubs was probably associated with a deeper water table since changesthat occurred in the canopy (such as decreased cover and density) would not be expected to increase shrub mortality. Interestingly, even though there was an increase in dead shrub cover, there was also an increase in live stem density, which would suggest that shrubs were still regenerating despite a deeper water table.

Hemispheric Photo Stations

Hemispheric photos were taken at stations associated with the West side vegetation transects and with all nest plots in August 2010, January 2011, and August 2011. Cover data collected through hemispheric photography for these plots are listed in Table 10. The East side vegetation transect photo stations were established and photos were taken in August 2011. Cover data for the East side plots are listed in Table 11.

Table 10.—Percent vegetation cover as measured with hemispheric photography for the vegetation transects along the North, Middle, and South Range Lines on the West side and for the vegetation quantification plots associated with SWFL nests.

	% Cover				% Cover		
Transect	**Summer Aug 2010**	**Winter Mar 2011**	**Summer Aug 2011**	**Nest plot**	**Summer Aug 2010**	**Winter Mar 2011**	**Summer Aug 2011**
N10S	94.4	47.8	79.1	PS#1	92.7	71.2	84.2
N10N	77.8	31.3	56.3	PS#2	90.2	63.5	71.9
N30S	93.0	51.9	83.4	PS#3	91.5	59.3	79.0
N30N	87.2	43.5	77.1	PS#4	96.0	60.3	80.8
N50S	97.1	72.1	85.5	PS#5	89.2	66.5	86.0
N50N	98.2	67.4	89.1	PS#6	87.7	59.9	86.2
Average	91.3	52.3	78.4	PS#7	96.5	62.5	86.4
M10S	92.4	40.7	68.0	PS#8	97.1	63.6	86.0
M10N	85.0	34.2	62.9	PS#9	96.7	61.8	90.0
M30S	86.0	27.7	61.6	PS#10	96.9	67.4	85.6
M30N	77.2	21.4	51.0	PS#11	88.7	63.4	91.7
M50S	68.2	23.8	48.8	PS#12	97.0	66.5	93.4
M50N	56.0	11.7	36.5	PS#13	98.0	60.3	88.9
Average	77.5	26.6	54.8	PS#14	98.0	58.2	85.0
S10S	78.9	46.1	52.2	PS#15	97.2	61.5	87.0
S10N	79.9	38.6	54.5	PS#16	89.6	54.1	78.9
S30S	39.5	13.2	15.8	PS#17	92.1	64.8	89.2
S30N	66.2	20.9	20.1	PS#18	96.5	49.4	78.3
S50S	47.1	8.8	19	PS#19	97.7	49.9	87.0
S50N	46.4	10.3	13.8	PS#20	95.2	58.2	87.6
Average	59.7	23.0	29.2	**Average**	94.2	61.1	85.2

Table 11.—Percent vegetation cover as measured with hemispheric photography for the North and South vegetation transects on the East side in August 2011 (Summer).

Transect	**% Cover**
North	
E1S	63.2
E1N	68.9
E2S	18.2
E2N	19.3
Average	42.4
South	
E3S	30.7
E3N	37.3
E4S	73.9
E4N	66.0
Average	52.0

Percent vegetation cover significantly decreased along the North Range Line (P=0.001), the Middle Range Line (P<0.001), and the South Range Line (P<0.001), as well as beneath nest trees (P<0.001) when comparing the August data sets from both years. These results were consistent with the other methods of vegetation monitoring in which vegetative cover was found to be statistically less in 2011 than in 2010. The drop in foliage cover is evident in Figure 9, which shows an example of photos taken at the same nest plot during each photo session. In fact, vegetative cover in August 2011 appears to be more similar to cover in March 2011 (when trees were defoliated) than to cover the previous August.

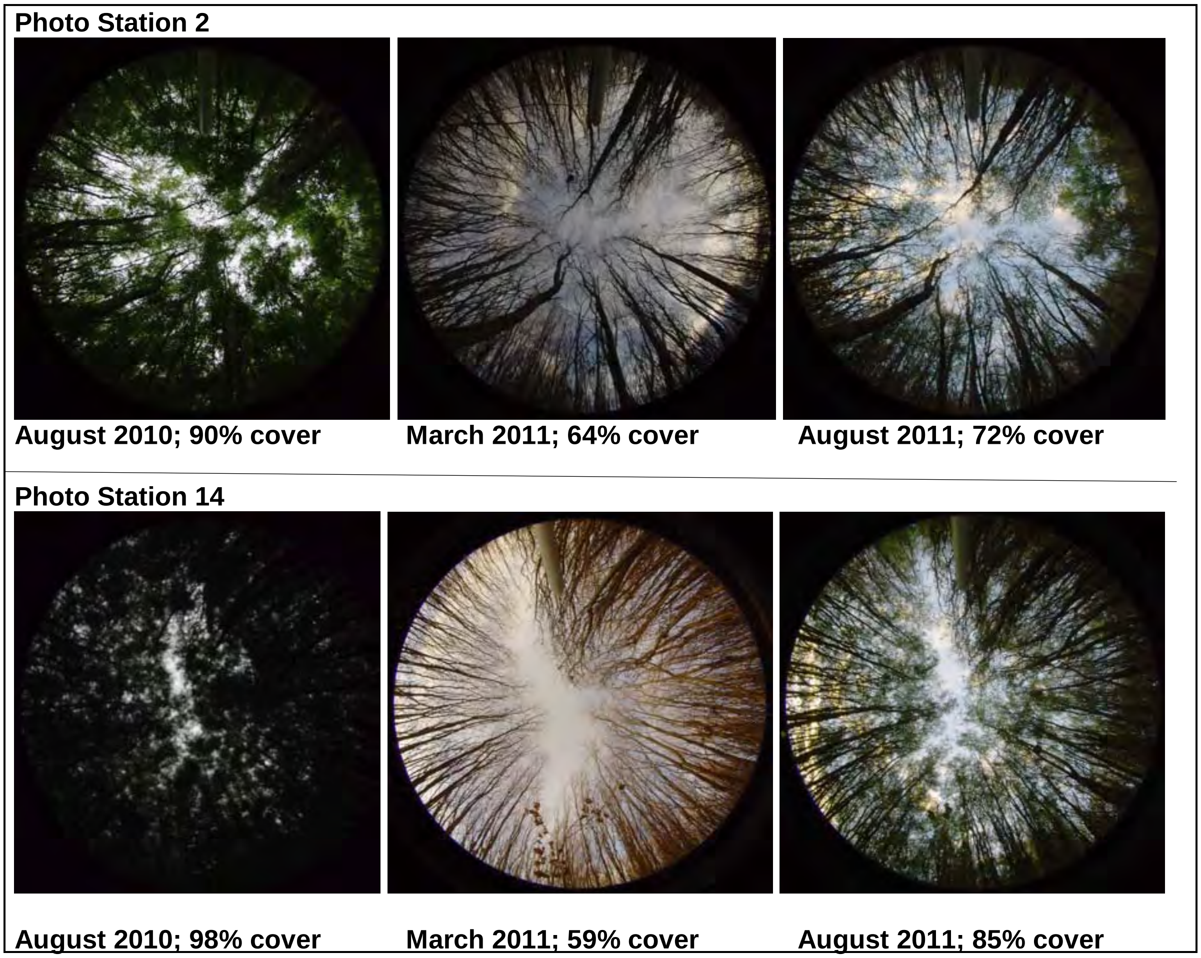


Figure 9.—Examples of hemispheric photos taken at nest plots in August 2010, March 2011, and August 2011 and associated percent vegetation cover.

Southwestern Willow Flycatcher Surveys/Nest Monitoring

There were 49 SWFL territories detected within the BDANWR during the 2011 breeding season (Figure 10). This number increased from 34 in 2010 and was considerably higher than the number of territories detected in any year from 2002 to 2008. The BDANWR

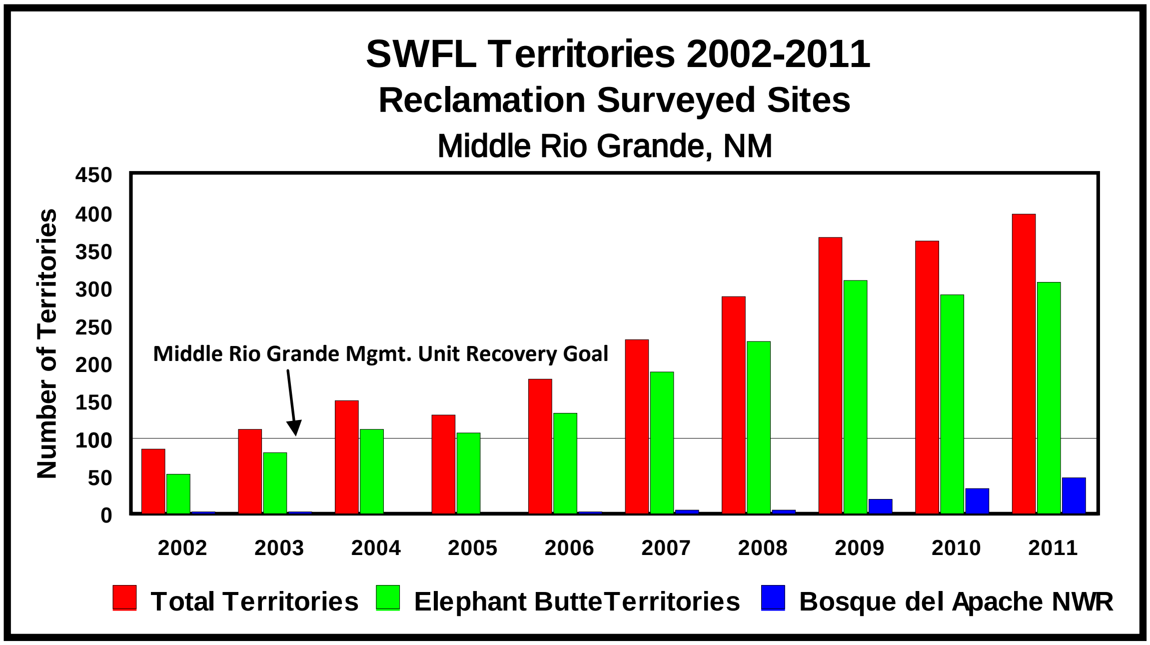


Figure 10.—Total number of SWFL territories detected in the Middle Rio Grande compared to those detected in Elephant Butte and BDANWR survey sites from 2002 to 2011.

SWFL population is becoming increasingly important to the Middle Rio Grande population (Figure 10) and to the population of the species as a whole. At 49 territories, it is the second largest population within the Middle Rio Grande (following Elephant Butte) and the third largest within the State of New Mexico.

The territories detected in 2011 within the BDANWR were mapped by habitat suitability type in Figures 11 and 12. Most of the nesting pairs were documented in areas that were identified as “Moderately suitable” or “Unsuitable.” SWFL habitat suitability was determined via ground truthing and/or photo interpretation in 2008 using 2007 aerial photography (Ahlers, *et. al* 2010). Since the formation of the sediment plug occurred after maps were produced, suitability classifications are probably no longer current. It is likely that SWFL habitat quality in the floodplain has improved. Reclamation anticipates mapping vegetation in 2012 to update existing SWFL habitat suitability maps for the Middle Rio Grande.

The vegetation types (i.e. native, exotic, or mixed) in which SWFL territories were found within the BDANWR from 2002 to 2011 are listed in Table 12, which also includes the frequency that each type was used for nesting. Vegetation types were defined as native if >75 percent of the surrounding vegetation was comprised of native species, as exotic if >75 percent of vegetation was comprised of exotic species, and as mixed if vegetation was comprised of <75 percent of both native and exotic species. Of the 79 nests detected over 10 years of monitoring, the majority (55 nests) were located within territories dominated by native vegetation types; 19 were found in mixed vegetation types and 5 were located in exotic vegetation types. These numbers demonstrate SWFLs preference for native habitat in the Middle Rio Grande. Nest success (determined by fledgling

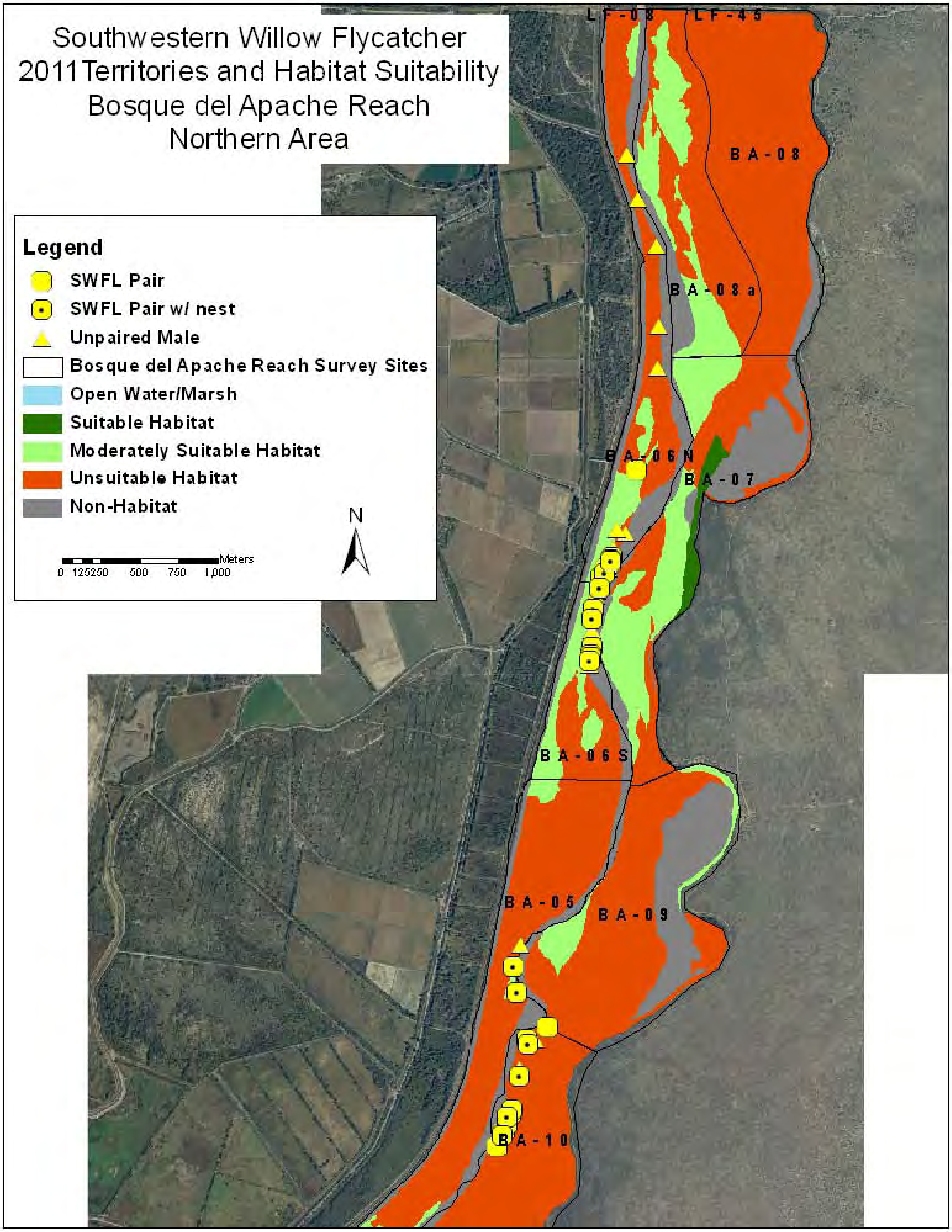


Figure 11.—SWFL territories detected in 2011 within the Northern portion of the BDANWR and habitat suitability as determined in 2008.

