Babacomari River Riparian Protection Project – # 09-164WPF

Final Report

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Arizona Water Protection Fund Commission

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Cover photo: Pronghorn on Hay Canyon burn, Babacomari Ranch, L. Kennedy, 5-31-13

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1. Executive Summary

The Babacomari River is a major tributary of the San Pedro River in Santa Cruz and Cochise counties, Arizona. This 140,000 acre catchment includes rolling grasslands on the Sonoita plain, oak woodlands in the Canelo Hills and the pine-oak forests of the northwestern Huachuca Mountains. The Babacomari River runs for 22 miles from its headwaters near Sonoita at 5000 feet elevation, eastward to join the San Pedro at Fairbanks at an elevation of 3850 feet. The US Geological Survey estimates that this important tributary contributes about 6000 acre feet of water annually to the San Pedro River system. The Arizona Dept. of Water Resources, through the Arizona Water Protection Fund Commission (WPF), awarded this 5 year study with a grant (09-164WPF) in 2009. Monitoring transects were installed in 2009 and 2010 and were re-read each year through 2013. The project objectives included: construction of about 2 miles of riparian boundary fence to improve grazing management of livestock along the Babacomari River, installation of six stream riparian vegetation and geomorphic monitoring transects and six vegetation and geomorphic transects on riparian grasslands (sacaton) on tributaries to the Babacomari River, analyze data and summarize results annually, and present that information to the participating ranch properties for use in making management decisions. Riparian monitoring stations were established in May of 2010, at three locations along the Babacomari River below the Babacomari Ranch (BR) headquarters and at three locations in June of 2010, on the Appleton-Whittell Research Ranch (ARR or TRR) of the National Audubon Society. These riparian monitoring transects were re-read in June of 2011, 2012 and 2013. Riparian grasslands include large bottomlands of giant sacaton (*Sporobolus Wrightii Monro ex Scribn*) on both the BR and the ARR. Riparian grassland monitoring stations (three on each property) were established in the fall of 2009, re-read in 2010, 2011, 2012 and 2013. Monitoring locations in both Riparian grasslands and Riparian stream plant communities show stable or improving trends in ecological conditions with below average precipitation during the duration of the study. The owners of the Babacomari have completed conservation easements on 3316 acres since 2007 with the intention of placing a total of 15,000 acres under easement. The easement holder is the United States via the BLM. The primary funding has been derived from the Dept. of the Army – Fort Huachuca, through the Army Compatible Use Buffer (ACUB) Program. The majority of land on the Research Ranch is already protected from development. Both properties have made a commitment to maintain the monitoring systems established as a result of this grant well into the future.

2. Introduction

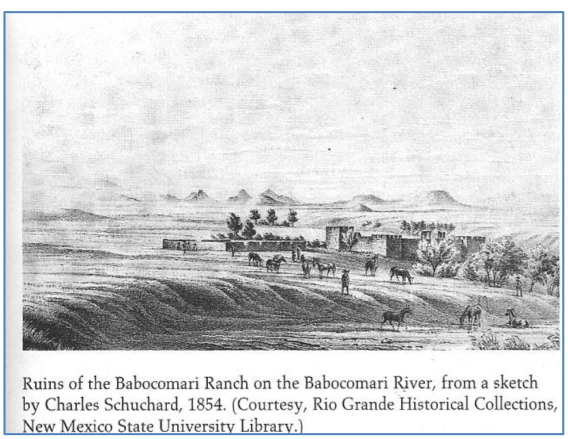
The Babacomari River (aka Babocomari River) is a major tributary of the San Pedro River in Santa Cruz and Cochise counties, Arizona. The 310 square mile catchment includes rolling grasslands on the Sonoita plain, Chihuahuan desert scrub of the Whetstone pediment, oak woodlands in the Canelo Hills and the pine-oak forests of the northwestern Huachuca Mountains. The Babacomari River runs for 22 miles from its headwaters near Sonoita at 5000 feet elevation, eastward to join the San Pedro at Fairbanks at an elevation of 3850 feet (Cook et al. 2009). This important tributary contributes about 6000 acre feet of water annually to the San Pedro River system (ADWR, 2005). Protection and monitoring of the Babacomari River and associated ecosystems are an important part of the management of water resources in the area. The Arizona Dept. of Water Resources funded a 5 year study with a grant (09-164WPF) in 2009. Monitoring transects were installed in 2009 and 2010 and were re-read each year through 2013.

The objectives of the grant: 1) construct 2 miles of fence to restrict access by livestock to the Babacomari River corridor, 2) install six vegetation and geomorphic transects on riparian grasslands (sacaton), 3) install six riparian vegetation and geomorphic monitoring transects, 4) present annual results to the participating ranch properties for use in making management decisions.

3. Background

The area has a long history of human occupation, cultural land use and vegetative change. Human use dates back at least 12000 years. Native American cultures slowly changed from big game hunters to hunter–gatherers and by 600 AD a Hohokam farming culture using ceramics occupied the San Pedro and Babacomari river valleys. It was estimated that 2000 native people lived in the area by the time of Spanish contact in the 1540s. Apache people arrived in the area in the late 1680s and by the time Fr. Kino (1692) visited the Sobaipuri village of Quiburi on the San Pedro, Apache raiding was already taking a toll. A Spanish presidio was established there in 1776 and by 1786 the Spanish were able to buy peace with the Apache with money and food. This lasted until Mexican independence in 1821 (Bahre 1977, 1991).

Spanish and Mexican cattle ranchers moved into the area in the early 1800s. The Elias family of Arispe, Sonora applied for title to large areas of land along both the San Pedro and Babacomari rivers in the 1820s (Elias 2008, Munsun 1976). They received title to 35,000 acres along the Babacomari in 1832 and another 37000 acres along the San Pedro in 1827 and 1833. These "Mexican Land Grants" became the first large scale ranching operations in the area. The newly minted Mexican government could not afford the Spanish program of "Apache pacification" and by the 1850s renewed raiding forced most ranching families to abandon their land grants for the safety of Sonora. Livestock went wild and were hunted by native people (Bahre 1991).



The original Babacomari Ranch headquarters (Elias Hacienda in1854).

West Guard tower Camp Wallen, built on the site of the Elias Hacienda in 1866. 1-24-09

The Gadsen Purchase in 1854 brought the area under control of the United States and by the late 1860s US Army posts had been established in the area to protect citizens and settlers. Camp Wallen was located on the Babacomari River at the site of the old Elias Hacienda in 1866. It was abandoned a few years later and moved to the present day site of Fort Huachuca because of malaria due to swampy conditions along the creek (Smith, C.C. 1976). Anglo and Mexican cattleman began to enter the region. By the 1870s Apache raiding was actively being suppressed by the Army and ranching began to prosper and spread. Mining soon followed and boomtowns like Tombstone and Bisbee brought considerable new settlement to the area (Bahre, 1991).

Wealthy Americans began investing in the region. Dr. E.B. Perrin of San Francisco bought the rights to the Babacomari Ranch from the Elias heirs in 1877. In 1903 the US Court of Private Land Claims awarded title to 33,792 acres to the Perrin family. G.H. Howard and George Hearst purchased the San Pedro properties from the Elias heirs in 1879. William Greene purchased the rights to another large area along the San Pedro River from the Camou family of Sonora in 1884 (Bahre 1991). These became the large ranches of the day; unfenced and ranging out as far as livestock could wander from the water in the river. Homesteading began in 1879 and in three years 41 small (160 acre) land claims were filed along the two rivers (Rodgers 1965).

The Southern Pacific Railroad from Yuma to Tucson was completed in 1877 and the line from Tucson to Benson completed in 1880. The Atchison, Topeka and Santa Fe Railroad Company completed the New Mexico and Arizona line from Benson to Fairbank in 1881 and through Nogales to the deep water port at Guaymas, Sonora in 1882 (Myrick 1981). This right of way, several wooden bridges and a steel bridge across the Babacomari River are still used for ranch transportation and access.

The rapidly growing population needed food and ranching met the needs. In 1882 it was estimated that 3,000 head of cattle were in the region. By 1890 the number was 36,000 head; more than double the estimated carrying capacity. Severe drought over the next few years resulted in the death of half to three quarters of the livestock in the area. The rangelands were devastated (Bahre 1991, Hastings and Turner 1965, Wilson 1995). An earthquake in May of 1887 caused a fissured zone the length of the San Pedro valley and changes in stream flow (Dubois 1980). Large floods in the 1890s initiated gully and channel erosion along both rivers. From 1900 to 1918 the San Pedro River cut down 15 to 20 feet from Fairbanks to Hereford (Hereford 1993). The Babacomari began to cut down to the new base level established in the San Pedro (Cooke 1976, Hereford 1993). Upland vegetation in the lower part of the valleys began to change from grassland to shrub-land. Many records have documented this trend especially photographic studies using repeat photography (Hastings and Turner 1965, Humphrey 1987). Higher elevation grasslands and woodlands were overgrazed, soils were compacted and runoff and erosion increased. Coronado National Forest reserves began in 1908 to protect woodlands and forests from destruction by the demands of mining and settlement (Wilson 1995).

By the 1930s ranchers were reducing herds and looking for ways to rebuild the ranges. The Taylor Grazing Act of 1934 resulted in adjudication and fencing of the public domain. US Forest

Service allotments were fenced and assigned livestock carrying capacities. The Civilian Conservation Corps (CCC) began doing erosion control and forest and range improvement work on both public and private lands in the area 1933 (US Forest Service 1991, Wilson 1995).

The Brophy family bought the Babacomari Ranch from the Perrin family in 1935. The Brophys were prominent merchants and bankers in the Cochise County mining towns of Bisbee and Douglas. The family immediately set about to rebuild the ranch and rehabilitate worn out rangelands that had been devastated by years of overgrazing and the "Dust Bowl" drought in the early 1930s. The family invited the CCC to work on erosion control structures on the ranch. Under the direction of the Soil Conservation Service these crews built several structures that have been maintained faithfully by the family over the years. One large dam and spillway near the ranch headquarters prevented the historic down-cutting of the Babacomari stream channel from proceeding upstream through the upper watershed of nearly 70,000 acres. This dam continues to function perfectly today. The Brophy family did not stock the ranch with livestock for over 20 years and instead focused their efforts on rehabilitating the worn out rangeland using practices like contour ripping, seeding, water-spreading and gully control. CCC works including dams and dikes controlled erosion in larger drainages while the family concentrated on improving vegetative (grassland and riparian) conditions (Frank Brophy Jr., personal communication). The Brophy family continues today to manage the ranch in a sustainable manner.

In the late 1940s Soil and Water Conservation Districts (SWCD) began to form and farmers and ranchers in the area joined the Santa Cruz and Hereford SWCDs to receive assistance with projects designed to control erosion, and improve management of rangelands, farmlands and woodlands. Riparian vegetation, especially trees like Fremont cottonwood (*Populous fremontii*) and Gooding or black willow (*Salix goddingii*), began to develop in the raw river channels of the Babacomari and the San Pedro where there were few trees before (Webb, 2007). Rangelands began to recover in the upper watershed and dikes and dams controlled gullies and head cuts. Through the 1950s and 60s rangeland conditions stabilized. Environmental pressure on US Government land management agencies in the 1970s and 80s resulted in actions that finally brought stocking rates into line with forage production and rangeland conditions actually began to improve.

The Appleton family bought the Clark Ranch from Newell Clark in 1959 and the Swinging H Ranch along O'Donnell Canyon in 1965 from Harold Tovrea. Tovrea and Clark had consolidated their ranches by purchase of smaller homesteads in the area. No less than seven original homesteads and a few that were never proven up combine to make up the Research Ranch today (Bahre 1977). The Appleton family began to ranch under the name "Elgin Hereford Ranch." They raised registered Hereford cattle and embarked on an ambitious program of rangeland improvement. Ranch managers Bill and Posy Piper oversaw activities including new fence line construction, livestock water developments, gully control dikes and large water spreading dikes in the sacaton bottomlands many of which still function today. In 1967 the Appleton family decided to remove cattle from the ranch and turn the property into a location for grassland research. Several years later it was transferred to the National Audubon society as a grassland research station for studies of native plants and animals and their environment

(Bahre 1977, Bock and Bock 2000). The Research Ranch is properly called the Appleton-Whittell Research Ranch of the National Audubon Society. The National Audubon Society, with its partners (BLM, USFS, TNC, Resolution Copper Mining, and The Research Ranch Foundation), continues to manage the property as a grassland research station according to the original intentions of the Appleton family.

Today most of the upper part of the watershed of the Babacomari River is in good to excellent vegetative condition and erosion is minimal. The small part of the watershed below Huachuca City is still in poor condition with dense stands of shrubby species that began to increase in the 1920s and 30s. Erosion of topsoil over the past 100 years, gypsic subsoils (USDA NRCS, 2008) and low annual rainfall in this area preclude a return to grassland conditions. Natural Resource Conservation Districts (former SWCDs, now NRCDs), land owners, military reservations and ranchers today continue to work to improve and maintain rangeland and riparian conditions. Development of private lands in the watershed of the Babacomari and San Pedro Rivers poses the greatest modern day threat to riparian and watershed conditions as well as surface and ground water supplies in the area.

4. Natural History

The upper watershed of the Babacomari River is formed by the rim of the Huachuca Mountains to the southeast, the Canelo Hills to the southwest, high elevation plains in the Sonoita – Elgin area, the Mustang Mountains and Whetstone Mountains to the north. The catchment or watershed area has its headwaters along the mountain tops with large canyons (from southeast to west to northeast) including Huachuca, Blacktail, Lyle, Turkey, O'Donnell, Post, Vaughn, O'Leary, Hay, Babacomari, Chapo Beatty and Javalina draining the uplands into the large areas of riparian grasslands (sacaton) primarily above the Babacomari Cienega. The classic system of catchment area, transport zone and accumulation zone (Zaimes, 2007) occurs above the Babacomari Cienega and Ranch headquarters. The area below the ranch headquarters is a sub-watershed which narrows as the Babacomari River approaches its confluence with the San Pedro River at Fairbanks, Arizona. (see Appendix B)

The mountains forming the watershed boundaries are largely composed of Mesozoic and Paleozoic limestones and associated sedimentary rocks over a very old basement of Proterozoic granites. From the southern Whetstone Mountains south across the Mustangs to the Huachucas these rocks are cut by thrust faults leaving east-west trending ridges with steep northwest strikes and large vertical displacement (US Geologic Survey, 1996 and Cook et al. 2009). The Babacomari River follows one of these faults east on its way to the San Pedro River. The Canelo Hills to the south and southwest are largely Naco Group limestone, lower Permian in age with intrusions of the lower Cretaceous, Canelo Hills volcanics and associated sedimentary rocks (US Geologic Survey, 1996). The watershed boundary to the west and northwest is a low ridge of alluvium in the Sonoita grasslands separating the Babacomari drainage from the watershed of Cienega and Sonoita Creeks.
Upland soils in the upper watershed of the Babcomari River are clayey to loamy ustolls, ustalfs, argids and calcids, largely Pleistocene in age and producing a luxurious plains grassland

vegetation (Brown ed.1982). These soils are mostly underlain by conglomerate and fanglomerate bedrock, cemented by lime and silica, variously assigned to the Pantano formation but ranging in age from .5 to 2 million years old (Cook et al.2009, USGS 1996). Soils found in the riparian grasslands are formed in younger (Holocene) alluvium and classified as ustic and ustertic torrifluvents in the thermic soil temperature regime and ustic aridic soil moisture regime. They include soil series like Comoro (sandyloam texture), Ubik (loam and silt loam textures), Pima (clayloam and silty clayloam textures) and Guest (clay and silty clayloam textures) (USDA-NRCS, 1976, 2001, 2002).

Soils found along rivers and in stream channels are classified as aquic torrifluvents and riverwash. They are mapped to family (fluvaquents) or as Brookline soil series and have anerobic (low oxygen) conditions all or most of the year. They are sandy and gravelly in texture (USDA-NRCS 2002).

Plant communities in the catchment area of the upper watershed include Pine-Oak woodlands at the highest elevations to Oak woodlands and savannah in middle elevations above 5000 feet. From about 4000 to 5000 feet is a plains grasslands zone dominated by species of grama grass (*bouteloua*), threeawn (*aristida*) and other warm season midgrass species. In the lower part of the watershed, below 4000 feet, former desert grasslands have changed to desert shrublands dominated by mesquite (*prosopis spp*.), creosotebush (*larrea tridentata*) and acacia species (*acacia spp*.).

Annual precipitation in the area ranges from 11.5 inches at Fairbanks at 3800 feet elevation along the San Pedro River to 15 inches at Sierra Vista, 17 inches at the Babacomari and Audubon Ranches, 18.5 inches at Canelo and over 25 inches in the tops of the Huachuca Mountains at 8000 feet elevation (WRCC, NOAA).

Giant sacaton (*sporobolous wrightii*) forms dense grasslands on loamy to clayey floodplains along the Babacomari River and its major tributaries. It is estimated that sacaton grasslands occupy less than 5 percent of their former extent in this region (Stromberg, 1993). Most of the sacaton grasslands across southern Arizona have been plowed and put into agricultural use or converted to urban and industrial areas. Those in the project area are some of the best examples left in the region.

Sacaton is a very large (2 meter) warm season (C4) bunchgrass. Although studies have not been done to determine natural lifespans of sacaton plants, it appears that plants can live well over 50 years and may even approach 100 years. Sacaton has vital functions on floodplains to spread floodwaters, dissipate energy, retain organic debris and sediment and increase opportunity time for flood waters to infiltrate into the alluvial aquifer. It also provides wildlife habitat for unique animal species (Bock & Bock 2000) and forage for livestock (Cox, et al. 1983). The ecological site description for the sacaton sites is called Loamy Bottom (#R041XA312AZ and R041XC312AZ) is available on the Natural Resources Conservation Service (NRCS) website, Ecological Site Information System (ESIS). This description includes information about the native potential plant community, soils and site characteristics and interpretations for land uses like livestock grazing and wildlife (USDA-NRCS 2005).

Annual above ground biomass production of sacaton stands can range from 4000 to 6000 pounds per acre per year on a dry weight basis. Sacaton begins growth in the spring, greening up by the first of April in the project area. A study conducted in the mid-1990s found that sacaton uses stored soil moisture and groundwater (if available) to grow and produce new green shoots in the spring after winter dormancy (Tiller 2004). The same study found that sacaton growth in the summer was entirely from rainfall received in the summer monsoon. The majority of the production of above ground biomass of sacaton occurs July through September during the summer monsoon (Cox 1984). Sacaton is deep rooted especially in loam textured soils. It is not uncommon to see sacaton roots one millimeter in diameter 7 meters deep in a gully head-cut in loam or silt loam soils like Ubik series. Fine textured soils may restrict root development if deeper layers are dense clay. A study recently completed on sacaton bottom sites on the Las Cienegas National Conservation Area managed by the Bureau of Land Management (BLM) illustrated the variation in sacaton plant communities along Cienega Creek (Tiller et al. 2012). The densest and most productive of these communities had water table within five meters of the surface. When water table drops below the sacaton root zone or incision of the floodplain lowers the water table, sacaton communities thin, erosion accelerates and shrubs like mesquite can invade. Depth to water table is variable in sacaton plant communities and capillary rise in loamy to clayey soils can bring soil water 1 to 2 meters closer to the root zone but when it drops to 10 meters or more it is generally unavailable to plant roots.

Although sacaton is very coarse and unpalatable as livestock forage it has high nutritional value. Sacaton regrowth after burning or mowing will be readily grazed (Cox 1985). Studies conducted by the Agricultural Research Service (ARS) on the Empire Ranch show that spring (Feb.-March) burning reduced the production of above ground biomass of sacaton for two to three years after the fire. Sacaton burned (and not grazed) in the summer (July-Aug.) recovered quickly during subsequent summer rains (Cox 1988). Sacaton plants burned in any season in dry years or burned and grazed (mowed) afterwards had reduced vigor for several years (Cox et al. 1989). The authors of these studies recommended not burning sacaton and grazing in the spring each year to keep grass cover productivity high.

Sacaton stands on the Research Ranch are not grazed by livestock. Sacaton floodplains in O'Donnell canyon north of the Swinging H Ranch burned in both 1975 and 1986. In both of these fires sacaton stands recovered in two to three growing seasons post fire (Bock and Bock 2000). In the WPF grant study period, sacaton burned on the Research Ranch in 2002 and 2009. Sacaton monitoring data documents complete recovery in two summer growing season after the 2009 fire.

Traditional practices call for burning sacaton during March and grazing the tender and nutritious regrowth during the spring and early summer. An additional safeguard is to burn only in years where cool season precipitation is 4 inches or more. This ensures plants have soil moisture to begin and sustain growth in the spring. If the plants are rested from grazing the summer growing season following the fire they recover to pre-burn levels in two seasons. Burning and grazing in this manner appears to be sustainable if the interval between fires is five years or more. Although natural fire free intervals are not well documented for these grasslands at least one study on the San Bernardino Cienega documented a natural fire interval of between 20 and 35 years in the past several hundred years (Brunella and Minckley 2009). Periodic burning in dense sacaton stands may be helpful in slowing the spread of mesquite into the areas. Studies done in Arizona in desert grasslands on the Santa Rita Experimental Range showed that at least 4500 pounds per acre of fine fuel was required to get 20 percent mortality on mature mesquite (Wright 1982). Sacaton grasslands regularly have 5000-7000 pounds per acre (dry weight) of fine fuel per acre, more than enough to kill some mature mesquite plants and certainly to kill most seedlings and young plants.

Sacaton has been difficult to re-establish on areas where it was lost or removed (Stromberg 1993). One study showed that at least 14 species of arbuscular mycorrhizal fungi live in the soil in association with the root system of sacaton and these fungi species may be necessary for successful establishment of sacaton on abandoned agricultural fields (Kennedy 2001). This highlights the importance of conserving the remaining stands of sacaton especially on intact floodplains and in functioning watersheds like that of the upper Babacomari River.

The Babacomari Cienega is one of the last intact southwestern wetlands left in the region (Hendrickson and Minckley 1984). Cienegas are true wetlands with water tables at or near the surface and anerobic soil conditions that limit the plant community to those species that can live in low oxygen environments. Soils in this area are high in clay and organic matter and exhibit grey and mottled colors due to the reduction of iron and other minerals. The plant community is dominated by wetland grass and grass-like species including alkalai muhly (*Muhlenbergia asperifolia*), sedges, rushes, spike rush, deergrass, slender wheatgrass (*Elymus trachycaulum*), three square bulrush (S*choenoplectus americanus*) and knotgrass (*Paspalum distichum*). Common wetland forbs include perennials like buttercup, yerba mansa, dock (*Rumex spp*.), white prairie aster (*Symphyotrichum falcatum* v*. commutatum*), blue eyed grass (*isrinchium demissum*) and checker mallow (*Sidalcea neomexicana*). Several rare plants occur in southwestern cienegas including one T&E species, a rare orchid, Canelo Hills Ladies Tresses (*Spiranthes delitescens*) which occurs in the Babacomari Cienega.

Stream riparian areas are thought to be one of the most threatened plant communities in the southwestern United States and northern Mexico. Commonly classified as Sonoran or Interior Riparian Deciduous Forest and Woodlands (Brown ed. 1982), these communities are dominated by broadleaf deciduous tree species like Fremont cottonwood and Goodding willow. They are said to support one third of the region's vascular plant species, provide habitat for a tremendous variety of wildlife and essential areas for migratory animals. Over 100 species of breeding birds use the San Pedro River riparian woodlands and 390 bird species use the area while foraging or in migration (Webb et al.2007).

The ecological site description for the stream riparian sites is called Sandy Bottom 12-16" precipitation zone (F041XC317AZ) and is available on the Natural Resources Conservation Service (NRCS) website, Ecological Site Information System (ESIS). This description includes information about the native potential plant community, soils and site characteristics and interpretations for land uses like livestock grazing and wildlife (USDA-NRCS 2005).

Although Fremont cottonwood and black willow dominate these riparian woodland communities, other important tree species include Arizona ash (*Fraxinus velutina*), black willow (*Juglans major*), netleaf hackberry (*Celtis laevigata* var. *reticulata*), Arizona sycamore (*Plantanus wrightii*), velvet mesquite (*Prosopis veluntina*) and western soapberry (*Sapindus saponaria*).

Early studies of the extent of stream riparian areas remaining in Arizona reported between that between 80 and 95 percent of these areas have been lost in the southwestern United States in the historic past. A more recent and thorough study of the extent of these plant communities involved the study of repeat still and aerial photography to look at changes in the historic past. Ninety photo stations document changes in the upper San Pedro River valley from 1880 through 2003. The repeat photography illustrates the tremendous increase in riparian woodland in the past 120 years. In 1880 photographs show virtually little development of riparian woodlands in the San Pedro. Scattered stands of cottonwood existed but the majority of the river was described as barren, swampy, marshy or grassy with sacaton species and full of beaver. Riparian woodland in the San Pedro expanded greatly after channel cutting began about the turn of the 20th century (Webb et al. 2007). Riparian tree species began to increase in extent and canopy cover in the 1930s and 1940s with stabilization in the stream channel and development of a new floodplain well below the historic level. This development has continued along the upper San Pedro River and its tributaries like the Babacomari River through the present.

The understory plant community of stream areas are dominated by aquatic plant species growing along the green-line (wet banks of the stream). Large, warm season perennial grass species including deergrass (*Muhlenbergia rigens*), sacaton, and alkalai sacaton (*Sporobolous airoides*) occur on top of stream banks and low floodplains while cool season grass and grass-like species including Canada wild rye (*Elymus canadensis*), sedges (*Carex* spp.), rushes (*JJuncus* spp.), spike rush (*Eleocharis* spp.) and horsetail (*Equisetum* spp.) occur on the greenline where the stream bank is wet and soil conditions are anerobic most of the time. Perennial aquatic forbs are also common and include native species like yerba mansa (*Anemopsis californica*), water marigold (*Bidens aurea*), water parsnip (*Berula erecta*), buttercup (*Ranunculous macranthus*) and non-native species like water cress (*Nasturtium officinale*), curly dock (*Rumex crispis*) and water speedwell (*Veronica anagallis-aquatica*).

