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*Managing Water in the West*

# Bosque del Apache Sediment Plug Baseline Studies

## Annual Report 2010

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

**June 2011**

## 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 2010

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**U.S. Department of the Interior**
**Bureau of Reclamation**
**Technical Service Center**
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# Contents

Page

**Introduction** ..... **1**
**Methods** ..... **4**
Ground Water Wells ..... 5
Vegetation Transects ..... 5
Vegetation Quantification Plots ..... 6
Hemispheric Photo Stations ..... 9
Southwestern Willow Flycatcher Surveys ..... 10
**Results and Discussion** ..... **10**
Ground Water Wells ..... 10
Vegetation Transects ..... 11
Vegetation Quantification Plots ..... 15
Hemispheric Photo Stations ..... 17
Southwestern Willow Flycatcher Surveys ..... 19
**Recommendations** ..... **22**
Ground Water Wells ..... 22
Vegetation Transects ..... 22
Vegetation Quantification Plots ..... 22
Hemispheric Photo Stations ..... 22
Southwestern Willow Flycatcher Surveys ..... 22
**Literature Cited** ..... **23**

## Appendices

**Appendix A**—Maps of Ground Well, Vegetation Transect, Vegetation Quantification Plot, and Hemispheric Photo Monitoring Locations
**Appendix B**—Results of Ground Water Well Monitoring
**Appendix C**—Vegetation Transect Photos 2010
**Appendix D**—Vegetation Quantification Plots: Nest Centered, Tree, and Shrub Data by Plot

## Tables

Page

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 Lines in 2010 ..... 12
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 ..... 13
3 Average total percent cover and height of plant species detected within the overstory layer of transects for North, Middle, and South Range Lines in 2010 ..... 13

# Contents (cont.)

## Tables

Page


4 Average percent canopy cover as measured with a densitometer by transect for the North, Middle, and South Range Lines in 2010.....14
5 Average, minimum, and maximum values for each parameter measured in association with nest center as well as the frequency each tree species was used as a nest substrate in the vegetation quantification plots in 2010 .....16
6 Average, minimum, and maximum values of each parameter measured for trees within vegetation quantification plots in 2010.....16
7 Average, minimum, and maximum values of each parameter measured for shrubs within vegetation quantification plots in 2010.....17
8 Percent vegetation cover as measured with hemispheric photography for the vegetation transects and the vegetation quantification plots associated with SWFL nests.....18


## Figures

Page


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).....2
2 Study area and general locations of the ground water wells, vegetation transects, and vegetation plots .....3
3 Vegetation quantification plot layout.....7
4 Riparian habitat showing three different canopy layers .....8
5 Typical SWFL habitat showing lack of upper canopy layer.....9
6 Relative percent cover of life-forms in the understory layer of transects for North, Middle, and South Range Lines in 2010 .....13
7 Example of hemispheric photos taken at the same site in August 2010 (left) and January 2011 (right). Canopy cover August = 93%; Canopy cover January = 52%; Foliage cover = 41%.....18
8 Number of SWFL territories detected in the BDANWR from 2002 to 2010 .....19
9 SWFL territories detected in 2010 within the Northern portion of the BDANWR and habitat suitability as determined in 2008 .....20
10 SWFL territories detected in 2010 within the Southern portion of the BDANWR and habitat suitability as determined in 2008 .....21

# 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 (Figures 1 and 2). 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 lowered. However, other alternatives such as channel realignment and channel excavation could also lower the adjacent water table. AAO is concerned that any of these scenarios could have a

**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.

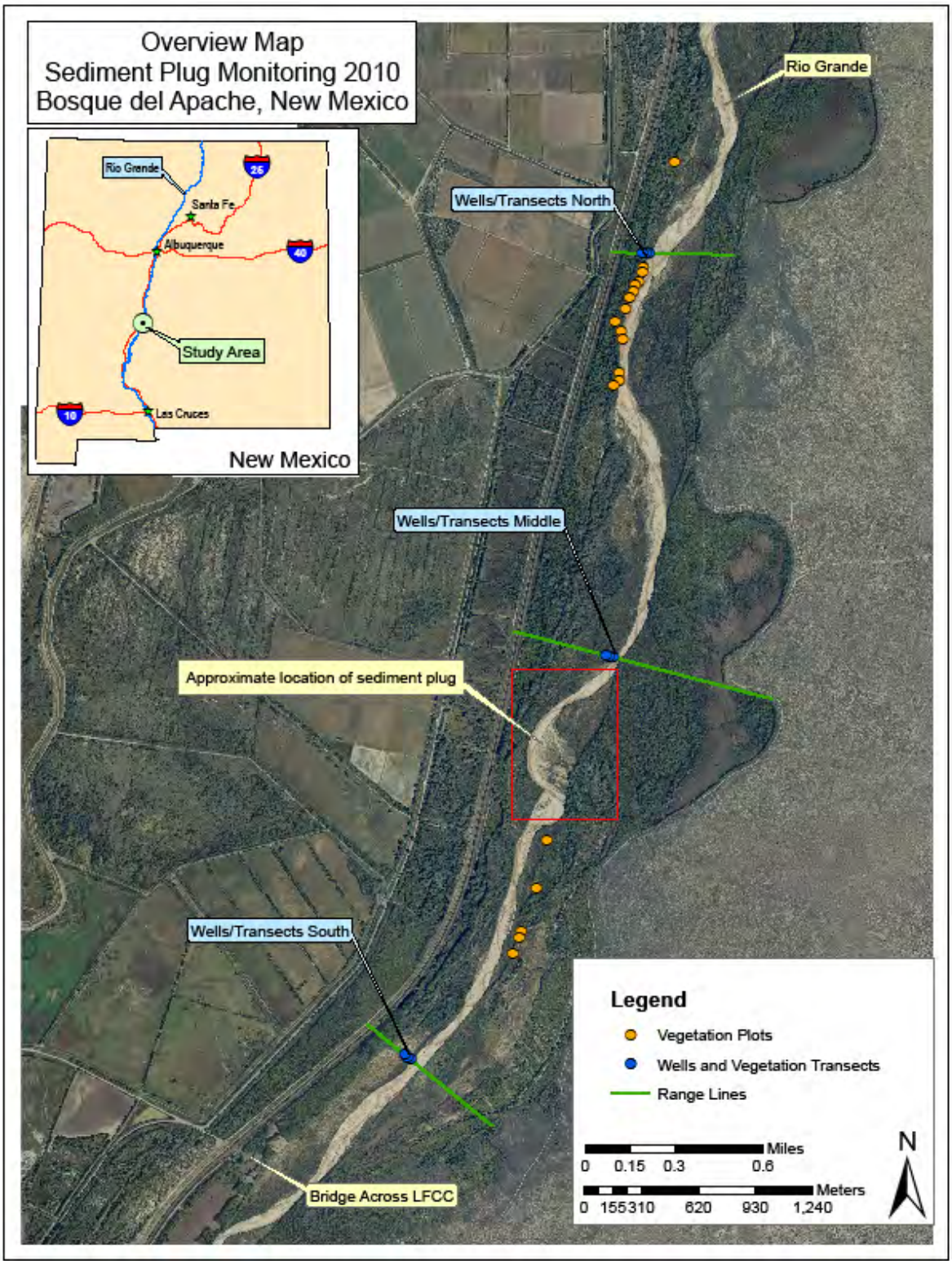


**Figure 2.**—Study area and general locations of the ground water wells, vegetation transects, and vegetation plots.

harmful 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 and 34 in 2010, which was likely correlated with an elevated water table 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 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. The map in Figure 2 shows the study area and includes 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. Range Lines are located upstream of, downstream of, and adjacent to the sediment plug. 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.

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. Wells 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).

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.

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 9 ground water monitoring wells, for a total of 18 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.

In the future, data from each sampling period will be compared to evaluate any statistically significant changes in vegetation over time. The paired t-test will be used to statistically compare normally distributed data, and the signed rank nonparametric test will be used to compare data that are not normally distributed. Because this was the first year of sampling, there were no comparisons to be made and therefore no statistical analyses were completed. Total percent cover (*i.e.* actual cover estimate) was used for understory and overstory cover estimates. 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

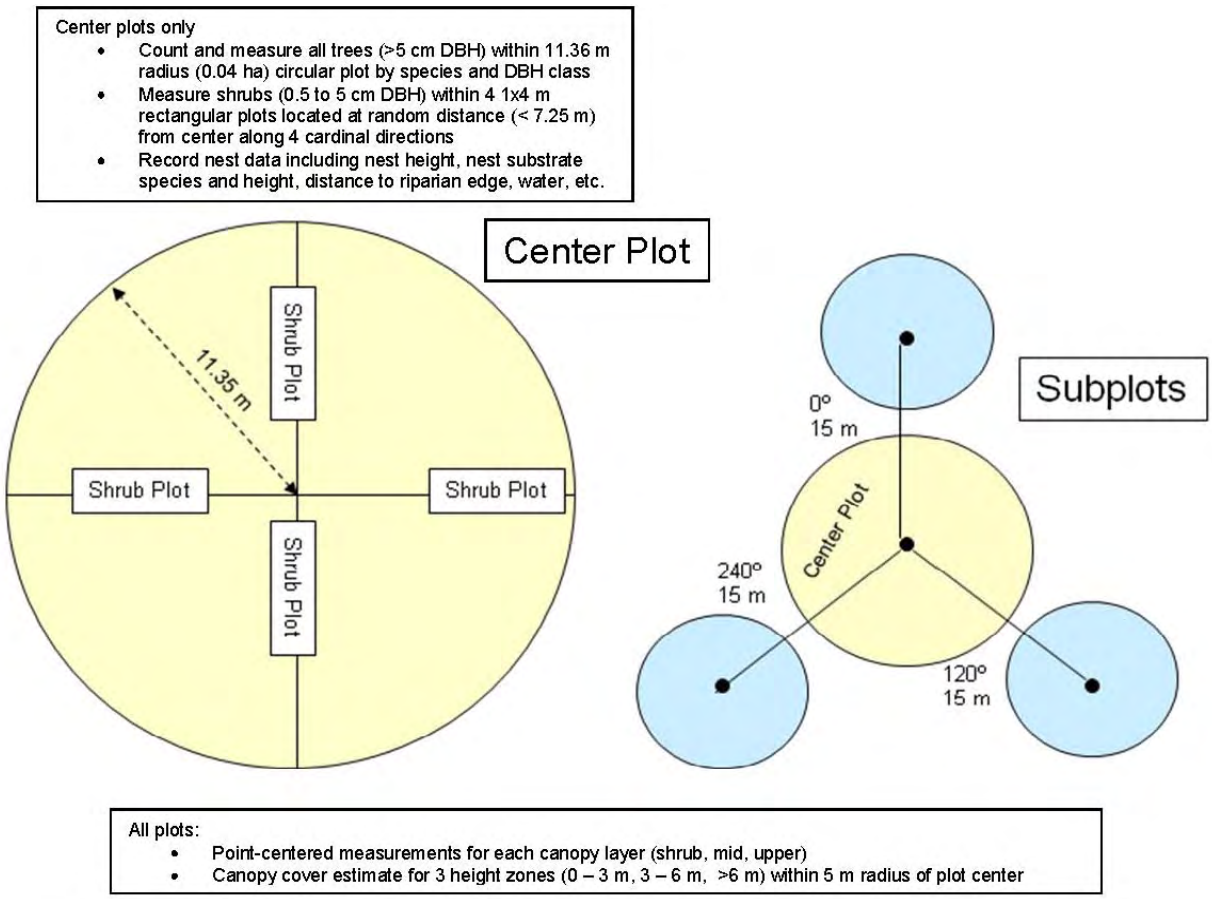


**Figure 3.—**Vegetation quantification plot layout.

the center plot were tallied by species and DBH class and densities, species composition, and percentage of dead trees were computed. Stems were considered trees when diameter at breast height (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 DBH, and Class III consisted of trees greater than 20 cm. 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 and 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. Nest-centered data were recorded within the 11.35 m radius center plot including: nest substrate species, height, and DBH, distance to substrate edge, distance to clump edge, distance to riparian edge, hydrology, distance to water, distance to road, ground cover, and canopy height.

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 equals 0 percent cover, 1 equals 1 to 10 percent, 2 equals 11 to 25 percent, 3 equals 26 to 50 percent, 4 equals 51 to 75 percent, 5 equals 76 to 90 percent, and 6 equals 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.

In the future, data from each sampling period will be compared to evaluate any statistically significant changes in SWFL habitat over time. The paired t-test will be used to statistically compare normally distributed data for vegetation variables, and the signed rank nonparametric test will be used to compare data that are not normally distributed. Because this was the first year of sampling, there were no comparisons to be made and therefore no statistical analyses were completed.