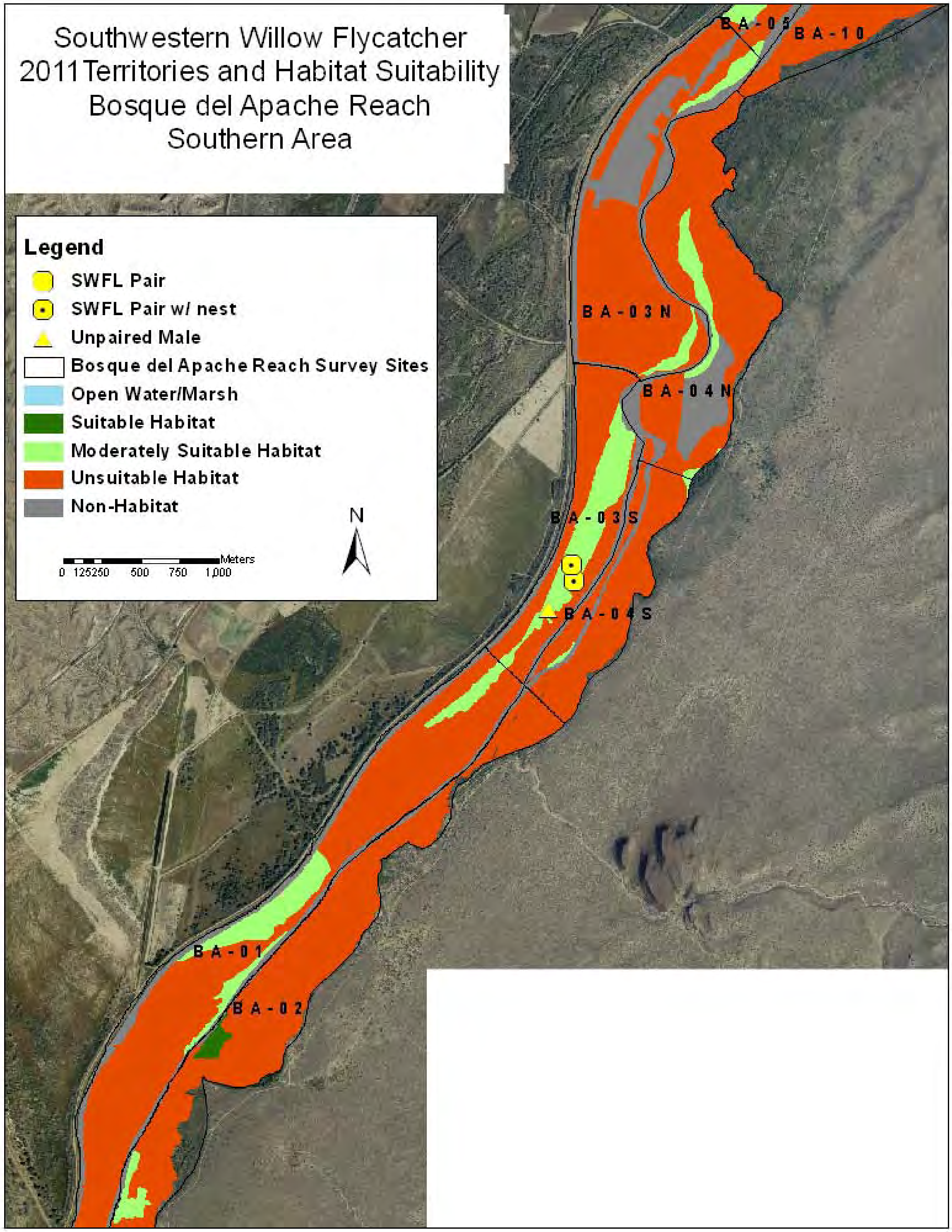


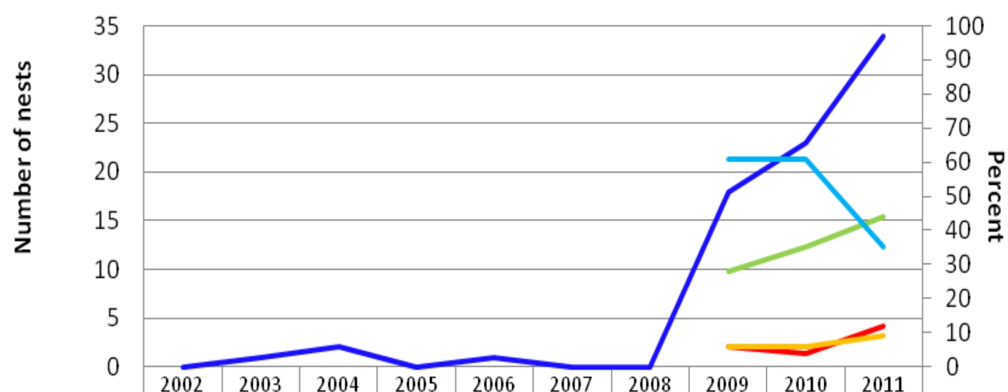
Figure 12.—SWFL territories detected in 2011 within the Southern portion of the BDANWR and habitat suitability as determined in 2008.

Table 12.—Dominant vegetation types in which SWFL territories were found within BDANWR from 2002 to 2011.

Vegetation Type	Number of nests	Percentage of total nests	Number of successful nests	Percentage of successful nests
Native	55	69.6	23	41.8
Exotic	5	6.3	2	40.0
Mixed	19	24.1	14	73.7
Total	**79**	**100.0**	**39**	**49.4**

SWFLs) was 49.4 percent for all nests in the BDANWR from 2002 to 2011. The most successful nests were located in territories dominated by mixed vegetation (73.7 percent), followed by nests found in territories dominated by native vegetation (41.8 percent). There was a relatively high success rate for nests in territories dominated by exotic vegetation as well (40.0 percent); however the small sample size (n=5) likely skews results.

Figure 13 summarizes the outcomes of SWFL nests in the BDANWR from 2002 to 2011. For a complete description of SWFL survey and nest monitoring results, refer to Moore and Ahlers (2011). The number of nests increased in 2011 from previous years, although the percentage of parasitism, predation, and abandonment also increased. Consequently, nest success dropped to 35 percent in 2011 from 61 percent in both 2009 and 2010. As discussed in the sections above, plant cover decreased in 2011, presumably due to a relatively dry year. Lack of foliage cover and greater exposure was likely related to increased parasitism and predation, which in turn led to lower nest success.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
# Nests	0	1	2	0	1	0	0	18	23	34
% Parasitism								6	4	12
% Predation								28	35	44
% Abandonment								6	6	9
% Nest success								61	61	35

Figure 13.— SWFL nest monitoring data summary in BDANWR from 2002 to 2011.

Conclusions

Ground water levels generally correlated closely with river flows, indicating connectivity between the river and water table at the project site. In 2010, when river discharge was higher (ranging from around 500 to 3300 cfs), the water table appeared to be nearer the surface, although exact depths were difficult to determine due to shallow wells. In 2011, wells were deepened to 57 – 80 inches in depth. River discharge rarely reached a maximum of around 500 cfs and the river was often dry throughout the hydrologic year. Deepened wells were dry throughout July and August (when monitoring for this data set ended).

Vegetation monitoring – which included vegetation transects associated with wells, vegetation plots associated with SWFL nests, and hemispheric photography – indicated that dryer conditions resulted in less plant cover in 2011 than in 2010. Less available water also appeared to affect plant composition, with fewer grasses and forbs relative to shrubs in the herbaceous layer of transects. In vegetation plots, there was a significant decrease in coyote willow while cottonwood increased in the tree layer and significant decreases in Goodding's willow and cottonwood in the shrub layer. There was also a significant increase in percent cover of dead shrubs.

Although the number of SWFL territories increased in 2011, nest success dropped considerably. This outcome was probably related to dry conditions that affected vegetation cover, causing nests to be more exposed and vulnerable to parasitism and predation. Photos in Figure 9 were taken beneath nest trees and the SWFL nest from Photo station 2 can be detected in the March and August 2011 photos when cover was less than in August 2010, when the nest is not obvious. The photos provide a clear picture of the effect reduced foliage can have on nesting SWFLs. The microclimate is also altered by a more open canopy, increasing the temperature and lowering relative humidity. With dryer conditions, the water table is lower, affecting the amount and duration of surface water, which appears to be an important factor for nesting SWFLs.

The interaction between ground water levels (as represented by river discharge, which is closely correlated), vegetative cover measured using hemispheric photography, and SWFL nest success is graphed in Figure 14. All of the variables decreased in 2011, which is probably not coincidental and likely due to an association between these factors. With only 2 years of data, a distinct correlation may be debatable, but further data collection will help determine if trends continue in this manner.

Based on information gathered during 2 years of monitoring at BDANWR, it appears that ground water levels have an indirect effect on the success of nesting SWFLs. Excavating or realigning the main channel, two of the alternatives being considered to address concerns associated with the sediment plug, would potentially lower the water table and

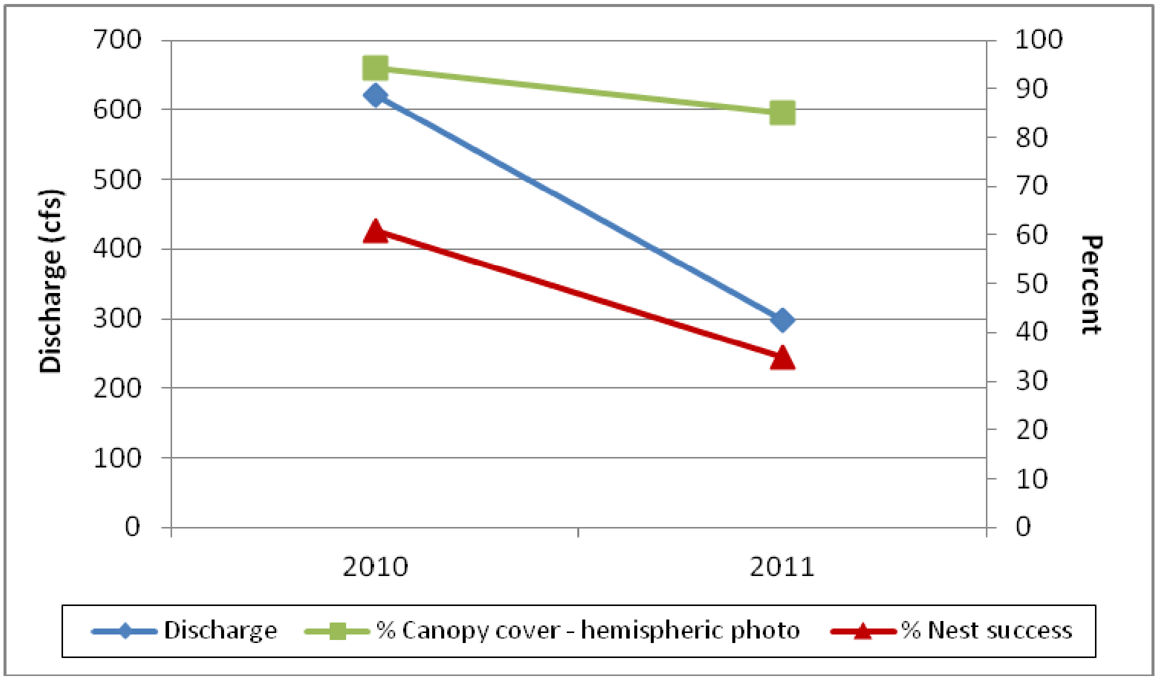


Figure 14.— Rio Grande annual average discharge (cfs) at San Antonio, NM compared with percent canopy cover as measured with hemispheric photography and SWFL nest success in BDANWR in 2010 and 2011.

hypothetically lead to detrimental effects to the breeding SWFLs. The population at BDANWR is important to the success of the species in the Middle Rio Grande as well as in the entire state of New Mexico.

Recommendations

Ground Water Wells

Data obtained from all of the monitoring wells were improved by increasing the depth of the wells, which increases the likelihood of detecting relationships between ground water and river levels at lower flows typical of the Rio Grande. TSC recommends collecting measurements of the bed level of the river channel to have a relative comparison with ground water levels, as the bed level of the river channel has potential to change with implementation of some alternatives. Ground water data will be important in evaluating project alternatives and potential impacts to the existing habitat. Data collected in 2010 and 2011 will be considered baseline for the project.

Vegetation Transects

Vegetation transects should continue to be monitored annually for the duration of the project to acquire vegetation data that is closely associated with hydrologic data collected on site. Data collected in 2010 and 2011 will be considered baseline for the project.

Vegetation Quantification Plots

The 20 permanent vegetation quantification plots should continue to be monitored annually for the duration of the project to examine direct effects to SWFL nesting habitat. Data collected in 2010 and 2011 will be considered baseline for the project.

Hemispheric Photo Stations

Hemispheric photos should continue to be taken in association with vegetation transects and quantification plots to monitor potential effects of changing hydrology on vegetative cover. These photographs have proven to be valuable in visualizing and interpreting cover estimates collected during vegetation monitoring. Photos will be taken annually in the summer and every other year in winter. Data collected in 2010 and 2011 will be considered baseline for the project.