These plant communities have been used for hundreds of years for food, medicine, wood, building materials and later for livestock grazing. Unrestricted livestock grazing has been documented to result in many negative impacts to riparian stream communities including loss of desirable herbaceous forage species, lowered reproduction of common tree species, trampling of stream-banks, erosion in channels and low floodplains and reduced water quality (Vavra ed. 1994). Livestock concentrate in riparian areas especially in late spring /early summer (May-July) when temperatures are high and green forage is lacking on adjacent rangelands. Most grazing studies in riparian areas have shown that livestock exclusion results in the most dramatic and rapid recovery of plant communities and soil stability (Vavra ed. 1994). Livestock exclusion in riparian areas is advisable in National Conservation Areas where conservation of plant and animal species is the primary objective. It is, however, impractical to fence out linear areas of riparian vegetation throughout the region and in grazed areas, it may be a better idea to develop riparian pastures fenced to include areas of uplands and to restrict grazing to the cooler months (fall, winter and spring) of the year when the need for shade and water is less and riparian plant species are not actively growing or reproducing. Grazing in this manner on the Babacomari River since 1997 resulted in stable or improving vegetative trend, good ecological conditions in riparian plant communities and positive geomorphic conditions as documented in this study.

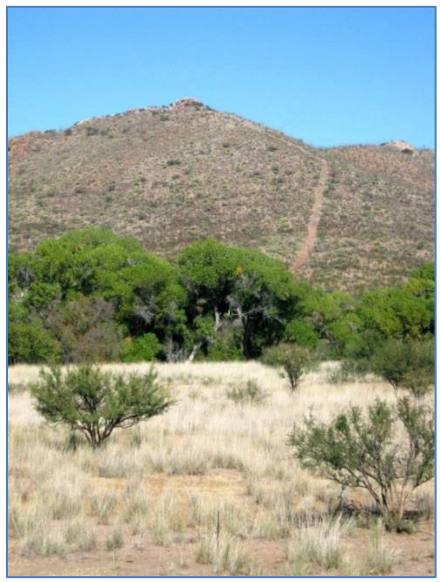
The greatest threat to riparian areas in this region is loss of groundwater due to increased pumping for cities and commercial development (ADWR 2005). Water levels declines exceeding 30 feet from the surface are sufficient to kill many obligate riparian tree species and can be caused by both groundwater pumping and stream channel down-cutting (Webb et al. 2007). The lowering of the water table upriver may take decades to propagate down-gradient to riparian ecosystems, and those like the upper San Pedro may already be imperiled regardless of future changes in groundwater use (Webb et al. 2007)

5. Actions

The following summary highlights action taken on the Babacomari River Riparian Protection Project (09-164-WPF) over the past five years. The grant award contract was signed by the Arizona Water Protection Fund (WPF) Commission on 7-01-09. Verbal permission was given by the Coronado Resource Conservation and Development (RC&D) Project coordinator Donna Matthews to Dan Robinett to begin work on developing plans and making investigative surveys in early July 2009. A formal subcontractor agreement between the Coronado RC&D Project (grant coordinator) and Robinett Rangeland Resources LLC (environmental contractor) was signed on 8-21-09. This contract was signed too late in 2009 to allow installation of riparian green-line and tree monitoring at six sites, three each on the Babacomari Ranch (BR) and the Audubon Research Ranch (ARR). These monitoring transects were installed in the spring of 2010. The six riparian grassland monitoring stations (three each on the BR and ARR) were installed in the fall of 2009. The following activities associated with this grant have been completed by Robinett Rangeland Resources LLC over the past five years.

Several plans were developed for the Water Protection Fund Commission in 2009. These include plans for 1) Monitoring riparian plant communties, 2) Outreach activities and 3) Fencing. New fencing (about 9350 feet three wires, solar electric) was completed by ranch manager Doug Ruppel and crew of the Babacomari Ranch in November 2009. This fencing forms the north boundary of the Bridge Pasture and isolates about 1.5 miles of the Babacomari

River with perennial flow into a small and easily managed riparian pasture. The fence right of way (ROW) was surveyed for T and E plants and animals, cultural resources, flagged and a report filed by the Natural Resources Conservation Service (NRCS) with the State Historic Preservation Office (SHPO). The project was approved by the SHPO in early October 2009. Permission was granted by Coronado RC&D for construction to begin after the Fence/Grazing plan had been approved and the ranch began to clear the ROW. Portions of the ROW were cleared by hand to avoid soil surface disturbance on steep slopes. More level parts of the ROW were cleared to a width of ten feet by a small Bulldozer. The fence was completed in late November and checked and approved by NRCS on 11-20-09. It is very well constructed and will provide excellent service for many years as well as providing good accommodation for native wildlife species and controlling livestock access to the river and its associated plant and animal community.



Fence Corner on top of the Indian Watchtower Ridge and new fence ROW for the Bridge Pasture along the Babacomari River in November 2009

Six riparian grassland monitoring sites were selected and vegetation / geomorphic surveys were established. Three locations are on the ARR and three are on the BR. Five of these locations occur at riparian grassland sites Dr. Ron Tiller used in his doctoral work at Arizona State University. This provides a geomorphic baseline that extends back to 1997. The sixth location, on the Babacomari Cienega, is a new location. A geomorphic cross section was established there as well.

Six riparian green-line, tree and geomorphic monitoring sites were established in May and June of 2010. Three of these are on the Babacomari Ranch. They are located on the Babacomari River with one at the USGS stream gauge in the River pasture (BR#1), another just above the Railroad bridge in the Bridge pasture (BR#2) and the third at the old Farm crossing just north of the irrigated land below the ranch headquarters. Three are located on the Audubon Research Ranch. One is in Turkey creek just north of the USFS boundary (TRR#1). Two are in O'Donnell canyon; one is in the perennial reach above the concrete dams (TRR#3) and the third is east of that location a half mile in an ephemeral reach of the creek (TRR#2).

Monitoring transects have been re-read annually from 2010 through 2013. Monitoring data is assembled and analyzed in excel spreadsheets (see Appendices D through U). Annual reports were prepared in 2009, 10, 11 and 12 for use by the ranch managers and the Arizona Water Protection Fund Commission and its employees. This Final Report serves as both the Annual Report for 2013 and the Final. Map locations of all monitoring locations can be found in Appendix B.

Throughout the WPF grant period plant species, growing in riparian grasslands and stream systems, have been collected and identified. Nearly 200 plant species are included in the list shown in Appendix A. The herbarium at the Audubon headquarters houses the collection of plants from the Research Ranch and from the collections made during this study.

6. Outreach Activities

An outreach plan was developed in 2009. Several outreach activities occurred in the summer and fall of 2009. Dan Robinett prepared a power-point presentation about this WPF project and presented it at the science meeting of the Sonoita Valley Planning Partnership held on 5-9-09 at the Audubon Research Ranch. In October both Robinett and Linda Kennedy hosted and lead presentations and tours for the annual meeting of the Arizona Riparian Council. The two day meeting was at the Audubon Research Ranch on October 3 and 4 of 2009. Robinett also gave a presentation about the riparian monitoring portion of the Babacomari WPF project. Robinett and Kennedy also lead a tour on Sunday the 4th to stops at monitoring locations TRR#1 on the Research Ranch and BR# 1 and 2 on the Babacomari Ranch.

Linda Kennedy addresses the Arizona Riparian Council at their annual meeting on the Audubon Research Ranch in O'Donnell Canyon just below the confluence with Post Canyon. 10-3-09

Outreach in 2010 consisted of Robinett and Kennedy hosting a meeting of the Coronado Resource Conservation and Development Council (RC&D) at the Audubon Research Ranch, giving a power point presentation to the RC&D council and interested public about the Babacomari WPF project and leading a field tour of the project area on both properties.

Field tour for the Coronado Resource Conservation and Development (RC&D) Council and public on the Babacomari WPF project, 3-10-10

Outreach activities in 2011 consisted of the preparation of a scientific poster paper and abstracts which were presented at two science symposiums in southern Arizona. The first was the “Science on the Sonoita Plain” symposium held at the Audubon Research Ranch on 6-4-11. This symposium is co-hosted by the Audubon Research Ranch, Bureau of Land Management, Fort Huachuca, the Sonoita Valley Planning Partnership and the US Forest Service. The second was the “Research Insights into Semiarid Ecosystems” (RISE) symposium held on 10-29-11 at the University of Arizona. It is co-sponsored by the U of A, School of Renewable Natural Resources and the Agricultural Research Service. Robinett and Kennedy attended both events and presented the poster entitled “Babacomari River Riparian Protection Project”.

Outreach activities in 2012 consisted of the preparation of a poster paper, a professional paper and abstracts which were presented at two science symposiums. The first was the annual meeting of the Society for Range Management held during the week of 1-27 to 2-3-2012 in Spokane, Washington. This annual meeting of a professional society devoted to the science of rangeland management, offers opportunity to reach an international audience. The second was the third (in 10 years) symposium of “Madrean Ecosystems” held in Tucson during the week 5-1 through 4-2012. This symposium was co-hosted by the University of Arizona, National Park Service, Bureau of Land Management, US Forest Service, and a variety of Environmental NGOs. Robinett and Kennedy attended both events and presented the professional paper and poster entitled “Babacomari River Riparian Protection Project”. The peer reviewed paper was published in the Madrean symposium proceedings. (US Forest Service, 2012)

Dan Robinett and Dr. Larry Fisher (UA) at the Third Madrean Symposium, Tucson, Az. 5-3-12

7. Methodology

Monitoring of riparian plant communities and their associated geomorphology was done to provide annual input to land managers of both the Babacomari Ranch and the Audubon Research Ranch. Yearly monitoring results help guide the use and management of the riparian grasslands and woodlands along Babacomari Creek and its associated tributaries including Turkey Creek, Lyle Canyon, Hay Canyon, Post Canyon and O'Donnell Canyon.

One of the most difficult aspects of vegetative monitoring is selecting areas with plant communities that are relatively uniform and where major plant species are well dispersed throughout the community (Ruyle 1997 and Smith 2012). Sacaton grasslands are excellent examples of plant communities that usually meet this description. However, sacaton communities at BR1, ARR1 and ARR2 are more diverse with dense sacaton in some areas and more open stands associated with shorter species of perennial grasses like blue grama (*Bouteloua gracilis*) and vine mesquite (*Panicum obtusum*). Standard error increases with increasing complexity of the plant community.

It is very difficult to find uniform conditions in the stream plant communities. For example, along a perennial reach of the Babacomari River the six transects at BR #1 span several different combinations of vegetative and stream morphologic conditions. Pool areas occur with and without dense tree canopy. Open areas along the banks of pools are dominated by deergrass. Tree shaded areas along pools are dominated by deergrass, sedges, horsetail and rushes. Riffle areas also occur with and without tree canopy. Riffle areas with little overstory canopy are dominated by watercress, with lesser amounts of berula and veronica. Riffle areas in shaded areas are dominated by yerba mansa, Colorado mint (*Mentha canadensis*), veronica, water marigold, spike rush and berula. The variation in the understory plant community (in short distances) makes it nearly impossible to find uniform areas for vegetation monitoring. Standard error, even for major species, can be quite high under these circumstances.

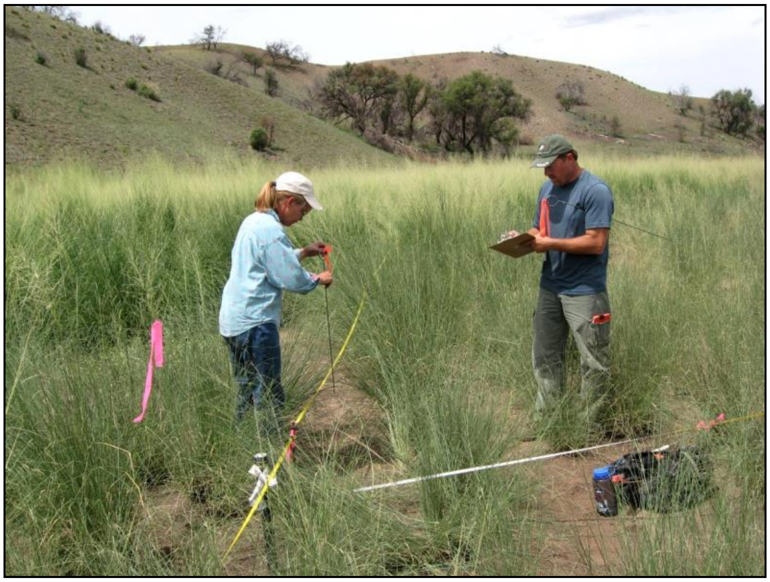
Vegetative monitoring employs a variety of techniques. Monitoring techniques include the use of point cover sampling for riparian grasslands, green-line sampling of cover (Daubenmire) and plant species frequency for riparian understory vegetation along stream- banks combined with belt transects to measure tree canopy cover on both sides of the stream (Ruyle 1997, Smith 2012). Geomorphic monitoring consists of surveyed cross sections of the floodplains and stream channels at the monitoring transect locations.

Precipitation is monitored at transect locations and property headquarters using rain gauges read monthly or twice a year. Photographs are taken each year of each transect and cross-section to document visual changes.

Riparian Grasslands

Five of the riparian grassland transect locations coincide with sites used by Ron Tiller in his 1997 work on giant sacaton for his dissertation at Arizona State University (Tiller, 2004). Dr. Tiller granted written permission to use his cross-section (x-section) data giving a baseline that extends back in time 12 years. He assisted with the first re-surveys of his original cross sections in the fall of 2009. The sixth transect location is a new one established on the Babacomari Cienega. Cross sections are re-surveyed with an engineer level and a 7 meter surveyor's rod using Dr. Tiller's original survey stations. Surveys were completed at the start of the project and repeated as changes (flooding, sedimentation, erosion) were noted. 1997 and 2009 surveys can be compared to assess erosion and sedimentation for the five sites established by Dr. Tiller.

Vegetation sampling for the riparian grasslands is accomplished by line- point data collection (500 points) for foliar and basal (soil) cover by plant species. This includes soil cover (litter, gravel/rock) and bare ground. Sampling was completed each year in the fall after the large rattlesnakes that inhabit these grasslands go to sleep for the winter. Locations for ten 50 meter lines were randomly selected along the x-section baseline. They are placed perpendicular to the baseline at fixed points marked by rebar stakes. Tapes are placed so that 25 meters extend on either of the baseline. Beginning at 1 meter from the centerline ground cover (soil), plant basal and plant canopy cover is recorded each meter using a pointed rod. A photograph is taken from both ends (monuments) of the baseline on the same dates the sampling is done. Precipitation is recorded at the monitoring location using a rain gauge made of 2 inch PVC pipe which is wired to the transect T-post. Rain fall is recorded twice each year to get cool season moisture (Oct.-April) and warm season moisture (May-Sept).



Linda Kennedy and Ron Tiller conducting line-point sampling of the sacaton plant community at TRR#1. The Post Canyon/O'Donnell piesometer is in the left foreground with white flagging. 8-11-09

Riparian Greenline Understory Vegetation

Monitoring of the understory plant communities (greenline vegetation) in riparian woodland areas consists of establishing vegetation transects coupled with geomorphic cross sections which will be re-read yearly in the spring (May-June). Each transect location consists of three greenline (Medina and Steed 2002) vegetation sub-transects installed in the understory of the riparian area. The sampling consists of canopy or foliar cover measurements (by plant species) at six transects at each monitoring location. Each transect consists of 40 quadrats (15cm x 40cm frame) along 40 meters of stream-bank on each sides of the channel. Quadrats are placed every two meters along the greenline. Each frame is placed on the streambank to record bank species; then it is flipped down to extend 10 cm into the water to record aquatic plant species. In total 240 quadrats are sampled each year at each monitoring location. The transect methodology samples both aquatic plant species as well as wetland species on the stream-bank; an advantage over other greenline monitoring methods (Medina 2008). Plant species cover is recorded as the mid-point for Daubenmire cover classes used. Species cover for both aquatic plots and bank plots is determined by determining the average cover from all quadrats. Standard error is displayed on the histograms used to display species cover information. Frequency for major plant species was calculated from the data-set to determine vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at the monitoring location. Standard error is displayed for frequency as well.

Riparian green-line vegetation monitoring technique developed by Alvin Medina, Jonathan Long and associates at the USFS Rocky Mountain Forest Experimental Station in Flagstaff, Arizona (Medina and Steed 2002).

This picture illustrates the transect layout and use of the 15 x 40 cm frame (placed each meter) along a 40 meter reach of both banks of the creek to monitor green-line vegetation. Each time the plot frame is placed it is put 10 cm into the water to record aquatic plant species (odd numbered plots) and then flipped end over end onto the bank to record wetland plant species (even numbered plots) growing on the bank. Information recorded includes plant cover and frequency by species, soil cover, stream bank stability and trampling. Three 40 meter transects occur at each monitoring location in a series 20 to 40 meters apart.

At each transect cluster, three geomorphic cross sections of the river channel and floodplain were installed with a level and a 7 meter surveyor's rod using fixed monuments and survey stations at regular intervals across the floodplain and stream channel. They were re-surveyed as appropriate to document erosion and sedimentation of the channel, floodplains and stream-banks.

The belt transects used to measure tree canopy cover start at the edge of the stream and extend 3 meters from a streambank. They parallel green-line transects on both banks of the creek. Geomorphic cross sections are surveyed across the floodplain and stream channel from bluff to bluff. They are used to monitor erosion and sedimentation of the floodplain and channel.

Riparian Tree Cover

At each sub-transect location a 40 meter long by 3 meter wide belt transect was installed along both banks to measure and monitor the canopy cover of the riparian trees by species and size class. Photographs were taken at each monitoring location and precipitation recorded using rain gages. Ecological status will be determined by using the Interagency (BLM, USFS, USGS) method “Riparian Proper Functioning Condition (Pritchard 1998).

Emilio Carrillo and Katie Cline (both NRCS) help read riparian tree belt transects on the Babacomari River (BR #1) monitoring site at the USGS Stream Gage.

Belt transects are used to estimate tree canopy cover by species and size class. A 40 x 3 meter belt was established on each bank at each individual transect location making a total of six belt subplots at a monitoring location. Canopy cover by species was recorded as the mid-point of Daubenmire cover classes. Total canopy cover was recorded as a separate category as often individual species canopies overlap in the over-story. Canopy cover by species and total canopy is the average canopy from a summary of the six belt transects and is displayed in histograms showing standard error (sampling error).

Monitoring data was entered into Excel spreadsheets for storage and analysis. Data was analyzed and results presented each year in a monitoring report. Trends in plant communities are used to advise land managers of the BR and the ARR on yearly grazing use (BR) and other land management actions like prescribed burning, erosion control measures and noxious weed control (BR and ARR).

Monitoring was also used to quantify the effects of natural events which impact the plant communities and stability of riparian sites on the BR and the ARR. Wildfires, drought and floods result in disturbance of riparian sites and recovery time (rates) factored into annual recommendations for use and management of these sites.

The objectives for management of riparian sites on both the BR and the ARR include:

Provide forage and other habitat elements for livestock and wildlife (BR),
Provide forage and other habitat elements for wildlife (ARR),
Maintain native plant diversity (BR and ARR),
Maintain habitat for rare and endangered plant and animal species (BR and ARR),
Maintain adequate plant cover to protect soils from erosion and to allow for sedimentation along streambanks and on floodplains (BR and ARR),
Manage for the sustainable use of riparian grassland forage resources (BR),
Manage for adequate and rapid recovery from natural disturbances (BR and ARR),
Maintain Riparian Proper Functioning Condition in riparian woodlands (BR and ARR).

Measurable parameters which will be evaluated to help determine progress towards meeting objectives include:

Plant species (identification, frequency, cover),
Plant canopy (foliar) and basal cover,
Soil surface cover (% litter, gravel/rock and bare soil),
Topographic changes,
Precipitation,
Flooding frequency and magnitude,
Mean daily stream discharge,
Depth to water table quarterly,
Riparian PFC (Proper Functioning Condition) ratings.

Lower O'Donnell sacaton bottom where it meets the Babacomari Cienega, in flood after heavy rains in and September 2007 at the Babacomari Ranch road crossing, 9-16-07.

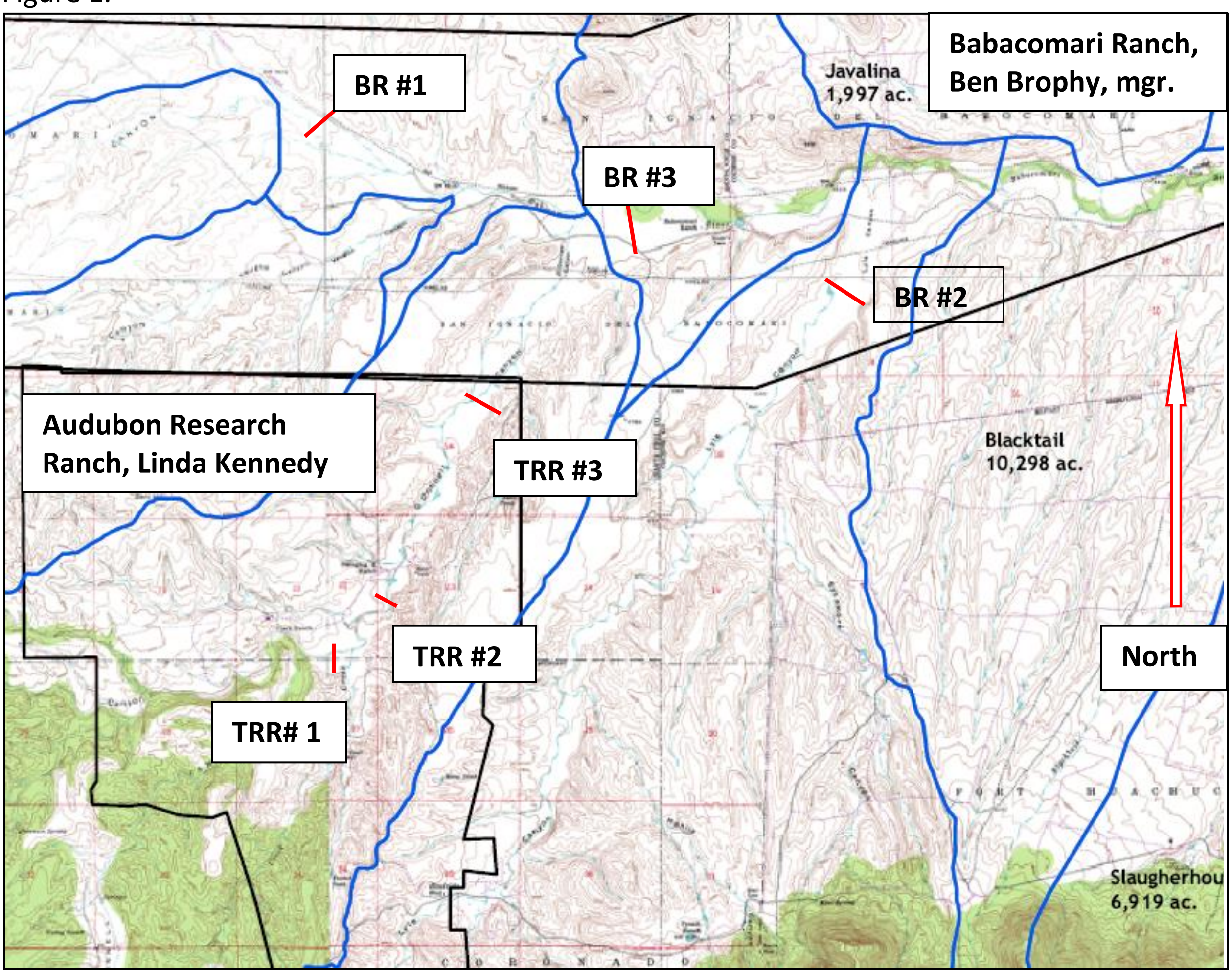
8. Monitoring Data and Trend

Riparian grasslands

Lyle Canyon, sacaton bottom, looking NW from the monitoring transect at BR #2, 16 inches of summer rainfall at this location in 2012 Photo taken 11-28-12.

Lyle Canyon, sacaton bottom, looking NW from the monitoring transect at BR #2, 11 inches of summer rainfall at this location in2013. Note the amount of standing dead in the giant sacaton compared to 2012. 11-2-13

Figure 1.



Riparian grasslands include large bottomlands of giant sacaton on both the Babacomari Ranch (BR) and the Audubon Research Ranch (ARR). These grasslands are vital floodplain components of the upper watershed of the Babacomari River. They also contribute greatly to the forage supplies for livestock on BR and as critical wildlife habitat on both the BR and the ARR. One site is on the Babacomari Cienega. This is grassland occupied by a mixture of sacaton and grass-like plant species of wetlands (sedges and rushes).

The six riparian grassland monitoring sites established in 2009 were re-surveyed for vegetative species composition by canopy and basal cover. The vegetative transect and survey methodologies are described in the monitoring plan. Geomorphic cross sections were re-surveyed through 2012 at sites (TRR#1 and TRR#2) below the confluence with Post / O'Donnell canyons (TRR#1) and Turkey creek / O'Donnell canyons (TRR#2). A large summer rainfall event on July 18, 2012 caused overbank flooding of the sacaton bottoms at these two locations. The floods carried all the way though the Audubon Research Ranch and flooded the east side of the sacaton bottom in lower O'Donnell canyon near the Babacomari Ranch boundary.

Post and O'Donnell canyons flooding on July 18, 2012, note flood water on sacaton floodplain near TRR#1. Picture by Roger Cogan.

Post and O'Donnell canyons flooding on July 15, 2007, note flood water remains in the stream channels through the sacaton floodplain near TRR#1

TRR #1 – Post Canyon/O'Donnell Sacaton

This transect location is on the Audubon Research Ranch just below the confluence of Post Canyon and O'Donnell Canyon. It is about .25 mile southeast of the Research Ranch headquarters. The rain gauge at the headquarters serves for this location. It provides monthly recordings of precipitation. A piesometer (7 meter deep well) is located near the southern monument of this transect and is monitored quarterly for depth to groundwater. The monument for this cross section and transect is at the southern end at an elevation of 4730 feet. The GPS coordinate is (NAD 83-12R) E0547476 and N3494520. The cross section runs from south to north across a sacaton floodplain and the Post/O'Donnell channel to a bank on the north end. It is 448.5 meters long.