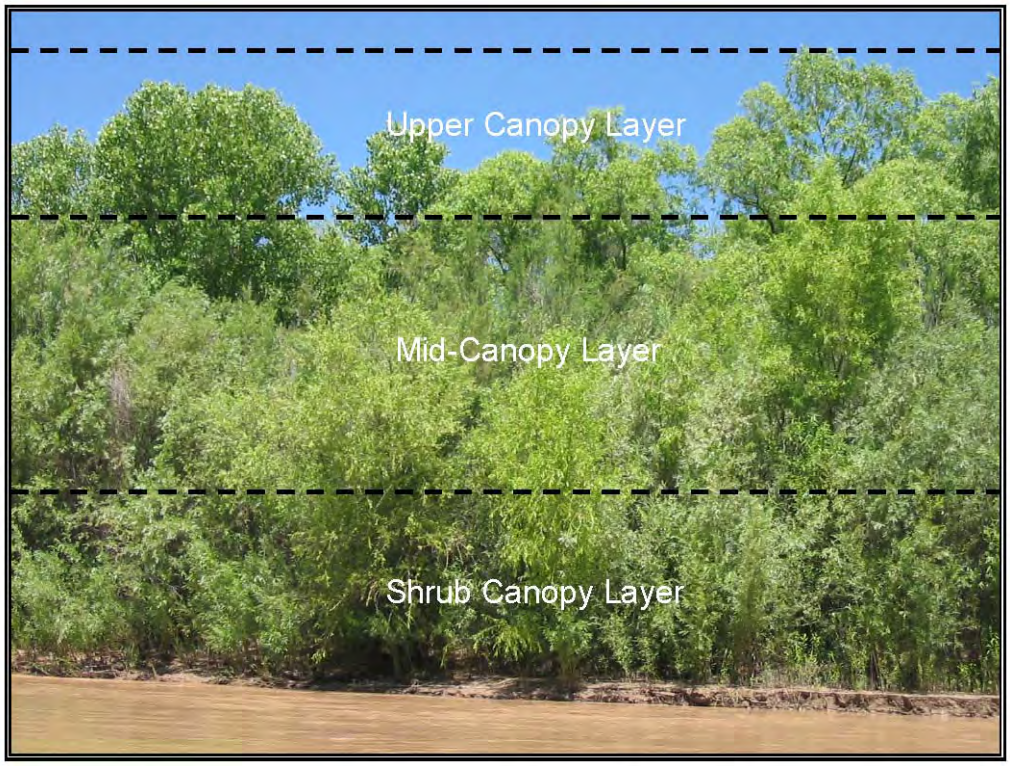


**Figure 4.—**Riparian habitat showing three different canopy layers.

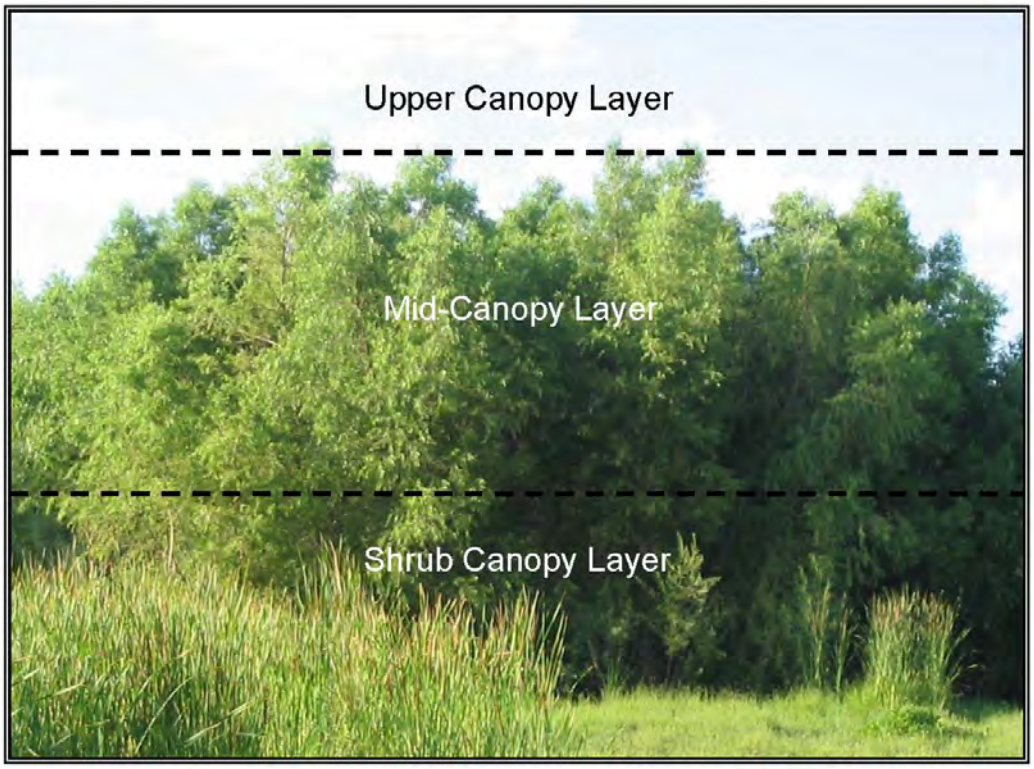


**Figure 5.—**Typical SWFL habitat showing lack of upper canopy layer.

## 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 in the vegetation quantification plots (Figures A-1 to A-5 in Appendix A). All photostations were permanently marked with a meta "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 provided from the 2010 hemispheric photos will be compared with data from future photos to detect any changes in canopy cover since this time.

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, equals the percent of 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

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 2010. These surveys were part of Reclamation's annual SWFL monitoring program conducted at selected sites along the Rio Grande from Velarde to Elephant Butte Reservoir (Moore and Ahlers 2010).

# Results and Discussion

## Ground Water Wells

Ground water wells were monitored from May 12, 2010 through March 16, 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.

Ground water levels generally correlated closely with river flows, indicating a hydrologic regime influenced by the riverine system at the project site. Associations between water table and river discharge rates were especially pronounced along the Middle Range Line and somewhat so along the South Range Line. Ground water was shallowest along the Middle Range Line, with the water table averaging around 2 ft. below the surface when flows ranged from approximately 250 to 1000 cfs. The shallow water table along this Range Line provided the best opportunity to detect changes in ground water levels. The water table along the South Range Line ranged between 30 and 40 in. below the surface when flows were between 1000 and 1500 cfs. In plots S10 and S30, variability in ground water levels was barely detected after the low flow season in summer and fall (Appendix B), which probably indicated that wells were not deep enough to isolate fluctuations in the water table.

The water table was deepest along the North Range Lines at lower flows. The wells along this Range line were 43 to 52 in. deep and no water was detected in the wells at flows as high as 1500 cfs. Thus, no changes in water table levels were observed after December 2010, the point at which flows in the river increased to 500 – 1500 cfs following low summer and fall flows (Appendix B). Most likely, these results indicate that water loggers were not placed deep enough to show variations in the water table, or

there may have been a clay lens limiting the movement of water through the soil profile. Soils were characterized during well installation, and records show that soils along the North Range Line had horizons with much higher clay content than the Middle or South Range Lines. Regardless, data from all of the monitoring wells could benefit by increasing the depth of the wells, which would increase the likelihood of detecting relationships between ground water and river levels at minimal flows typical of the Rio Grande.

## Vegetation Transects

Vegetation transects were measured in August 2010. The average total percent cover of individual plant species, life-forms, and cover types in the understory layer by Range Line is shown in Table 1. Twenty species were detected in the understory along all three Range Lines during the first year of monitoring. Average relative percent cover of life-forms by Range Line is graphed in Figure 6. All Range Lines had relatively low total herbaceous plant cover beneath the overstory (Table 1). The Middle Range Line had the highest total cover at 22.8 percent composed of primarily introduced forbs and native shrubs (shrubs under 1 m in height). 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 with the dominant life-forms being native grasses and native forbs. Finally, the North Range Line had only 6 percent total understory cover made up of predominantly native grasses and native forbs.

Along all Range Lines, native species were more abundant relative to introduced species in the understory layer (Table 2). This was particularly true along the South Range Line, where native species had a relative cover of 84.5 percent with thin paspalum, sedge, and spearleaf rabbitbrush (all native) being the dominant plant species. Although the understory along the North Range Line was mostly litter covered, plant species that were detected were predominantly native with a relative cover of 64.4 percent. The dominant species along this Range Line were horseweed, thin paspalum, and sedge – again all natives.

Total percent cover and average height of overstory species by Range Line are shown in Table 3. Six woody plant species were detected in the overstory layer along all Range Lines combined. Based on total overstory cover estimates, the North Range Line was characterized by a tall canopy of cottonwood with predominantly 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 with cottonwood, seep willow, and saltcedar in somewhat equal proportions.

**Table 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 Lines in 2010.

| Average Total Percent Cover - Understory Layer | | | |
|---|---|---|---|
| **Species** | **North Total % cover** | **Middle Total % cover** | **South Total % cover** |
| Cottonwood (*Populus deltoides*) | 0.0 | 1.0 | 0.7 |
| Coyote willow (*Salix exigua*) | 0.0 | 5.0 | 1.3 |
| Seep willow (*Baccharis salicifolia*) | 0.0 | 1.3 | 0.7 |
| **Total native shrubs** | 0.0 | 7.3 | 2.7 |
| Saltcedar (*Tamarix ramosissima*) | 0.0 | 0.3 | 0.0 |
| **Total introduced shrubs** | 0.0 | 0.3 | 0.0 |
| Witchgrass (*Panicum capillare*) | 0.0 | 0.3 | 0.7 |
| Thin paspalum (*Paspalum setaceum*) | 1.0 | 2.7 | 3.6 |
| Sedge (*Carex* sp.) | 0.0 | 0.0 | 2.7 |
| Teal lovegrass (*Eragrostis hypnoides*) | 0.0 | 0.3 | 0.3 |
| Common reed (*Phragmites australis*) | 1.0 | 0.0 | 0.0 |
| Hardstem bulrush (*Schoenoplectus acutus*) | 0.0 | 0.7 | 0.0 |
| **Total native grasses** | 2.0 | 4.0 | 7.3 |
| Barnyard grass (*Echinochloa crus-galli*) | 0.3 | 0.3 | 2.0 |
| **Total introduced grasses** | 0.3 | 0.3 | 2.0 |
| Horseweed (*Conyza canadensis*) | 1.7 | 0.7 | 1.3 |
| Beggarstick (*Bidens frondosa*) | 0.3 | 0.0 | 0.0 |
| Spearleaf rabbitbrush (*Chrysothamnus linifolius*) | 0.0 | 0.3 | 2.7 |
| Cottonbatting cudweed *(Pseudognaphalium stramineum*) | 0.0 | 0.3 | 0.0 |
| Hooker's evening primrose (*Oenothera elata*) | 0.7 | 0.3 | 0.0 |
| Bundleflower (*Desmanthus illinoensis*) | 0.3 | 0.0 | 0.0 |
| American water horehound (*Lycopus americanus*) | 0.0 | 0.0 | 0.3 |
| Smooth scouringrush (*Equisetum laevigatum*) | 0.0 | 0.0 | 1.3 |
| **Total native forbs** | 3.0 | 1.6 | 5.6 |
| White sweetclover (*Melilotus albus*) | 0.7 | 9.3 | 0.7 |
| **Total Introduced forbs** | 0.7 | 9.3 | 0.7 |
| Total herbaceous vegetation | 6.0 | 22.8 | 18.3 |
| Litter | 88.0 | 74.0 | 64.0 |
| Bare soil | 5.3 | 3.0 | 17.7 |
| **Total cover** | 99.3 | 99.8 | 100.0 |

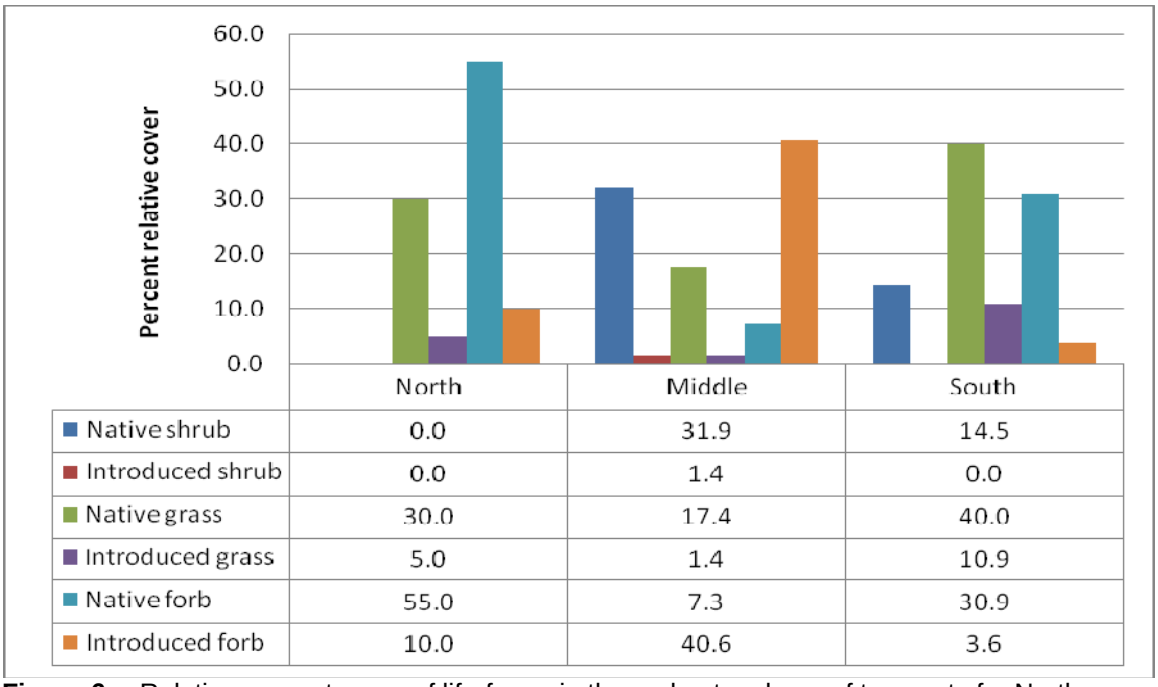


**Figure 6**.—Relative percent cover of life-forms in the understory layer of transects for North, Middle, and South Range Lines in 2010.