Southwestern Willow Flycatcher Surveys/Nest Monitoring

Reclamation will continue to survey for endangered Southwestern willow flycatchers along the Rio Grande annually. Therefore this data will be available to determine the status of SWFLs in the BDANWR. TSC recommends mapping vegetation in 2012 to update the SWFL habitat suitability model and maps for the Middle Rio Grande.

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Appendix A

Maps of Ground Well, Vegetation Transect,
Vegetation Quantification Plot, and Hemispheric Photo
Monitoring Locations

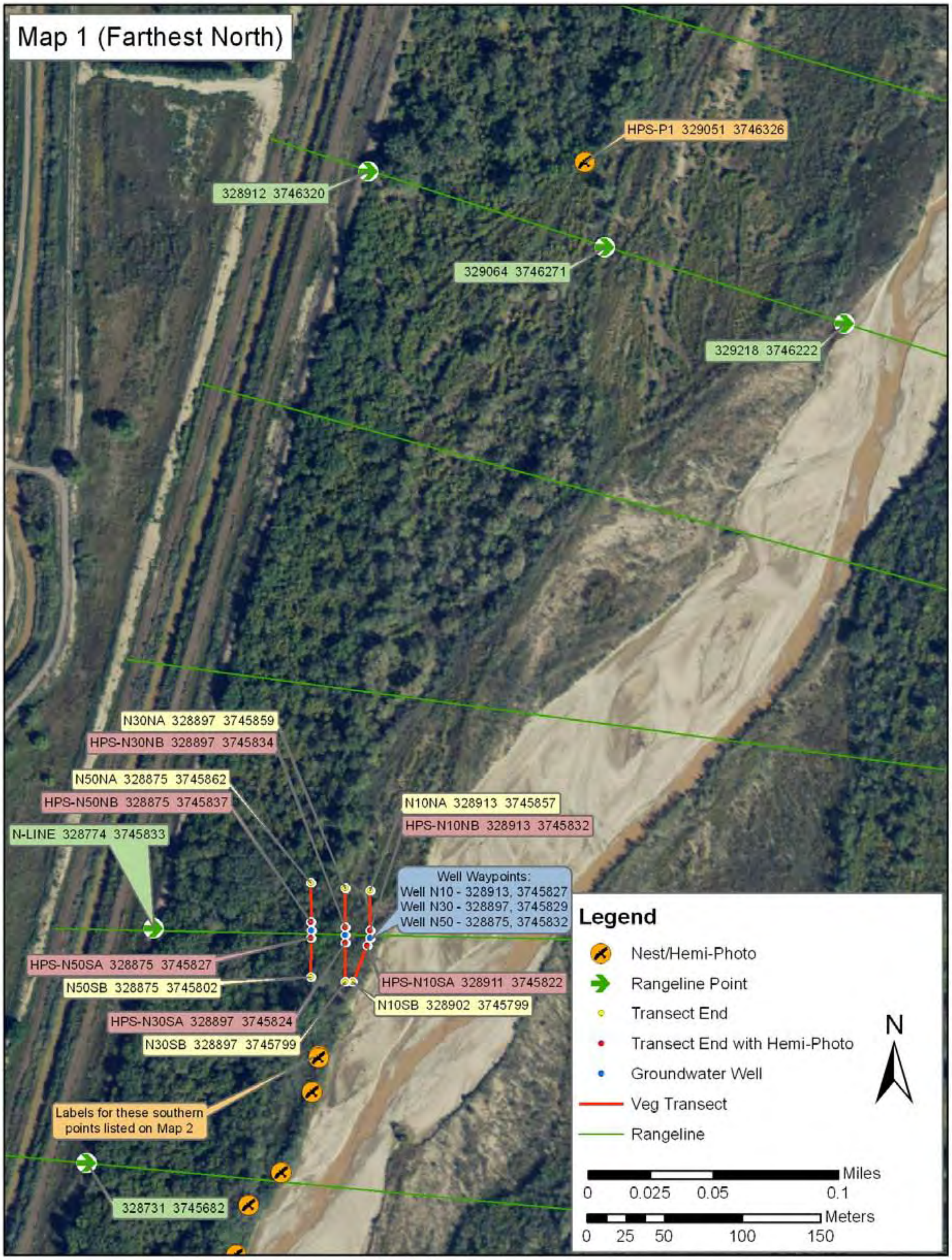


Figure A-1.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations

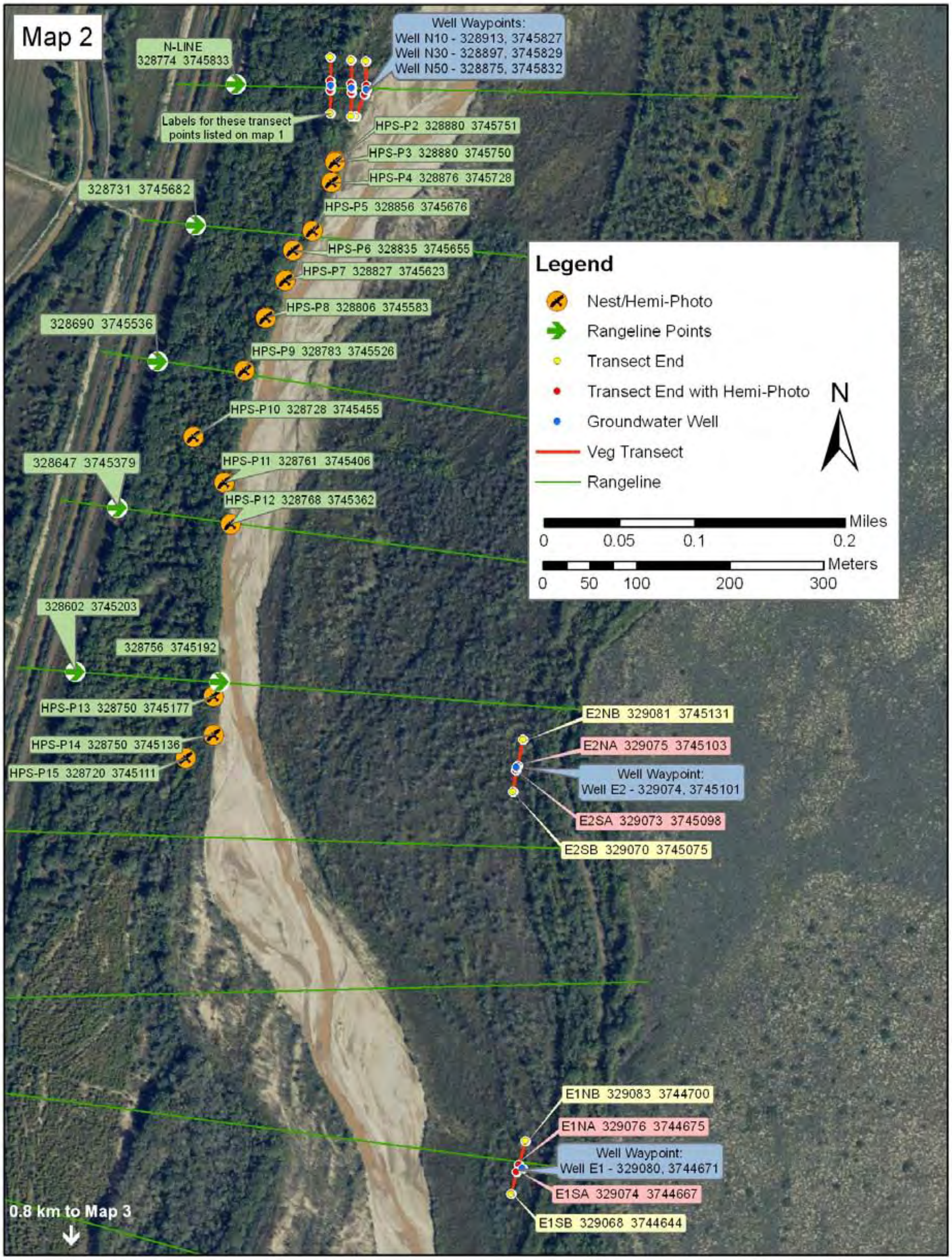


Figure A-2.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

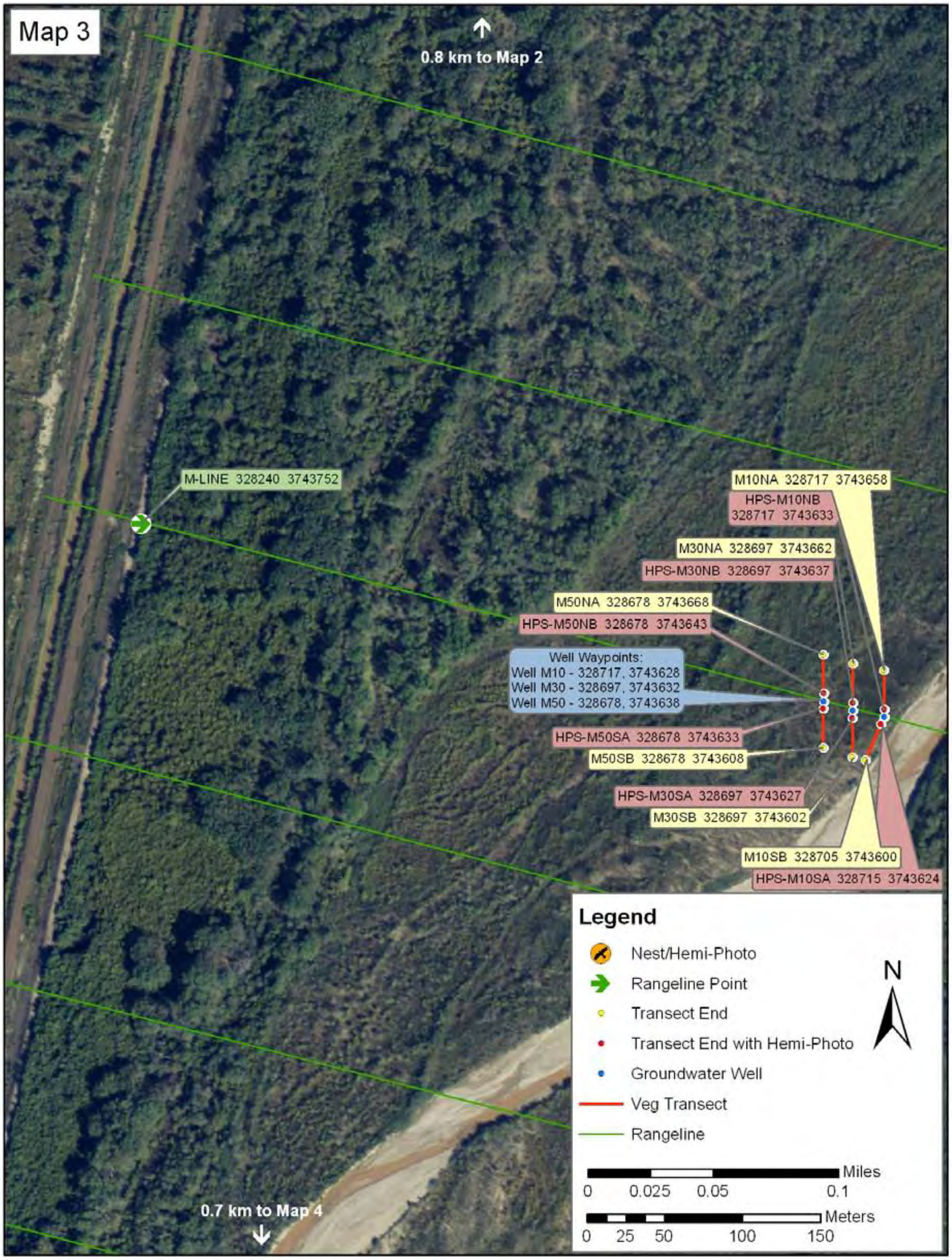


Figure A-3.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

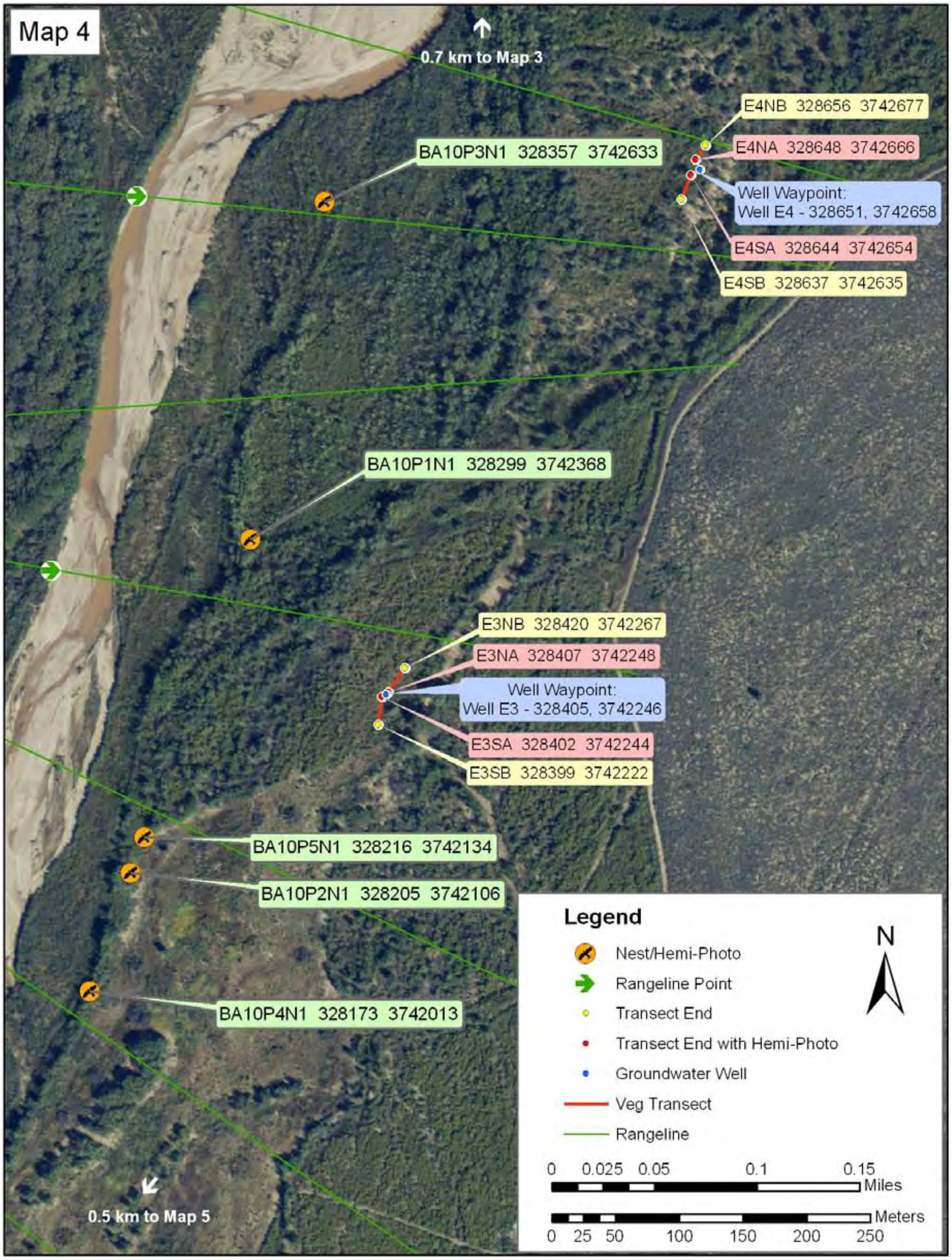


Figure A-4.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

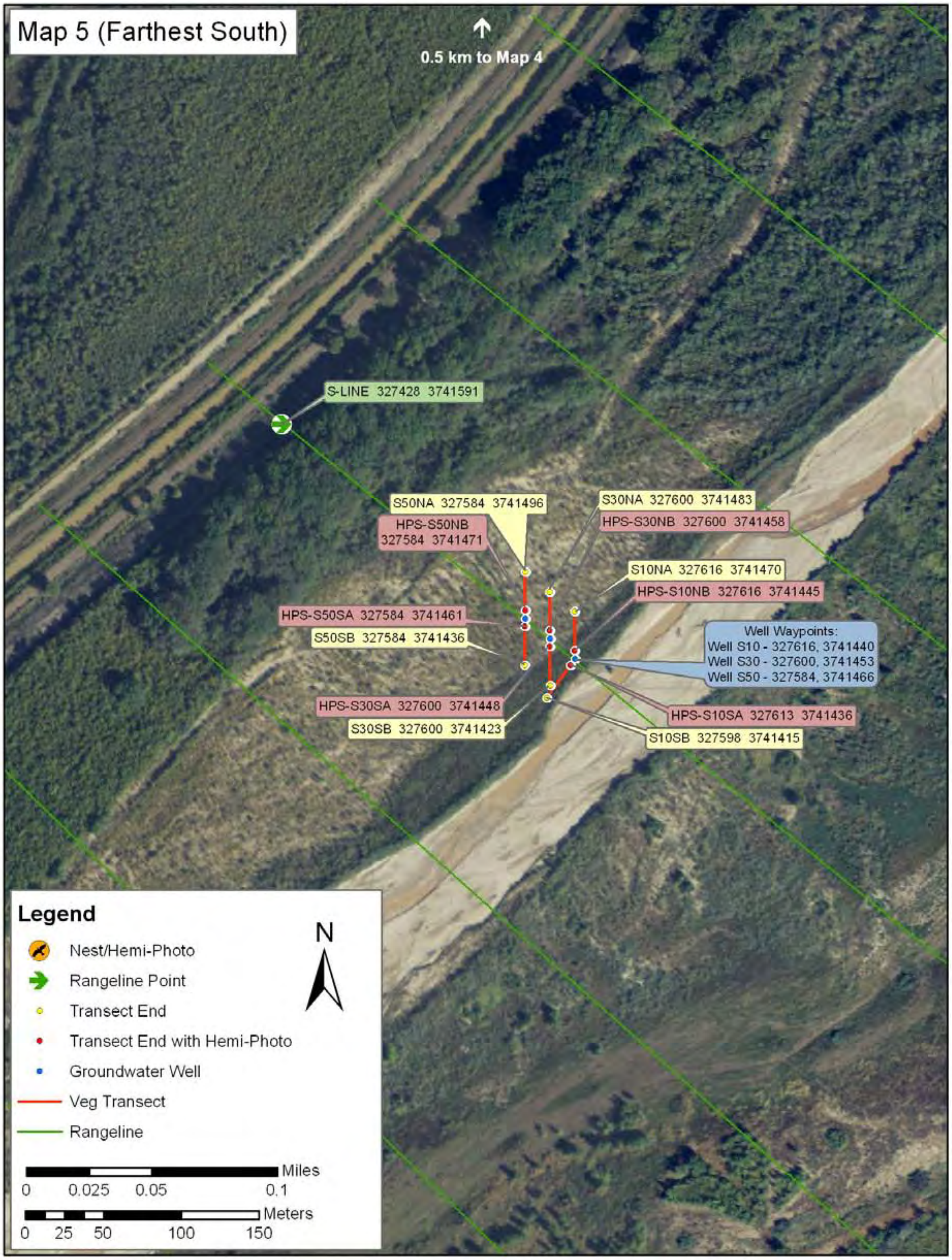
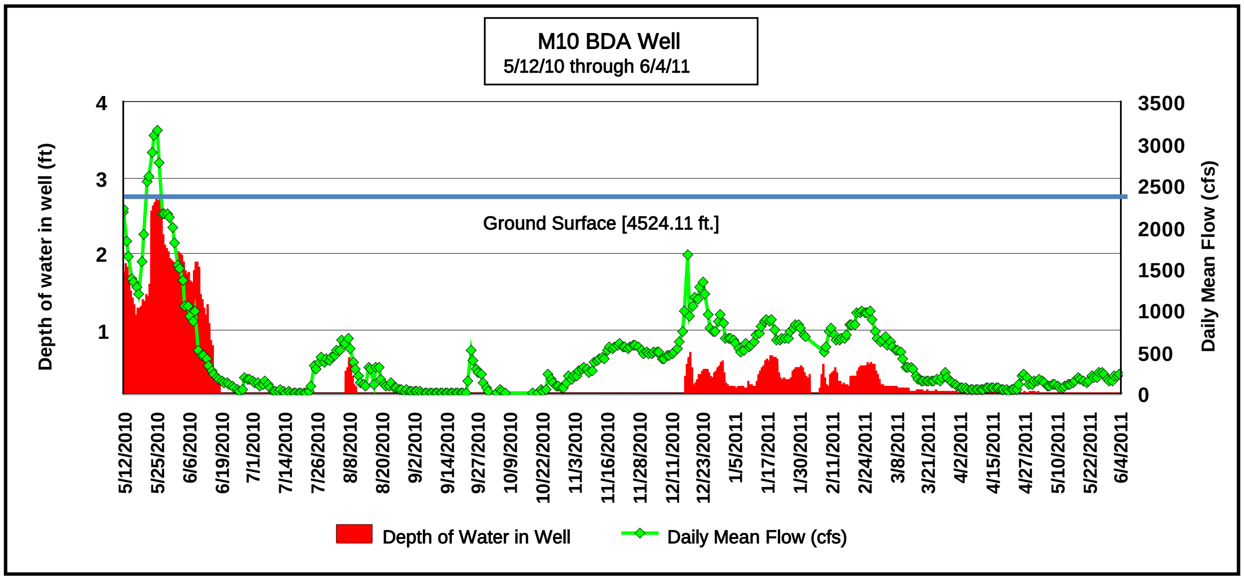


Figure A-5.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

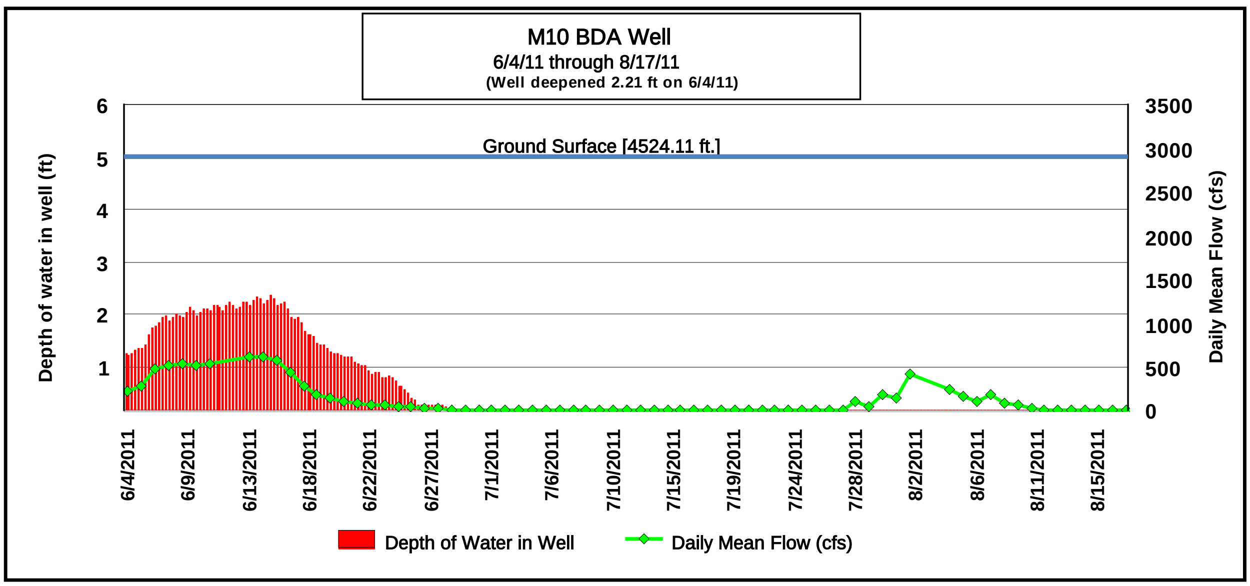
Appendix B

Results of Ground Water Well Monitoring

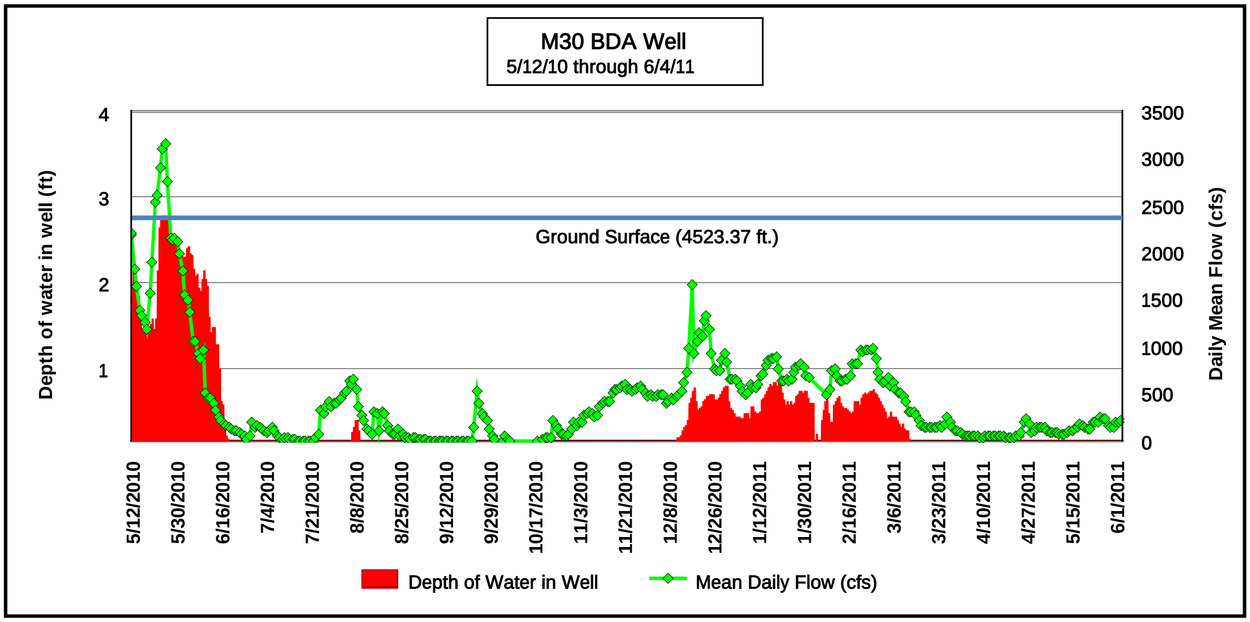
Middle wells



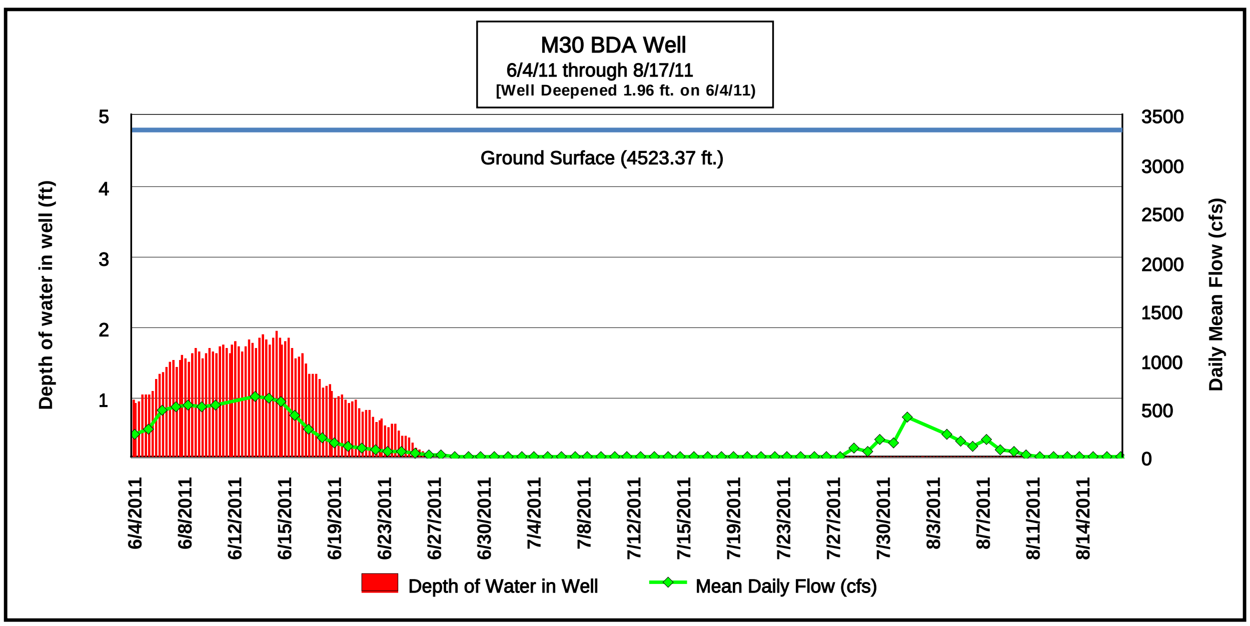
M10 Well at 33.5 in. depth.