The southern half of the cross section burned in the Canelo fire (wildfire) on May 6, 2009. Everything north of the Post/O'Donnell channel was unburned. The entire transect area burned in the Ryan Fire in April of 2002 during severe drought.

The monument is on the south side of transect TRR#1. Looking north across the Post canyon / O'Donnell creek channel, four weeks after the Canelo fire: photo taken on 6-12-09.

The monument is on the south side of transect TRR#1. Looking north across the Post canyon / O'Donnell creek channel on 11-16-2010

Looking north across the Post canyon / O'Donnell creek channel on 11-1-2011. Roger Cogan, Cons. Coordinator, Audubon Research Ranch

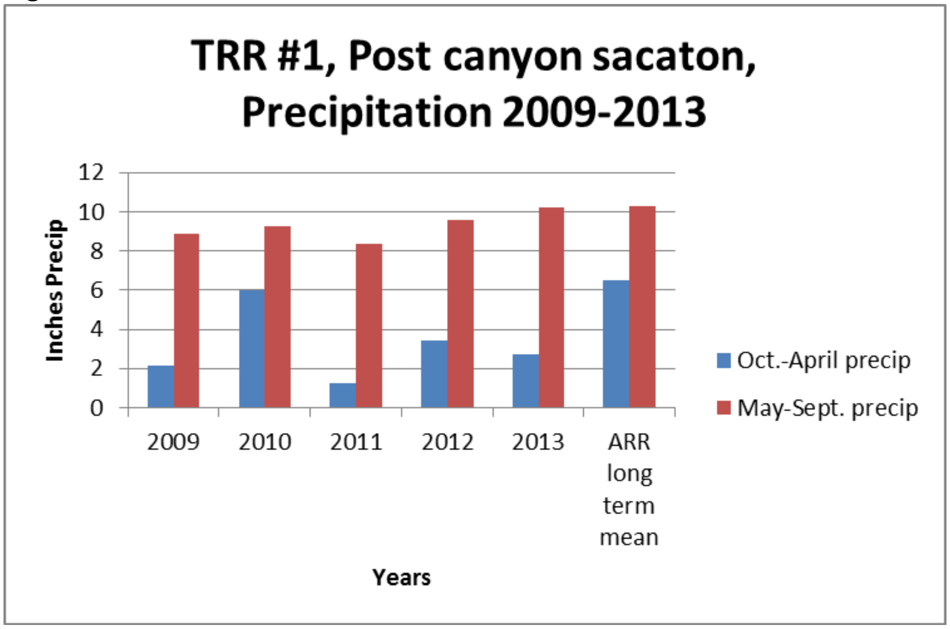
Looking north across the Post canyon / O'Donnell creek channel on 11-6-2012. Roger Cogan, Cons. Coordinator, Audubon Research Ranch. Everything in picture flooded in the July storm in 2012.

Looking north across the Post canyon / O'Donnell creek channel on 11-14-2013. No flooding in 2013. Summer rainfall was average and winter precipitation below average in 2013

Ten, 100 meter lines at fixed stations along the 448.5 meter cross section were re-sampled for vegetative cover by species and soil cover. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the Excel spreadsheet for TRR#1.

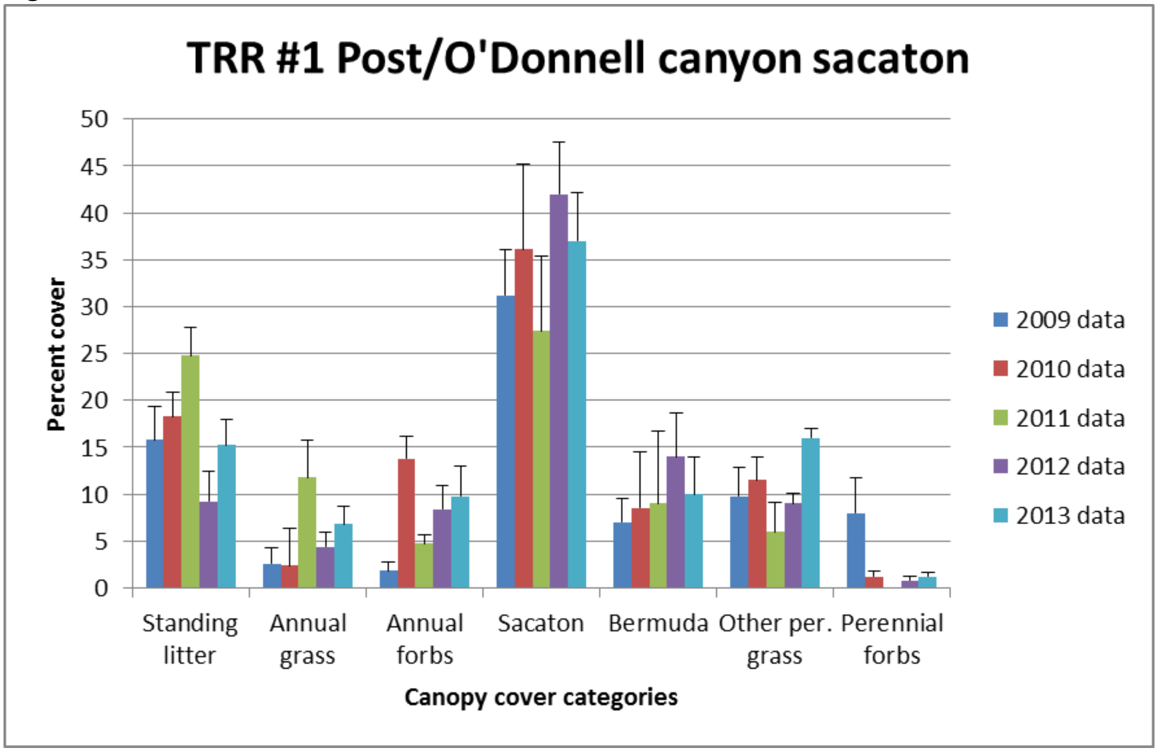
Precipitation in 2013 was average for the summer period and below average for the cool season. Average annual precipitation at the Research Ranch headquarters is 17 inches. This year the ranch received 13.88 inches at this location or 81% of the average. In 2013 the total perennial grass foliar cover on this transect is 62% with 13% basal cover. Most of this cover is giant sacaton. Other perennial grasses, including vine mesquite, blue grama, green sprangletop (*Leptochloa dubia*), Bermuda grass (*Cynodon dactylon*) and sideoats grama (*Bouteloua curtipendula*) make up the remainder of the cover. Basal cover of litter was higher and bare soil lower this year than last, although the differences are within sampling error. Also note the lack this year of annual forbs due to below average winter-spring moisture. The annual forbs present this year are warm season species like pigweed (*Amaranthus palmeri*), New Mexico copperleaf (*Acalypha neomexicana*), dogweed (*Dyssodia foetida*) and little horseweed (*Laennecia coulteri*).

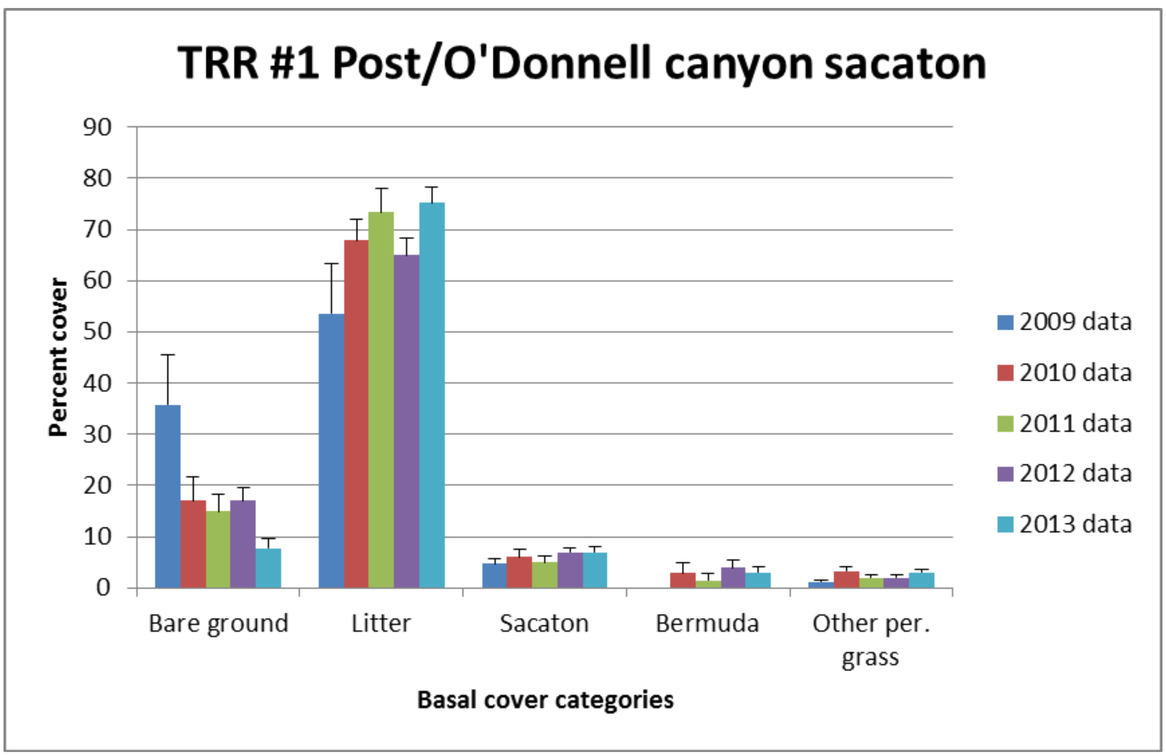
Figure 2.



In summary the vegetative monitoring data show the quick recovery of both soil cover and plant basal cover after the Canelo fire in 2009. Note how sacaton foliar cover tracks the summer rainfall amounts for the five years of this study. Perennial forbs (largely cool season species) were low in 2013 due to another dry winter. Large standard error show the diversity of this site with some areas having dense stands of sacaton and other areas with more open stands of sacaton with other species of perennial grasses co-dominant. Sacaton basal cover is very stable on the site. Canopy cover of sacaton varies from year to year with summer rainfall.

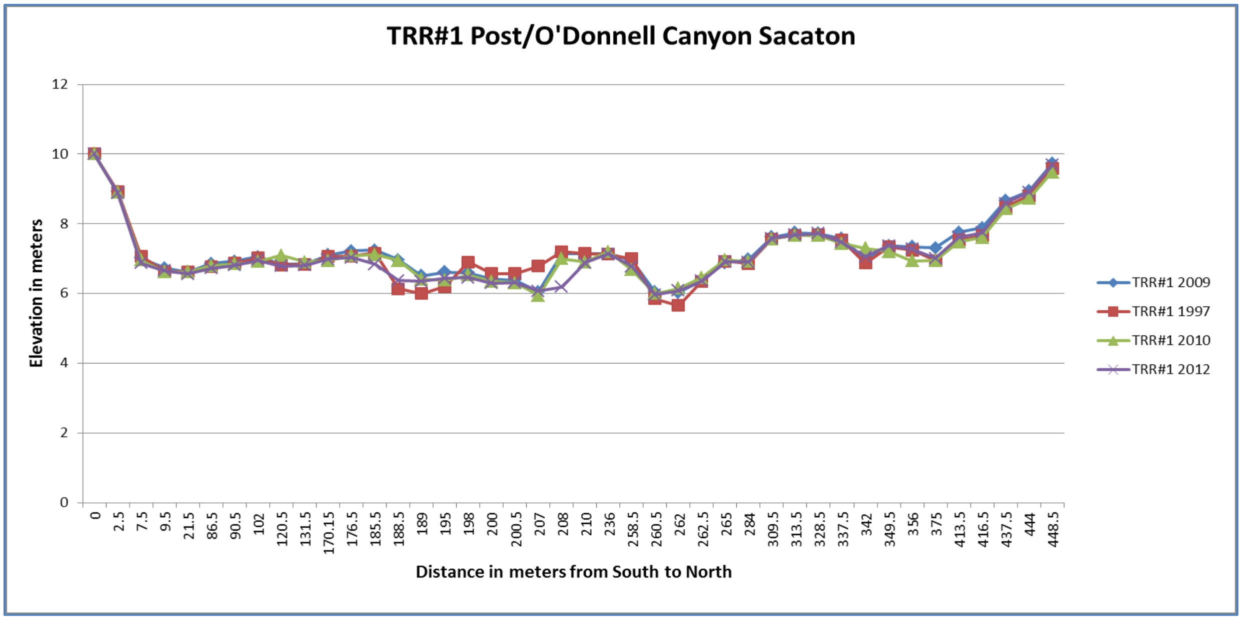
Figure 3.





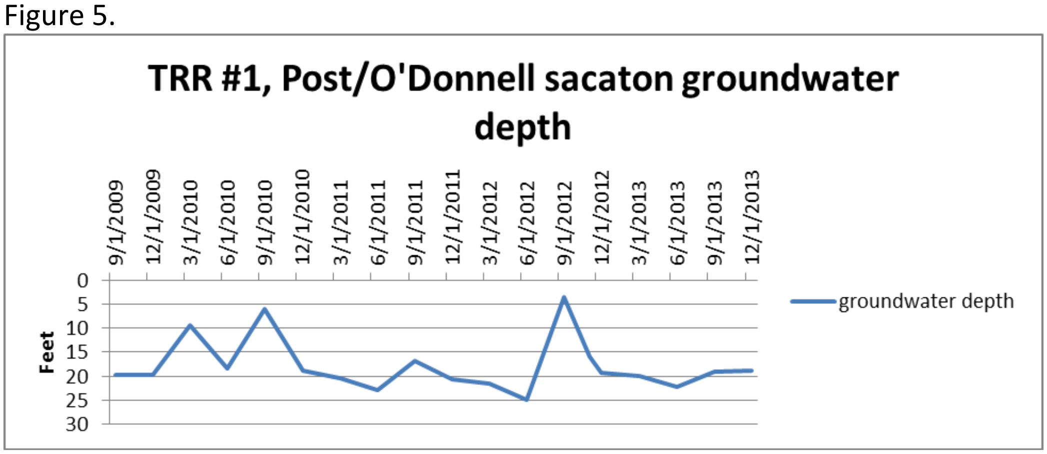
The geomorphic cross section was last re-surveyed on 11-6-2012. Stream channel flooding in 2009 to 2011 caused channel erosion with lateral movement of the north bank several feet. Overbank flooding of the Post-O'Donnell channel in July of 2012 caused additional erosion of the stream channel and sedimentation across the floodplains. The last time this location flooded across the sacaton floodplain was in the “El Nino” event of October of 2000. It also flooded in “El Nino” events in Oct. 1983 and Jan. 1993. The cross section was not surveyed in 2013 as there was very little runoff in Post – O’Donnell canyons this year.

Figure 4.



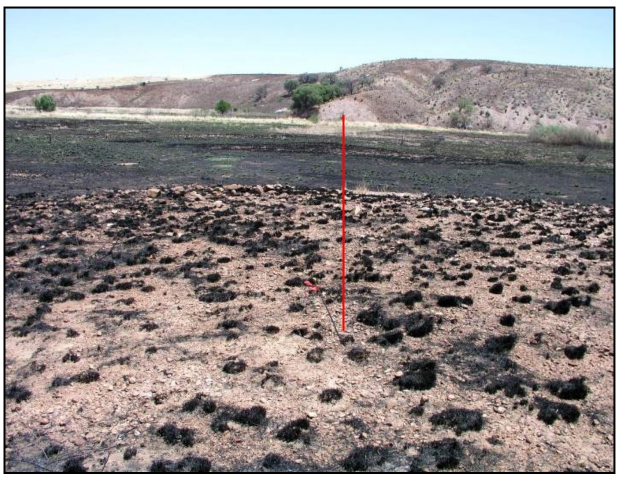
Stream alluvium (sandy and gravelly soils) occurs in the middle of this cross section from station 185.5 to 309.5. The present day channel appears to be moving north across the bed of sandy alluvium that the channel has meandered across for millennia. Considerable erosion of soil material has occurred in the stream channel in this area in the past thirteen years. This is a dynamic area just below the confluence of two large canyons. A large water spreading dam was constructed across the channel at this location in the early 1960s. It washed out in large floods in 1983 and may be part of the reason the channel at this location is unstable. Note the rise in groundwater level by September 2012 as a result of the flood and the lack of recharge in 2013.

Figure 5.

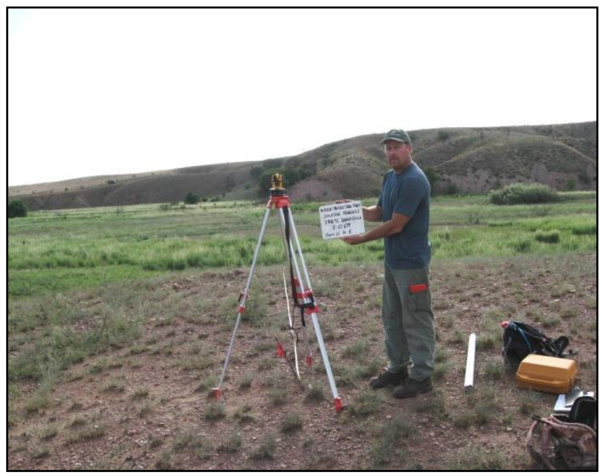


TRR #2 – Turkey Creek/O'Donnell Sacaton

This transect location is on the Audubon Research Ranch just below the intersection of Turkey Creek and O'Donnell Canyon. It is about 1.25 mile east of the Research Ranch headquarters and one mile downstream from transect TRR#1. The rain gauge near the bunkhouse will serve for this location. It provides a bi-annual record of precipitation. A well near the bunkhouse is read quarterly for depth to groundwater. The monument for this cross section and transect is at the western end at an elevation of 4700 feet. The GPS coordinate is (NAD 83) 12R - E0547841 and N3495350. The cross section runs from west to east across the sacaton floodplain and the Turkey/O'Donnell channel to a steep conglomerate bluff on the east end. It is 275.5 meters long. The entire cross section burned in the Canelo fire on May 6, 2009. Overbank flooding of the Turkey Creek and Post / O'Donnell channels in July of 2009 caused considerable sedimentation in the ponded area and channel on this transect and some sedimentation across the floodplains. The last time this location flooded across the sacaton floodplain was in the "El Nino" event of October of 2000. It also flooded in "El Nino" events in Oct. 1983 and Jan. 1993.



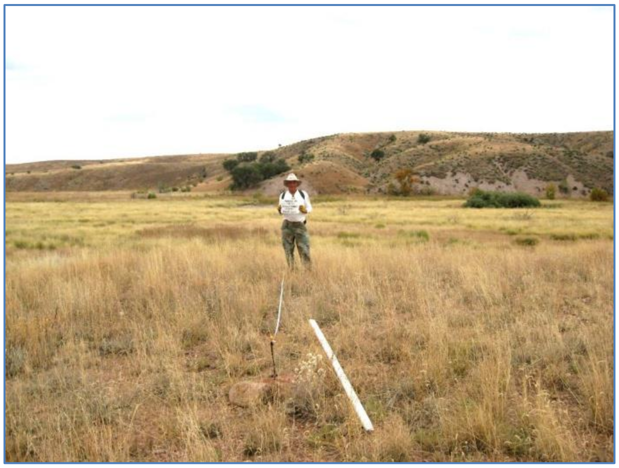
TRR#2, Turkey/O'Donnell, Canelo fire, 5-2009



TRR#2, Turkey/O'Donnell, x-section 8-2009

TRR#2, Turkey/O'Donnell, R. Cogan, 11-17-10

TRR#2, Turkey/O'Donnell, 11-2-11



TRR#2 just below the confluence of Turkey creek and O'Donnell canyon. The entire floodplain flooded in July of 2012. Photo 11-8-12.

TRR#2 just below the confluence of Turkey creek and O'Donnell canyon, no flooding in 2013. Photo 11-17-13.

Ten, 100 meter lines at fixed stations along the 275.5 meter cross section were sampled for vegetative cover by species and soil cover. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the Excel spreadsheet for TRR#2.

Precipitation in 2013 was less than that received in 2012 but summer rainfall was more than the average summer rainfall at the Research Ranch headquarters. Cool season precipitation was below average this year as it has been since 2010. Total perennial grass foliar cover on this transect this year was 56% with 12.6% basal cover. Most of this cover was giant sacaton. Other perennial grasses including vine mesquite, blue grama, sideoats grama and non-native species, Bermuda grass and Johnson grass (*Sorghum halapense*), made up the remainder of the cover. Basal cover of litter was significantly lower and bare soil higher in 2012 reflecting the flooding and sedimentation which covered litter. Both cover categories improved in 2013 due to litter accumulation. Note low amounts in cover of annual forbs in 2013 due to another year with below average winter-spring moisture. The main forb species at this location this year are summer annuals like pigweed, daisy (*Erigeron divergens*), lambsquarter, yellow daisy (*Machaeranthera gracilis*), fetid marigold, little horseweed and New Mexico copperleaf.

Figure 6.

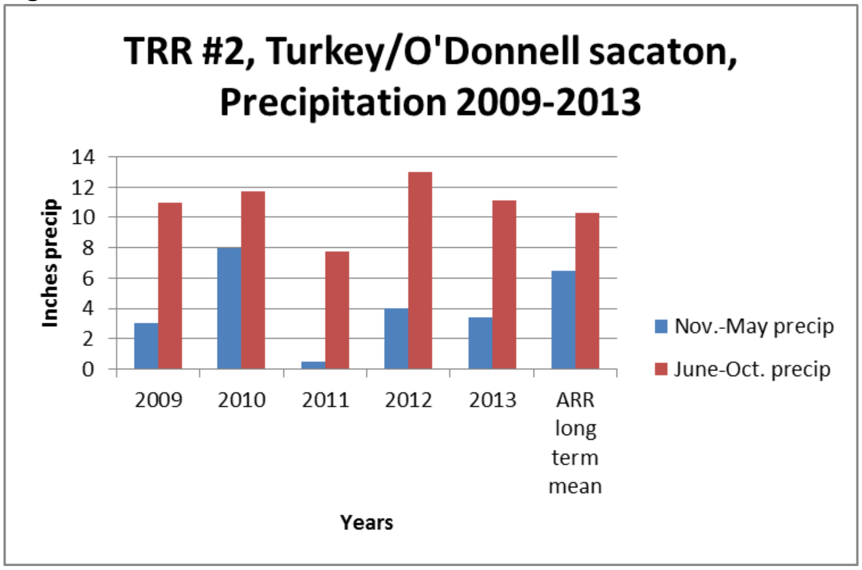
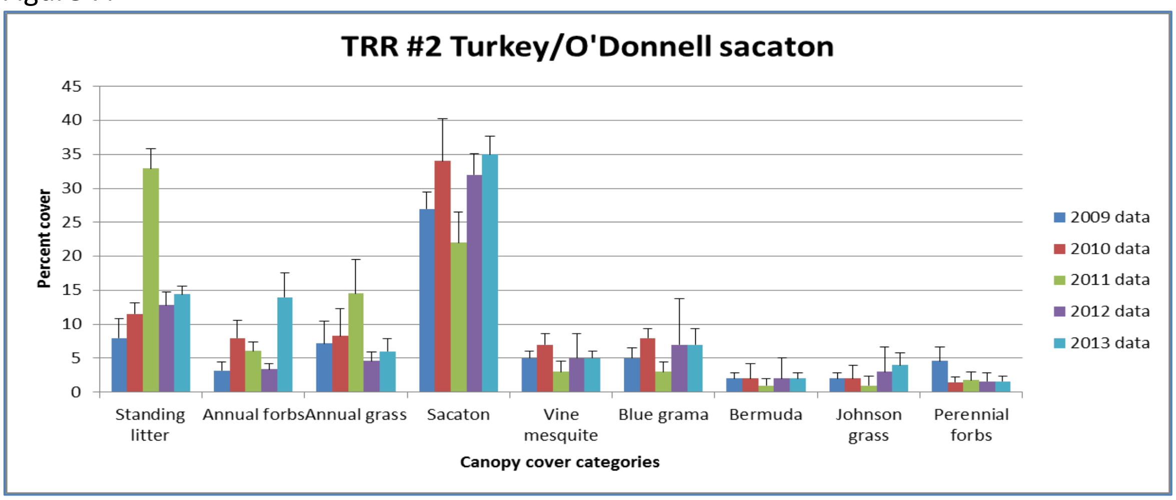
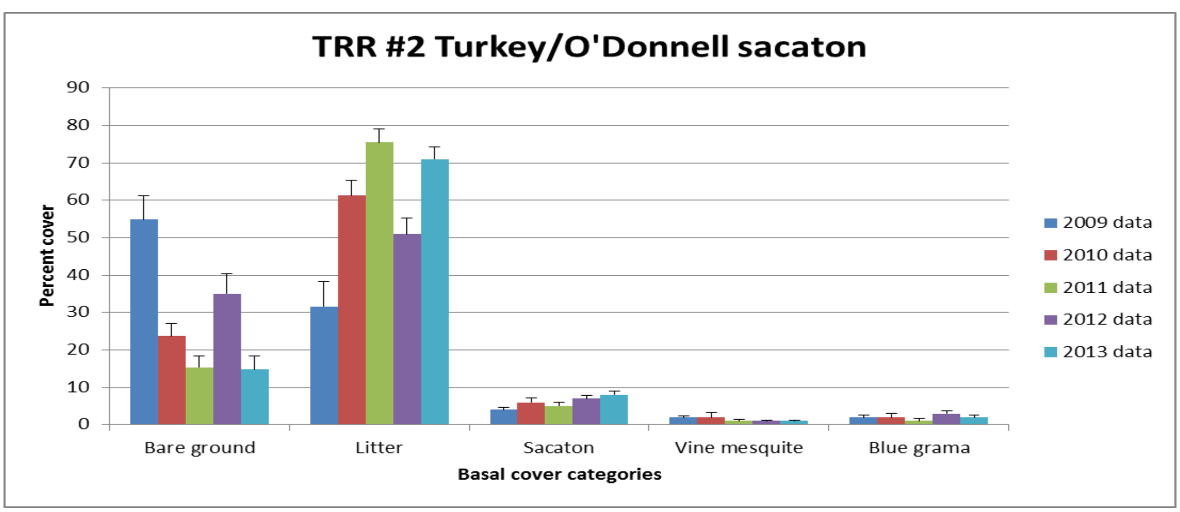


Figure 7.