**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.

| Average Relative Percent Cover | | | | |
|---|---|---|---|---|
| **Range Line** | **Understory Layer** | | **Overstory Layer** | |
| | **Native spp.** | **Introduced spp.** | **Native spp.** | **Introduced spp.** |
| North | 64.4 | 35.6 | 71.9 | 28.1 |
| Middle | 58.1 | 41.9 | 94.9 | 5.1 |
| South | 84.5 | 15.5 | 83.4 | 16.6 |

**Table 3.**—Average total percent cover and height of plant species detected within the overstory layer of transects for North, Middle, and South Range Lines in 2010.

| Average Total Cover and Height - Overstory Layer | | | | | | |
|---|---|---|---|---|---|---|
| **Species** | **North** | | **Middle** | | **South** | |
| | **Total % cover** | **Height (m)** | **Total % cover** | **Height (m)** | **Total % cover** | **Height (m)** |
| Cottonwood (*Populus deltoides*) | 77.1 | 13.1 | 54.8 | 3.5 | 16.5 | 4.4 |
| Coyote willow (*Salix exigua*) | 7.6 | 3.3 | 63.5 | 3.4 | 45.5 | 2.9 |
| Gooddings willow (*Salix gooddingii*) | 7.4 | 7.4 | 1.9 | 6.0 | 0.0 | 0.0 |
| Seep willow (*Baccharis salicifolia*) | 0.1 | 1.7 | 4.1 | 1.9 | 11.2 | 2.2 |
| Saltcedar (*Tamarix ramosissima*) | 25.4 | 3.8 | 4.5 | 2.0 | 14.5 | 1.9 |
| Russian olive (*Eleagnus angustifolia*) | 10.7 | 3.7 | 2.1 | 5.1 | 0.1 | 2.5 |
| **AVG. % TOTAL COVER*** | **92.9** | | **92.1** | | **73.9** | |

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

Total overstory cover was approximately 92 percent along the North and Middle Range Lines and near 75 percent along the South Range Line (Table 3). Values for canopy cover as measured with the densitometer were similar to those collected 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 (Table 4).

**Table 4**.—Average percent canopy cover as measured with a densitometer by transect for the North, Middle, and South Range Lines in 2010.

| Percent Canopy Cover | | | |
|---|---|---|---|
| **Transect** | **Point A** | **Point B** | **Average % Canopy Cover** |
| **N10S** | 100.0 | 100.0 | 100.0 |
| **N10N** | 93.5 | 82.6 | 88.0 |
| **N30S** | 100.0 | 100.0 | 100.0 |
| **N30N** | 99.0 | 100.0 | 99.5 |
| **N50S** | 100.0 | 100.0 | 100.0 |
| **N50N** | 99.7 | 100.0 | 99.9 |
| | | **Avg % North Range Line** | **97.9** |
| | | | |
| **M10S** | 95.3 | 97.1 | 96.2 |
| **M10N** | 93.0 | 95.1 | 94.0 |
| **M30S** | 94.0 | 96.4 | 95.2 |
| **M30N** | 90.4 | 89.3 | 89.9 |
| **M50S** | 83.4 | 99.5 | 91.4 |
| **M50N** | 100.0 | 75.0 | 87.5 |
| | | **Avg % Middle Range Line** | **92.4** |
| | | | |
| **S10S** | 100.0 | 99.5 | 99.7 |
| **S10N** | 95.3 | 93.8 | 94.5 |
| **S30S** | 73.2 | 94.3 | 83.8 |
| **S30N** | 97.9 | 91.9 | 94.9 |
| **S50S** | 71.1 | 40.7 | 55.9 |
| **S50N** | 88.8 | 69.8 | 79.3 |
| | | **Avg % South Range Line** | **84.7** |

Native plant species were far more abundant than introduced species in the overstory along all three Range Lines 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, although coverage was still moderate compared to native species.

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), 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. The wells along this Range Line were 43 to 52 in. deep and no water was detected in the wells at flows as high as 1500 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 ranged from approximately 250 to 1000 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 between 1000 and 1500 cfs, which fell between the other two Range Lines in 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 Gooddings 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.

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, while maintaining dryer surface conditions for the establishment of 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 C. These photos will serve as baseline with which to visually compare future conditions.

## Vegetation Quantification Plots

Vegetation quantification plot data was collected in August of 2010 following the SWFL breeding season. Data from 17 of 60 subplots 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, which resulted in data from 24 of 80 quarter plots being excluded from analysis.

Averages and ranges of data collected in association with the nest tree (*i.e.* plot center) are in Table 5. Nest centered data is listed by individual plots in Table D-1 in Appendix D. Table 5 also includes the frequency that each plant species was used as a nest substrate. Coyote willow was the most common species in which nests were placed (55 percent of the time), followed relatively closely by saltcedar (40 percent of the time).

Tree data collected in the center plots and subplots is summarized in Table 6, which shows averages and ranges for each parameter measured. Tree data by individual plot is in Table D-2 in Appendix D. Tree densities varied considerably between plots, from 988 trees/hectare (ha) to 38,699 trees/ha. Trees selected as nest substrates were, on average, smaller than trees within the surrounding area. The average height of nest trees and plot trees were 4.7 m (Table 5) and 5.8 m (Table 6), respectively, while the average DBH of nest trees and plot trees were 3.4 cm (which classifies as a shrub under this protocol) and 5.3 cm, respectively.

**Table 5**.—Average, minimum, and maximum values for each parameter measured in association with nest center as well as the frequency each tree species was used as a nest substrate in the vegetation quantification plots in 2010.

| Nest Centered Data (n=20) | | | |
|---|---|---|---|
| **Parameter** | **Average** | **Minimum** | **Maximum** |
| **Nest height (m)** | 3.1 | 1.6 | 4.5 |
| **Nest substrate height (m)** | 4.7 | 3.3 | 6.3 |
| **Nest substrate DBH (cm)** | 3.4 | 1.4 | 7.4 |
| **Distance to substrate edge (m)** | 0.3 | 0.0 | 0.7 |
| **Distance to riparian edge (m)** | 162.2 | 1.0 | 350.0 |
| **Distance to channel (m)** | 30.4 | 1.0 | 110.0 |
| **Distance to road (m)** | 180.0 | 70.0 | 350.0 |
| **Frequency of substrate species used (%)** | | | |
| **Coyote willow** | 55 | | |
| **Saltcedar** | 40 | | |
| **Cottonwood** | 5 | | |

**Table 6**.—Average, minimum, and maximum values of each parameter measured for trees within vegetation quantification plots in 2010.

| Tree Data (n=20) | | | |
|---|---|---|---|
| **Parameter** | **Average** | **Minimum** | **Maximum** |
| **Density (#/ha)** | 9862.2 | 988.1 | 38699.3 |
| **Height (m)** | 5.8 | 3.7 | 7.3 |
| **Crown width (m)** | 1.8 | 0.6 | 3.3 |
| **DBH (cm)** | 5.3 | 1.9 | 10.2 |
| **Cover 0-3 m (%)** | 67.7 | 43.7 | 89.0 |
| **Cover 3-6 m (%)** | 58.8 | 34.0 | 83.0 |
| **Cover >6 m (%)** | 25.7 | 5.0 | 48.0 |
| **Tree stem species compostion (%)** | | | |
| **Gooddings willow** | 10.2 | 0.0 | 41.7 |
| **Saltcedar** | 26.8 | 0.0 | 86.7 |
| **Coyote willow** | 31.4 | 0.0 | 92.9 |
| **Cottonwood** | 24.5 | 0.0 | 97.0 |
| **Russian olive** | 7.1 | 0.0 | 33.3 |
| **Dead trees (%)** | 11.0 | 0.0 | 32.1 |
| **Tree stem size-class composition (%)** | | | |
| **Class I (5-10 cm dbh)** | 81.2 | 56.3 | 98.8 |
| **Class II (10-20 cm dbh)** | 15.4 | 1.2 | 36.8 |
| **Class III (>20cm dbh)** | 3.4 | 0.0 | 16.7 |

Vegetation cover was highest in the layer 0-3 m from the ground, with a mean of 67.7 percent. The layer from 3-6 m followed with a mean percent cover of 58.8 percent. 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). The vast majority of trees (81.2 percent) were in the 5 to 10 cm DBH size-class. The average percentage of dead trees per plot based on stem counts was 11.0.

Shrub data collected in the center plots and subplots is summarized in Table 7, which shows averages and ranges for each parameter measured. Shrub data by individual plot is shown in Table D-3 in Appendix D. As with trees, density was highly variable, ranging from 1,655 shrubs/ha to 36,281 shrubs/ha. Coyote willow was the most common shrub species as determined by average stem counts, with a relative percent cover of 50.8 percent. Saltcedar was the next most common with a relative percent cover of 26.4 percent. The average percentage of dead shrub stems within each plot was 39.1.

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

| Shrub Data (n=20) | | | |
|---|---|---|---|
| **Parameter** | **Average** | **Minimum** | **Maximum** |
| **Density (#/ha)** | 11845.1 | 1654.7 | 36281.2 |
| **Height (m)** | 1.5 | 0.9 | 2.3 |
| **Crown width (m)** | 0.4 | 0.3 | 0.7 |
| **Shrub stem species compostion (%)** | | | |
| **Gooddings willow** | 8.1 | 0.0 | 46.2 |
| **Saltcedar** | 26.4 | 0.0 | 75.7 |
| **Coyote willow** | 50.8 | 0.0 | 95.7 |
| **Cottonwood** | 8.0 | 0.0 | 32.9 |
| **Seep willow** | 1.4 | 0.0 | 24.2 |
| **Russian olive** | 4.8 | 0.0 | 43.6 |
| **Dead shrubs (%)** | 39.1 | 15.2 | 66.7 |

## Hemispheric Photo Stations

Hemispheric photos were taken at all stations in August 2010 and January 2011. Figure 7 shows an example of photos taken at a vegetation transect along the North Range Line during each season.

Cover data collected through hemispheric photography in August are listed in Table 8. Percent vegetative cover along the North Range Line correlated relatively closely among the three methods of measurement used. Average cover was 92.9 percent using the line intercept method (Table 3), 97.9 percent using the densiometer (Table 4), and 91.3 percent using hemispheric photography (Table 8). Cover estimates with hemispheric photography were lower in the Middle and South Range Lines than with the two other methods. Average percent cover along the Middle Range Line was 92.1, 92.4, and 77.5 percent using the line intercept method (Table 3), densiometer (Table 4), and hemispheric photography (Table 8), respectively. Percent cover along the South Range Line was 73.9, 84.7, and 59.7 percent using the line intercept method (Table 3), densiometer (Table 4), and hemispheric photography (Table 8), respectively. Of the three methods used to estimate vegetative cover, hemispheric photography is presumed to be the most accurate and repeatable. Further studies will determine if this presumption is true.

**Figure 7.—**Example of hemispheric photos taken at the same site in August 2010 (left) and January 2011 (right). Canopy cover August = 93%; Canopy cover January = 52%; Foliage cover = 41%.

**Table 8.** —Percent vegetation cover as measured with hemispheric photography for the vegetation transects along the North, Middle, and South Range Lines and for the vegetation quantification plots associated with SWFL nests.

| Transect | % Cover | Nest plot | % Cover |
|---|---|---|---|
| N10S | 94.4 | PS#1 | 92.7 |
| N10N | 77.8 | PS#2 | 90.2 |
| N30S | 93.0 | PS#3 | 91.5 |
| N30N | 87.2 | PS#4 | 96.0 |
| N50S | 97.1 | PS#5 | 89.2 |
| N50N | 98.2 | PS#6 | 87.7 |
| **North Average** | **91.3** | PS#7 | 96.5 |
| M10S | 92.4 | PS#8 | 97.1 |
| M10N | 85.0 | PS#9 | 96.7 |
| M30S | 86.0 | PS#10 | 96.9 |
| M30N | 77.2 | PS#11 | 88.7 |
| M50S | 68.2 | PS#12 | 97.0 |
| M50N | 56.0 | PS#13 | 98.0 |
| **Middle Average** | **77.5** | PS#14 | 98.0 |
| S10S | 78.9 | PS#15 | 97.2 |
| S10N | 79.9 | PS#16 | 89.6 |
| S30S | 39.5 | PS#17 | 92.1 |
| S30N | 66.2 | PS#18 | 96.5 |
| S50S | 47.1 | PS#19 | 97.7 |
| S50N | 46.4 | PS#20 | 95.2 |
| **South Average** | **59.7** | **Nest Plot Average** | **94.2** |

Based on hemispheric photo data, the average percent canopy cover associated with SWFL nests in the vegetation quantification plots was 94.2 percent (Table 8). Cover estimates were gathered within three height layers in vegetation plots (Table 6); therefore values cannot be compared with hemispheric photo data.

## Southwestern Willow Flycatcher Surveys

There were 34 SWFL territories detected within the BDANWR during the 2010 breeding season (Figure 8). This number increased from 20 in 2009 and was considerably higher than the number of territories detected in any year from 2002 to 2008.