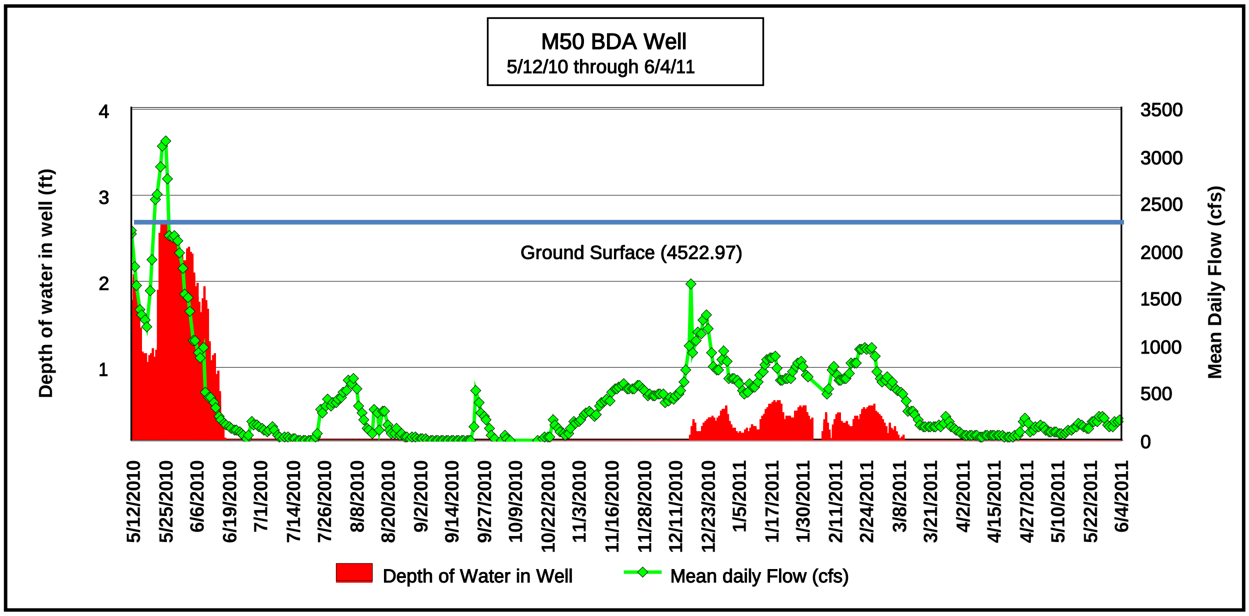
M10 Well at 60 in. depth.



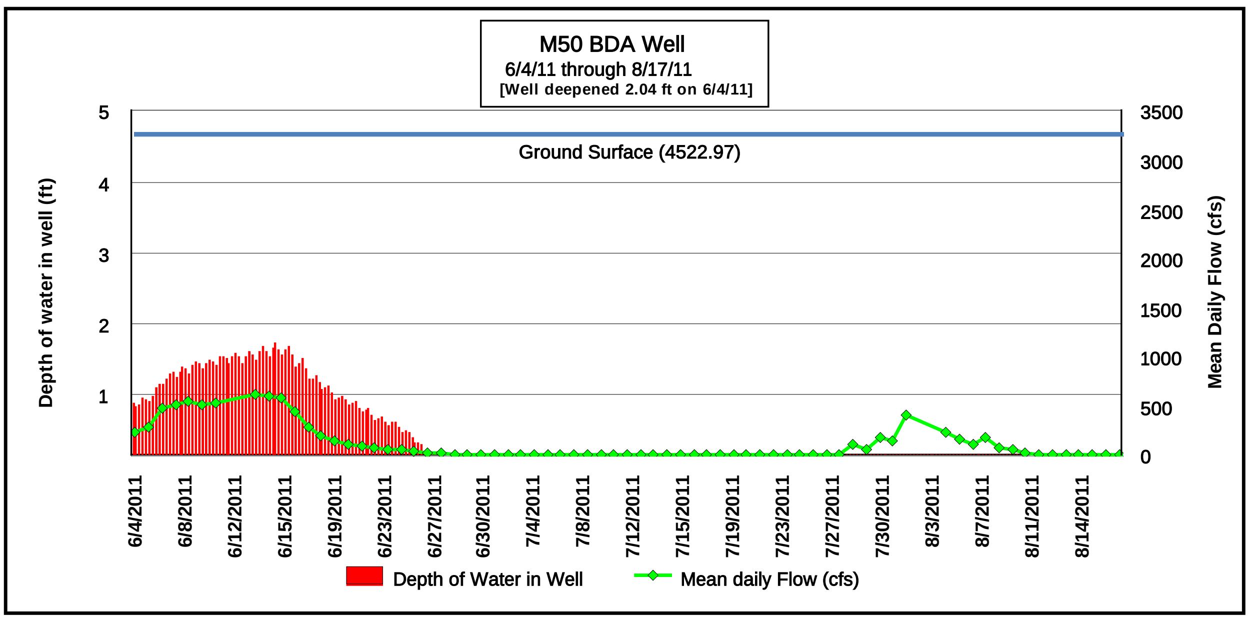
M30 Well at 33.5 in. depth.



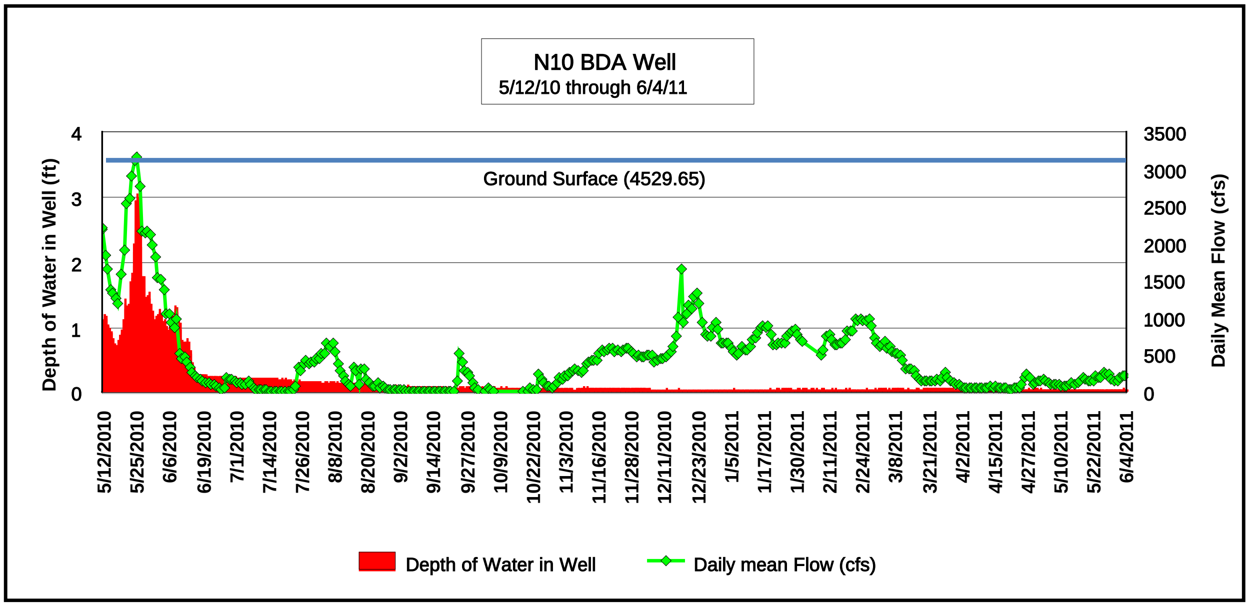
M30 Well at 57 in. depth.



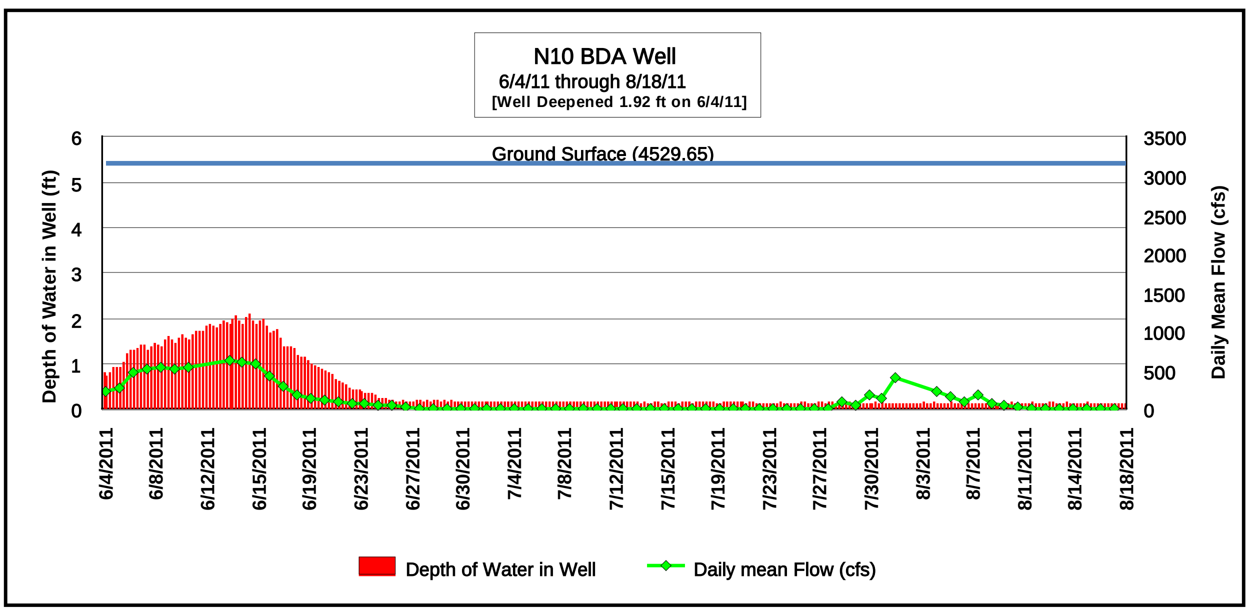
M50 Well at 32.5 in. depth.



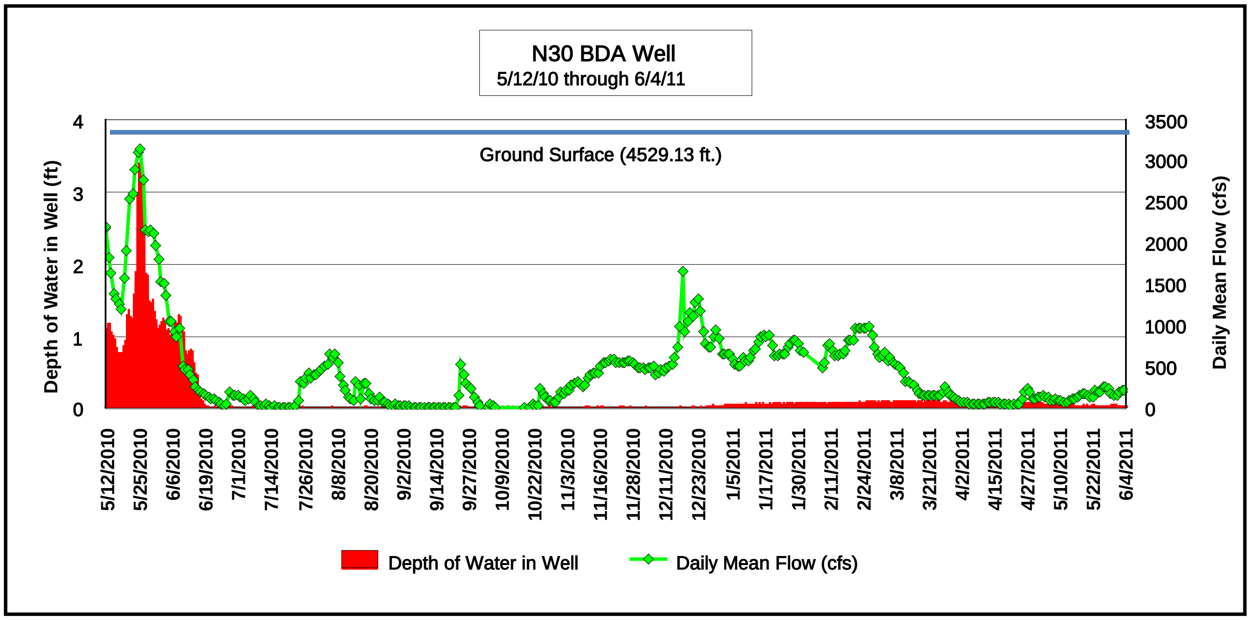
M50 Well at 57 in. depth.



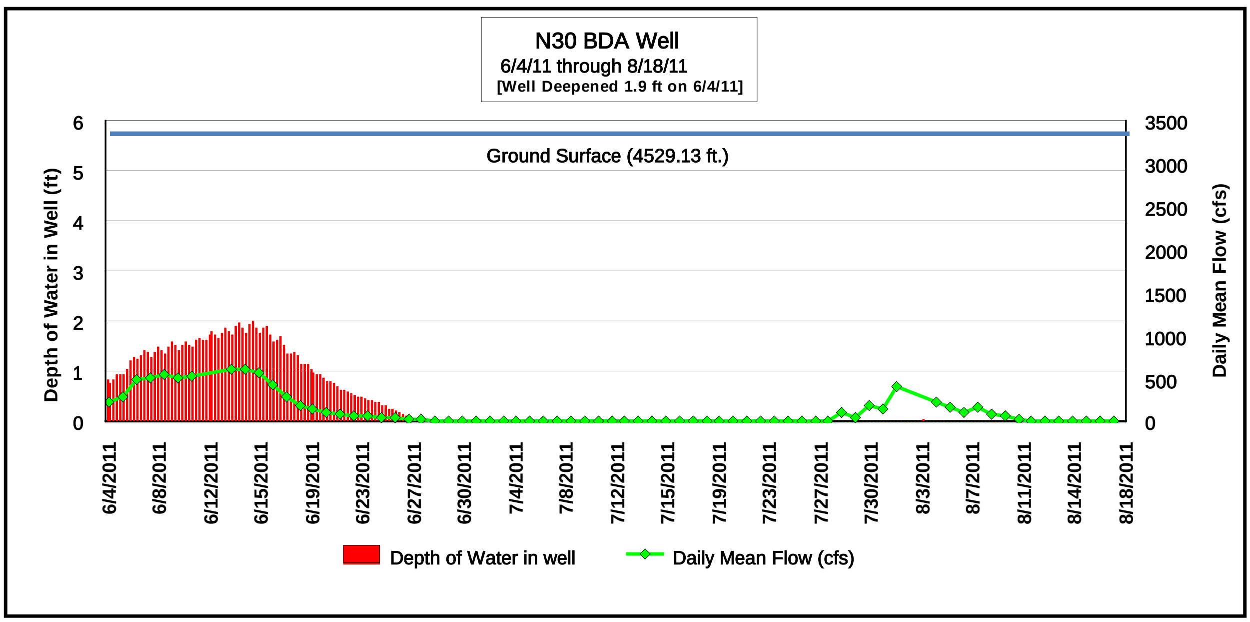
N10 Well at 43 in. depth.