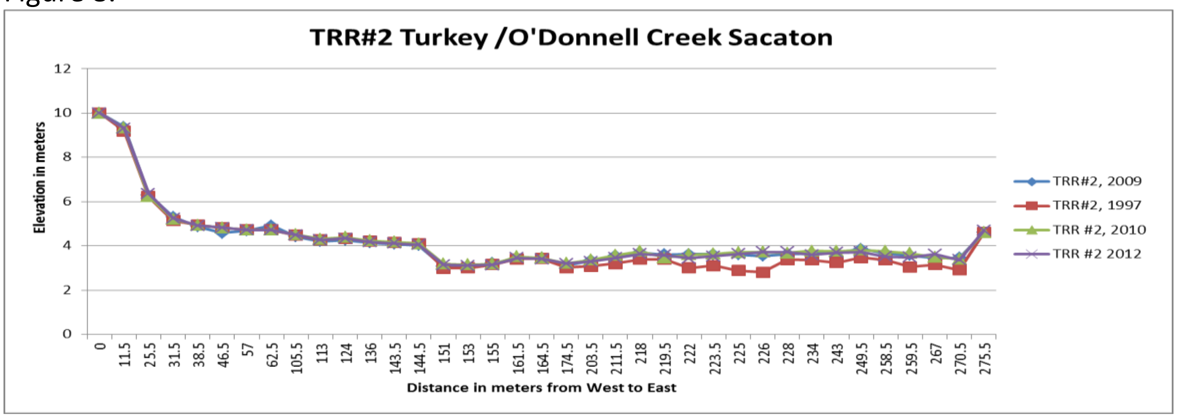




Note that standing litter increased this year and sacaton foliar cover decreased since last year. Standing litter (primarily dead sacaton shoots) has an inverse relationship to sacaton foliar cover. Also note how sacaton foliar cover tracks the summer rainfall amounts for the five years of this study. Basal cover of sacaton appears to be trending up over the past years even though foliar cover has changed due to fire, flooding and drought effects. Soil cover of bare litter appears to be trending up and bare ground is trending down reflecting recovery from the 2009 Canelo fire. The dip in % bare soil in 2012 was caused by sedimentation from the July flood which covered most of the litter from the previous year.

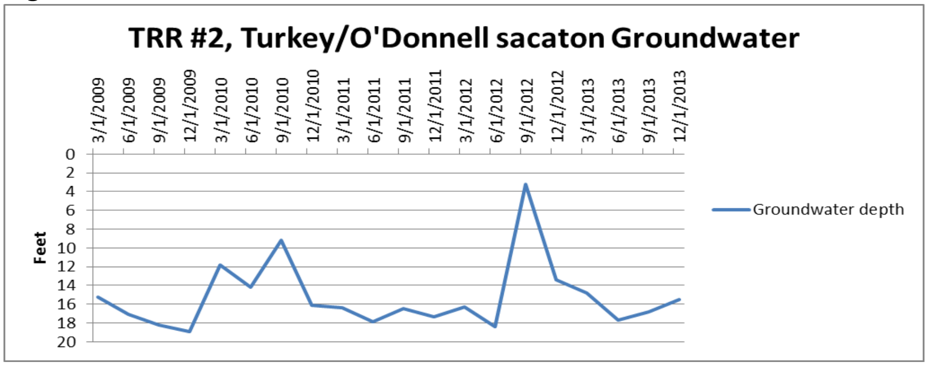
The geomorphic cross section was re-surveyed on 11-8-2012 due to major flooding through the area. It was not resurveyed in 2013 due to a lack of flooding or stream flow through the area.

Figure 8.



This location shows considerable sedimentation since the original survey of the cross section by Ron Tiller in 1997. Sediment being eroded from the stream channel in the Post Canyon area, through the cross section and transect at TRR # 1 continues to be deposited downstream in this location. Stream alluvium (sandy and gravelly soils) occurs in the eastern one fourth of this cross section from station 218 to 275. At present two shallow channels are braided across the bed of sandy alluvium that occurs to the eastern bluff. This is a dynamic area just below the confluence of three large canyons. Another large water spreading dam built upstream of this location in the early 1960s failed in a previous flood (1983) and may have contributed to the sedimentation occurring today. Also note the rise in groundwater level due to this flood.

Figure 9.



TRR#2 Picture showing the flood resistance of giant sacaton and large debris dam deposited on the upstream side by a July flood event. 11-8-12

TRR #3 –O'Donnell Canyon Sacaton

This transect location is on the Audubon Research Ranch just south of the ranch boundary fence with the Babacomari Ranch. It is about 2.25 mile northeast of the Research Ranch headquarters and 1.5 mile north of the road crossing below the bunkhouse. A rain gage is located on the mesa just west of this location. There is no piesometer at this location. The monument for this cross section and transect is at the western end at an elevation of 4660 feet. The GPS coordinate is (NAD 83) 12R - E0548687 and N3497484. The cross section runs from west to east across the sacaton floodplain and the O'Donnell channel to a bank on the east end. It is 513 meters long. This sacaton bottom burned in 1975 and again in 1986 and fire effects on plant and animal communities were documented (Bock and Bock 2000). This area last burned in the Ryan fire which occurred in April of 2002.

West monument at sta. 0+00 and cross section baseline at transect TRR#3. Looking east across the O'Donnell canyon floodplain. 9-3-09

Roger Cogan at west monument and cross section baseline at transect TRR#3. Looking east across O'Donnell canyon. 12-3-2010

Roger Cogan at west monument and cross section baseline at transect TRR#3. Looking east across O'Donnell canyon. 11-3-2011

Linda Kennedy at west monument and cross section baseline at transect TRR#3. Looking east across O'Donnell canyon. 11-19-2012

West monument and cross section baseline at transect TRR#3. Looking east across O'Donnell canyon. 11-19-2013

Ten, 100 meter lines at fixed stations along the 513 meter cross section were sampled for vegetative cover by species and soil cover. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the excel spreadsheet for TRR#3.

Cool season precipitation in 2013 was lower than the average for the Audubon headquarters at this location but summer rainfall was higher than the average. Total perennial grass foliar cover on this transect was 55% with 10.2% basal cover. Nearly all of this cover was giant sacaton. Cover of bare ground was 9.4% and litter was 79% cover. These are normal cover amounts for dense sacaton grasslands several years after fire when the site has reached equilibrium with soils and climate (First author experience). Low standard errors for all cover categories illustrate how uniform this dense plant community of sacaton is.

Figure 10.

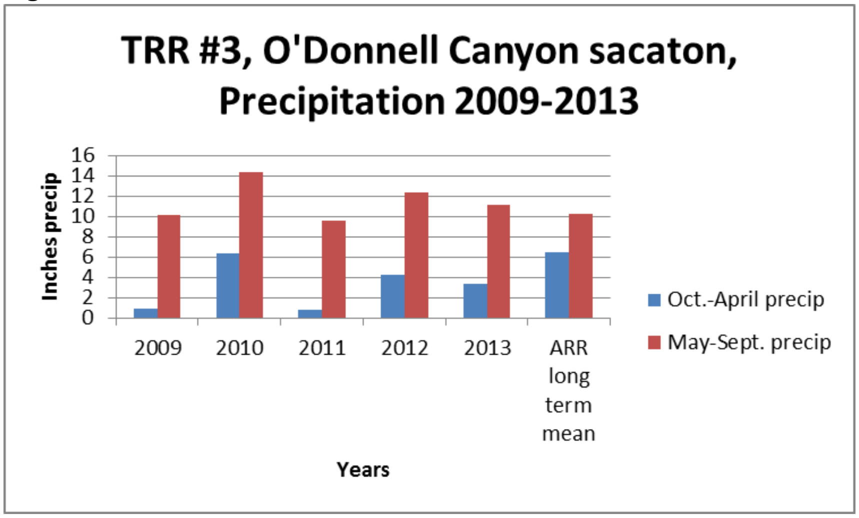
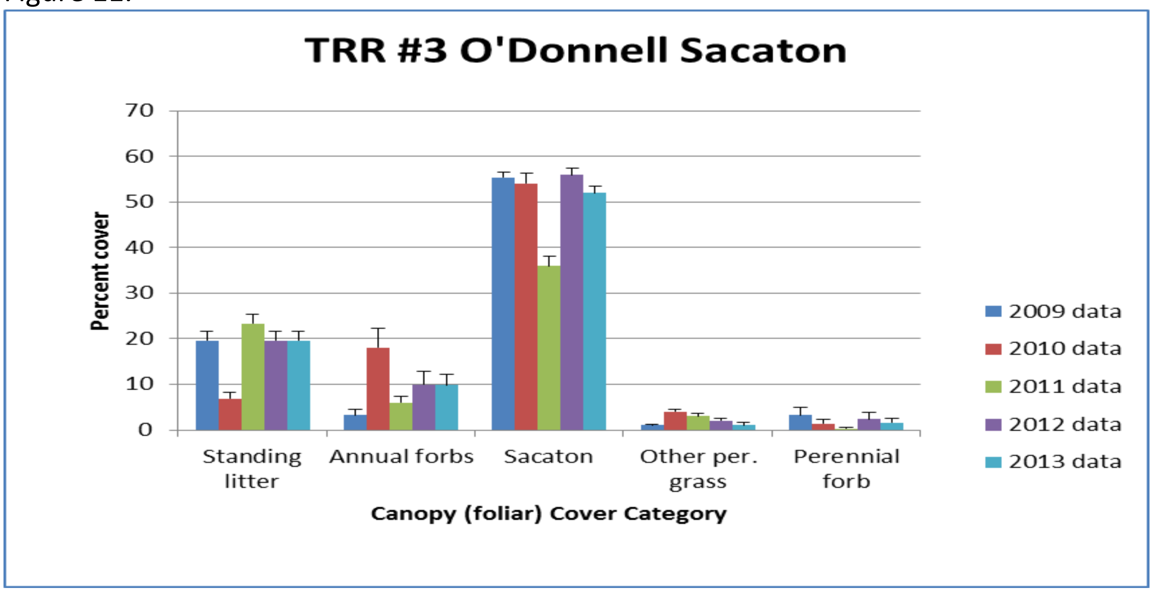
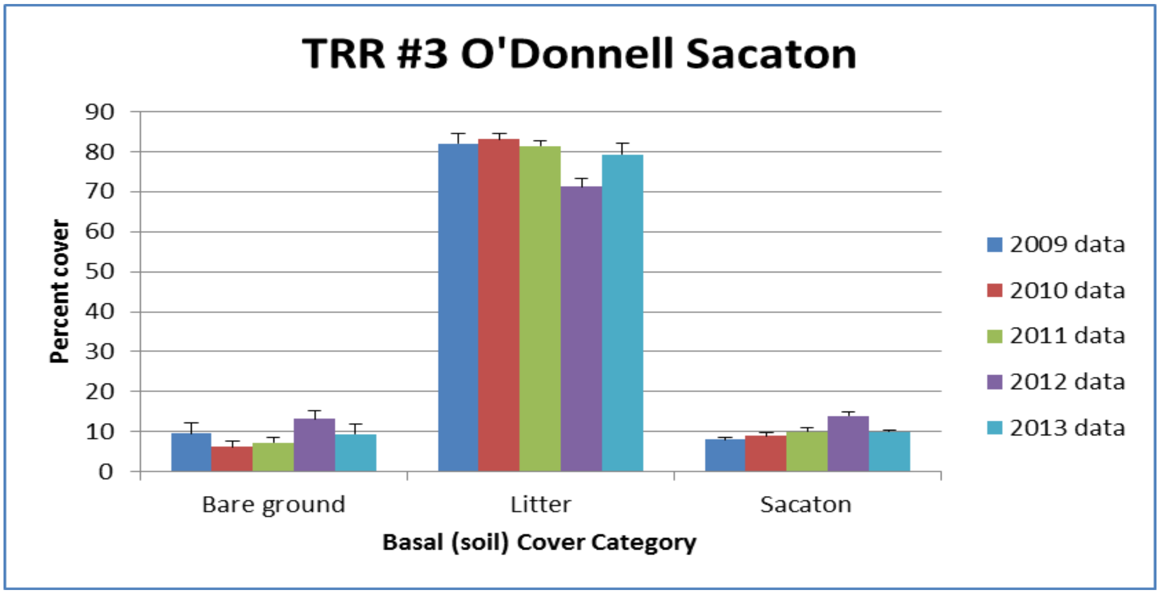


Figure 11.

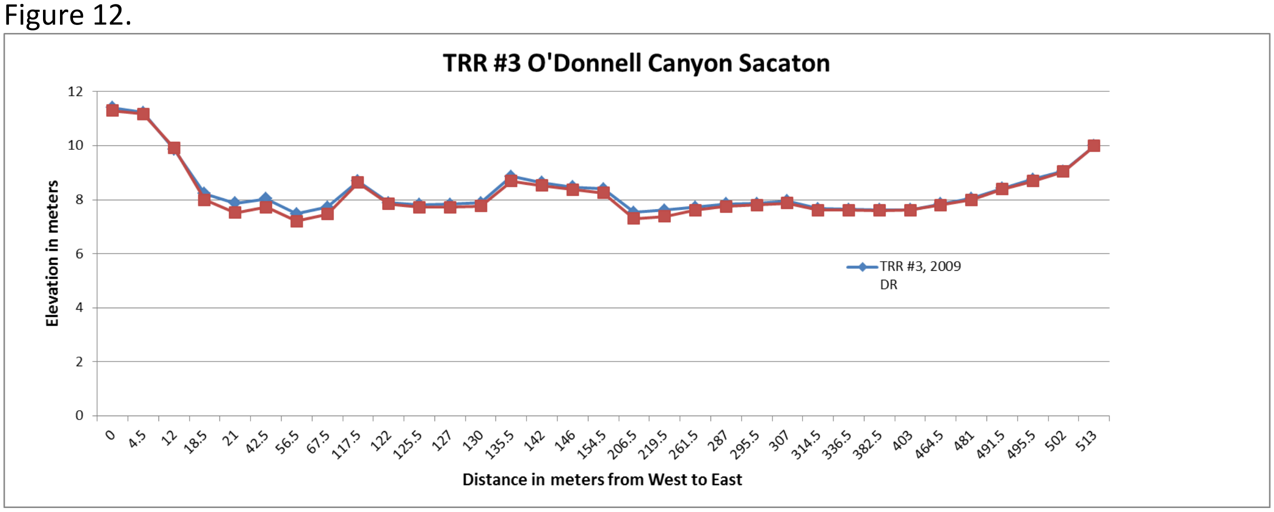




Note that basal cover of sacaton is unchanged on this site over the five years of this study. Levels of bare soil are very low and litter cover on the soil is very high.

This portion of O'Donnell canyon on the Research Ranch is a good candidate for prescribed fire (or prescribed natural fire) in the next few years. This area last burned more than 10 years ago. Sacaton plants are in good vigor and basal cover is adequate to protect the floodplain from erosion. A lightning caused wildfire burned 30 acres in this floodplain in the summer of 2012 but was suppressed by Bureau of Land Management (BLM) fire crews. The Audubon Research Ranch staff will work with their partners and the Bureau of Land Management to develop a plan for prescribed fire for this portion of O'Donnell canyon in 2014. The plan will allow natural fire to occur as an ecosystem process in this grassland. The planned burn area would include the floodplain and uplands from the researcher housing at the old Swinging H Ranch headquarters north to the Audubon / Babacomari boundary and from the road on East Mesa west to a fire break on North Mesa.

Figure 12.



The geomorphic cross section was re-surveyed in 2010. It has not been re-surveyed since as the area has not flooded. The re-survey of the 1997 (R. Tiller) cross section showed some filling in the old stream channel in the twelve years between 1997 and 2010.

The thalweg (elevation low point) on TRR #3 cross section (looking north). The old stream channel has filled with sediment since 1997.

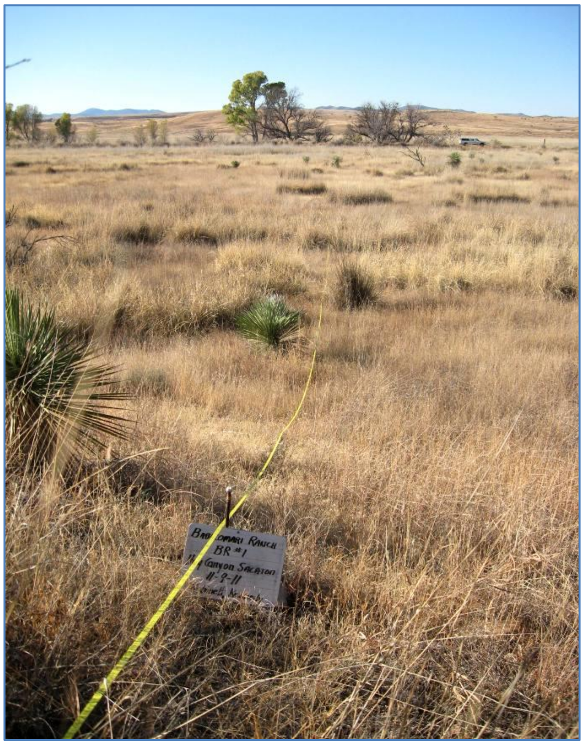
BR #1 –Hay Canyon/Babacomari Sacaton

This transect location is on the Babacomari Ranch just below the confluence of Hay Canyon and the Babacomari River. The river is dry at this location. BR#1 is about 3.25 mile northwest of the Babacomari Ranch headquarters and .5 mile north of the main ranch road. A rain gauge is located on the floodplain at station 103 about 200 feet north of the railroad grade. Precipitation is recorded twice a year at this location (October and May, to get cool and warm season precipitation). There is no piesometer at this location. The monument for this cross section and transect is at the northern end at an elevation of 4631 feet. The GPS coordinate is (NAD 83) 12R - E0547464 and N3500984. The cross section runs from north to south across the sacaton floodplain and the Babacomari channel to a bank on the south end. This transect is 425 meters long. This area last burned in a prescribed fire conducted by the Babacomari Ranch, Ft Huachuca Station B and the Sonoita-Elgin Fire Department in February, 1999.
The southern part of this transect line was burned in a prescribed fire in March, 2013. The fire was proposed by the Babacomari Ranch, conducted by the Sonoita-Elgin Fire Department, and funded by the Arizona Antelope Foundation. Livestock and wildlife grazed the area until mid-August, 2013 when cattle were moved from the pasture to allow sacaton and other perennial

grasses to recover. Pronghorn and mule deer continued to use the burn area into the fall of 2013.

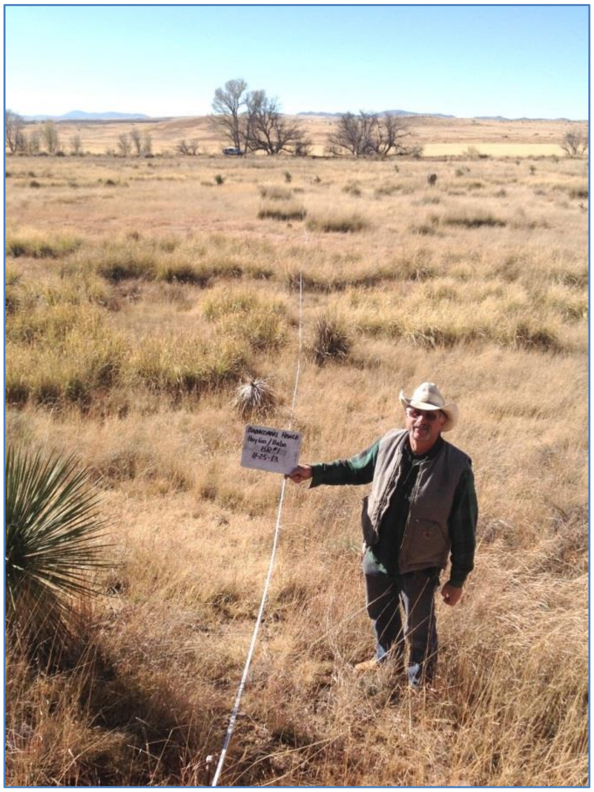
BR #1, Hay canyon / Babacomari on 6-8-09

BR #1, Hay Canyon / Babacomari on 12-13-10



BR #1, Hay Canyon / Babacomari on 11-8-11

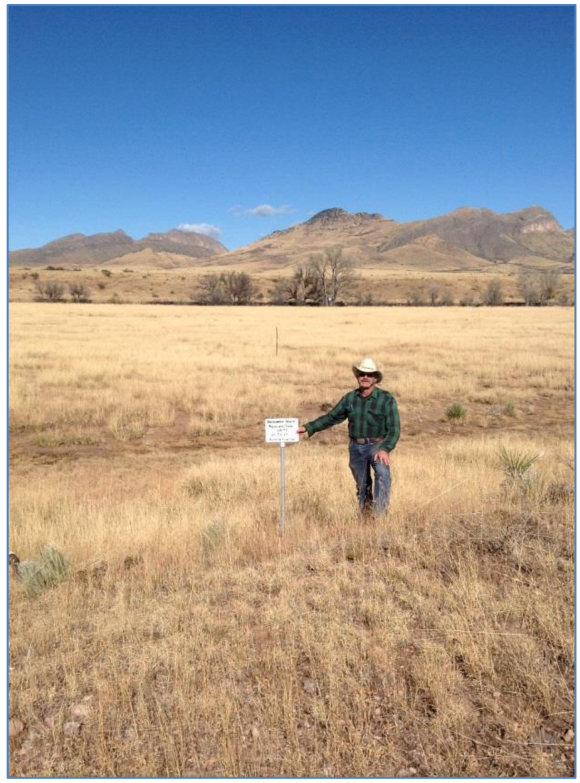
BR #1, Hay canyon / Babacomari on 11-26-12



BR #1, Hay Canyon/Babacomari on 11-25-13

BR #1, Hay Canyon / Babacomari Creek cross section from north to south. Note the open stand of sacaton north of the stream channel. The area south of the stream channel is dense sacaton. Jim Koweek in picture, 11-25-13

BR #1, Hay Canyon / Babacomari creek, transect line in relation to prescribed fire area in March of 2013. North is up.



BR #1, Hay canyon burn, from S. end 4-5-13

BR #1, Hay canyon burn from S. end, 11-25-13

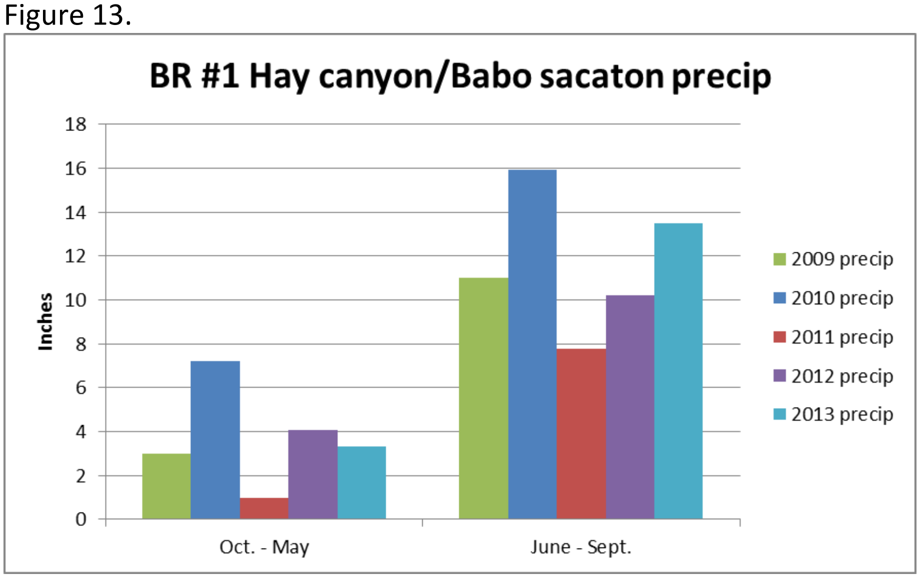
Pronghorn does and fawns on Hay Canyon burn, 6-17-13

Mule deer does on Hay Canyon burn, 11-14-13

Ten, 50 meter lines at fixed stations along the 425 meter cross section were sampled for vegetative cover by species and soil cover. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the Excel spreadsheet for BR#1.

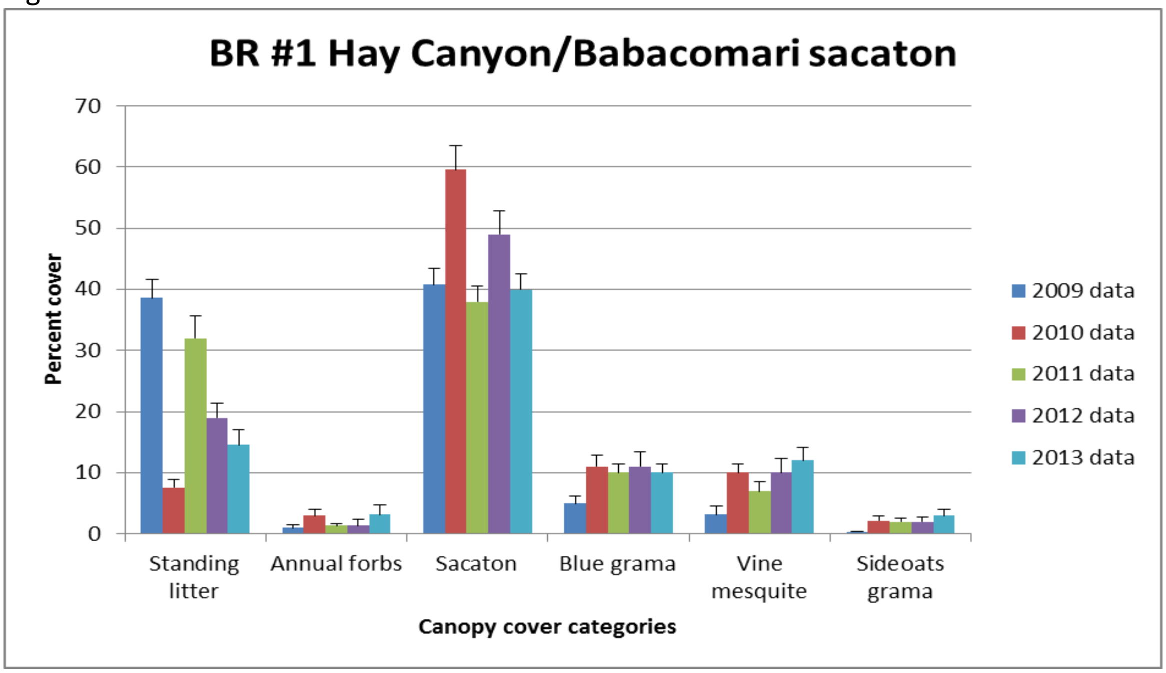
Precipitation in 2013 was higher than in 2012. Average annual precipitation at the Babacomari Ranch headquarters is about 17 inches. This year the ranch received 14.5 inches at this location or 90% of the average (a drought year is one with less than 70% of the long term average precipitation). Cool season precipitation has been well below average four years out of five during this study.