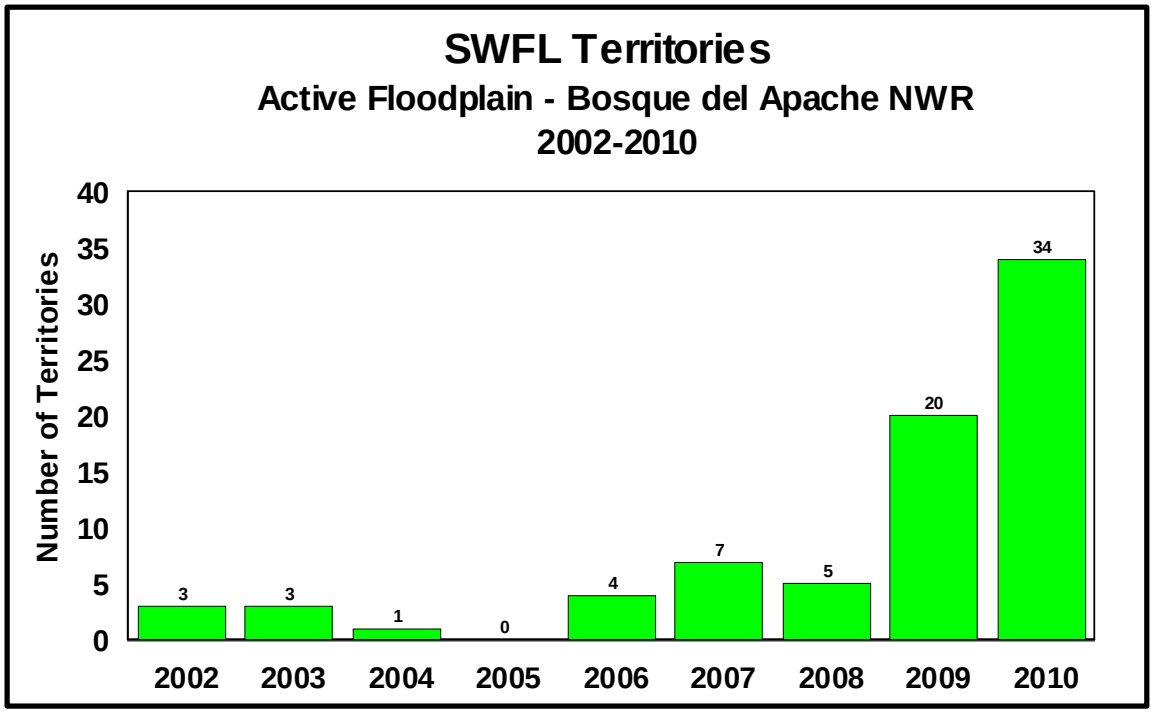


**Figure 8.**—Number of SWFL territories detected in the BDANWR from 2002 to 2010.

The territories detected in 2010 within the BDANWR were mapped by habitat suitability type in Figures 9 and 10. Most of the nesting pairs were documented in areas that were identified as "Moderately suitable" or "Unsuitable." SWFL habitat suitability was determined 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.

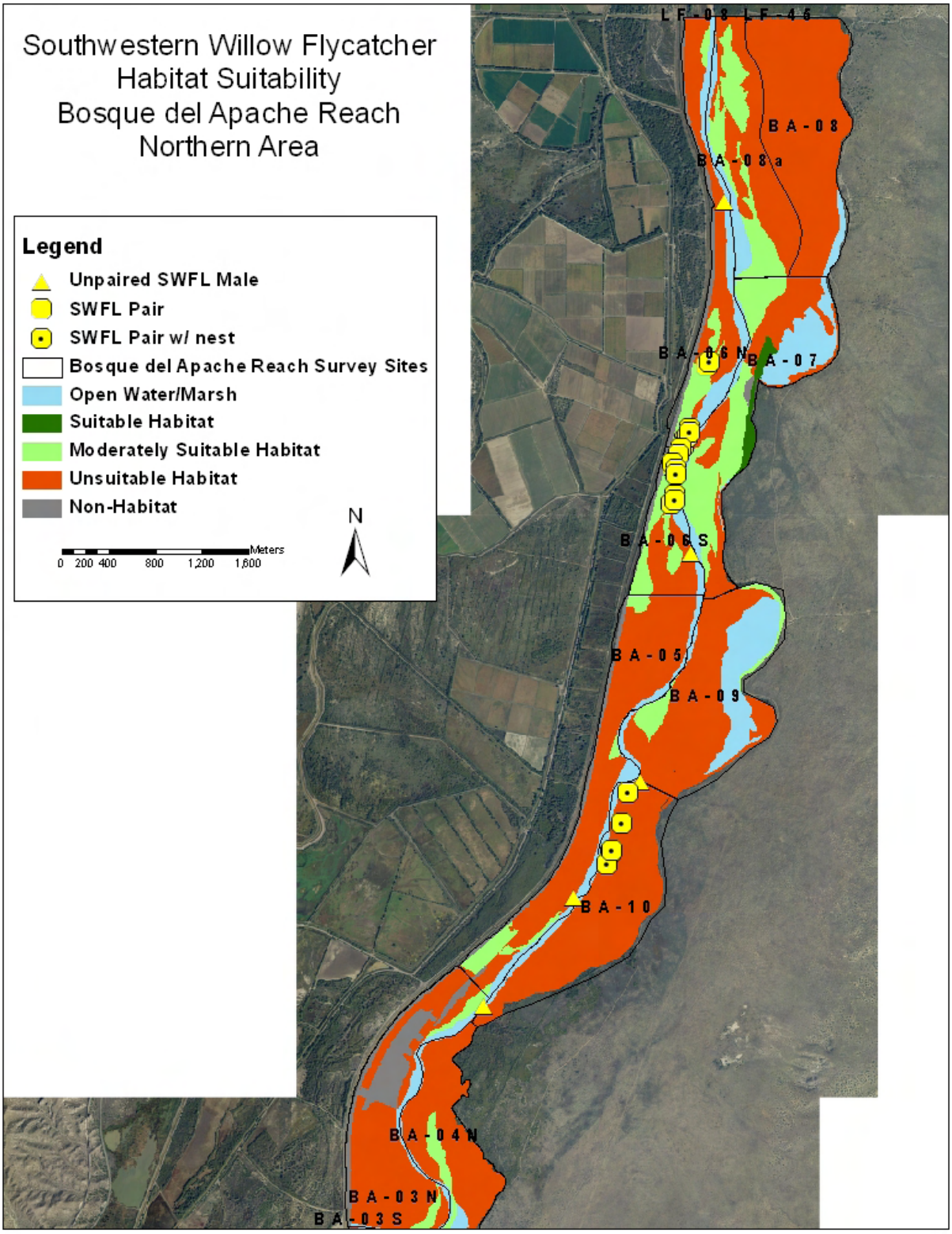


**Figure 9.**—SWFL territories detected in 2010 within the Northern portion of the BDANWR and habitat suitability as determined in 2008.

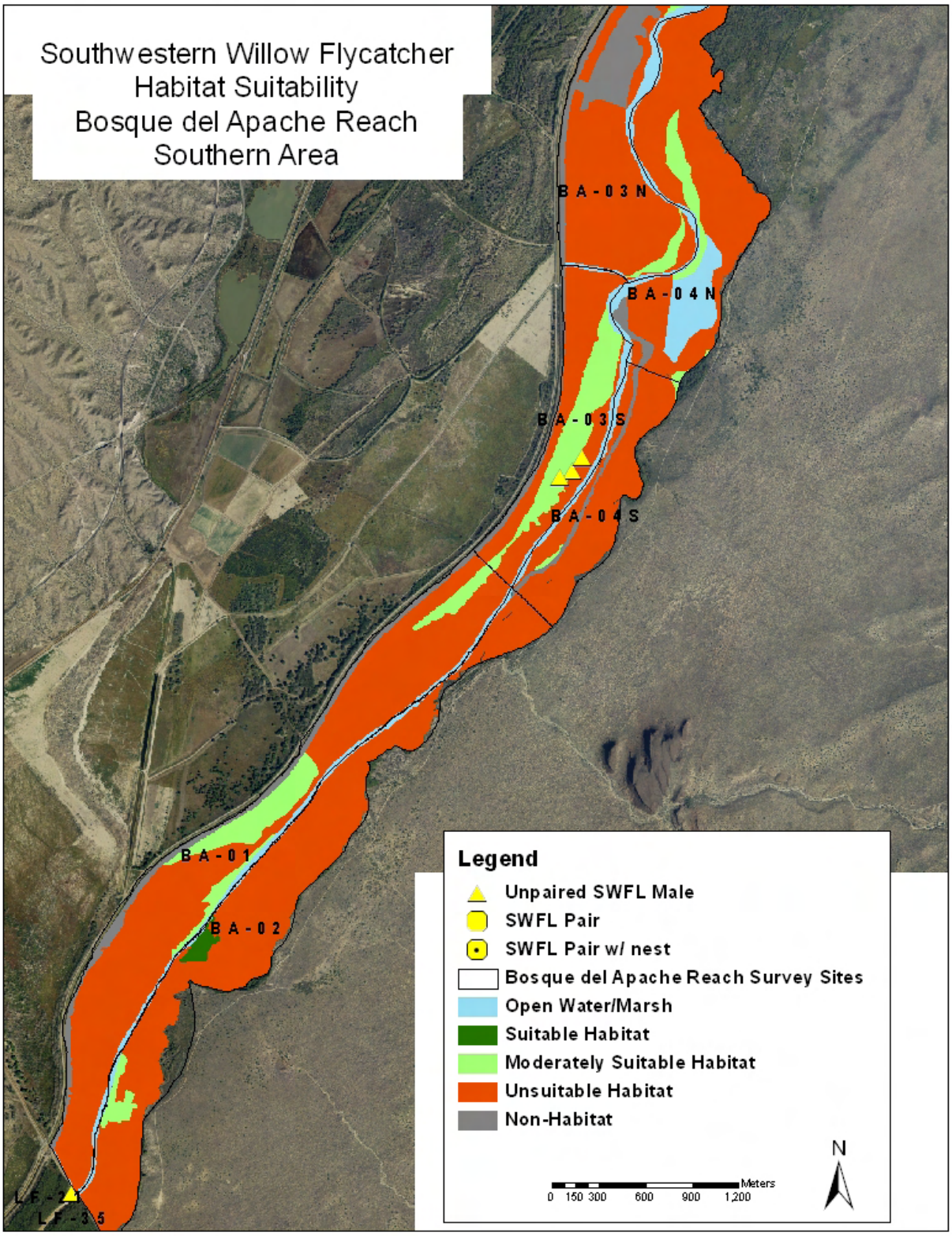


**Figure 10.**—SWFL territories detected in 2010 within the Southern portion of the BDANWR and habitat suitability as determined in 2008.

# Recommendations

## Ground Water Wells

Data obtained from all of the monitoring wells could be improved by increasing the depth of the wells. Deepening wells would increase the likelihood of detecting relationships between ground water and river levels at lower flows typical of the Rio Grande. At the time wells were installed, depth of each well was determined by the depth of the water table. Therefore, modifications to the monitoring wells would be best implemented during dryer periods.

## 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 prior to alternative implementation 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 prior to alternative implementation 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. Data collected in August 2010, January 2011, and prior to alternative implementation will be considered baseline for the project.

## Southwestern Willow Flycatcher Surveys

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.