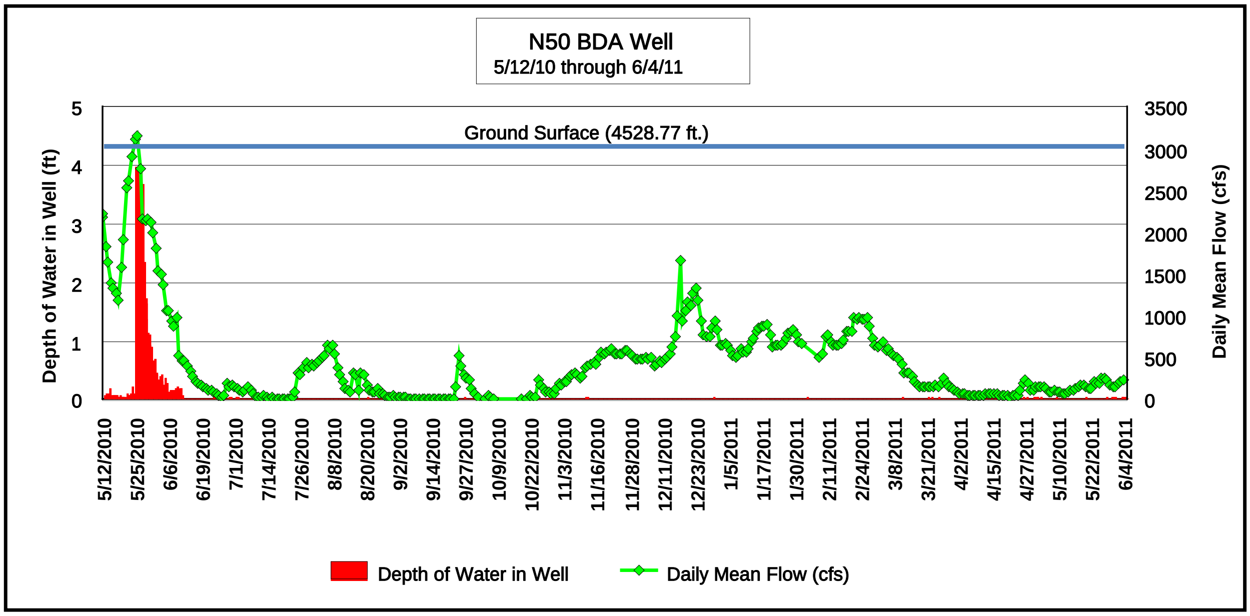
N10 Well at 65 in. depth.



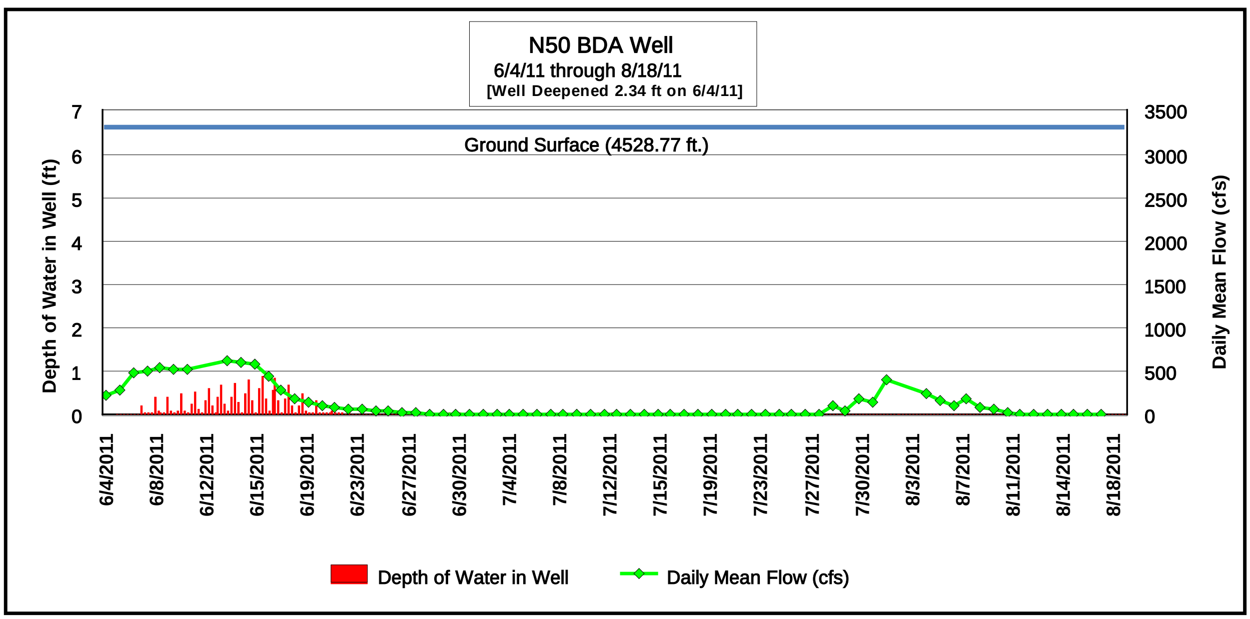
N30 Well at 46.5 in.depth.



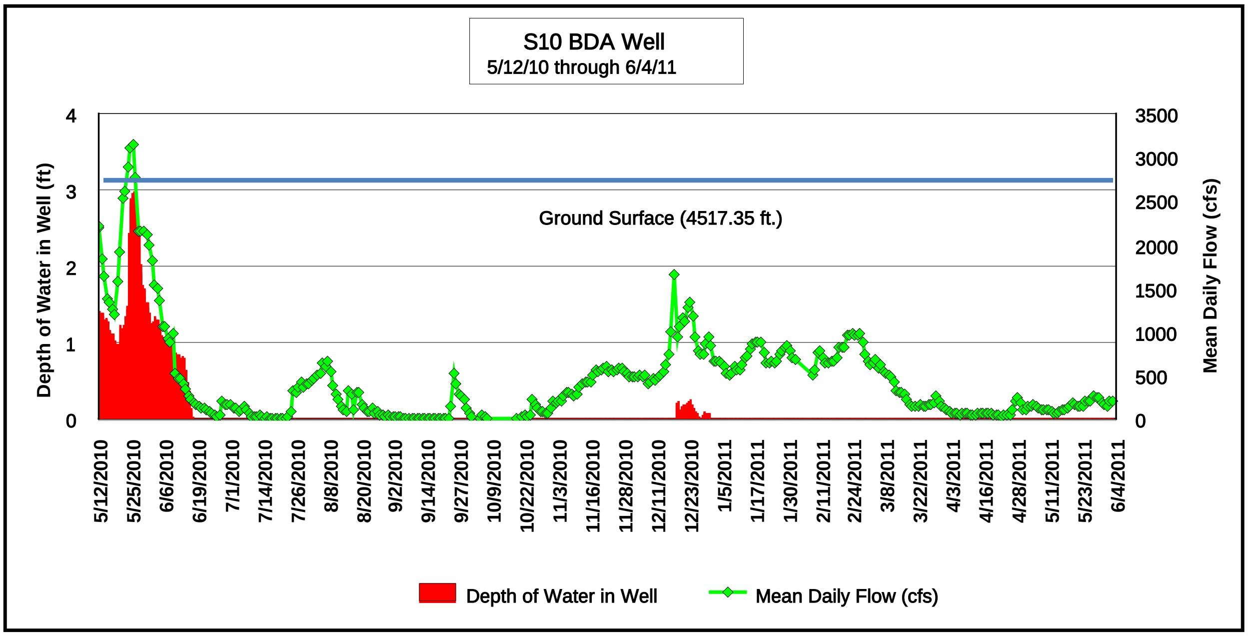
N30 Well at 69 in. depth.



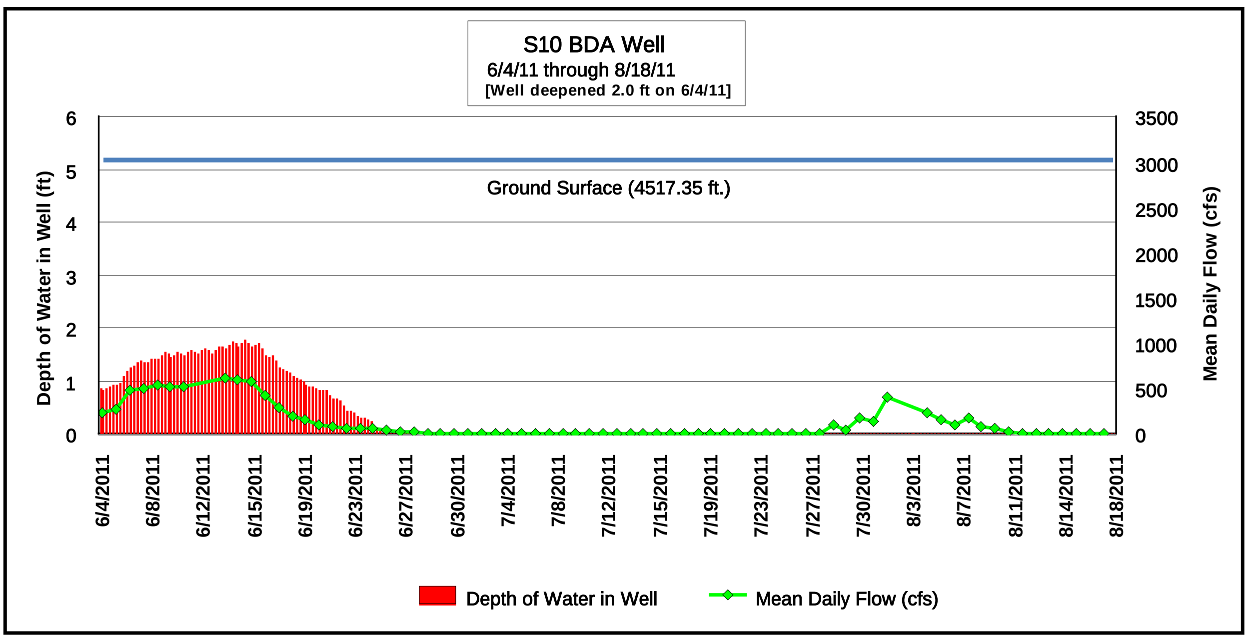
N50 Well at 52 in. depth.



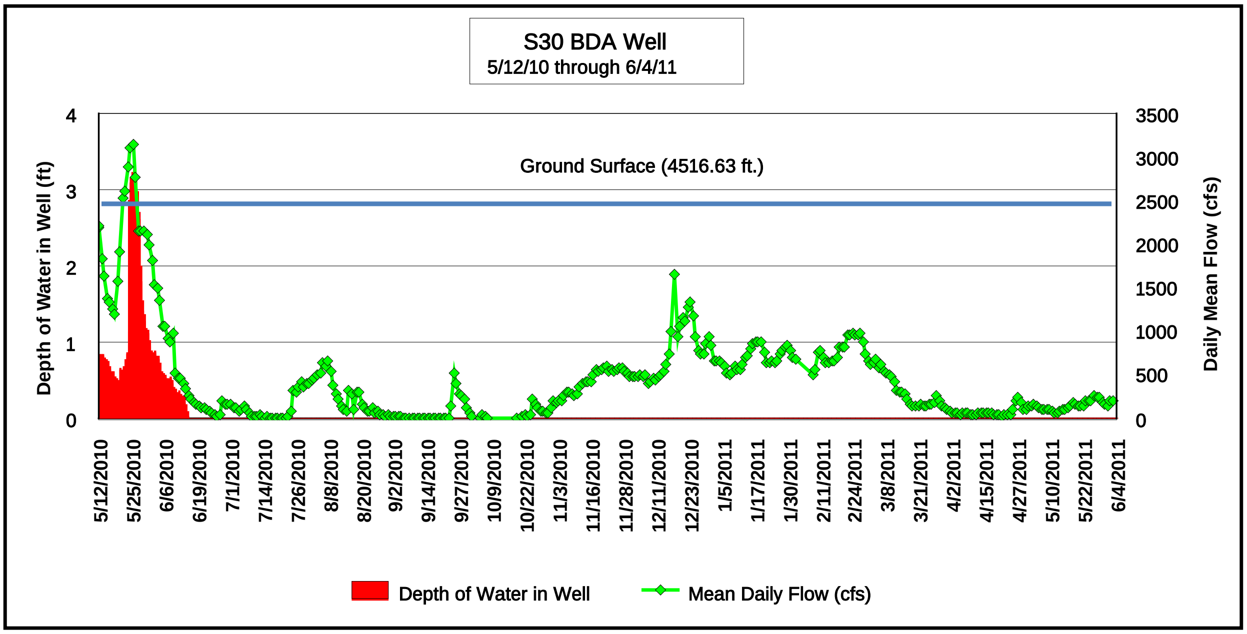
N50 Well at 80 in. depth.