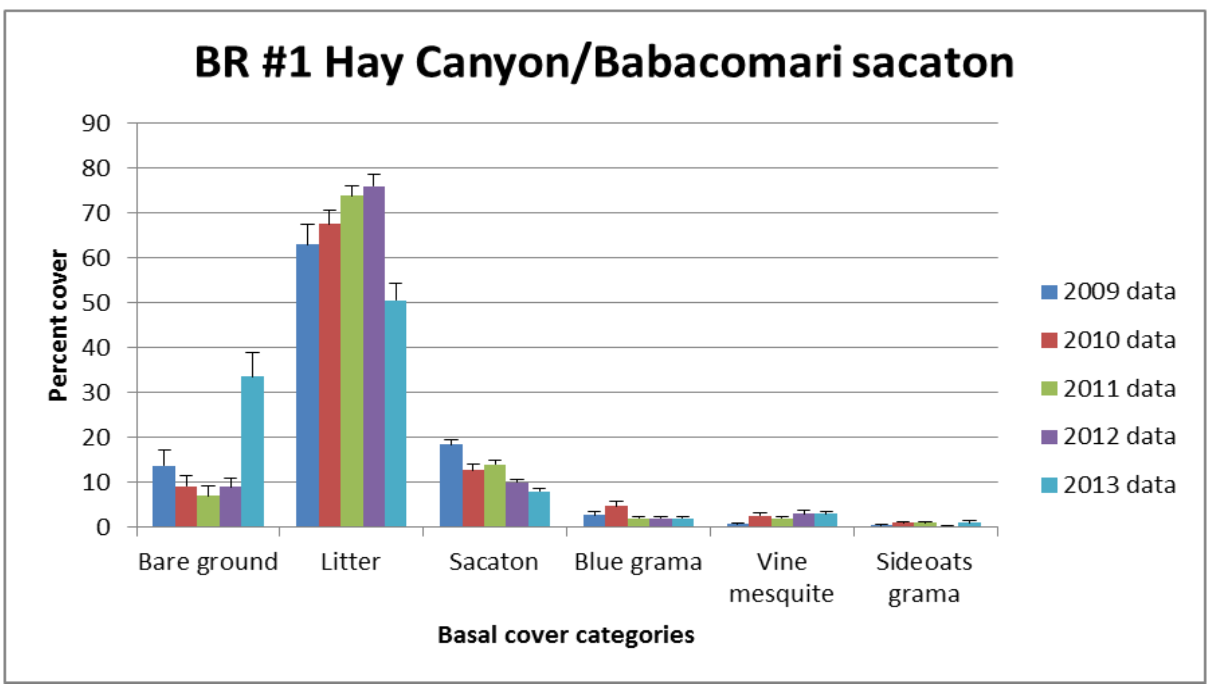
Figure 13.



Total perennial grass foliar cover on this transect was 68% with basal cover at 16% in 2013. Most of the cover is giant sacaton with lesser amounts of vine mesquite, blue grama, mat muhly (M*uhlenbergia repens*) and sideoats grama. Note the large standard error especially for canopy cover categories of major plant species. The north half of the cross section is an open stand of giant sacaton with stands of other native perennial grasses. The half of the cross section south of the stream channel is a dense stand of sacaton with very little cover of other perennial grass species.

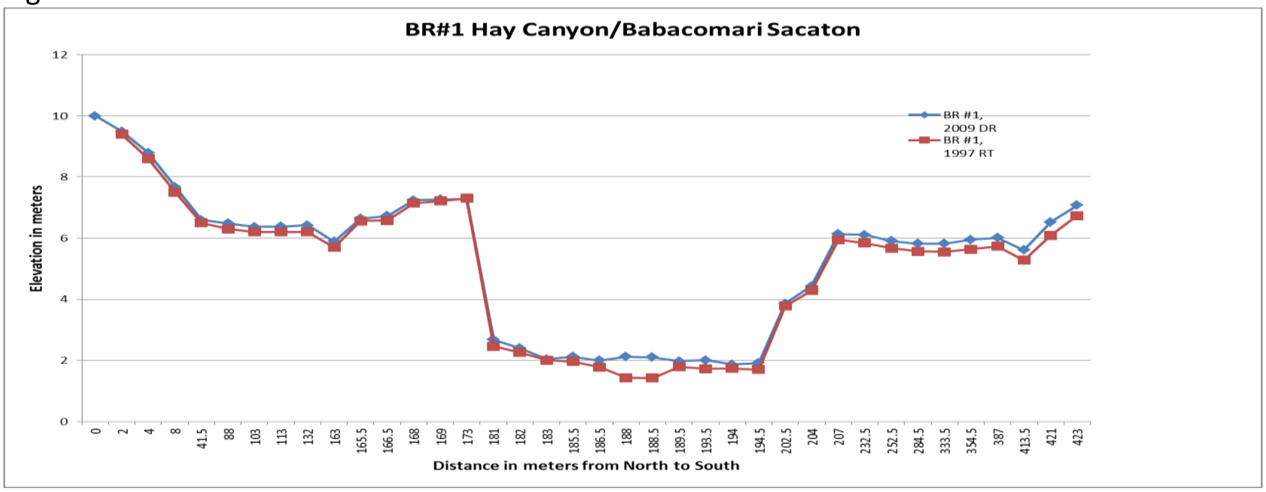
Figure 14.





Both foliar and basal cover of sacaton declined in 2013 due to the prescribed burn. The fire did not burn the area north of the stream channel where cover of other perennial grasses is the greatest so their cover levels remained the same. The burn portion of the cross section was grazed by livestock and wildlife in the spring and early summer with heavy utilization on sacaton as expected. It was rested during the summer growing season of 2013 allowing sacaton to partially recover from the fire/grazing combination. Also note the increase in amount of bare ground and the decrease in soil cover of litter. This is expected after fire but should recover quickly to pre-burn conditions.

Figure 15.



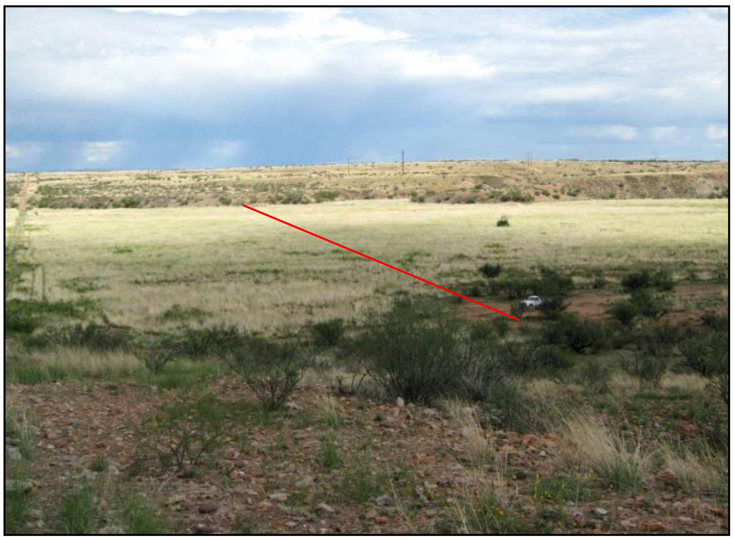
The channel of the Babacomari at BR #1 had little or no stream flow this year and the channel appeared no different from last year. Hay canyon did contribute some flood waters to the cross section on the south side of the Babacomari channel this summer; however there was no apparent need to re-survey the cross section this year.

The re-survey of the 1997 (R. Tiller) cross section showed some channel filling in the twelve year time elapsed. Differences in elevations on the floodplain (both south and north of the stream channel) are due to survey error rather than any accumulation of sediment from 1997 to 2009. Floodplain areas have loamy to clayey textured soils and span the entire floodplain at this location. Stream alluvium (sandy and gravelly soils) occurs only from station 185.5 to 202.5. At present the old stream channel is completely healed. This is fairly static area of floodplain with a low gradient. It no longer floods from the main channel of the Babacomari River as it is 4 meters deep and 15 meters wide. It does flood periodically from Hay Canyon on the south side. The north floodplain is drier and has a more open community of sacaton and native perennial grasses.

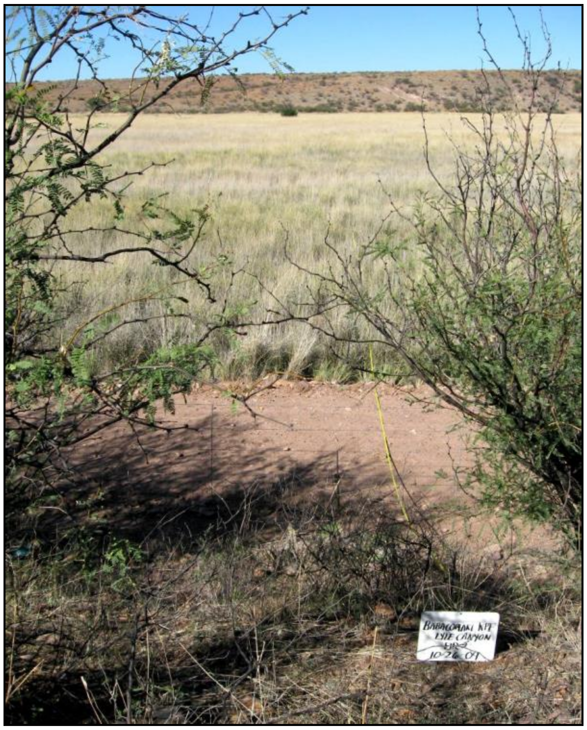
BR #2 –Lyle Canyon sacaton

This transect location is on the Babacomari Ranch in Lyle canyon just upstream of the El Paso Natural Gas line. It is about 1 mile southeast of the Babacomari Ranch headquarters and .25

mile south of the ranch road along the railroad grade. A rain gauge is located on the floodplain at station 280.5 about 120 meters east of the road along the west side. Precipitation is recorded twice a year at this location (October and May, to get cool and warm season precipitation). A piesometer is located nearby at station 285. No ground water has been recorded in the piesometer in the five years of the study. Depth to groundwater has exceeded 7 meters in this period. The monument for this cross section and transect is at the eastern end at an elevation of 4528 feet. The GPS coordinate is (NAD 83) 12R - E0553594 and N3499107. The cross section runs from east to west across the sacaton floodplain to a bank on the west side. It is 440.5 meters long. This area last burned in a prescribed fire conducted by the Babacomari Ranch and the Sonoita-Elgin Fire Department in March 2008. In the authors' experience the sacaton bottom at this location flooded in "El Nino" events in early October of 1983, January of 1993 and October of 2000 but has not flooded since.



Transect line from west looking to the east monument at BR#2. The rain gauge and piesometer are about 100 meters east of the pickup truck on the cross section line.



BR #2, Lyle Canyon sacaton on 10-27-09

BR #2, Lyle Canyon sacaton on 12-18-10

BR #2, Lyle Canyon sacaton on 11-10-11

BR #2, Lyle Canyon sacaton on 11-28-12

BR #2, Lyle Canyon sacaton on 12-2-13

BR #2, Lyle Canyon sacaton floodplain looking south towards the Canelo Hills from above BR #2, sacaton transect location.

Ten, 50 meter lines at fixed stations along the 440 meter cross section were sampled for vegetative cover by species and soil cover. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the Excel spreadsheet for BR#2.

Total perennial grass canopy cover on this transect in 2013 was 57% with 19.4% basal cover, down from 2013. All of this cover was giant sacaton. This is a dense stand of sacaton with exceptional cover five seasons after fire. It is difficult to walk through and sampling and surveying is very difficult. Excellent summer precipitation in 2012 resulted in significantly higher litter cover, sacaton canopy cover and lower bare ground on this transect. In 2013 a dry winter-spring coupled with average amounts of summer rainfall resulted in lower canopy cover and basal cover of sacaton on this transect but bare ground continued to diminish and litter cover on the soil continued to increase. Note the low standard error for all cover categories on this transect. This is a very uniform and dense stand of giant sacaton with few other plant species. Annual forbs like goldentop (*Xanthocephalum gymnospermoides*), annual sunflower (*Helianthus annuus*), pigweed and longleaf goldeneye (*Heliomeris longifolia* var. *longifolia*) can be common in wet years.

Precipitation in 2013 was lower than in 2012. Average annual precipitation at the Babacomari Ranch headquarters is 17 inches. This year the ranch received 14.5 inches at this location or 90 % of the average. Cool season precipitation has been well below average in four out of the last five years of the study.

Figure 16.

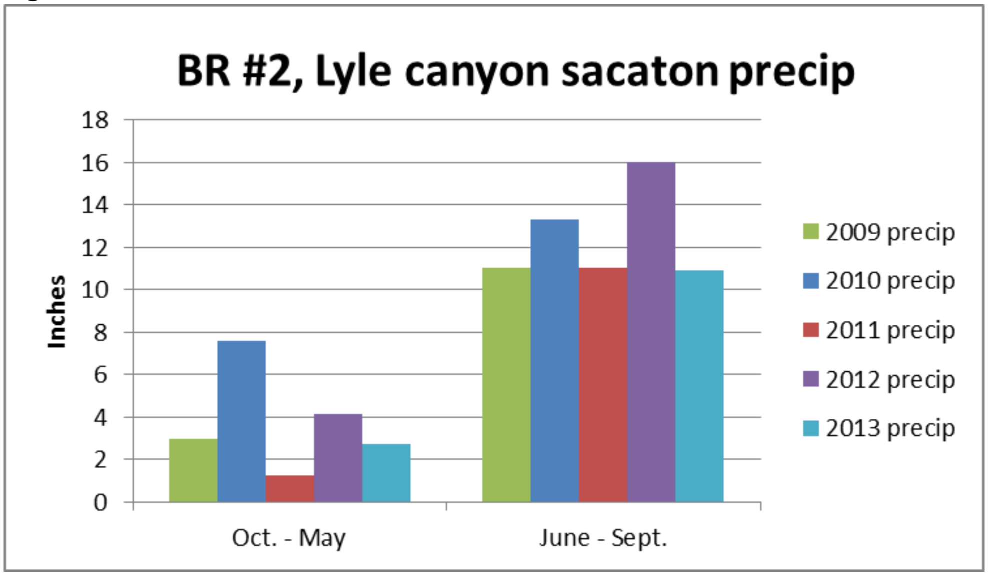
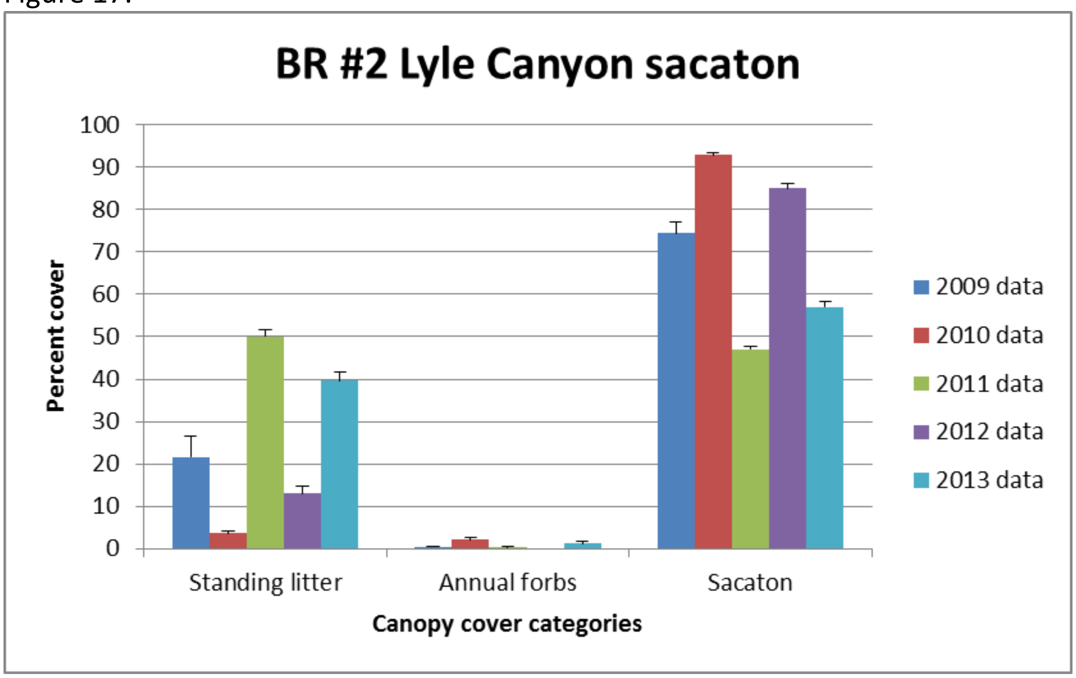
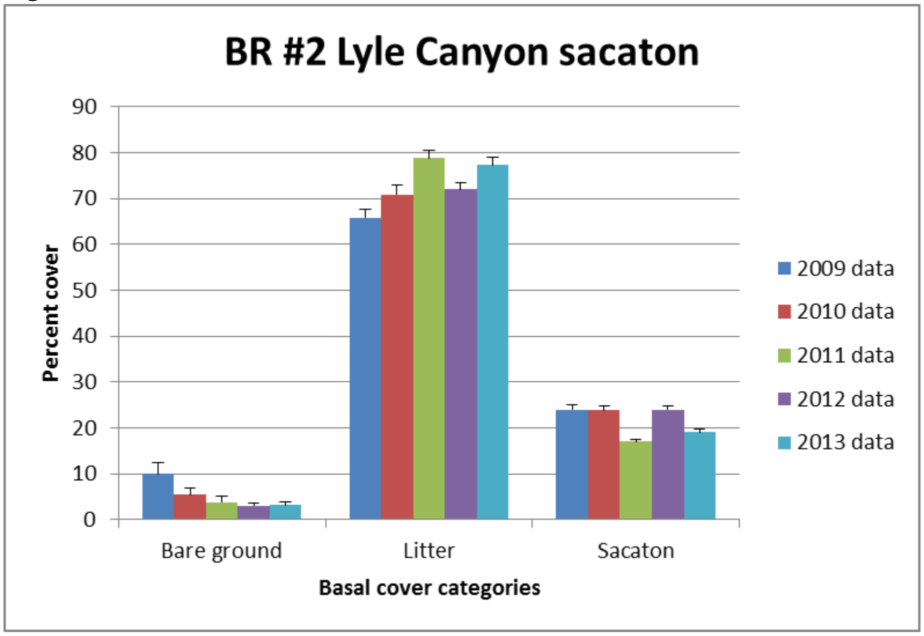


Figure 17.



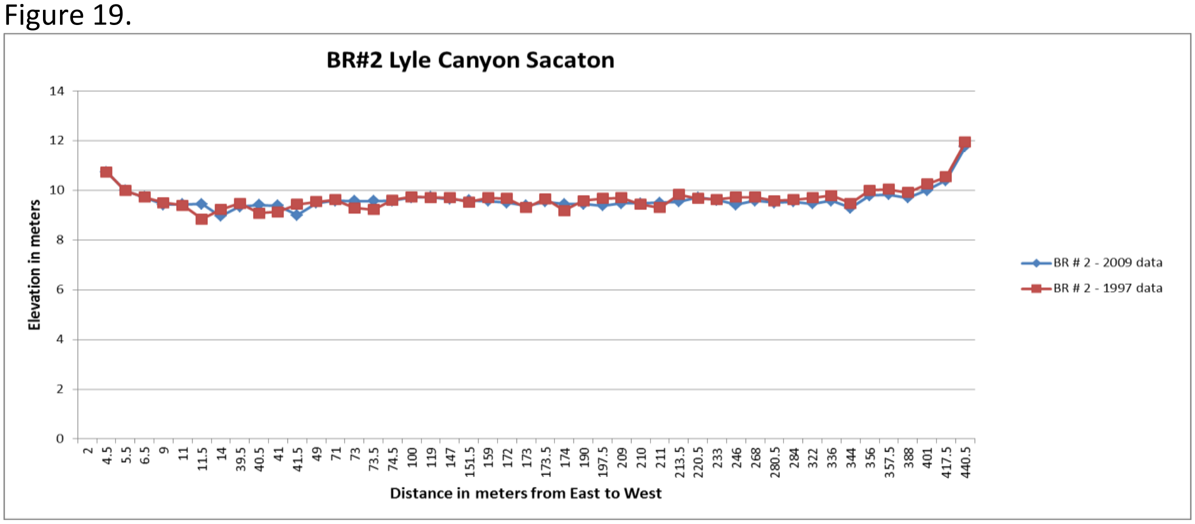
Note that standing litter increased this year and sacaton foliar cover decreased. This is due to reduced summer rainfall from that received in 2012. Note how well sacaton canopy cover tracks summer rainfall. This pasture was grazed this year from January through November. It had moderate use through the summer on upland areas in the pasture but very light utilization on giant sacaton. Overall the trend in this plant community is for very stable conditions with a decrease in the amount of bare ground and an slight increase in litter since the last fire in 2008. Basal cover of giant sacaton is unchanged.

Figure 18.



Lyle canyon has experienced no flooding at this location during the five years of the study. It was not necessary to re-survey the cross section this year.

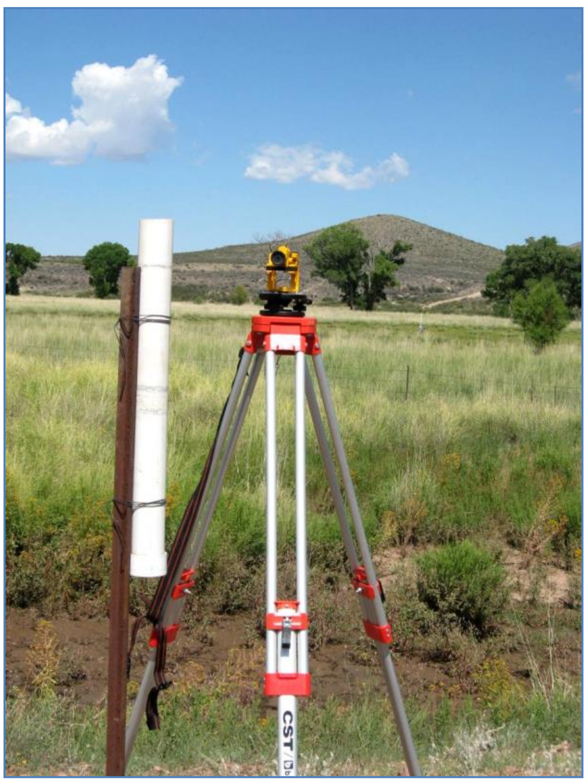
Figure 19.



The re-survey of the 1997 (R. Tiller) cross section showed small channels (gullies) filling in places and cutting in others in the 12 year time period. Floodplain areas have loamy to clayey textured soils and span the entire floodplain at this location. Stream alluvium is not present in this floodplain. This is fairly static area of sacaton floodplain. Discontinuous gullies seem to migrate across these low gradient floodplains over time. The change in cross section from 1997 to 2009 certainly seems to illustrate this phenomenon.

BR #3 – Babacomari Cienega (sacaton and wetland)

This transect location is on the Babacomari Ranch in the Cienega just upstream of the Babacomari Ranch headquarters and 50 meters north of the main ranch road. A rain gage is located on a T-post on the terrace at station 0+00 (the South monument). Precipitation is recorded twice a year at this location (October and May, to get cool and warm season precipitation). Currently there is no method to track groundwater depth at this location. Plans are to install a 6 meter deep piezometer in the spring of 2014. The monument for this cross section and transect is at the southern end at an elevation of 4580 feet. The GPS coordinate is (NAD 83) 12R - E0550723 and N3499485. The cross section runs from south to north across the sacaton and wetland floodplain to a bank on the west side. It is 518 meters long. This area last burned in the Ryan fire which occurred in April 2002. This transect location has two sites represented by different plant communities. The middle area of the cross section is wet meadow or cienega with a high water table (1-2 m). The southern and northern flanks of the cross section are dominated by giant sacaton with greater depth to ground water.



BR #3, Cienega, x-section looking N, 10-19-09

BR #3, Cienega, x-section on 12-8-10

BR #3, the Babacomari Cienega on 11-8-11. Linda Kennedy at station 0+00 and rain gauge location

BR #3, the Babacomari Cienega on 12-7-12. Dan Robinett at station 0+00 and rain gauge location

BR #3, the Babacomari Cienega on 12-12-13. Dan Robinett at station 0+00 and rain gauge location

Ten, 100 meter lines at fixed stations along the 518 meter cross section were sampled for vegetative cover by species and soil cover. Sampling across the cross section was broken into two vegetative types. 500 points of cover (10 lines of 50 points each) were sampled in each vegetative type. Sacaton vegetation was encountered from station 0+25 to 1+00 and again from station 2+75 to 5+00. Wetland vegetation dominated by alkalai muhly, black-creeper sedge (*Carex praegracilis*), Baltic rush (*Juncus mexicana*) and knotgrass was encountered from station 1+25 to 2+50. Point cover sampling was used at one meter intervals to obtain foliar and basal cover by species as well as cover of litter, gravel/rock and bare soil. Vegetative data are summarized in the Excel spreadsheet for BR#3. This cross section spans two riparian grassland vegetative types. The relationship between the two vegetation types is controlled by depth to groundwater and hydric (anerobic) soil conditions near the surface.