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# Appendix A

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

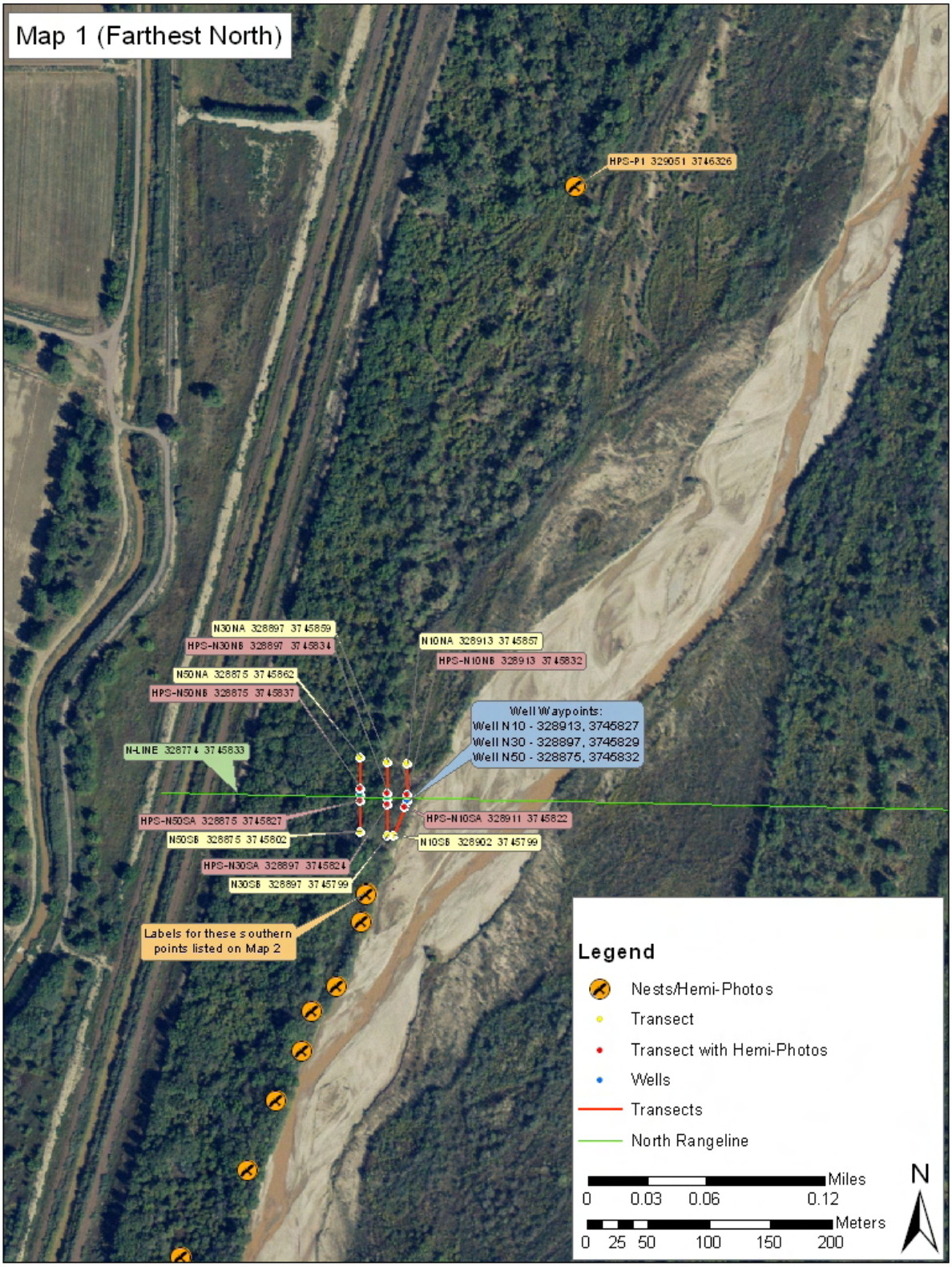



**Figure A-1**.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations

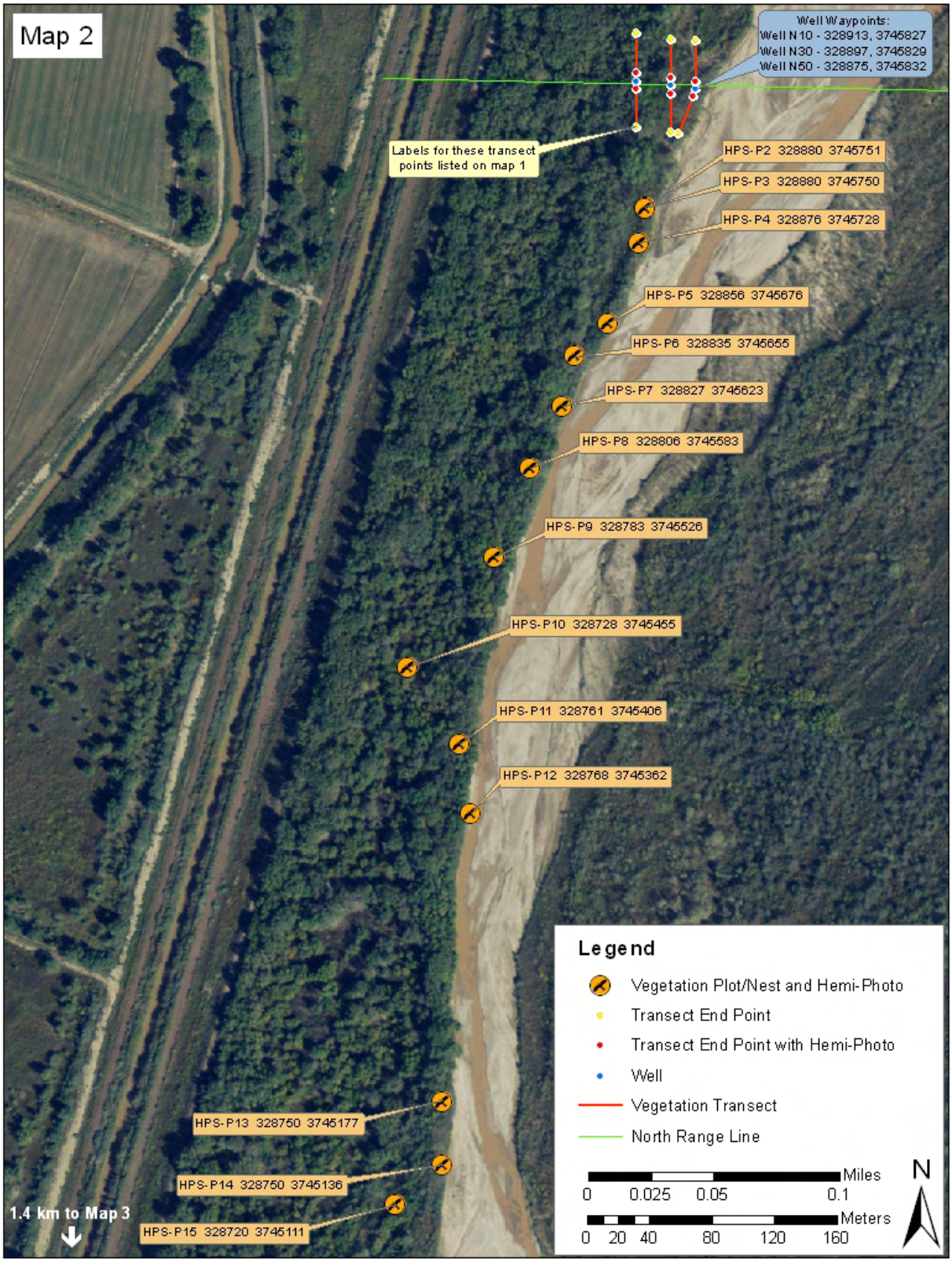



**Figure A-2**.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

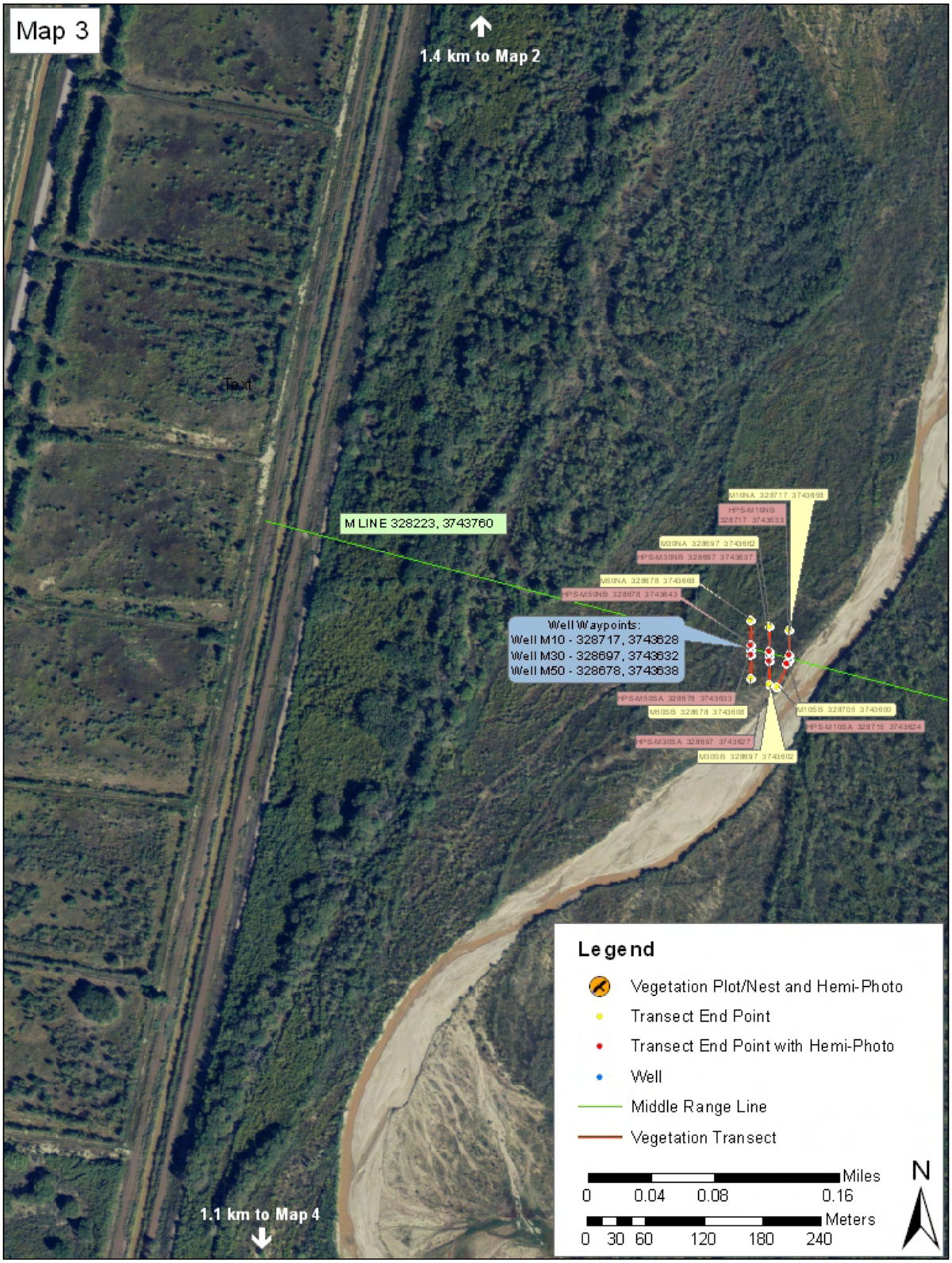