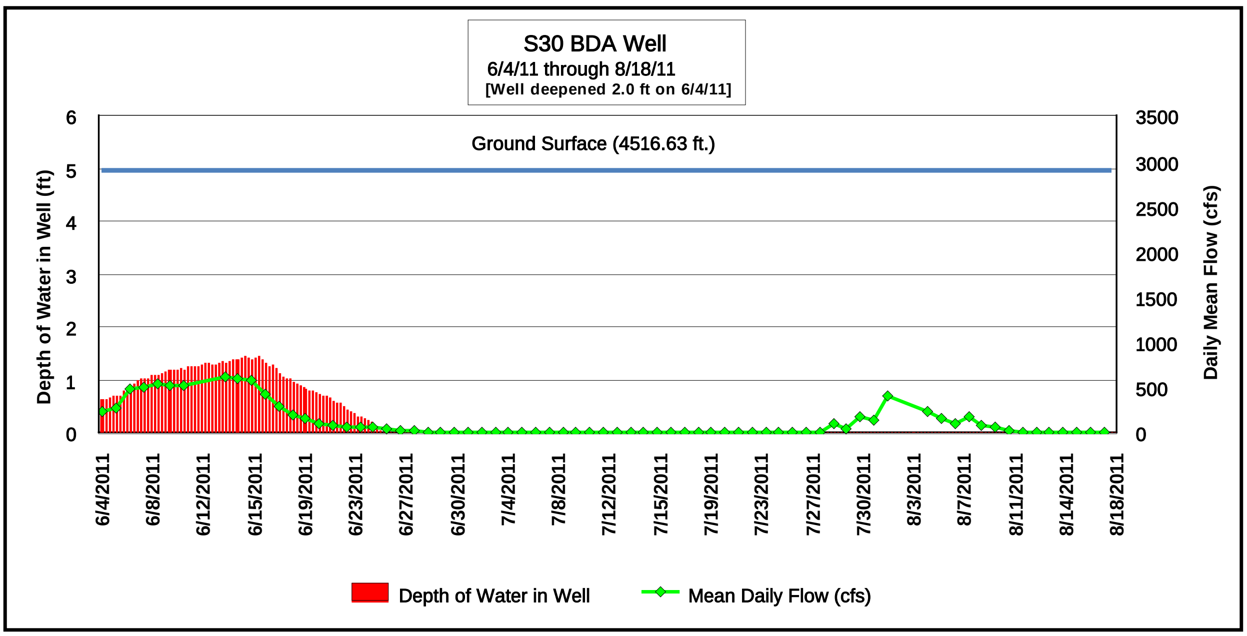
S10 Well at 37 in. depth.



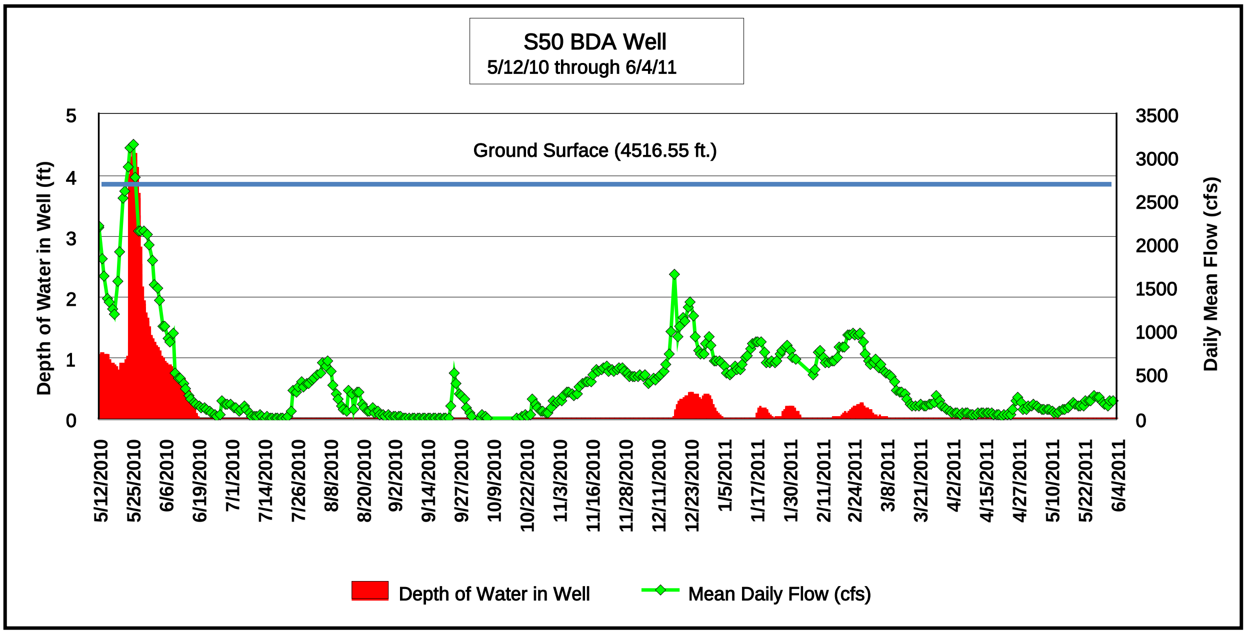
S10 Well at 61 in. depth.



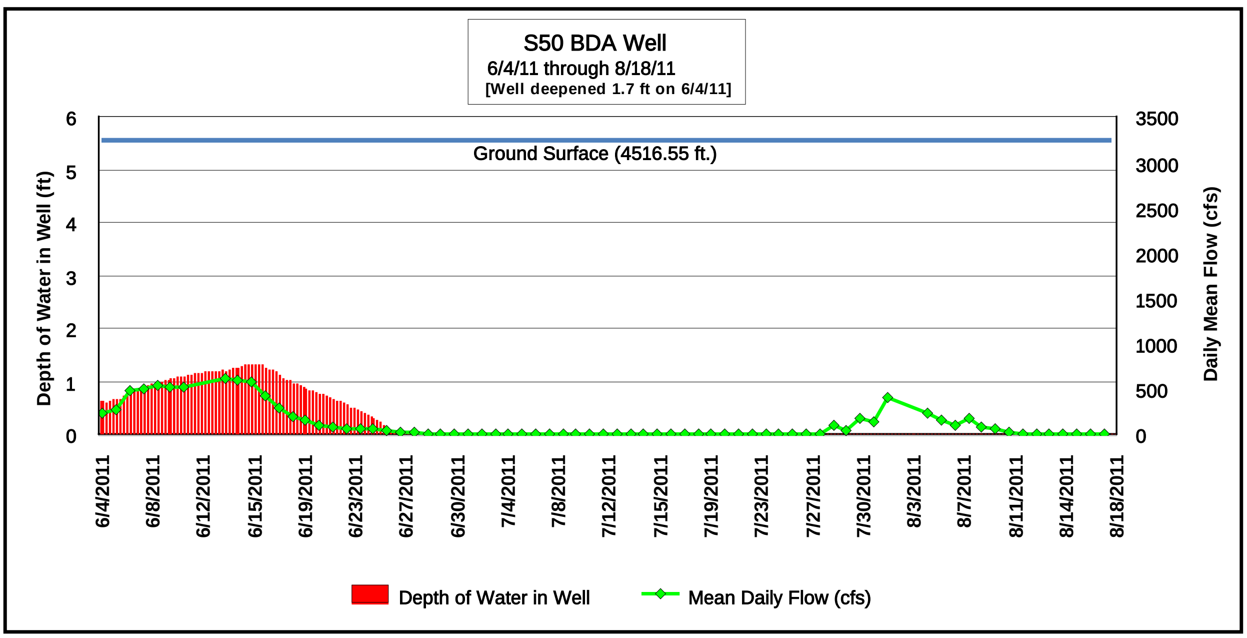
S30 Well at 33.5 in. depth.



S30 Well at 60 in. depth.



S50 Well at 46.5 in. depth.



S50 Well at 67 in. depth.

Appendix C

Total percent cover of individual plant species, life-forms, and cover types
in the understory layer of vegetation transects

Table C-1.—Total percent cover of individual plant species, life-forms, and cover types in the understory layer of transects for the North, Middle, and South Range Lines in 2010 and 2011.

Average Total Percent Cover - Understory Layer West Side Transects						
	North		Middle		South	
Species	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
Rio Grande ottonwood (*Populus deltoids* ssp. *wislizenii*)	0.0	0.0	1.0	0.7	0.7	0.0
Coyote willow (*Salix exigua*)	0.0	0.3	5.0	2.0	1.3	2.0
Seep willow (*Baccharis salicifolia*)	0.0	0.3	1.3	3.0	0.7	2.0
Screwbean mesquite (Prosopis pubescens)	0.0	0.3	0.0	0.0	0.0	0.0
Total native shrubs	**0.0**	**0.9**	**7.3**	**5.7**	**2.7**	**4.0**
Saltcedar (*Tamarix ramosissima*)	0.0	0.0	0.3	1.3	0.0	2.3
Total introduced shrubs	**0.0**	**0.0**	**0.3**	**1.3**	**0.0**	**2.3**
Witchgrass (*Panicum capillare*)	0.0	0.0	0.3	0.0	0.7	0.0
Thin paspalum (*Paspalum setaceum*)	1.0	0.0	2.7	1.6	3.6	0.3
Sedge (*Carex* sp.)	0.0	0.0	0.0	0.0	2.7	0.0
Teal lovegrass (*Eragrostis hypnoides*)	0.0	0.0	0.3	0.0	0.3	0.0
Common reed (*Phragmites australis*)	1.0	0.0	0.0	0.0	0.0	0.0
Hardstem bulrush (*Schoenoplectus acutus*)	0.0	0.0	0.7	0.0	0.0	0.0
Baltic rush (*Juncus balticus*)	0.0	0.0	0.0	0.3	0.0	0.0
Total native grasses	**2.0**	**0.0**	**4.0**	**1.9**	**7.3**	**0.3**
Barnyard grass (*Echinochloa crus-galli*)	0.3	0.0	0.3	0.0	2.0	0.0
Total introduced grasses	**0.3**	**0.0**	**0.3**	**0.0**	**2.0**	**0.0**
Horseweed (*Conyza canadensis*)	1.7	0.0	0.7	0.0	1.3	0.0
Beggarstick (*Bidens frondosa*)	0.3	0.0	0.0	0.0	0.0	0.0
Spearleaf rabbitbrush (*Chrysothamnus linifolius*)	0.0	0.0	0.3	0.3	2.7	0.7
Cottonbatting cudweed *(Pseudognaphalium stramineum*)	0.0	0.0	0.3	0.7	0.0	0.0
Hooker's evening primrose (*Oenothera elata*)	0.7	0.0	0.3	0.0	0.0	0.0
Bundleflower (*Desmanthus illinoensis*)	0.3	0.0	0.0	0.0	0.0	0.0
American water horehound (*Lycopus americanus*)	0.0	0.0	0.0	0.0	0.3	0.0
Smooth scouringrush (*Equisetum laevigatum*)	0.0	0.0	0.0	0.0	1.3	0.7
Total native forbs	**3.0**	**0.0**	**1.6**	**1.0**	**5.6**	**1.4**
White sweetclover (*Melilotus albus*)	0.7	0.0	9.3	2.3	0.7	0.0
Total Introduced forbs	**0.7**	**0.0**	**9.3**	**2.3**	**0.7**	**0.0**
Total herbacious vegetation	6.0	0.9	22.8	12.2	18.3	8.0
Litter	88.0	98.3	74.0	86.3	64.0	80.3
Bare soil	5.3	0.7	3.0	1.7	17.7	11.7
Total cover	**99.3**	**99.9**	**99.8**	**100.2**	**100.0**	**100.0**

Table C-2.—Total percent cover of individual plant species, life-forms, and cover types in the understory layer of transects for the North and South transects on the East side in 2011.

Average Total Percent Cover - Understory Layer East Side Transects		
Species	**North transects**	**South transects**
Rio Grande cottonwood (*Populus deltoides* ssp. *wislizenii*)	0.0	1.0
Coyote willow (*Salix exigua*)	5.5	3.0
Seep willow (*Baccharis salicifolia*)	0.5	2.0
Total native shrubs	**6.0**	**6.0**
Saltcedar (*Tamarix ramosissima*)	0.5	1.0
Total introduced shrubs	**0.5**	**1.0**
Thin paspalum (*Paspalum setaceum*)	0.0	1.0
Alkali sacaton (*Sporobolus airoides*)	0.0	1.5
Total native grasses	**0.0**	**2.5**
Smooth scouringrush (*Equisetum laevigatum*)	0.5	0.0
Horsetail milkweed (Asclepias subverticillata)	0.0	1.0
Total native forbs	**0.5**	**1.0**
White sweetclover (*Melilotus albus*)	2.0	0.0
Total Introduced forbs	**2.0**	**0.0**
Total herbacious vegetation	9.0	10.5
Litter	90.0	77.5
Bare soil	1.0	11.5
Total cover	**100.0**	**99.5**

Appendix D

Vegetation Transect Photos 2010 and 2011

North Range Line

N10Na

2010

2011

N10Nb

2010

2011

N10Sa

2010

2011

N10Sb

2010

2011

N30Na

2010

2011

N30Nb

2010

2011

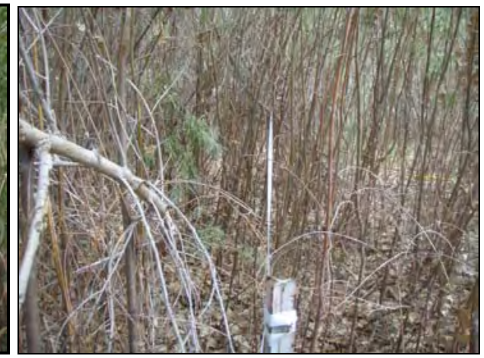
N30Sa

2010

2011

N30Sb

2010



2011

N50Na

2010

2011

N50Nb

2010

2011

N50Sa

2010

2011

N50Sb

2010

2011

Middle Range Line

M10Na

2010

2011

M10Nb

2010

2011

M10Sa

2010

2011

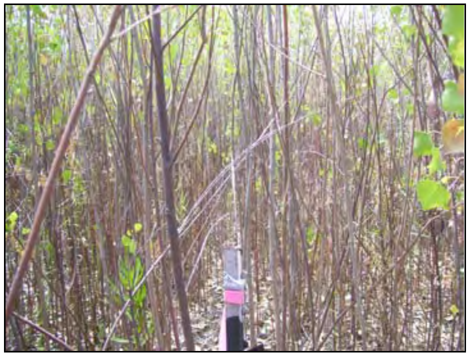
M10Sb

2010

2011

M30Na

2010



2011

M30Nb

2010

2011

M30Sa

2010

2011

M30Sb

2010

2011

M50Na

2010

2011

M50Nb

2010

2011

M50Sa

2010

2011

M50Sb

2010

2011

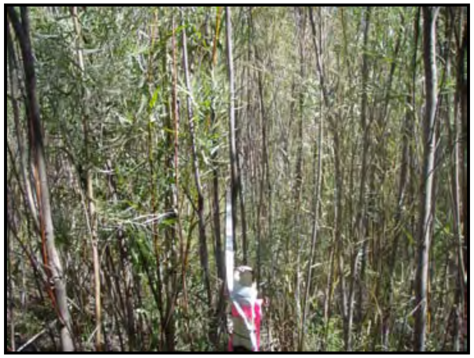
South Range Line

S10Na

2010

2011

S10Nb



2010

2011

S10Sa

2010

2011

S10Sb

2010

2011

S30Na

2010

2011

S30Nb

2010

2011

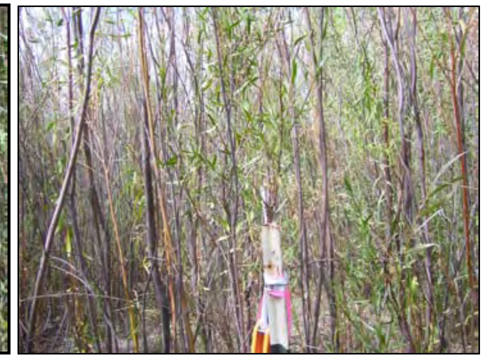
S30Sa

2010

2011

S30Sb

2010



2011

S50Na

2010

2011

S50Nb

2010

2011

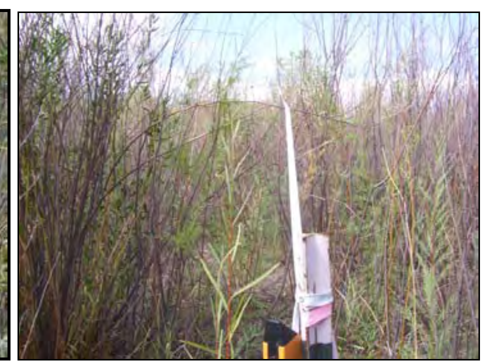
S50Sa

2010

2011

S50Sb

2010



2011

Appendix E

Vegetation Quantification Plots
Tree and Shrub Data by Plot

Table E-1.—Tree data by vegetation quantification plot in 2010 and 2011.