Precipitation in 2013 was less than in 2012. Average annual precipitation at the Babacomari Ranch headquarters is 17 inches. This year the ranch received 14.5 inches at this location or 91% of the average. Winter precipitation has been well below average for four out of the past five years.

Figure 20.

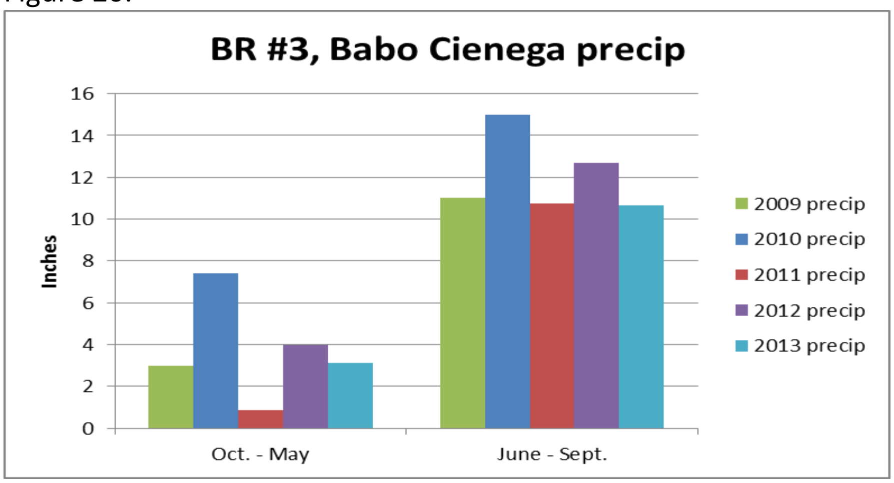
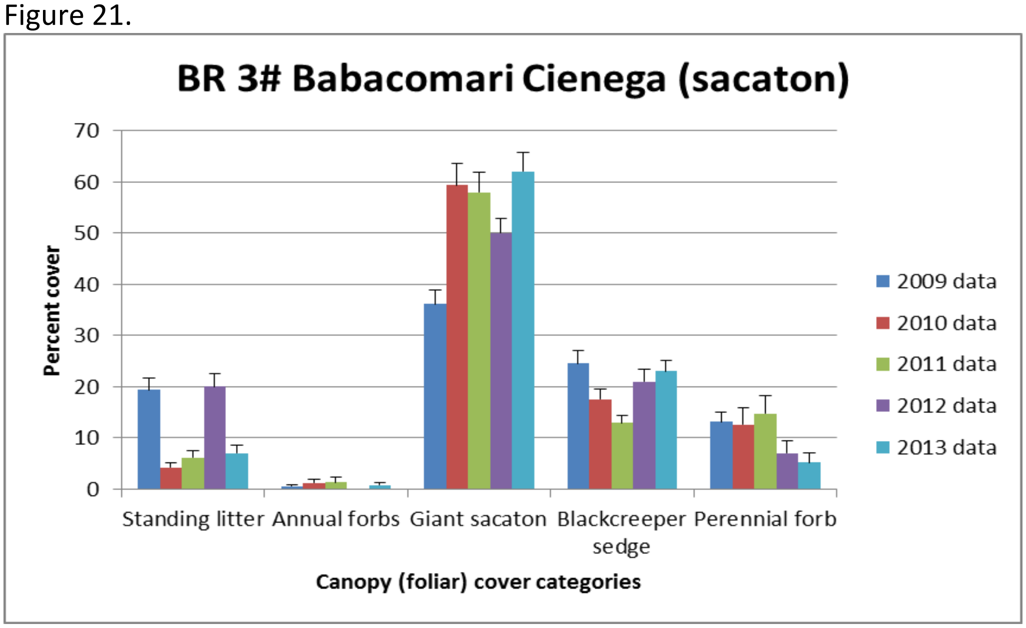
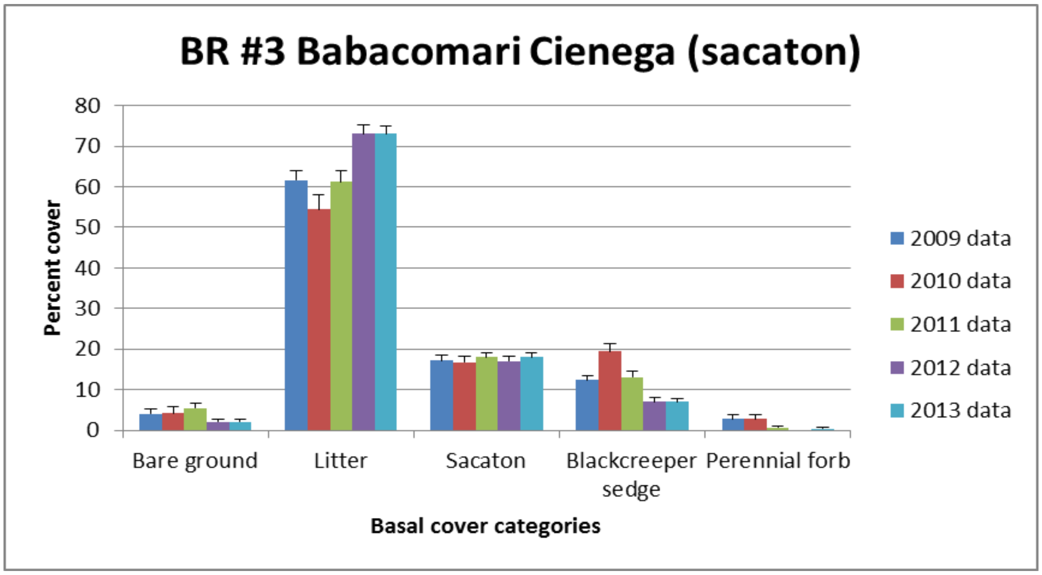


Figure 21.



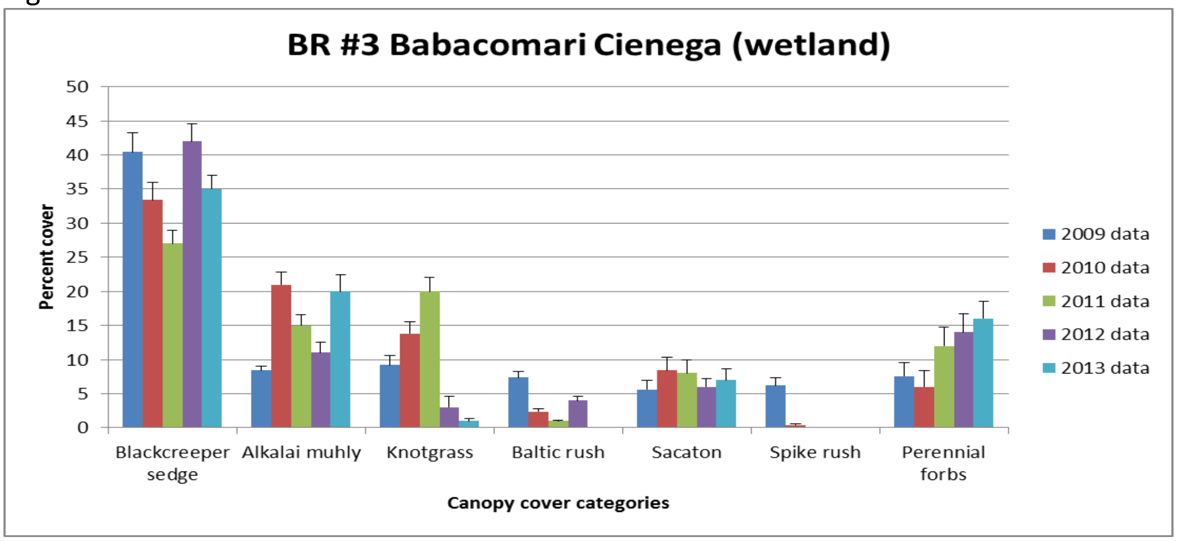


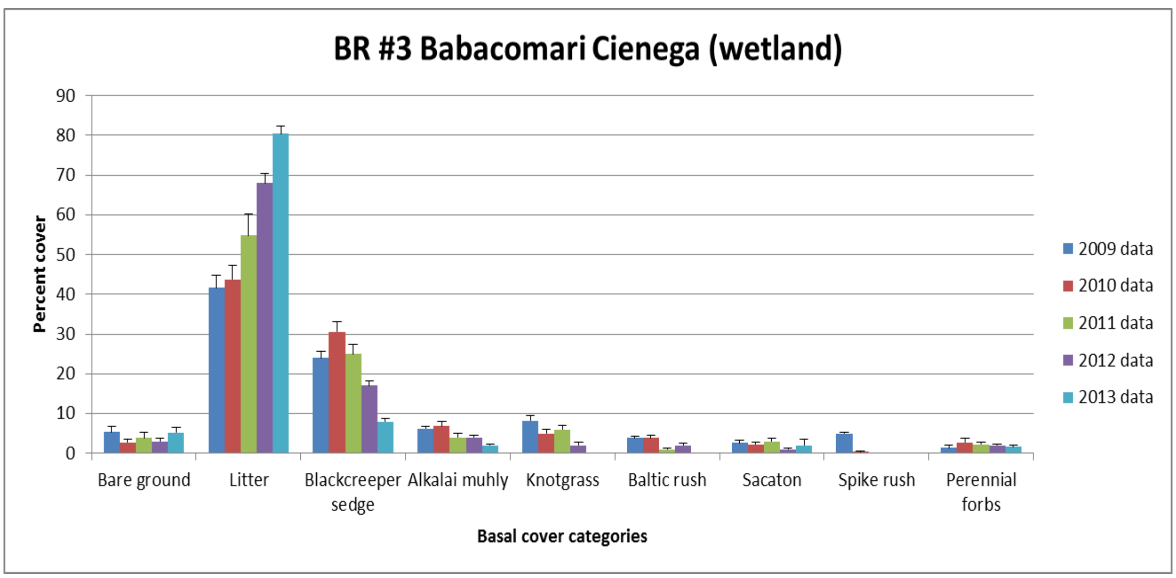
Total perennial grass/grass-like foliar cover on the **Giant Sacaton** portion of this transect was 86% with 25% basal cover. Over half of this total cover was giant sacaton (62% foliar and 18% basal cover respectively). Black-creeper sedge made up 23% foliar and 7% basal cover. Native perennial forbs, ragweed (*Ambrosia confertifolia*) and white prairie aster, had 5% foliar cover. There was no significant change in canopy or basal cover of sacaton since 2010 but black-creeper sedge had a significant decrease in basal cover from 2010 to 2013, perhaps due to the below average winter precipitation the past three years. The grass-like plants (sedges and rushes) on this transect are cool season species. Note the low standard error for cover categories in the sacaton part of the cross section. This is a dense and uniform stand of giant sacaton with very high levels of cover. Groundwater appears to be within 2 or 3 meters of the surface at this location. Bare ground is very low on the sacaton area and litter cover of the soil is very high. The site is very stable with the most productive stand of giant sacaton in the study area.

Dan Robinett recording cover of sacaton and associated species in the sacaton portion of the Babacomari Cienega. 12-11-10

Linda Kennedy recording cover of wetland plant species in the Babacomari Cienega. Alkalai muhly, sedges and rushes are dominant, 12-11-10

Figure 22.

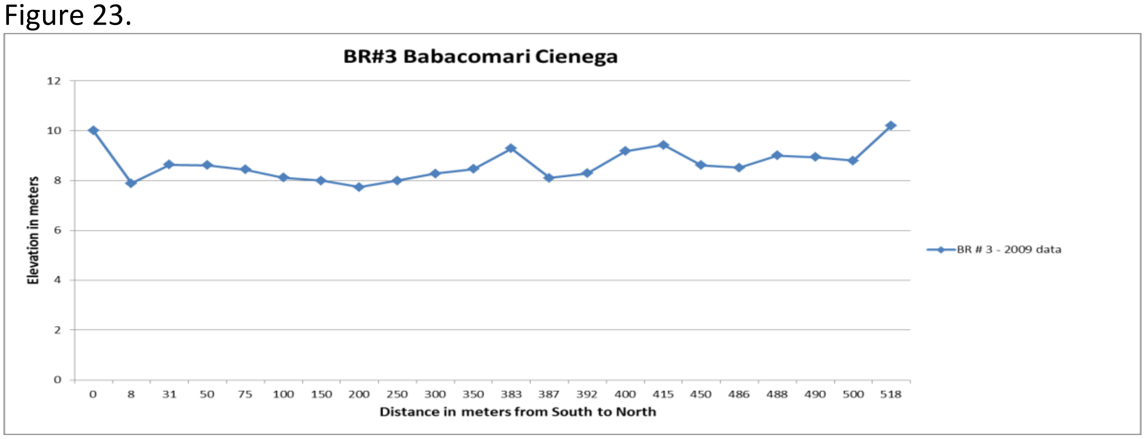




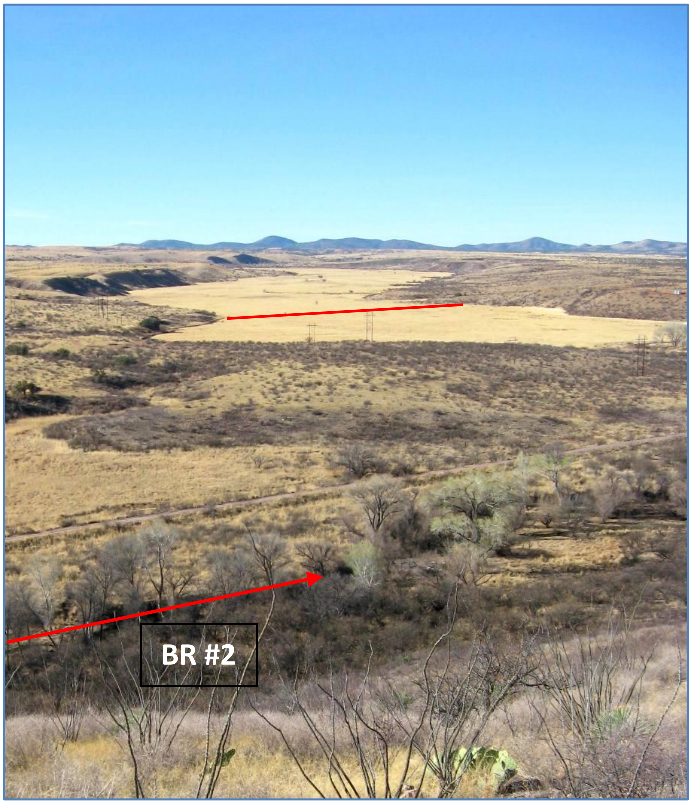
Total plant cover for the **Wetland** portion of this transect was 69% foliar and 13% basal cover down significantly from previous years. The dominant wetland perennial plant species include black-creeper sedge, alkalai muhly, knotgrass and spike rush at this location. Foliar cover of the major species, black-creeper sedge and alkalai muhly are high and have not changed over the course of the study. There are however, significant decreases in the basal cover of knotgrass, alkalai muhly, spike rush, Baltic rush and black-creeper sedge over the course of the study. Many of these are good forage species but grazing was only heavy during the growing season at this location in 2012. The declines may be due to a lack of cool season precipitation during the past three years and/or a decline in depth to groundwater. There is now way to confirm this without an accurate measurement of depth to groundwater. This area last flooded during a large rainfall event in September 2007. We plan to install a 6 meter deep piezometer at this location in the spring of 2014 to track this indicator. It will be installed at station 1+00 at the boundary of the sacaton and wetland portions of the cienega. Perennial forbs like ragweed, white prairie aster and yerba mansa had no change in foliar or basal cover on the wetland part of the cross section. Perennial forbs had 16% foliar cover this year. Note the high standard error for canopy cover categories and moderate standard error for basal cover categories on this transect. This illustrates the variability in species composition across the wetland part of the transect cross section.
The Cienega Pasture was open with the Calf Pasture this fall and grazing utilization, at the time this transect was read, was light on forage species in the wetland portion of the pasture. There was little to no grazing use on the sacaton portion.

Spring and summer stream flow in the Babacomari channel through this cross section was minimal in 2013. The channel has changed little over the course of the past five years. None of the valley side drainages have flooded into the Cienega during the course of this study. There was no reason to resurvey the cross section this year.

Figure 23.



The cross section starts on the south end on an upland terrace (station 0+00) and drops down into sacaton floodplain from station 8+00 to 1+00. It then grades into wetland vegetation (dominated by hydric and/or aquatic plant species) from station 1+00 to 3+00 and then back into sacaton the remainder of the cross section. Floodplain areas have loamy to clayey textured soils and span the entire floodplain at this location. Stream alluvium (sandy, gravelly soils) is present only in the old stream channel of the Babacomari River from station 3+87 to 3+92. This is fairly static area of sacaton and cienega floodplain. The old river channel is still receiving some sediment and appears to be slowly filling. Its elevation is at present, higher than the thalweg (low point of the cross section) at station 2+00 in the middle of the cienega.



Babacomari River in Bridge pasture looking south across BR#2 greenline and tree transect towards the Lyle canyon sacaton bottom and BR #2 sacaton transect (in background). 2-25-09

Riparian Greenline, Tree Canopy and Geomorphic Monitoring

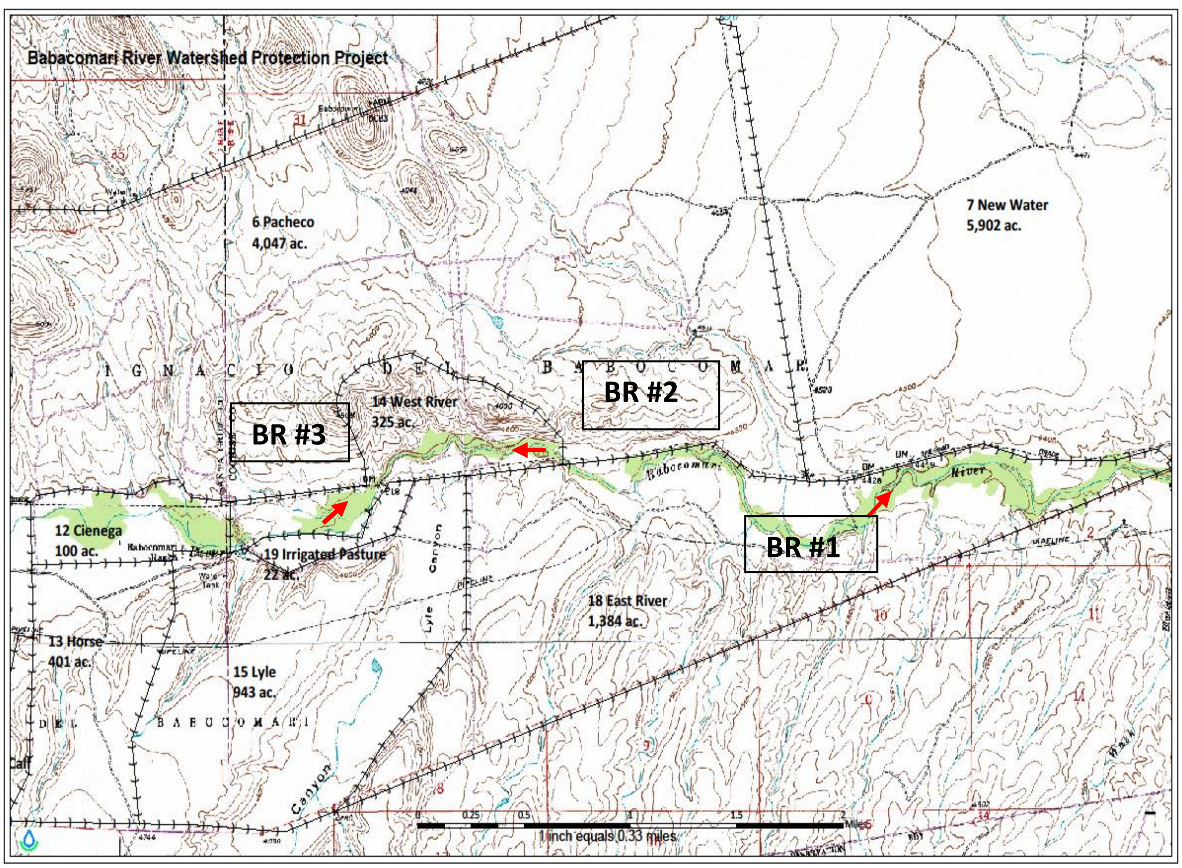
Riparian monitoring stations were established in May of 2010 at three locations along the Babocomari River below the Babocomari Ranch headquarters. They were re-read in June 2011, 2012 and 2013.

The first location (BR #1) is located just below the USGS stream gauge at the mouth of Blacktail canyon approximately 4 miles east of the ranch headquarters. It begins at the existing monitoring transect at KA #24 established in 1995. This stretch of the river has perennial flow, pool and riffle topography, moderately wide floodplains (100 – 150 feet) and has a good source of sediment being contributed by Little Blacktail and Javalina canyons. A USGS stream gage was installed in 1999 at the road crossing where Little Blacktail Canyon enters the Babacomari River. It provides measures of peak flood flows, mean daily/monthly/yearly water discharge and precipitation. This location is in the River pasture. This area was fenced by the Babacomari Ranch in 1996 in an effort to improve management of grazing in the riparian areas along the creek and to break the very large Pacheco Pasture into more manageable units. It encompasses about three miles of the stream riparian area in Babacomari Creek. The pasture is 1384 acres in size and consists primarily of grassy hillsides and uplands flanking the river channel and floodplain.

The second location (BR #2) is immediately upstream from the 1881 Eiffel railroad bridge about one and a half mile east of the ranch headquarters. This stretch of the river is very similar to the first monitoring location but lacks an outside source of sediment. It is cut off from sediment by the structures (CCC) upstream that protect the Babacomari Cienega and Lyle Canyon sacaton. This is a new pasture, the Bridge pasture, created by fencing included in the WPF grant. It encompasses about one mile of the stream riparian zone below the Babacomari Ranch headquarters. The pasture is approximately 325 acres in size.

The third station (BR #3) was established just north of the irrigated field east of the Ranch headquarter. It is in the spillway channel of the CCC structure that protects the Cienega. This location is a former livestock water access and road crossing point. New fencing and water development now allow livestock to water outside of the creek and include this transect in the Bridge pasture formed by the WPF fencing component. It was chosen because it has very little tree cover and should respond quickly to better livestock grazing management.

Figure 24.



Huachuca water umbel (*Lilaeopsis schaffneriana* var. *recurva*) a federally listed T&E species at BR #3 just downstream from T-3. June 2009

View showing diameter and constrictions on stem of Huachuca water umbel.

Riparian monitoring stations were established at three locations in June of 2010 on the Audubon Research Ranch. They were re-read in May of 2011, 2012 and 2013.

The first location (TRR #1) is in an ephemeral stretch of Turkey creek just north of the USFS boundary. This area has prolonged stream flow during the winter with a shorter period during the summer monsoon. It has few trees and a rocky channel.

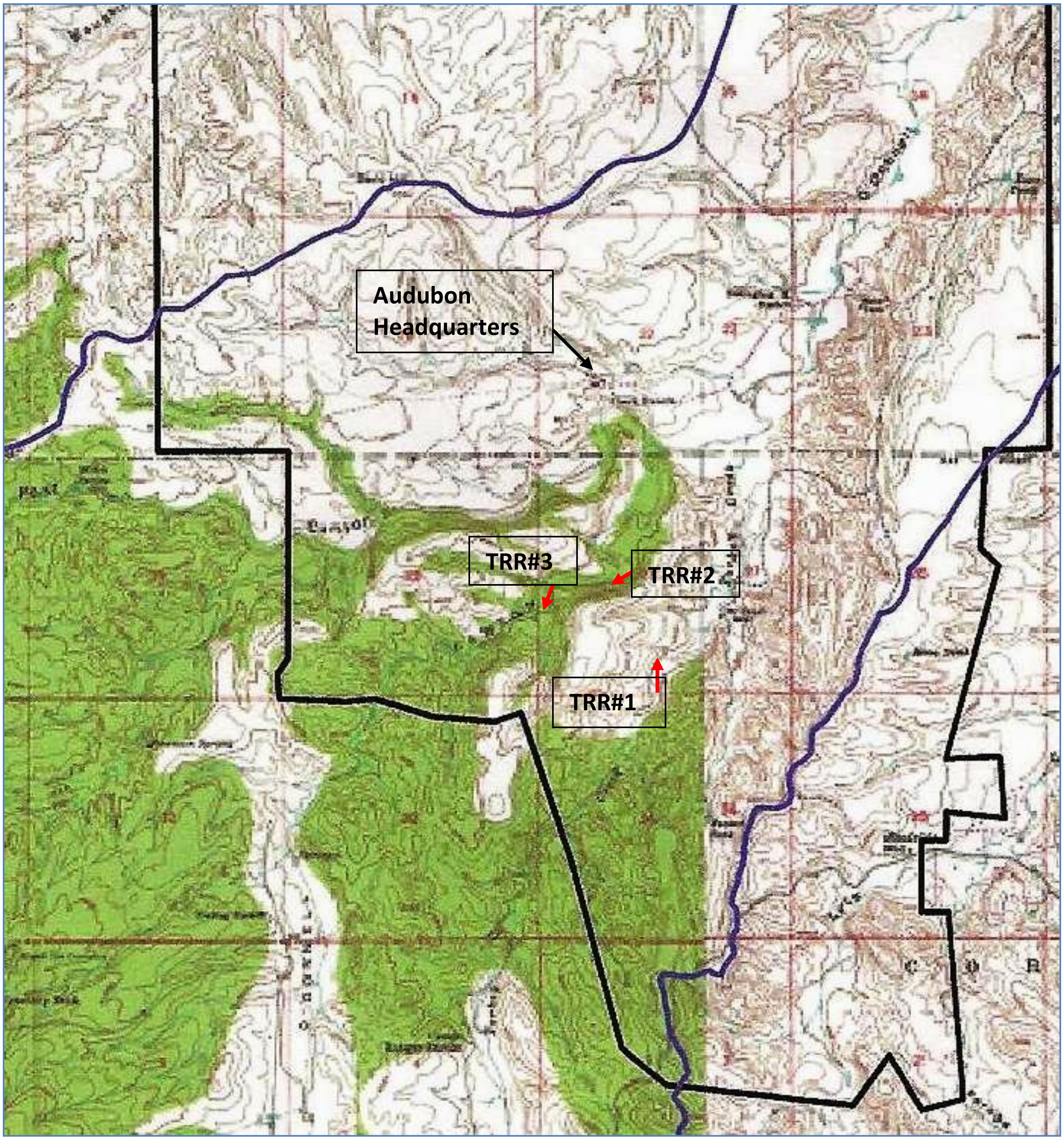
The second location (TRR#2) is in an ephemeral stretch of O'Donnell canyon about 1 mile south of the Audubon headquarters. This area has prolonged stream flow during the winter with a shorter period during the summer monsoons. It has an excellent canopy of riparian trees which experienced fire in April 2002 (Ryan fire). The Canelo fire burned in May of 2009 but only on the south bank of this location. The stream channel through this transect is rocky and straight.