**Figure A-3**.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

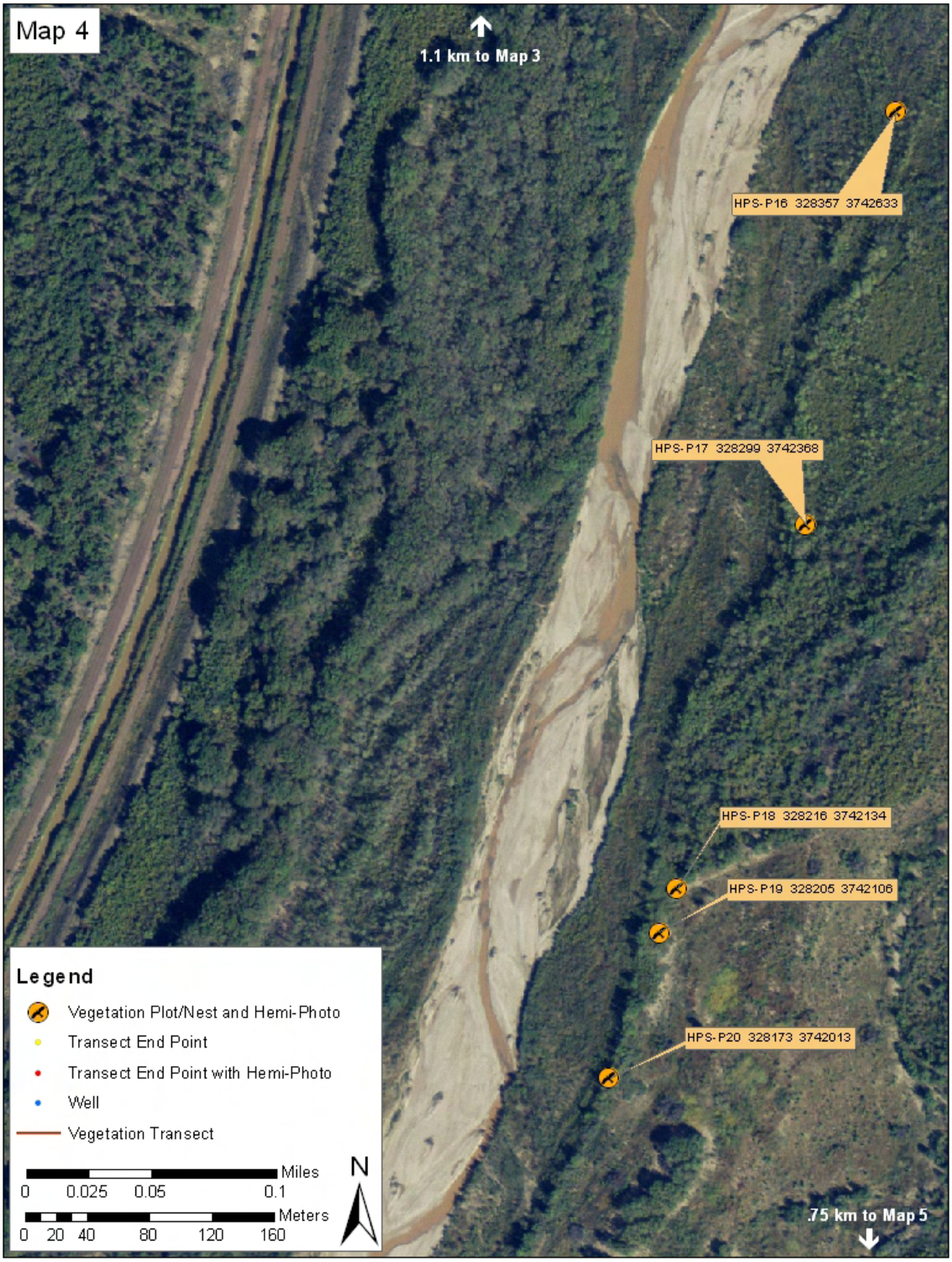



**Figure A-4**.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

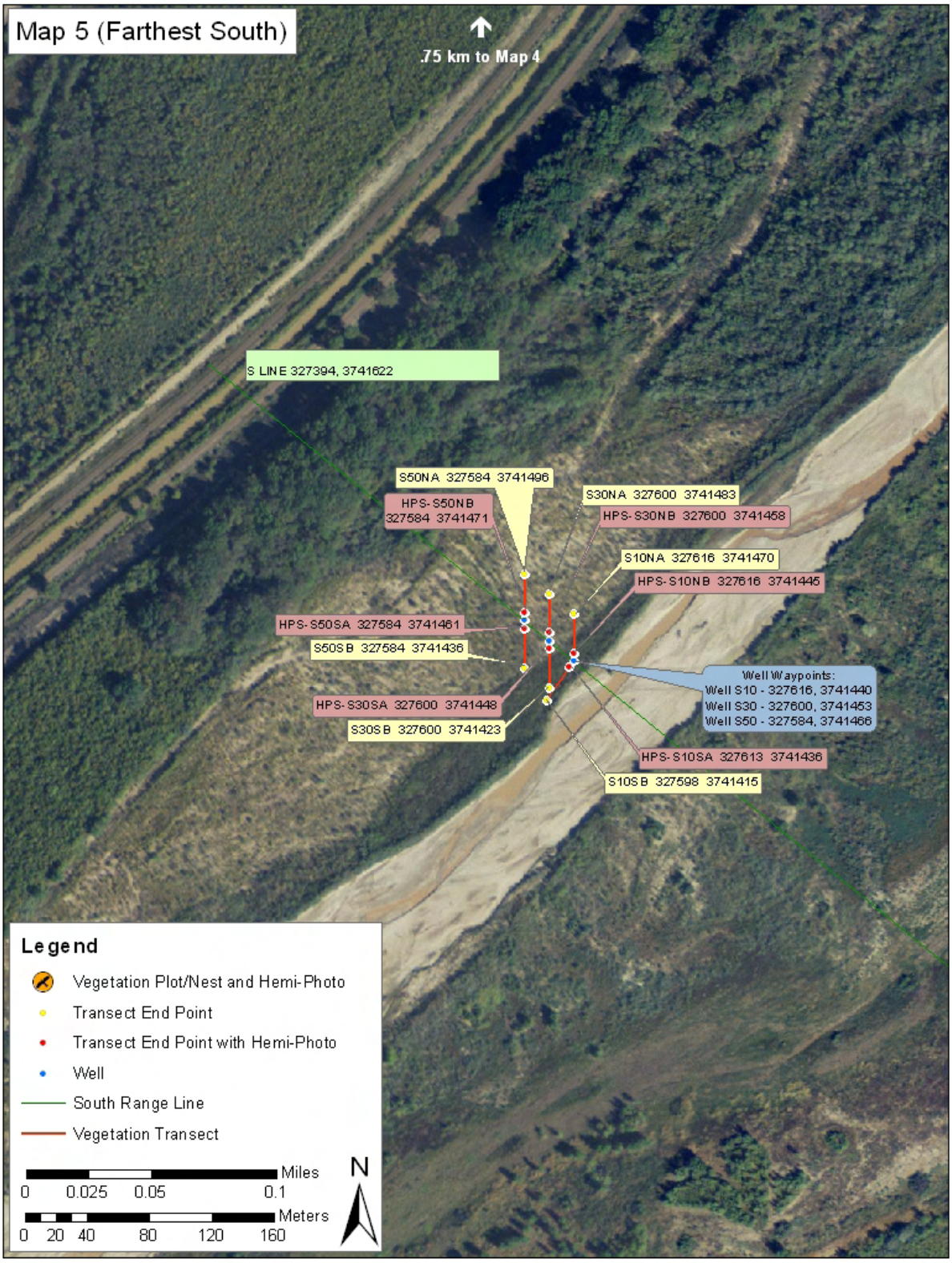
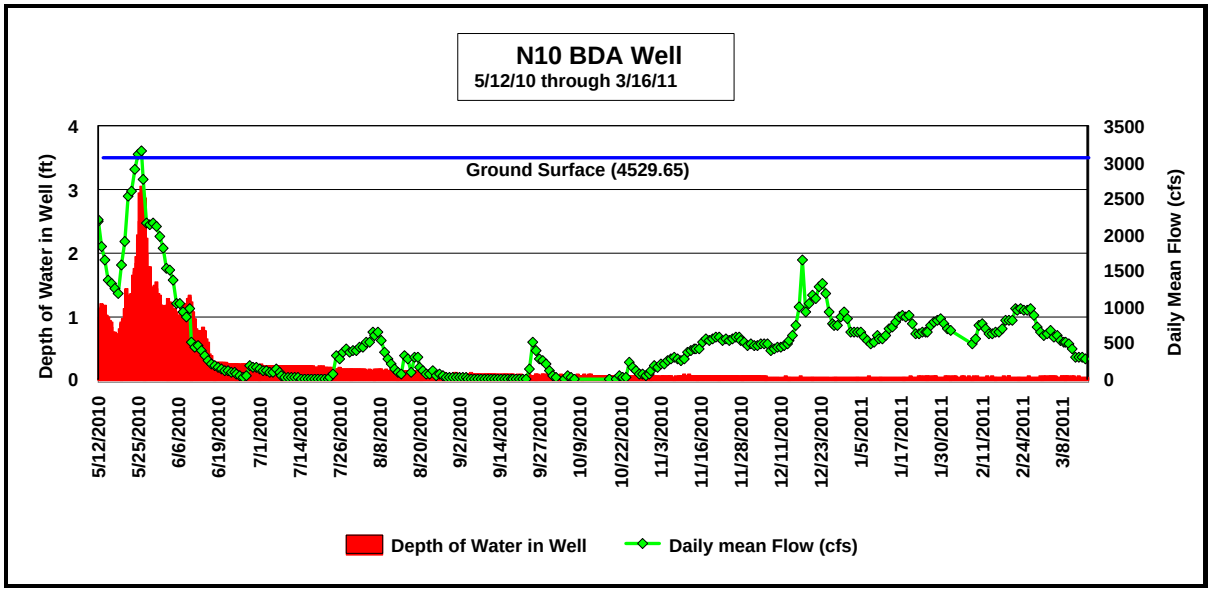
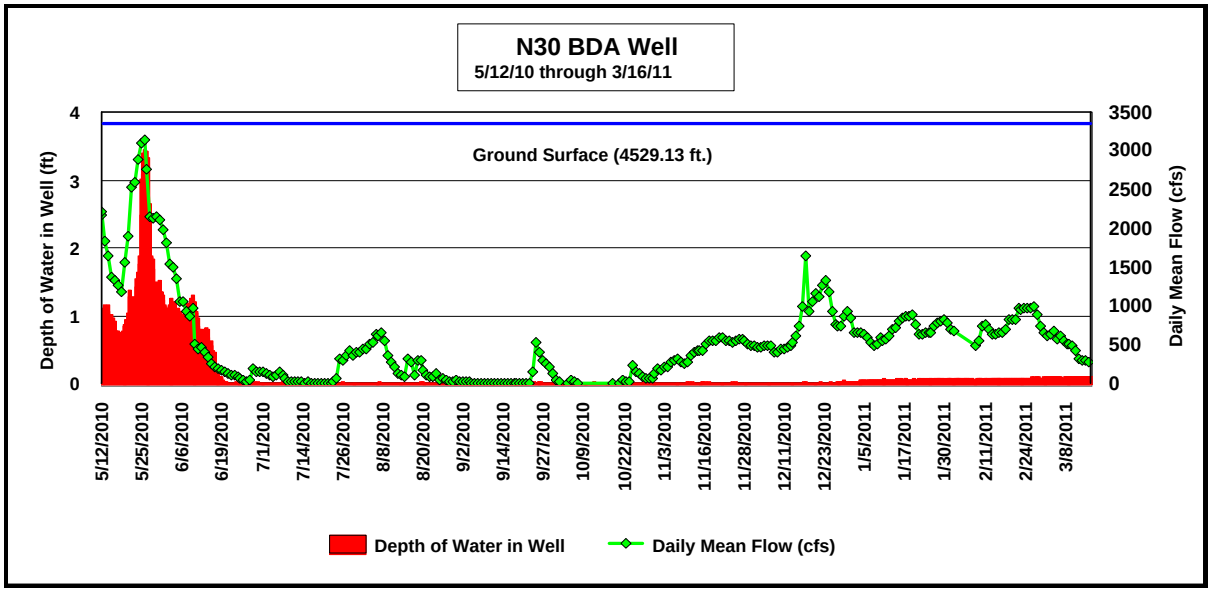


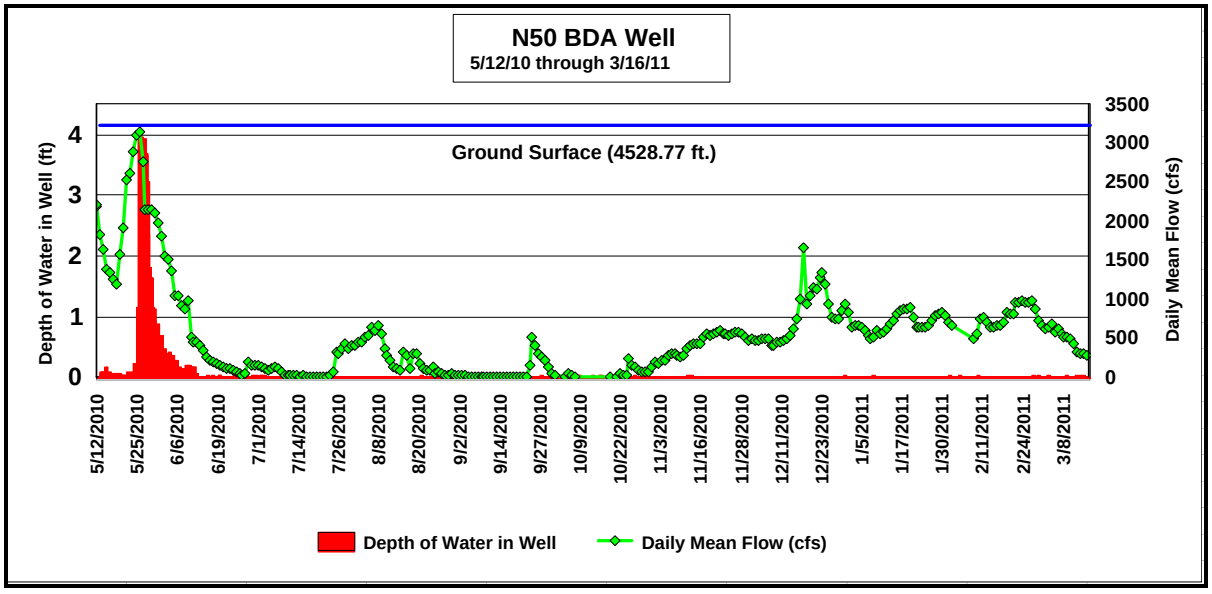

**Figure A-5**.—Locations of groundwater wells, vegetation transects, vegetation quantification (*i.e.*nest) plots, and hemispheric photo stations.