Year	Photo-station/ Plot ID	Height (m)	DBH (cm)	Crown width (m)	Average canopy cover (%) 0 to 3 m	Average canopy cover (%) 3 to 6 m	Average canopy cover (%) >6 m	SAGO	TARA	SAEX	PODE	ELAN	Dead	Class I	Class II	Class III	All classses (trees/ha)
2010	HPS-P1	6.1	6.0	2.1	61.8	47.3	10.3	4.4	66.2	25.0	2.9	1.5	32.0	95.6	2.9	1.5	1680.26
	HPS-P2	5.7	5.6	1.8	61.3	61.3	33.0	38.7	12.9	22.6	9.7	16.1	29.5	74.2	22.6	3.2	766.00
	HPS-P3	6.5	4.1	1.3	63.0	83.0	31.3	9.3	11.6	58.1	7.0	14.0	4.4	88.4	11.6	0.0	1136.64
	HPS-P4	5.5	3.3	1.1	69.7	61.3	24.7	10.5	0.0	47.4	42.1	0.0	0.0	78.9	21.1	0.0	642.45
	HPS-P5	6.0	4.5	1.8	63.0	69.7	31.3	0.0	4.7	82.6	12.8	0.0	0.0	98.8	1.2	0.0	2075.61
	HPS-P6	5.5	4.0	1.8	54.7	61.3	31.3	3.4	6.8	66.1	8.5	15.3	11.9	89.8	8.5	1.7	1383.74
	HPS-P7	6.6	6.1	2.2	63.0	76.3	38.0	12.9	0.0	40.0	41.4	5.7	11.4	68.6	20.0	11.4	2965.16
	HPS-P8	6.1	5.3	2.0	54.7	54.7	39.7	39.6	0.0	35.4	22.9	2.1	5.9	56.3	27.1	16.7	1581.42
	HPS-P9	6.5	8.5	2.5	76.3	61.3	48.0	9.1	58.4	5.2	7.8	19.5	14.4	80.5	15.6	3.9	1482.58
	HPS-P10	6.8	7.2	2.8	44.3	44.3	40.5	17.4	79.3	0.0	3.3	0.0	12.9	86.8	13.2	0.0	2989.87
	HPS-P11	5.8	7.4	2.3	63.0	38.0	18.0	0.0	86.7	6.7	2.2	4.4	3.2	82.2	15.6	2.2	2668.64
	HPS-P12	7.3	9.5	3.3	43.7	39.7	35.3	2.8	47.2	38.7	0.0	11.3	13.8	89.6	10.4	0.0	2075.61
	HPS-P13	6.6	10.2	2.6	83.0	73.0	28.0	41.7	0.0	16.7	8.3	33.3	4.0	83.3	4.2	12.5	1136.64
	HPS-P14	5.3	3.7	1.3	76.3	69.7	16.0	0.0	2.4	92.9	0.0	4.8	4.5	97.6	2.4	0.0	2075.61
	HPS-P15	5.9	5.5	1.6	78.0	63.0	15.3	0.9	81.3	4.5	0.0	13.4	24.3	86.6	13.4	0.0	2767.48
	HPS-P16	4.9	2.4	1.1	76.3	76.3	24.7	3.5	0.0	1.8	94.7	0.0	8.1	86.0	14.0	0.0	1976.77
	HPS-P17	6.5	5.7	1.9	89.0	63.0	21.5	0.0	1.5	1.5	97.0	0.0	2.9	71.2	27.3	1.5	1630.84
	HPS-P18	4.3	2.3	1.0	83.0	53.0	5.0	0.0	72.7	9.1	18.2	0.0	0.0	81.8	18.2	0.0	271.81
	HPS-P19	4.2	2.1	0.6	69.7	46.3	13.7	0.0	4.3	52.2	43.5	0.0	4.2	69.6	21.7	8.7	568.32
	HPS-P20	3.7	1.9	0.7	81.0	34.0	9.0	10.5	0.0	21.1	68.4	0.0	32.1	57.9	36.8	5.3	938.97
2011	HPS-P1	5.6	6.5	1.9	45.5	29.8	7.0	11.8	68.6	19.6	0.0	0.00	19.0	86.3	13.7	0.0	1260.19
	HPS-P2	6.7	3.7	1.0	31.3	46.3	24.7	13.3	33.3	33.3	20.0	0.00	6.3	73.3	26.7	0.0	741.29
	HPS-P3	6.1	5.3	2.3	27.0	38.0	31.3	16.3	12.2	36.7	6.1	28.57	16.9	77.6	18.4	4.1	1210.77
	HPS-P4	5.8	3.6	1.1	54.7	54.7	18.0	4.2	8.3	54.2	33.3	0.00	4.0	70.8	29.2	0.0	1186.06
	HPS-P5	5.0	3.3	1.4	54.7	38.0	9.3	0.0	13.5	56.8	29.7	0.00	7.5	97.3	2.7	0.0	1828.51
	HPS-P6	5.5	4.0	1.9	48.0	54.7	20.3	2.1	14.6	72.9	4.2	6.25	23.8	97.9	2.1	0.0	1186.06
	HPS-P7	5.9	6.2	2.6	46.3	46.3	31.3	15.4	1.9	36.5	36.5	9.62	17.5	65.4	23.1	11.5	2569.80
	HPS-P8	5.6	5.3	2.2	54.7	46.3	33.0	48.3	0.0	17.2	27.6	6.90	12.1	37.9	41.4	20.7	1433.16
	HPS-P9	6.4	7.5	2.9	54.7	54.7	39.7	8.7	34.8	0.0	17.4	39.13	32.4	56.5	34.8	8.7	1136.64
	HPS-P10	5.4	7.0	2.8	44.3	34.3	13.3	35.6	56.2	0.0	8.2	0.00	0.0	65.8	30.1	4.1	1803.81
	HPS-P11	5.1	5.0	2.0	61.3	61.3	5.0	0.0	83.8	10.8	5.4	0.00	2.6	83.8	13.5	2.7	1828.51
	HPS-P12	6.6	6.7	4.1	43.7	43.7	16.0	0.0	78.9	0.0	0.0	21.05	11.6	81.6	18.4	0.0	1877.93
	HPS-P13	3.3	2.7	2.0	54.7	54.7	27.0	45.5	0.0	9.1	9.1	36.36	15.4	81.8	9.1	9.1	543.61
	HPS-P14	5.2	3.6	1.8	76.3	69.7	9.3	0.0	0.0	88.9	3.7	7.41	6.9	96.3	0.0	3.7	1334.32
	HPS-P15	5.4	3.7	2.3	68.0	63.0	7.0	0.0	91.1	0.0	0.0	8.86	15.1	79.7	20.3	0.0	1952.06
	HPS-P16	5.3	2.5	1.3	54.7	63.0	13.7	1.8	0.0	0.0	98.2	0.00	6.6	75.4	24.6	0.0	2816.90
	HPS-P17	7.1	7.2	2.5	56.8	44.3	19.8	0.0	1.5	0.0	98.5	0.00	5.7	56.1	40.9	3.0	1630.84
	HPS-P18	4.1	2.1	1.1	42.3	29.8	3.8	0.0	62.5	0.0	37.5	0.00	0.0	62.5	25.0	12.5	197.68
	HPS-P19	4.7	3.1	1.3	50.5	44.3	15.3	0.0	5.0	45.0	50.0	0.00	45.9	65.0	25.0	10.0	494.19
	HPS-P20	4.1	2.5	1.0	50.5	31.0	7.0	3.0	0.0	21.2	75.8	0.00	2.9	54.5	33.3	12.1	815.42

*SAGO=Gooddings willow; TARA=Saltcedar; SAEX=Coyote willow; PODE=Cottonwood; ELAN=Russian olive

Table E-2.—Shrub data by vegetation quantification plot in 2010 and 2011.

Year	Plot ID	Height (m)	Crown width (m)	Shrub stem spp comp (%)							Total # live stem/m^2
				SAGO	TARA	SAEX	PODE	BASA	ELAN	Dead	
2010	HPS-P1	1.3	0.4	4.7	75.7	10.3	0.0	0.0	9.3	38.2	2.38
	HPS-P2	1.7	0.7	26.4	26.4	19.8	0.0	24.2	3.3	43.1	2.70
	HPS-P3	1.3	0.4	12.7	3.2	80.0	0.5	0.0	3.6	32.7	2.05
	HPS-P4	1.4	0.4	0.0	35.9	51.2	9.4	3.1	0.4	19.0	1.58
	HPS-P5	1.5	0.3	0.0	40.5	52.7	6.8	0.0	0.0	16.7	1.39
	HPS-P6	1.4	0.3	18.5	0.8	66.4	7.6	0.0	6.7	50.0	3.13
	HPS-P7	1.8	0.5	0.0	1.3	90.0	8.8	0.0	0.0	59.2	4.93
	HPS-P8	1.3	0.4	46.2	1.1	30.1	22.6	0.0	0.0	42.9	3.58
	HPS-P9	1.6	0.5	0.0	51.3	5.1	0.0	0.0	43.6	15.2	1.27
	HPS-P10	1.8	0.7	43.2	56.8	0.0	0.0	0.0	0.0	51.9	3.25
	HPS-P11	1.3	0.3	0.0	58.5	41.5	0.0	0.0	0.0	33.3	2.78
	HPS-P12	1.3	0.4	0.0	72.9	22.4	0.0	0.0	4.7	24.1	1.51
	HPS-P13	2.3	0.7	4.4	0.0	65.6	30.0	0.0	0.0	25.0	2.08
	HPS-P14	1.5	0.5	0.0	0.0	87.4	12.6	0.0	0.0	39.1	3.25
	HPS-P15	1.9	0.6	3.0	62.7	0.0	0.0	0.0	23.9	55.3	3.46
	HPS-P16	1.9	0.5	3.3	11.1	61.1	24.4	0.0	0.0	46.1	3.84
	HPS-P17	1.3	0.3	0.0	20.7	46.3	32.9	0.0	0.0	66.7	4.17
	HPS-P18	1.4	0.5	0.0	4.3	95.7	0.0	0.0	0.0	15.3	0.95
	HPS-P19	1.6	0.4	0.0	4.5	95.5	0.0	0.0	0.0	50.0	3.13
	HPS-P20	0.9	0.3	0.0	1.1	94.3	4.5	0.0	0.0	58.3	3.64
2011	HPS-P1	1.5	3.2	0.0	74.4	25.6	0.0	0.0	0.0	69.0	4.32
	HPS-P2	1.0	0.1	30.2	0.0	69.8	0.0	0.0	0.0	85.9	7.15
	HPS-P3	1.6	1.0	9.7	64.5	25.8	0.0	0.0	0.0	75.9	4.74
	HPS-P4	1.1	0.4	0.0	0.0	57.9	0.0	0.0	42.1	70.3	5.86
	HPS-P5	1.5	0.4	0.0	18.2	80.3	1.5	0.0	0.0	49.2	4.10
	HPS-P6	1.0	0.4	3.8	0.0	96.2	0.0	0.0	0.0	81.8	5.11
	HPS-P7	1.3	0.9	0.0	0.0	100.0	0.0	0.0	0.0	60.6	5.05
	HPS-P8	1.2	0.3	0.0	4.1	87.8	8.2	0.0	0.0	50.0	4.17
	HPS-P9	1.0	0.4	0.0	62.0	0.0	0.0	0.0	38.0	55.1	4.59
	HPS-P10	1.7	1.0	5.3	47.4	0.0	0.0	47.4	0.0	91.0	5.69
	HPS-P11	1.2	0.4	0.0	80.5	19.5	0.0	0.0	0.0	50.2	4.19
	HPS-P12	1.1	0.4	0.0	83.5	16.5	0.0	0.0	0.0	62.7	5.23
	HPS-P13	1.3	0.7	0.0	0.0	77.9	22.1	0.0	0.0	50.6	4.21
	HPS-P14	1.5	0.5	0.0	0.0	90.5	9.5	0.0	0.0	68.2	5.69
	HPS-P15	1.1	1.0	0.0	95.0	0.0	0.0	0.0	5.0	65.9	4.12
	HPS-P16	1.9	0.5	0.0	16.2	66.2	17.6	0.0	0.0	40.3	3.36
	HPS-P17	1.1	0.4	0.0	66.7	30.2	3.2	0.0	0.0	71.4	4.46
	HPS-P18	1.1	0.3	0.0	4.7	94.5	0.8	0.0	0.0	36.2	2.26
	HPS-P19	0.7	0.3	0.0	1.9	98.1	0.0	0.0	0.0	67.2	4.20
	HPS-P20	0.7	0.3	0.0	10.0	78.3	11.7	0.0	0.0	65.9	4.12

*SAGO=Gooddings willow; TARA=Saltcedar; SAEX=Coyote willow; PODE=Cottonwood; BASA=Seep willow; ELAN=Russian olive