The third location (TRR#3) is the perennial stretch of O'Donnell canyon about a half mile west of the TRR#2. It is just above the two concrete dams constructed in the late 1950s for livestock water. This location has a canopy of riparian trees but has burned twice in the recent past (the Ryan fire of April 2002, and the Canelo fire of May 2009). It has a rocky and sinuous stream channel.

Upper O'Donnell Dam, T-3 (TRR #3) is just upstream of this structure in the perennial reach of O'Donnell Canyon, 1-11-14.

Dan Robinett reading transect, T-3 (TRR #3) in a perennial reach of O'Donnell Canyon, 5-24-12.

Figure 25.



BR #1 Babacomari River USGS Stream Gauge

This location begins about 200 feet downstream of the USGS stream gauge established in 1999 and runs from the southwest to northeast. This transect also begins at the point of the 1995 pace-frequency monitoring transect called Key Area 24. This portion of the Babacomari River was fenced to make a separate (River) pasture in 1996 and has been managed by grazing during the fall, winter and spring months since then. It has improved in condition since it was fenced and the riparian community is in very good condition (Personal observation by first author). Dan Robinett and Jeff Simms (aquatic and riparian specialist with the Tucson BLM office) made an assessment of Riparian Proper Functioning Condition (BLM 1993, Prichard 1998) on this transect location in May 2009 The area was determined to be in Proper Functioning Condition with a stable trend. Ample sediment enters the river at this location from Little Blacktail Canyon to allow for stream pool – riffle development and stream bank and floodplain building. The pasture was not grazed in either 2009 or 2010. It was grazed in the fall, winter and spring of 2011-12. It was not grazed through the growing season (May1 through Oct 30-2012) in 2012 and slightly in the growing season of 2013.


BR #1 USGS stream gauge on the River


BR #1 Depth gauge and mouth of Blacktail Canyon

Monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long on both banks. Plants species composition is recorded by canopy cover in quadrats (plot frames) placed every two meters along the green-line on both banks. At each interval quadrats are read both on the bank and another partially submerged in the water. At each green-line transect 40 quadrats are read on both stream banks and another 40 quadrats are read partially submerged in the water. This technique helps sample the plant community for both the aquatic species and stream-bank species. Cover data are presented separately for bank and water quadrats. Herbaceous vegetative data are presented as average canopy cover by species summed for all six transects in the cluster. Frequency data are aggregated for all 240 quadrats in the six transects in the cluster. Tree vegetative data are presented as average canopy cover by species and total canopy cover for the area of the belts along both banks and summed for all three transects. Total cover is less than the sum of individual tree species cover as canopies often overlap. Geomorphic monitoring includes three survey cross sections, one perpendicular to the stream channel at the midpoint of each transect in the cluster.


BR #1, transect 1, looking east, 6-11-10


BR #1, transect 1, looking east, 6-21-11


BR #1, transect 2, looking east, 6-11-10


BR #1, transect 2, looking east, 6-21-11


BR #1, transect 3, looking east, 6-11-10


BR #1, transect 1, looking east, 6-21-11


BR #1, USGS stream gauge, T-1, 6-2-12


BR #1, USGS stream gauge, T-1, 6-18-13

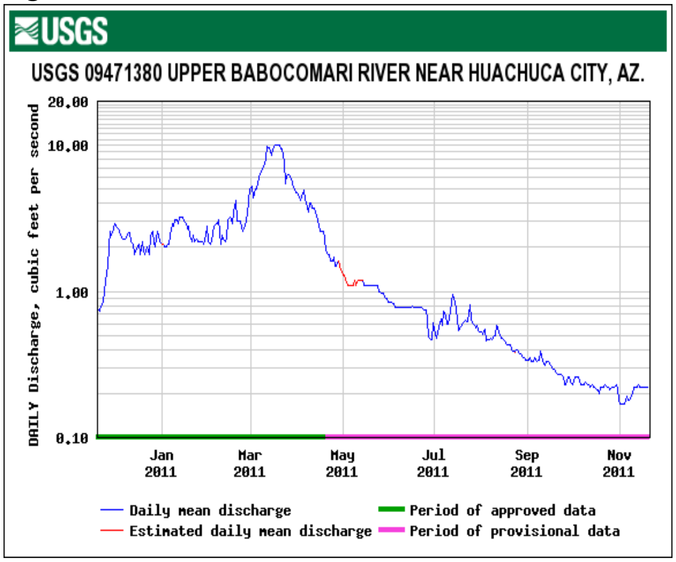

BR #1, USGS stream gauge, T-2, 6-2-12


BR #1, USGS stream gauge, T-2, 6-18-13

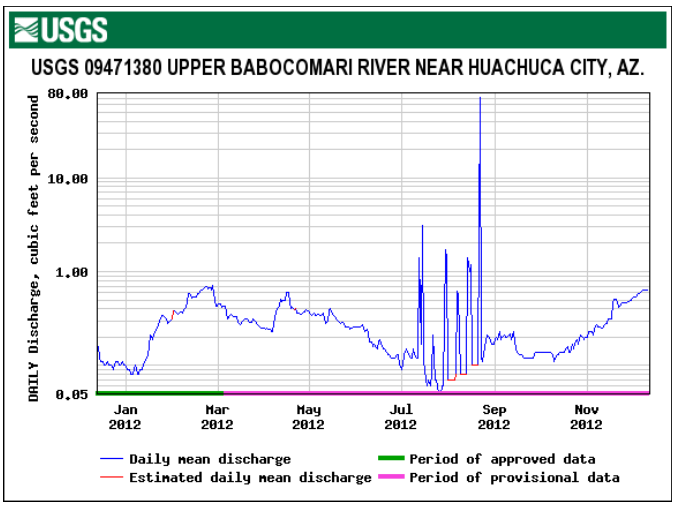

BR #1, USGS stream gauge, T-3, 6-2-12


BR #1, USGS stream gauge, T-3, 6-18-13

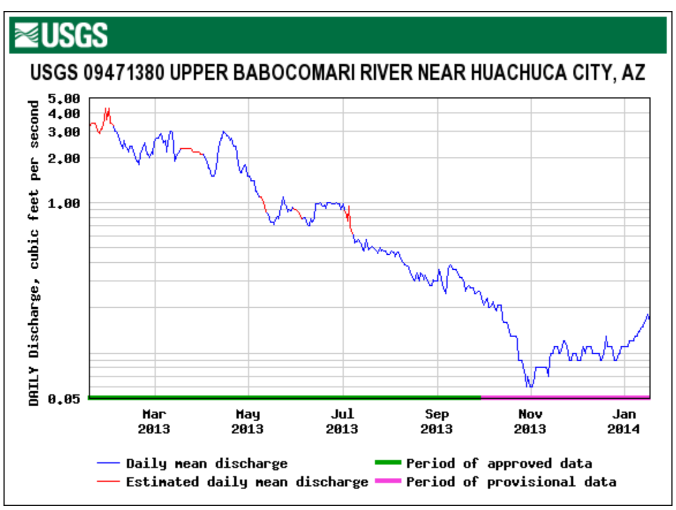
Figure 26.



Mean discharge for the Babacomari River at the USGS stream gauge near BR#1 for 2011



Mean discharge for the Babacomari River at the USGS stream gauge near BR#1 for 2012



Mean discharge for the Babacomari River at the USGS stream gauge near BR#1 for 2013

Figure 27.

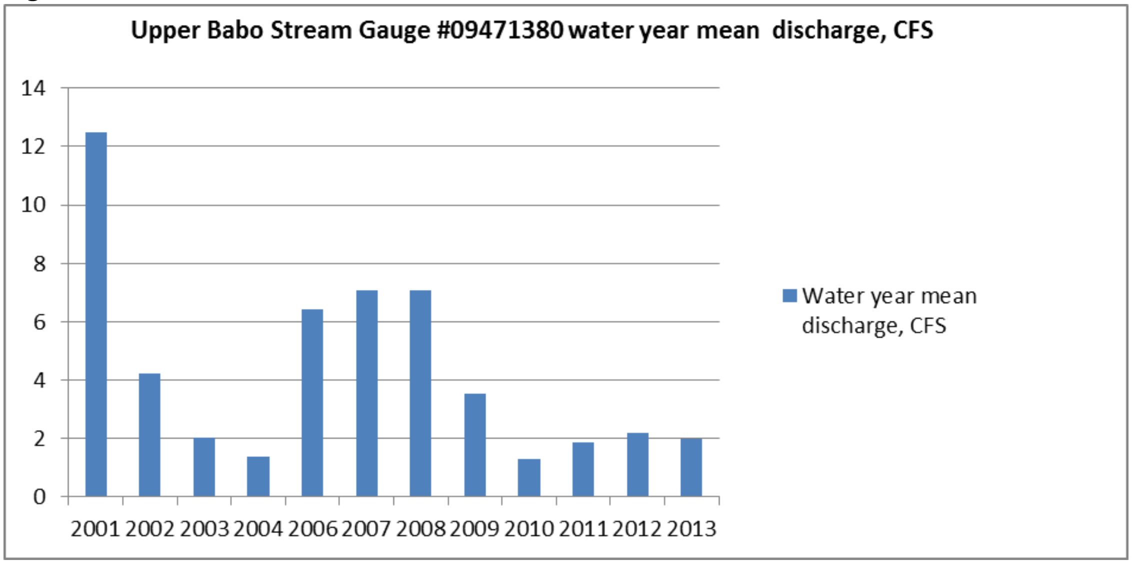
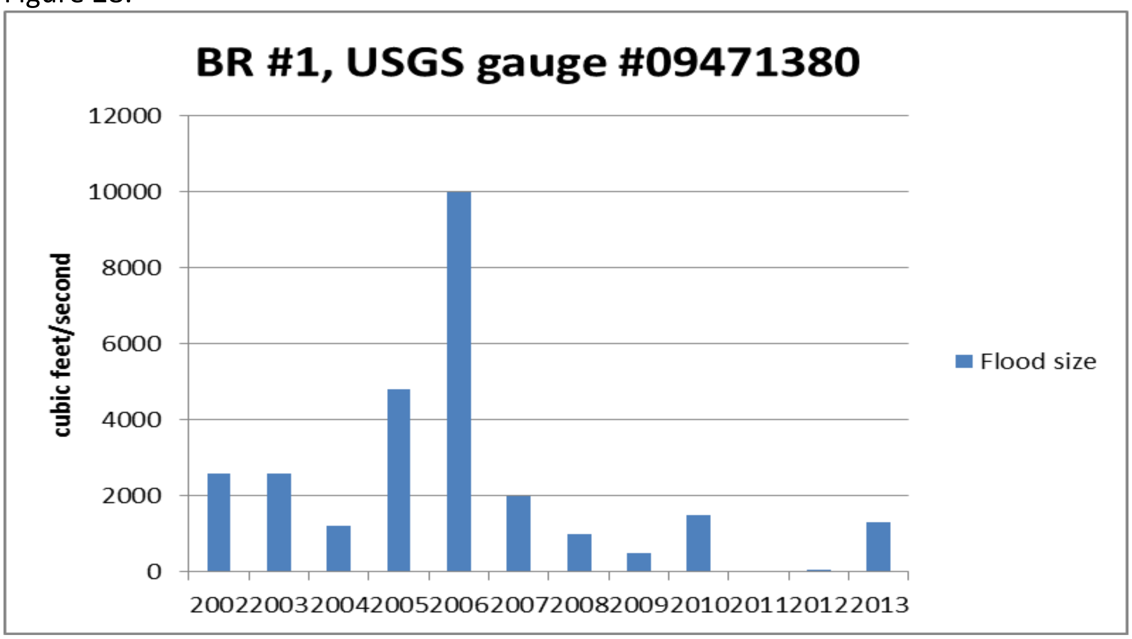
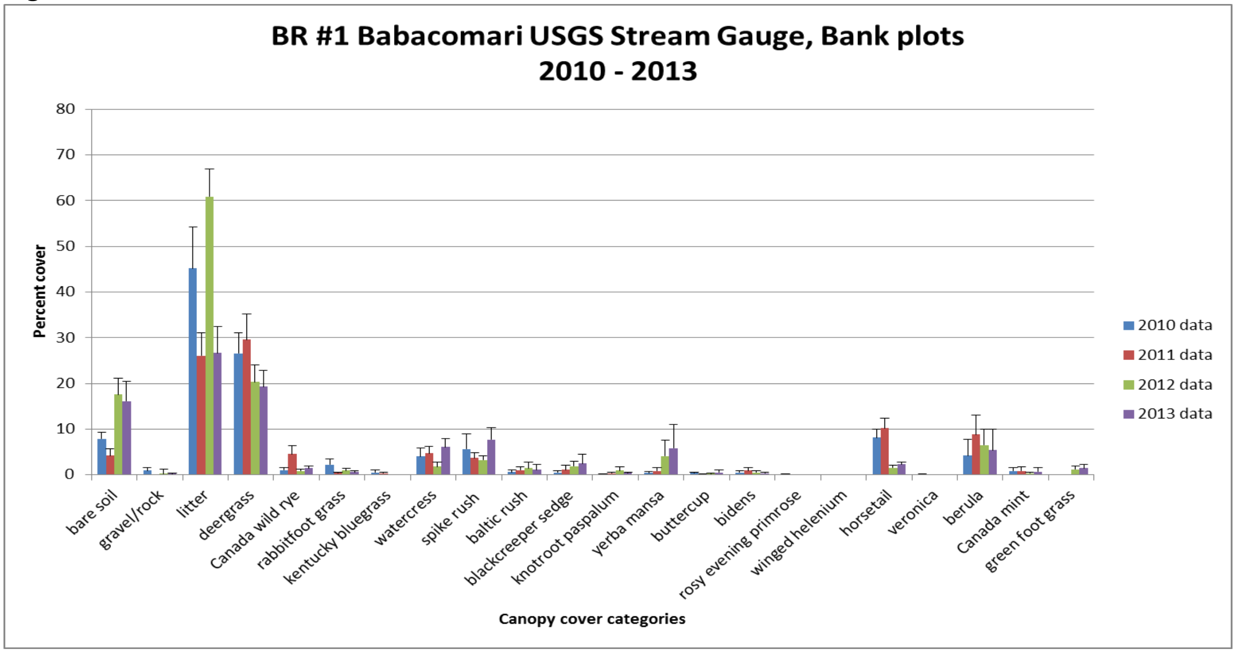


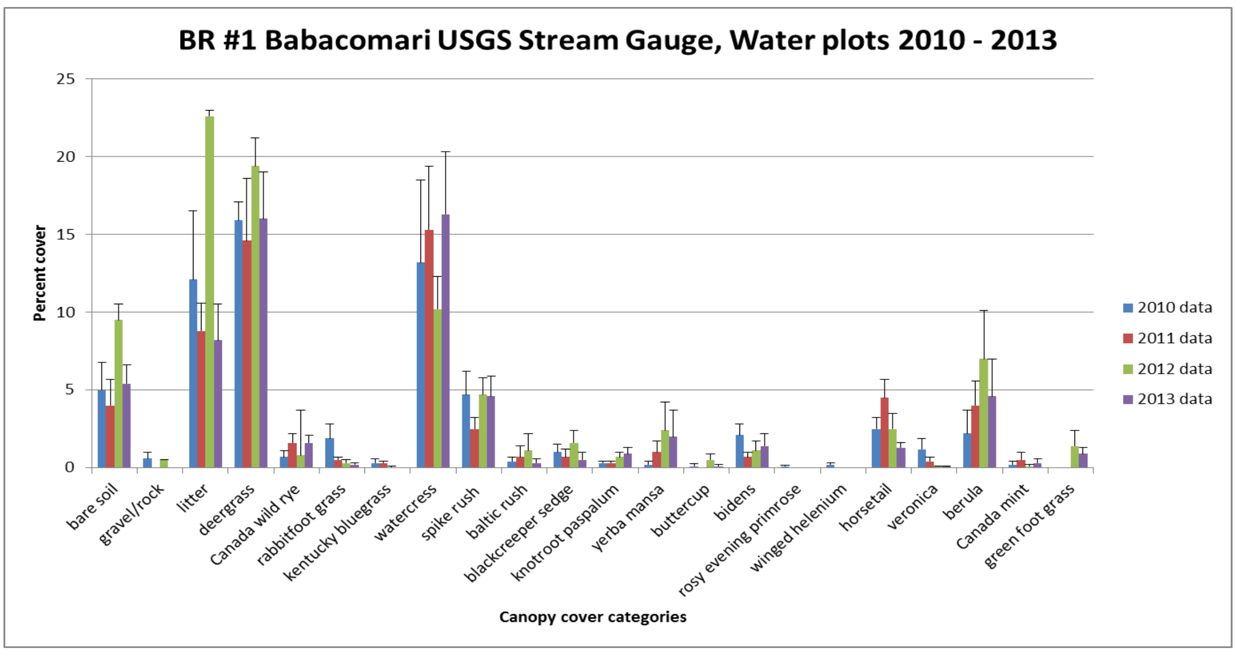
Figure 28.



The USGS gauge shows only one flood event per year (all in August except 2002 (Sept.), 2011 (March)). The large flood in August of 2006 scoured the stream banks but they quickly recovered. The peak flow in 2011 was only 12 cubic feet per second (CFS) on 3-12-11. The peak flow in 2012 was only 72 CFS (one CFS = 450 gallons per minute) on 8-22-12. A flood of 1700 CFS in August of 2013 did minor scouring of vegetation through the transect area. The lack of flooding in the past eight years resulted in a buildup of silt and mud in the pools at this location.

Figure 29.





Vegetative data show a diverse plant community dominated by native wetland species. Deergrass dominates the **bank plots** with lesser amounts of horsetail and spike rush. Deergrass and watercress dominate the **water plots** with lesser amounts of spike rush, horsetail and several important aquatic forbs like water speedwell, water parsnip and water marigold. Banks are extremely well vegetated with less than 10% (exposed) soil.

There were few significant changes in the understory plant community from 2010 to 2013. Both litter cover and percent bare soil are up significantly in 2013 probably due to a longer grazing season (December through July) this year than in the past. Also horsetail has significantly less canopy cover on the bank plots than in past years. Moderate grazing use on this species was noted when this transect was re-read in June in both 2012 and 2013, accounting for less canopy cover than in previous years. Frequency data for horsetail show recovery in 2013 to previous levels.

Large standard error for all cover categories results from the variation in plant community along the banks and in the water at this location. The six transects at BR #1 span several different combinations of vegetative and stream morphologic conditions. Pool areas occur with and without dense tree canopy. Open areas along the banks of pools are dominated by deergrass. Tree shaded areas along pools are dominated by deergrass, sedges, horsetail and rushes. Riffle areas also occur with and without tree canopy. Riffle areas with little overstory canopy are dominated by watercress, with lesser amounts of berula and veronica. Riffle areas in shaded areas are dominated by yerba mansa, Colorado mint (*Mentha coloradensis*), veronica, water marigold and berula. The variation in the understory plant community (in short distances) makes it nearly impossible to find uniform areas for vegetation monitoring.

Frequency for major plant species was calculated from the data-set to determine vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at location BR #1. Frequency is presented in the table below. Although standard error is still large for major species the data seem to show a very stable to upward trending understory plant community for this site over the course of the study. Further analysis would help sort out trends when at least ten years of sampling has occurred.

Figure 30.

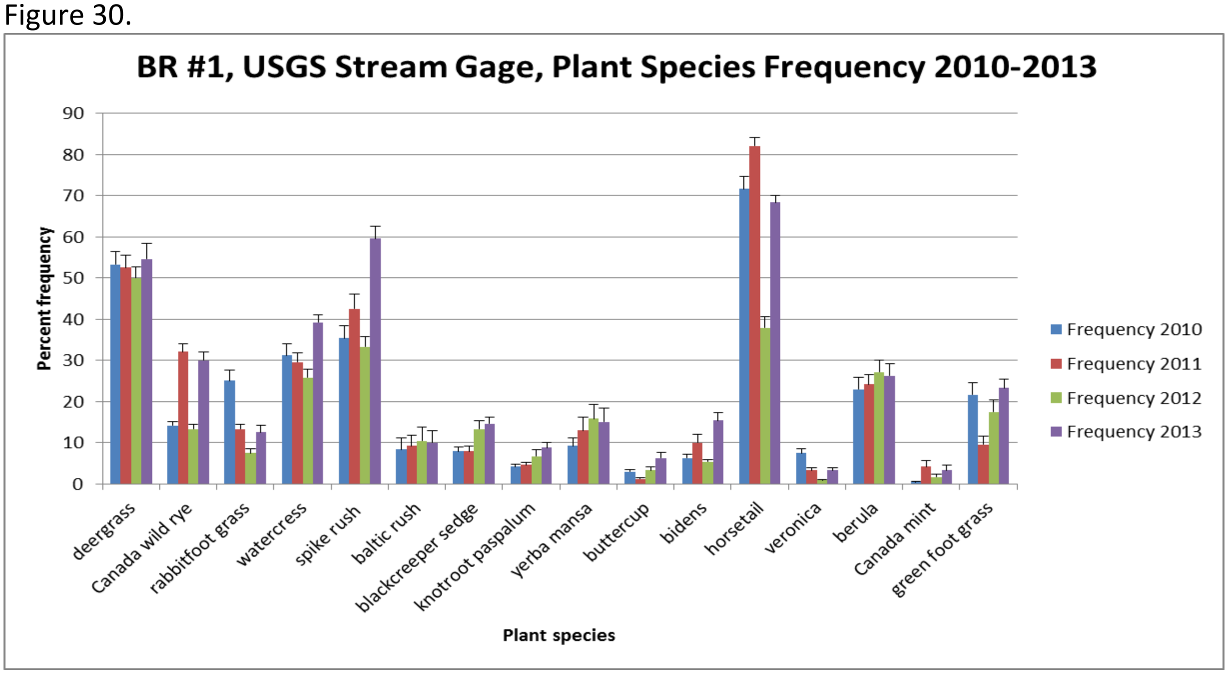
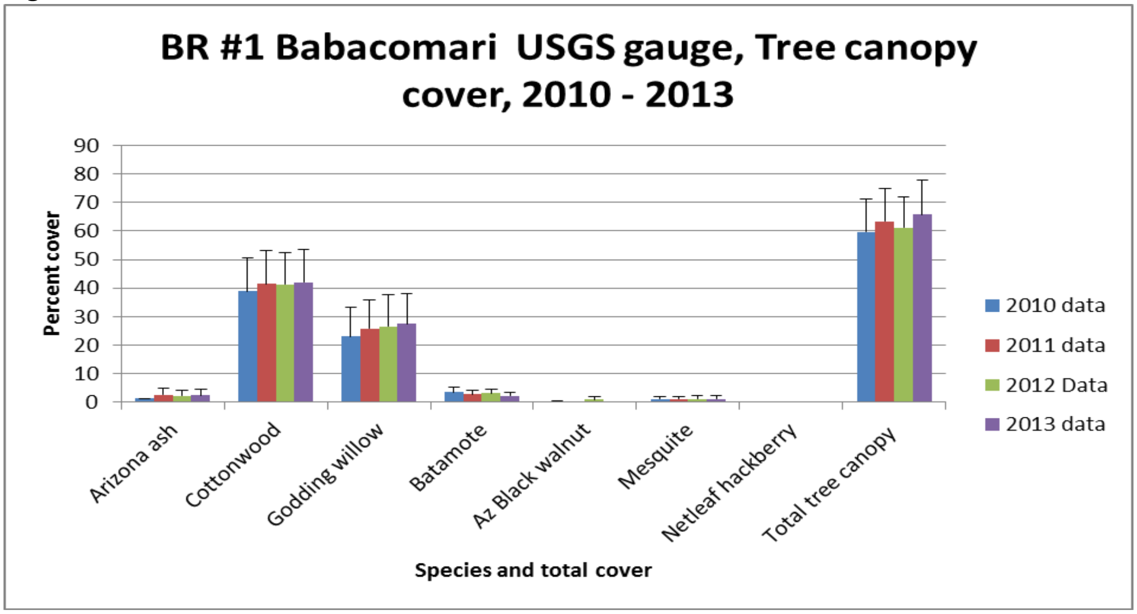


Figure 31.