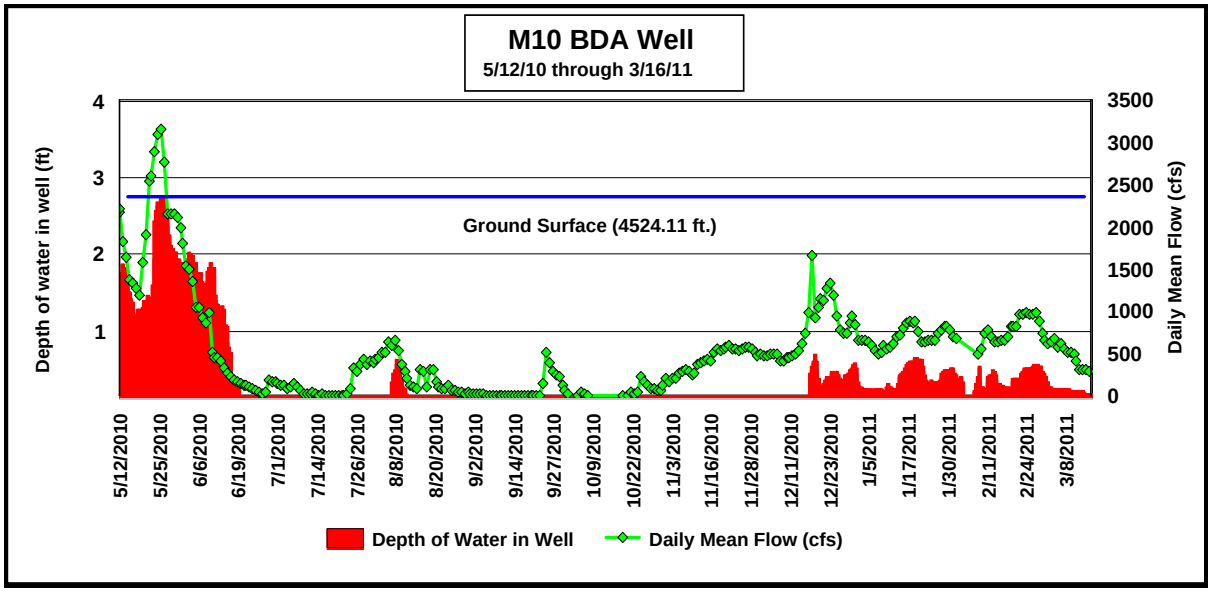
# Appendix B

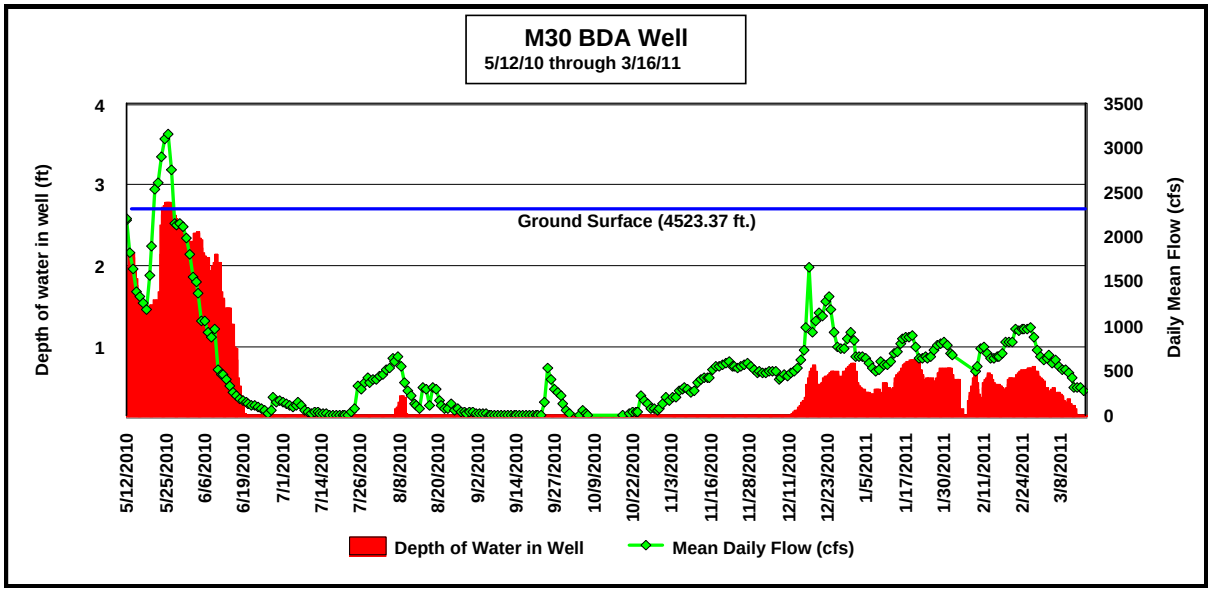
Results of Ground Water Well Monitoring

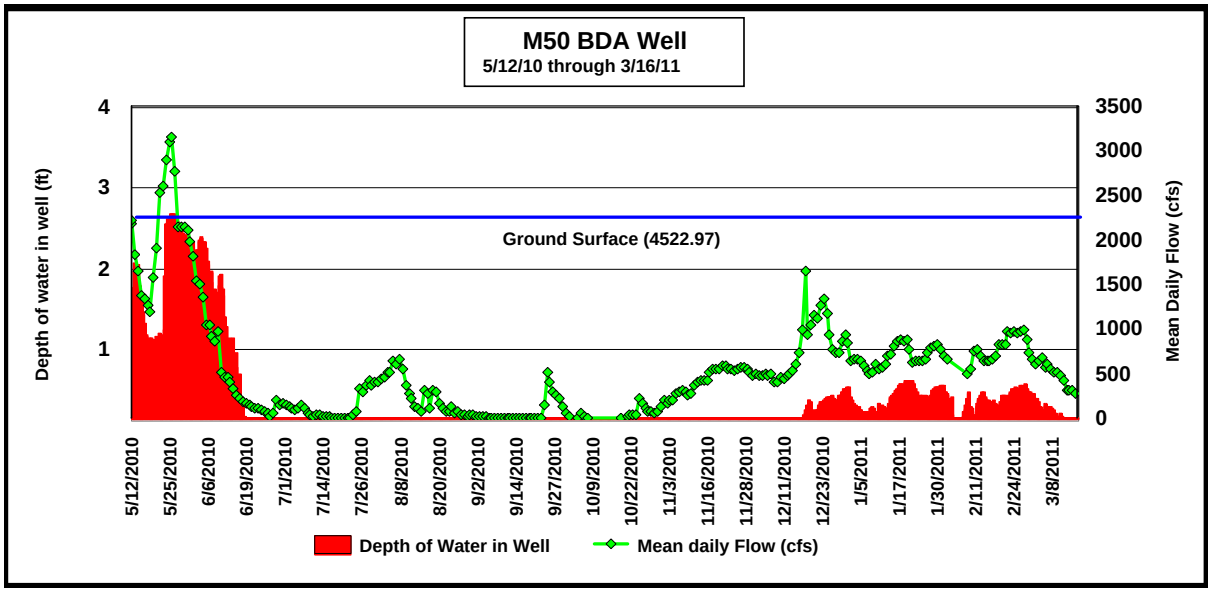

N10 BDA Well
5/12/10 through 3/16/11
Ground Surface (4529.65)
Depth of Water in Well (ft)
Daily Mean Flow (cfs)
0
1
2
3
4
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Daily mean Flow (cfs)

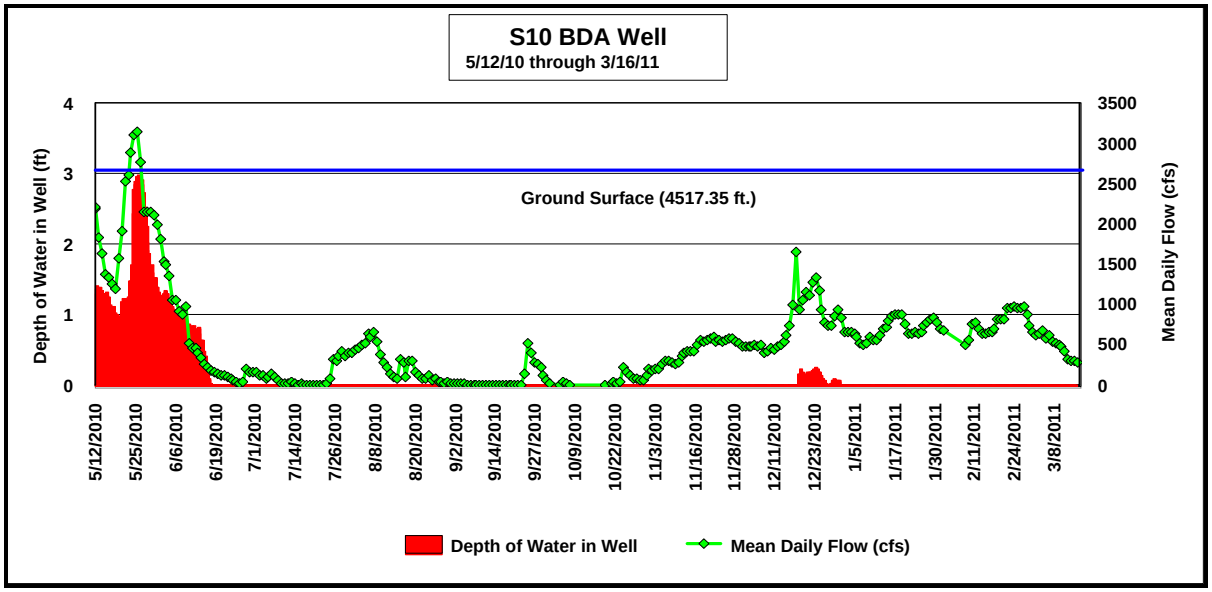

N30 BDA Well
5/12/10 through 3/16/11
Ground Surface (4529.13 ft.)
Depth of Water in Well (ft)
Daily Mean Flow (cfs)
0
1
2
3
4
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Daily Mean Flow (cfs)

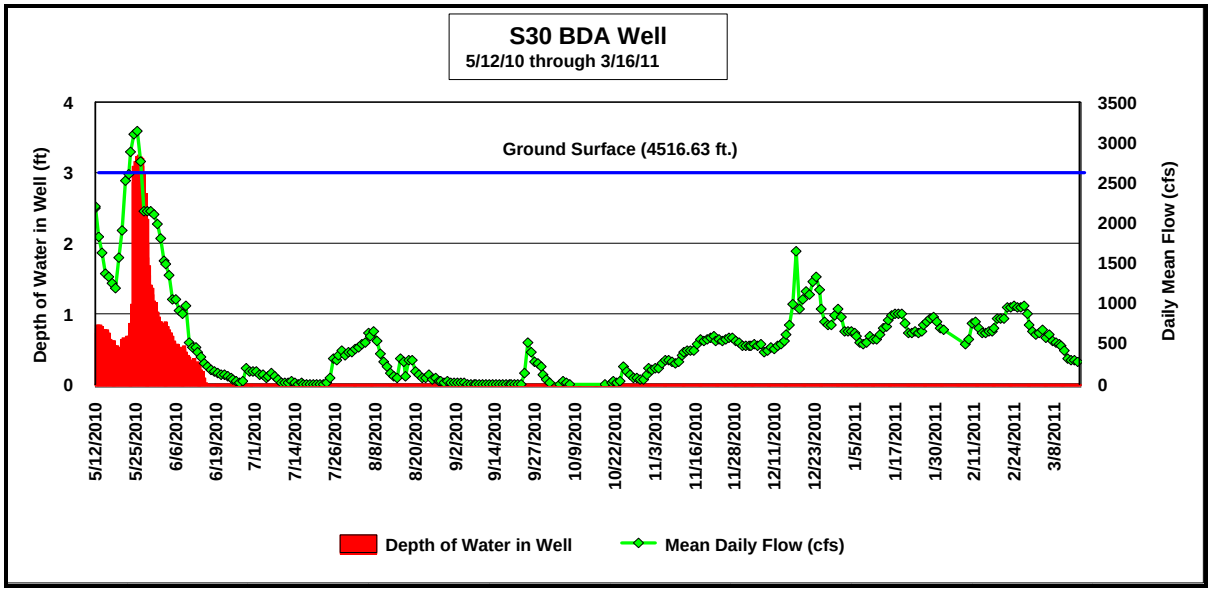

N50 BDA Well
5/12/10 through 3/16/11
Ground Surface (4528.77 ft.)
Depth of Water in Well (ft)
Daily Mean Flow (cfs)
0
1
2
3
4
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Daily Mean Flow (cfs)

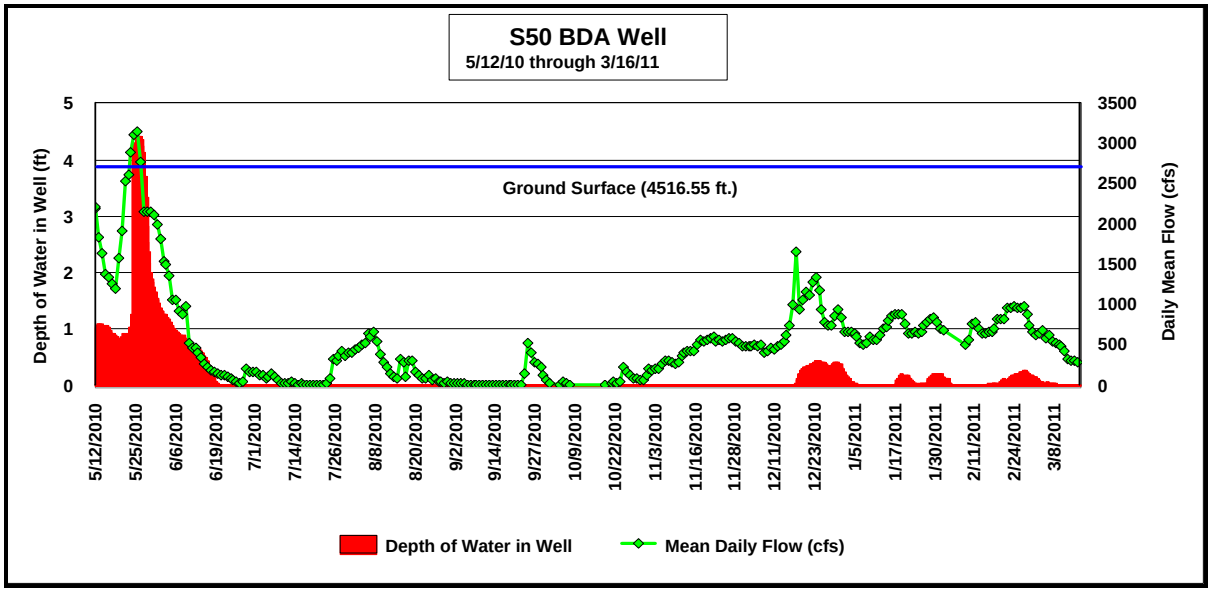

M10 BDA Well
5/12/10 through 3/16/11
Depth of water in well (ft)
Daily Mean Flow (cfs)
Ground Surface (4524.11 ft.)
Depth of Water in Well
Daily Mean Flow (cfs)


M30 BDA Well
5/12/10 through 3/16/11
Depth of water in well (ft)
Daily Mean Flow (cfs)
Ground Surface (4523.37 ft.)
Depth of Water in Well
Mean Daily Flow (cfs)


M50 BDA Well
5/12/10 through 3/16/11
Depth of water in well (ft)
Mean Daily Flow (cfs)
Ground Surface (4522.97)
Depth of Water in Well
Mean daily Flow (cfs)


S10 BDA Well
5/12/10 through 3/16/11
Ground Surface (4517.35 ft.)
Depth of Water in Well (ft)
Mean Daily Flow (cfs)
0
1
2
3
4
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Mean Daily Flow (cfs)


S30 BDA Well
5/12/10 through 3/16/11
Ground Surface (4516.63 ft.)
Depth of Water in Well (ft)
Daily Mean Flow (cfs)
0
1
2
3
4
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Mean Daily Flow (cfs)


S50 BDA Well
5/12/10 through 3/16/11
Ground Surface (4516.55 ft.)
Depth of Water in Well (ft)
Daily Mean Flow (cfs)
0
1
2
3
4
5
0
500
1000
1500
2000
2500
3000
3500
5/12/2010
5/25/2010
6/6/2010
6/19/2010
7/1/2010
7/14/2010
7/26/2010
8/8/2010
8/20/2010
9/2/2010
9/14/2010
9/27/2010
10/9/2010
10/22/2010
11/3/2010
11/16/2010
11/28/2010
12/11/2010
12/23/2010
1/5/2011
1/17/2011
1/30/2011
2/11/2011
2/24/2011
3/8/2011
Depth of Water in Well
Mean Daily Flow (cfs)

# Appendix C

Vegetation Transect Photos 2010

## North Range Line

N10Na

N10Nb

N10Sa

N10Sb

N30Na

N30Nb

N30Sa

N30Sb

N50Na

N50Nb

N50Sa

N50Sb

## Middle Range Line

M10Na

M10Nb

M10Sa

M10Sb

M30Na

M30Nb

M30Sa

M30Sb

M50Na

M50Nb

M50Sa

M50Sb

## South Range Line

S10Na

S10Nb

S10Sa

S10Sb

S30Na

S30Nb

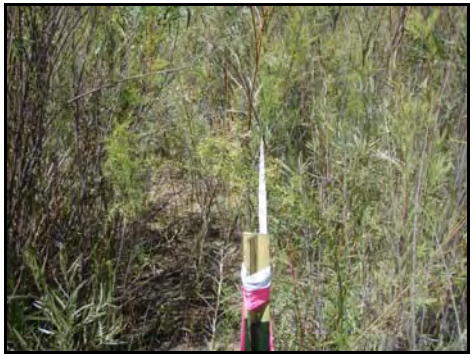
S30Sa

S30Sb

S50Na

S50Nb

S50Sa


S50Sb

# Appendix D

Vegetation Quantification Plots
Nest Centered, Tree, and Shrub Data by Plot

**Table D-1**.—Nest centered data by vegetation quantification plot.

| Nest ID | Photostation/Plot ID | Nest Ht (m) | Nest substrate ht (m) | Nest substrate dbh (cm) | Canopy ht (m) | Dist to substrate edge (m) | Dist to riparian edge (m) | Dist to channel (m) | Dist to road (m) |
|---|---|---|---|---|---|---|---|---|---|
| BA-06NP1N1 | HPS-P1 | 2.5 | 3.5 | 1.7 | 7.6 | 1.0 | 130.0 | 210.0 | 130.0 |
| BA-06NP6N1 | HPS-P2 | 3.0 | 5.4 | 2.5 | 11.0 | 0.0 | 65.0 | 50.0 | 70.0 |
| BA-06NP2N1 | HPS-P3 | 2.6 | 4.6 | 4.0 | 8.4 | 0.0 | 1.0 | 1.0 | 120.0 |
| BA-06NP8N1 | HPS-P4 | 3.5 | 5.2 | 4.5 | 8.0 | 0.6 | 120.0 | 8.0 | 120.0 |
| BA-06NP7N1 | HPS-P5 | 2.4 | 3.8 | 2.0 | 5.5 | 0.2 | 150.0 | 2.0 | 150.0 |
| BA-06NP3N1 | HPS-P6 | 4.0 | 5.1 | 3.0 | 6.0 | 0.5 | 165.0 | 5.0 | 165.0 |
| BA-06NP4N1 | HPS-P7 | 3.8 | 5.2 | 5.5 | 8.1 | 0.6 | 140.0 | 30.0 | 140.0 |
| BA-06SP1N1 | HPS-P8 | 2.7 | 5.2 | 2.7 | 8.1 | 0.2 | 310.0 | 3.5 | 340.0 |
| BA-06SP2N1 | HPS-P9 | 1.9 | 6.3 | 3.2 | 10.8 | 0.4 | 185.0 | 110.0 | 350.0 |
| BA-06SP3N1 | HPS-P10 | 2.7 | 3.3 | 1.4 | 4.9 | 0.5 | 340.0 | 110.0 | 350.0 |
| BA-06SP4N1 | HPS-P11 | 3.5 | 4.7 | 3.0 | 10.0 | 0.2 | 340.0 | 110.0 | 350.0 |
| BA-06SP5N1 | HPS-P12 | 2.8 | 4.7 | 3.5 | 6.4 | 0.5 | 125.0 | 18.3 | 125.0 |
| BA-06SP6N1 | HPS-P13 | 2.5 | 3.8 | 2.1 | 10.9 | 0.4 | 350.0 | 90.0 | 350.0 |
| BA-06SP9N1 | HPS-P14 | 2.9 | 3.8 | 1.9 | 6.5 | 0.3 | 125.0 | 5.8 | 125.0 |
| BA-06SP7N1 | HPS-P15 | 4.5 | 5.8 | 2.4 | 6.1 | 0.5 | 130.0 | 4.0 | 130.0 |
| BA-10P3N1 | HPS-P16 | 3.8 | 5.7 | 5.0 | 6.5 | 0.7 | 125.0 | 2.5 | 125.0 |
| BA-10P1N1 | HPS-P17 | 3.3 | 4.6 | 7.4 | 5.3 | 0.7 | 110.0 | 14.0 | 110.0 |
| BA-10P5N1 | HPS-P18 | 3.3 | 4.2 | 3.4 | 8.1 | 0.3 | 110.0 | 5.1 | 110.0 |
| BA-10P2N1 | HPS-P19 | 1.6 | 3.7 | 1.8 | 8.1 | 0.0 | 100.0 | 3.9 | 100.0 |
| BA-10P4N1 | HPS-P20 | 3.5 | 5.0 | 6.0 | 6.7 | 0.0 | 90.0 | 5.0 | 90.0 |

**Table D-2.**—Tree data by vegetation quantification plot.

| Nest ID | Photostation/Plot ID | Density (#/ha) | Height (m) | Crown width (m) | DBH (cm) | Average canopy cover (%) 0 to 3 m | Average canopy cover (%) 3 to 6 m | Average canopy cover (%) >6 m | Tree stem species composition (%)* | | | | | | Tree stem size-class comp (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | SAGO | TARA | SAEX | PODE | ELAN | Dead | Class I | Class II | Class III |
| BA-06NP1N1 | HPS-P1 | 2613.1 | 6.1 | 2.1 | 6.0 | 61.8 | 47.3 | 10.3 | 4.4 | 66.2 | 25.0 | 2.9 | 1.5 | 32.0 | 95.6 | 2.9 | 1.5 |
| BA-06NP6N1 | HPS-P2 | 1836.7 | 5.7 | 1.8 | 5.6 | 61.3 | 61.3 | 33.0 | 38.7 | 12.9 | 22.6 | 9.7 | 16.1 | 29.5 | 74.2 | 22.6 | 3.2 |
| BA-06NP2N1 | HPS-P3 | 19025.0 | 6.5 | 1.3 | 4.1 | 63.0 | 83.0 | 31.3 | 9.3 | 11.6 | 58.1 | 7.0 | 14.0 | 4.4 | 88.4 | 11.6 | 0.0 |
| BA-06NP8N1 | HPS-P4 | 24287.4 | 5.5 | 1.1 | 3.3 | 69.7 | 61.3 | 24.7 | 10.5 | 0.0 | 47.4 | 42.1 | 0.0 | 0.0 | 78.9 | 21.1 | 0.0 |
| BA-06NP7N1 | HPS-P5 | 5102.0 | 6.0 | 1.8 | 4.5 | 63.0 | 69.7 | 31.3 | 0.0 | 4.7 | 82.6 | 12.8 | 0.0 | 0.0 | 98.8 | 1.2 | 0.0 |
| BA-06NP3N1 | HPS-P6 | 5354.0 | 5.5 | 1.8 | 4.0 | 54.7 | 61.3 | 31.3 | 3.4 | 6.8 | 66.1 | 8.5 | 15.3 | 11.9 | 89.8 | 8.5 | 1.7 |
| BA-06NP4N1 | HPS-P7 | 4544.9 | 6.6 | 2.2 | 6.1 | 63.0 | 76.3 | 38.0 | 12.9 | 0.0 | 40.0 | 41.4 | 5.7 | 11.4 | 68.6 | 20.0 | 11.4 |
| BA-06SP1N1 | HPS-P8 | 5289.3 | 6.1 | 2.0 | 5.3 | 54.7 | 54.7 | 39.7 | 39.6 | 0.0 | 35.4 | 22.9 | 2.1 | 5.9 | 56.3 | 27.1 | 16.7 |
| BA-06SP2N1 | HPS-P9 | 3600.0 | 6.5 | 2.5 | 8.5 | 76.3 | 61.3 | 48.0 | 9.1 | 58.4 | 5.2 | 7.8 | 19.5 | 14.4 | 80.5 | 15.6 | 3.9 |
| BA-06SP3N1 | HPS-P10 | 988.1 | 6.8 | 2.8 | 7.2 | 44.3 | 44.3 | 40.5 | 17.4 | 79.3 | 0.0 | 3.3 | 0.0 | 12.9 | 86.8 | 13.2 | 0.0 |
| BA-06SP4N1 | HPS-P11 | 2844.4 | 5.8 | 2.3 | 7.4 | 63.0 | 38.0 | 18.0 | 0.0 | 86.7 | 6.7 | 2.2 | 4.4 | 3.2 | 82.2 | 15.6 | 2.2 |
| BA-06SP5N1 | HPS-P12 | 2629.8 | 7.3 | 3.3 | 9.5 | 43.7 | 39.7 | 35.3 | 2.8 | 47.2 | 38.7 | 0.0 | 11.3 | 13.8 | 89.6 | 10.4 | 0.0 |
| BA-06SP6N1 | HPS-P13 | 2770.1 | 6.6 | 2.6 | 10.2 | 83.0 | 73.0 | 28.0 | 41.7 | 0.0 | 16.7 | 8.3 | 33.3 | 4.0 | 83.3 | 4.2 | 12.5 |
| BA-06SP9N1 | HPS-P14 | 3947.3 | 5.3 | 1.3 | 3.7 | 76.3 | 69.7 | 16.0 | 0.0 | 2.4 | 92.9 | 0.0 | 4.8 | 4.5 | 97.6 | 2.4 | 0.0 |
| BA-06SP7N1 | HPS-P15 | 5590.0 | 5.9 | 1.6 | 5.5 | 78.0 | 63.0 | 15.3 | 0.9 | 81.3 | 4.5 | 0.0 | 13.4 | 24.3 | 86.6 | 13.4 | 0.0 |
| BA-10P3N1 | HPS-P16 | 19930.8 | 4.9 | 1.1 | 2.4 | 76.3 | 76.3 | 24.7 | 3.5 | 0.0 | 1.8 | 94.7 | 0.0 | 8.1 | 86.0 | 14.0 | 0.0 |
| BA-10P1N1 | HPS-P17 | 10655.6 | 6.5 | 1.9 | 5.7 | 89.0 | 63.0 | 21.5 | 0.0 | 1.5 | 1.5 | 97.0 | 0.0 | 2.9 | 71.2 | 27.3 | 1.5 |
| BA-10P5N1 | HPS-P18 | 38699.3 | 4.3 | 1.0 | 2.3 | 83.0 | 53.0 | 5.0 | 0.0 | 72.7 | 9.1 | 18.2 | 0.0 | 0.0 | 81.8 | 18.2 | 0.0 |
| BA-10P2N1 | HPS-P19 | 18179.5 | 4.2 | 0.6 | 2.1 | 69.7 | 46.3 | 13.7 | 0.0 | 4.3 | 52.2 | 43.5 | 0.0 | 4.2 | 69.6 | 21.7 | 8.7 |
| BA-10P4N1 | HPS-P20 | 19357.3 | 3.7 | 0.7 | 1.9 | 81.0 | 34.0 | 9.0 | 10.5 | 0.0 | 21.1 | 68.4 | 0.0 | 32.1 | 57.9 | 36.8 | 5.3 |

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

**Table D-3**.—Shrub data by vegetation quantification plot.

| Nest ID | Plot ID | Density (#/ha) | Height (m) | Crown width (m) | Shrub stem species composition (%)* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SAGO | TARA | SAEX | PODE | BASA | ELAN | Dead |
| BA-06NP1N1 | HPS-P1 | 5337.7 | 1.3 | 0.4 | 4.7 | 75.7 | 10.3 | 0.0 | 0.0 | 9.3 | 38.2 |
| BA-06NP6N1 | HPS-P2 | 8140.7 | 1.7 | 0.7 | 26.4 | 26.4 | 19.8 | 0.0 | 24.2 | 3.3 | 43.1 |
| BA-06NP2N1 | HPS-P3 | 11687.4 | 1.3 | 0.4 | 12.7 | 3.2 | 80.0 | 0.5 | 0.0 | 3.6 | 32.7 |
| BA-06NP8N1 | HPS-P4 | 31141.9 | 1.4 | 0.4 | 0.0 | 35.9 | 51.2 | 9.4 | 3.1 | 0.4 | 19.0 |
| BA-06NP7N1 | HPS-P5 | 7243.1 | 1.5 | 0.3 | 0.0 | 40.5 | 52.7 | 6.8 | 0.0 | 0.0 | 16.7 |
| BA-06NP3N1 | HPS-P6 | 7785.5 | 1.4 | 0.3 | 18.5 | 0.8 | 66.4 | 7.6 | 0.0 | 6.7 | 50.0 |
| BA-06NP4N1 | HPS-P7 | 7141.4 | 1.8 | 0.5 | 0.0 | 1.3 | 90.0 | 8.8 | 0.0 | 0.0 | 59.2 |
| BA-06SP1N1 | HPS-P8 | 8264.5 | 1.3 | 0.4 | 46.2 | 1.1 | 30.1 | 22.6 | 0.0 | 0.0 | 42.9 |
| BA-06SP2N1 | HPS-P9 | 1654.7 | 1.6 | 0.5 | 0.0 | 51.3 | 5.1 | 0.0 | 0.0 | 43.6 | 15.2 |
| BA-06SP3N1 | HPS-P10 | 1849.9 | 1.8 | 0.7 | 43.2 | 56.8 | 0.0 | 0.0 | 0.0 | 0.0 | 51.9 |
| BA-06SP4N1 | HPS-P11 | 36281.2 | 1.3 | 0.3 | 0.0 | 58.5 | 41.5 | 0.0 | 0.0 | 0.0 | 33.3 |
| BA-06SP5N1 | HPS-P12 | 2081.9 | 1.3 | 0.4 | 0.0 | 72.9 | 22.4 | 0.0 | 0.0 | 4.7 | 24.1 |
| BA-06SP6N1 | HPS-P13 | 10794.4 | 2.3 | 0.7 | 4.4 | 0.0 | 65.6 | 30.0 | 0.0 | 0.0 | 25.0 |
| BA-06SP9N1 | HPS-P14 | 25600.0 | 1.5 | 0.5 | 0.0 | 0.0 | 87.4 | 12.6 | 0.0 | 0.0 | 39.1 |
| BA-06SP7N1 | HPS-P15 | 17199.7 | 1.9 | 0.6 | 3.0 | 62.7 | 0.0 | 0.0 | 0.0 | 23.9 | 55.3 |
| BA-10P3N1 | HPS-P16 | 8391.1 | 1.9 | 0.5 | 3.3 | 11.1 | 61.1 | 24.4 | 0.0 | 0.0 | 46.1 |
| BA-10P1N1 | HPS-P17 | 10385.8 | 1.3 | 0.3 | 0.0 | 20.7 | 46.3 | 32.9 | 0.0 | 0.0 | 66.7 |
| BA-10P5N1 | HPS-P18 | 5419.9 | 1.4 | 0.5 | 0.0 | 4.3 | 95.7 | 0.0 | 0.0 | 0.0 | 15.3 |
| BA-10P2N1 | HPS-P19 | 8140.7 | 1.6 | 0.4 | 0.0 | 4.5 | 95.5 | 0.0 | 0.0 | 0.0 | 50.0 |
| BA-10P4N1 | HPS-P20 | 22360.0 | 0.9 | 0.3 | 0.0 | 1.1 | 94.3 | 4.5 | 0.0 | 0.0 | 58.3 |

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