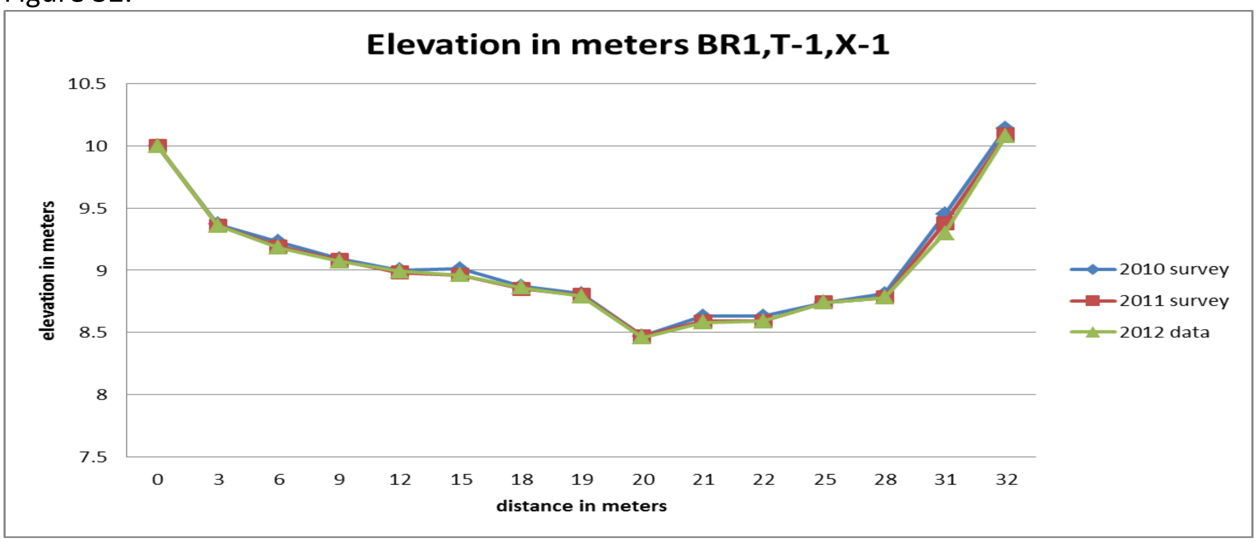
The total tree canopy cover averaged over all three transects is 65%. Large standard error for tree species canopy are due to the variability in tree cover among the six transects. Cottonwood is dominant and Goodding willow is sub-dominant. Numerous seedlings and saplings of Arizona ash are recorded at this location. Arizona ash appears to be increasing along the Babacomari as well as along Cienega creek on the Empire Ranch on Las Cienegas National Conservation Area (K. Simms, BLM, personal communication). There are no significant changes in tree canopy on this site from 2010 to 2013. These data illustrates the repeatability of the methods used to monitor tree canopy cover in this study.

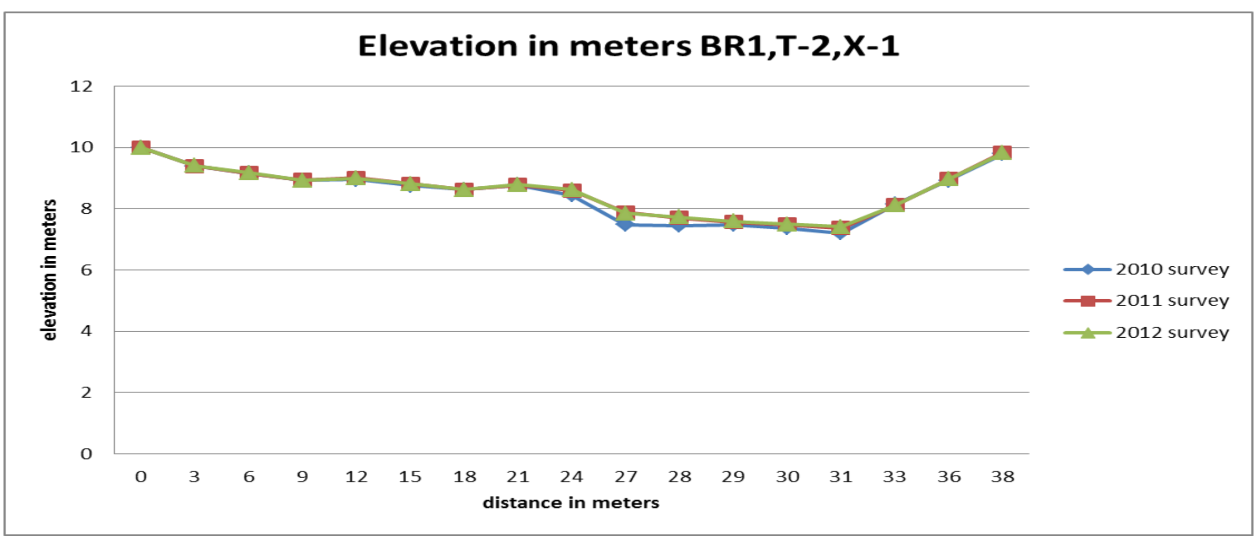
Geomorphic cross sections were surveyed at appropriate intervals and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. Data from 2010 to 2013 show sedimentation occurring on the floodplain at cross sections #1 and #2. Sediment contributed from valley side drainages like Javalina and Little Blacktail canyon is being trapped on the floodplains at this location. Cross section #3 has minor changes in the channel dimensions over the study period.

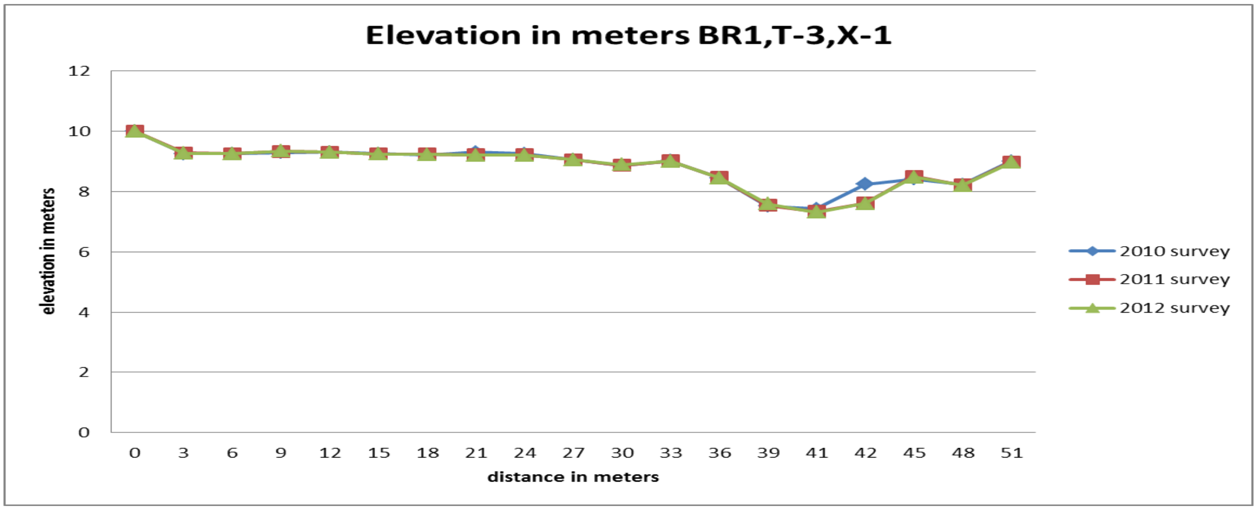
All three cross section areas appeared to have accumulated more silt and mud in the pool areas over the past three years making it increasingly difficult to wade through the pools while reading the transect. This could be due to a lack of any significant flooding in the past four years at this location. Flooding would help remove mud and silt and deposit fine soil materials on floodplains helping to maintain a gravelly bottom in the channel and pool areas. The last large flood (10,000 cfs) through this area occurred in August of 2006. Cross sections were not surveyed in 2013 as there appeared to be no erosion or sedimentation at the time the transects were read in June. The small flood that occurred in August of 2013 appeared to have little impact on channel morphology as seen in a visit to the monitoring location on 1-4-14.

BR #1, at transect #1 on 1-4-14, Cross section #1 is in foreground

Figure 32.







BR #2 Babacomari River Railroad Bridge

This location begins about 400 feet upstream of the steel Railroad Bridge built in the 1880s. This portion of the Babacomari River was part of the much larger Pacheco Pasture. It was fenced as a separate (Bridge) pasture in 2009 and is managed by resting from grazing during the period of June through September each year. This part of the river burned in the Ryan fire in April 2002. It has improved in condition since the change in range management on the ranch in 1995 and the riparian community is in good condition (citation). Dan Robinett and Jeff Simms (Aquatic and riparian specialist with the BLM) made an assessment of Riparian Proper Functioning Condition (BLM 1993 and Prichard 1998) on this transect location in May of 2009. The area was determined to be in Proper Functioning Condition with a moderate risk for bank and floodplain erosion. This location lacks an outside source of sediment. New sediment for bank building and pool/ riffle development can only be re-worked from within the existing floodplains and banks. It was grazed in 2009 May through July. It was not grazed in 2010. It was grazed in May and June of 2011. The pasture was open to cattle in the Lyle canyon pasture from December through the end of May in 2012. It was not grazed during the spring – summer growing season in 2013.

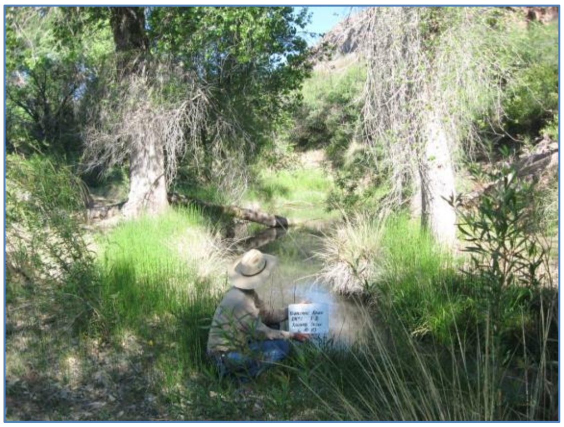
The steel railroad bridge on the New Mexico and Arizona Railroad was constructed in 1881 just downstream of BR #2. The bridge kit (Eiffel patent) was manufactured by the Phoenix Bridge Works of Phoenixville, Pennsylvania (Kelso 2009 and Myrick 1981). Amy Markstein (BLM Tucson) and Sarah Russell helped read transects at BR #2 in 2012.

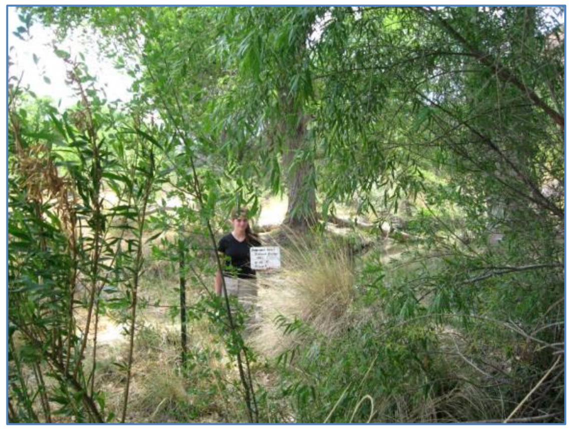
The monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long, along both banks. Plants species composition is recorded by canopy cover in quadrats placed every two meters along the green-line. At each interval quadrats are read both on the bank and another partially submerged in the water. At each green-line transect 40 plots are read on both stream banks and another 40 plots are read partially submerged in the water. This technique helps sample the plant community for both the aquatic species and bank species. Data are presented separately for bank plots and water plots. Herbaceous vegetative data are presented as average canopy cover by species summed for all three transects in the cluster. Frequency data are aggregated for all 240 quadrats in the six transects in the cluster at BR #2. Tree vegetative data is presented as average canopy cover by species and total canopy cover for the area of the belts along both banks and summed for all three transects. Total cover is less than the sum of individual tree species cover as canopies often overlap. Geomorphic monitoring includes three survey cross sections, one perpendicular to the stream channel at the midpoint of each transect in the cluster.

BR #2, transect 1, looking west, 6-10-10

BR #2, transect 1, looking west, 6-16-11

BR #2, transect 2, looking west, 6-10-10   BR #2, transect 2, looking west, 6-16-11





BR #2, transect 3, looking west, 6-10-10   BR #2, transect 3, looking west, 6-16-11

BR #2, Transect 1, Sarah Russell, 6-28-12   BR #2, Transect 1, Roger Cogan, 5-31-13

BR #2, Transect 2, Sarah Russell, 6-28-12

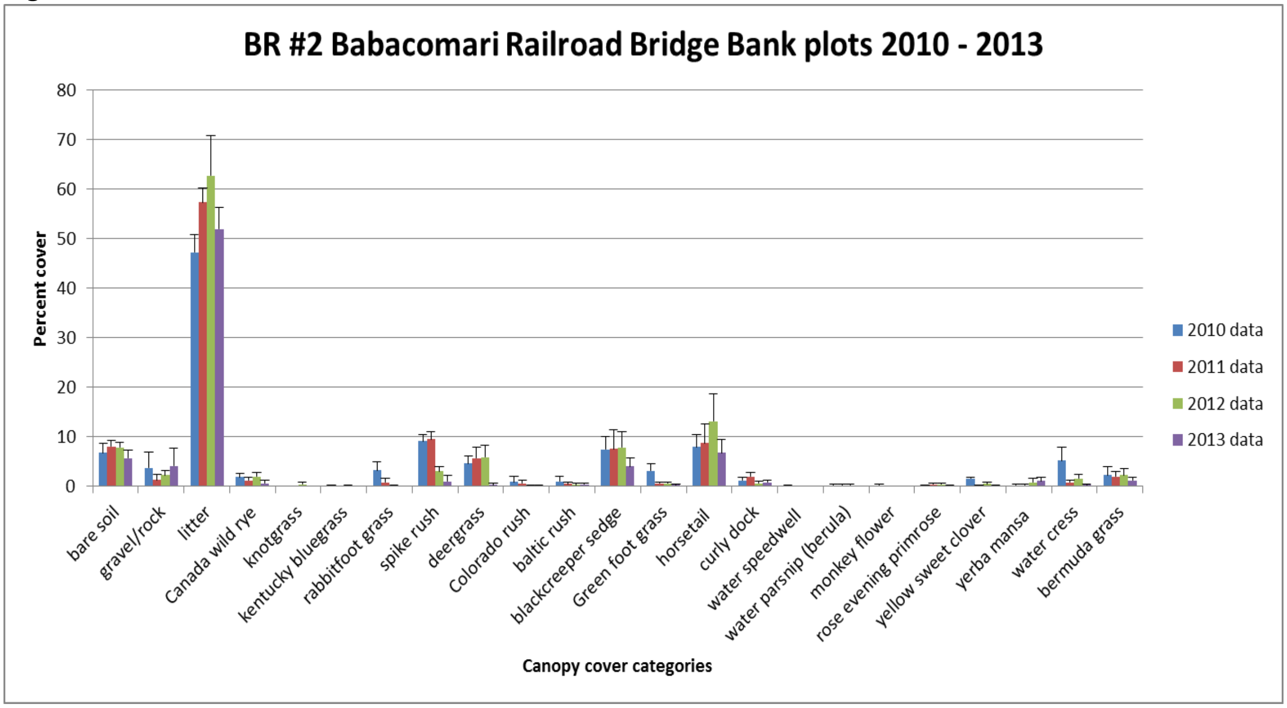
BR #2, Transect 2, Roger Cogan, 5-31-13

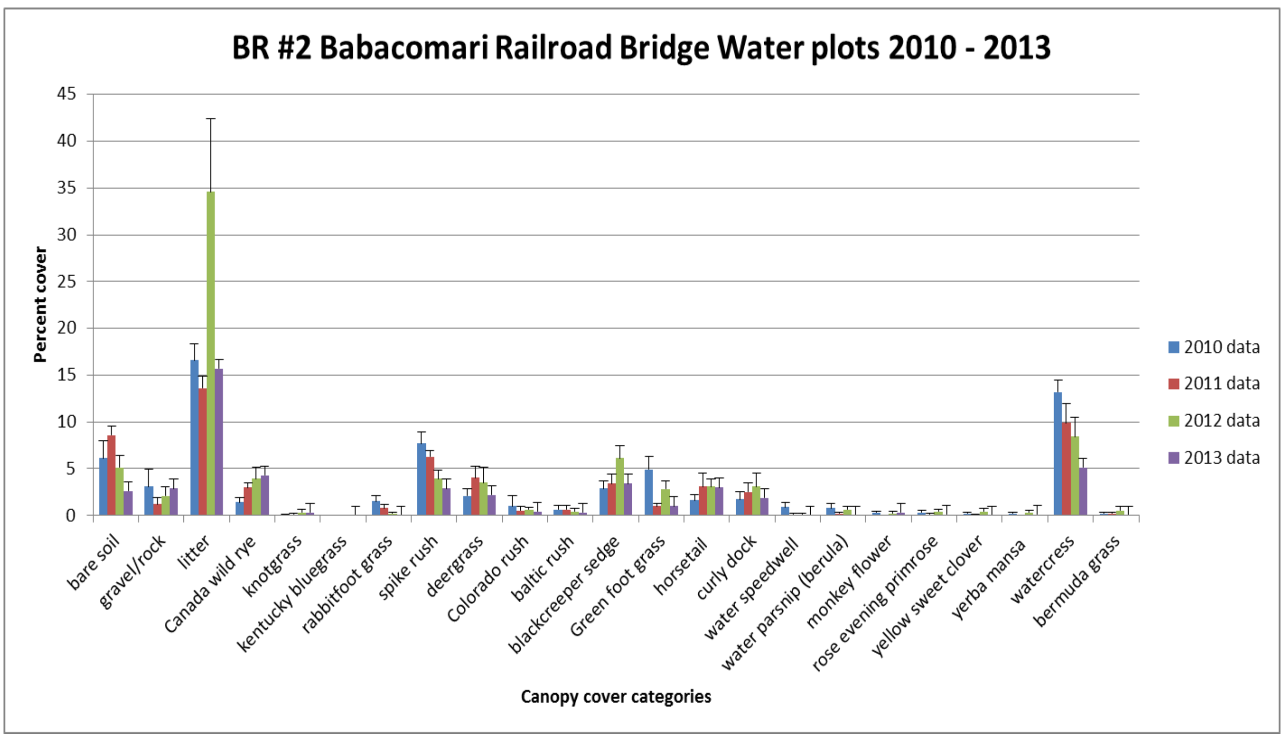
BR #2, Transect 3, Sarah Russell, 6-28-12

BR #2, Transect 3, Roger Cogan, 5-31-13

Bank plots are dominated by a diverse assemblage of native wetland plant species. Dominant species include deergrass, spike rush, baltic rush, blackcreeper sedge and horsetail. Several non-native weedy species are common here including rabbitfoot grass (*Polypogon monspeliensis*), yellow sweet clover (*Melilotus indicus*), and Bermuda grass. This site has received more grazing use in the recent past than BR #1 in the River pasture. This may account for the higher proportion of weedy species and low relative amounts of cover of desirable native species. It was not grazed in 2010. It was grazed lightly in May and June of 2011. Grazing use was moderate at this location in 2012 and very light in 2013.

Figure 33.





Water plots are dominated by watercress, a non-native perennial aquatic forb. They also have high cover of important native aquatic species like spike rush, three square bulrush, Baltic rush, blackcreeper sedge, horsetail and curly dock. Weedy, non-native species including rabbitfoot grass and greenfoot grass (*Polypogon viridis*) have moderate levels of cover. Important aquatic forbs like water speedwell, water-parsnip, monkey flower (*Mimulus guttatus*) and yerba mansa are common.

There were no significant differences in the understory plant community from 2010 to 2013 with the exception of cover of watercress and spikerush which declined significantly in both bank and water plots. There is no apparent reason for this as grazing has not been significant at this location during the study except in 2012 and watercress is not a forage species. It declined at the other BR transects as well indicating perhaps climatic or other environmental factors are at play. The amount of bare soil is very low and litter cover is moderate on both bank and water plots.

Standard error is quite high for cover of major greenline plant species at this location due to variability in the plant community from one transect to the others. This makes it difficult to establish trends.

Frequency for major plant species was calculated from the data-set to help sort out vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at location BR #3. Frequency data are presented in the table below. Although standard error is moderate for major species the data seems to show a stable trend for the greenline plant community for this site over the course of the study. Note the increasing figures for frequency of Canada wild rye and stable trend of blackcreeper sedge, horsetail and curly dock all major species at this location. On the other hand both spike rush and watercress declined in frequency significantly in 2012 and remained at that level in 2013 for unknown reasons. Further analysis would help sort out trends when at least ten years of sampling has occurred.

Figure 34.

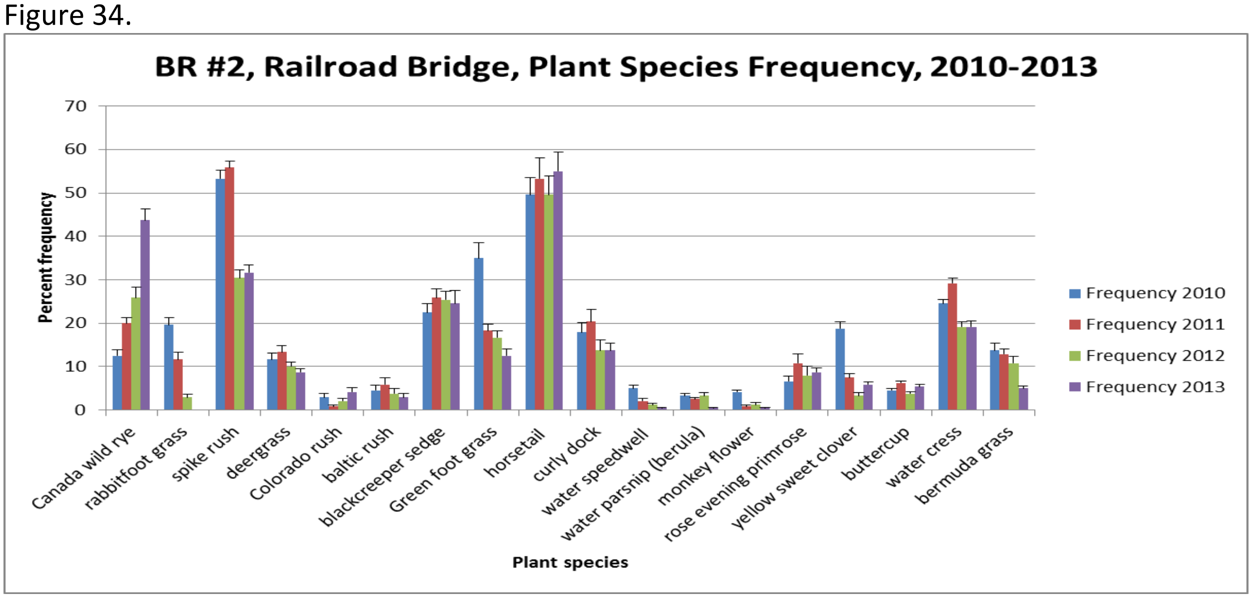
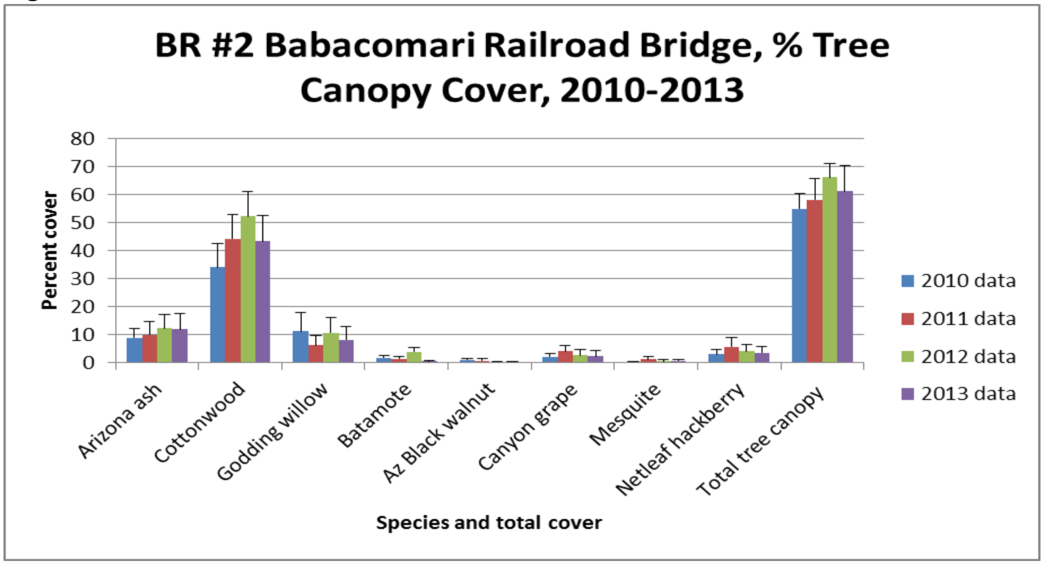


Figure 35.

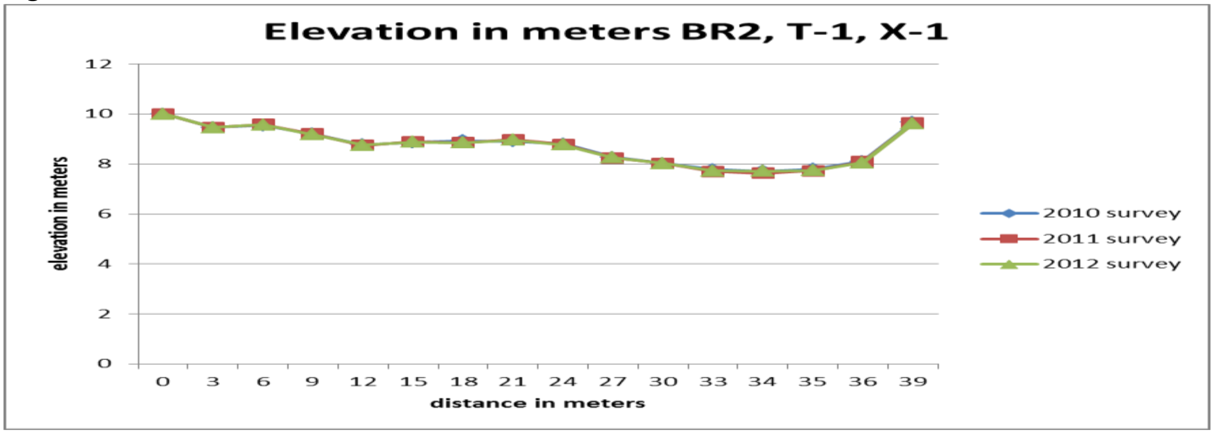


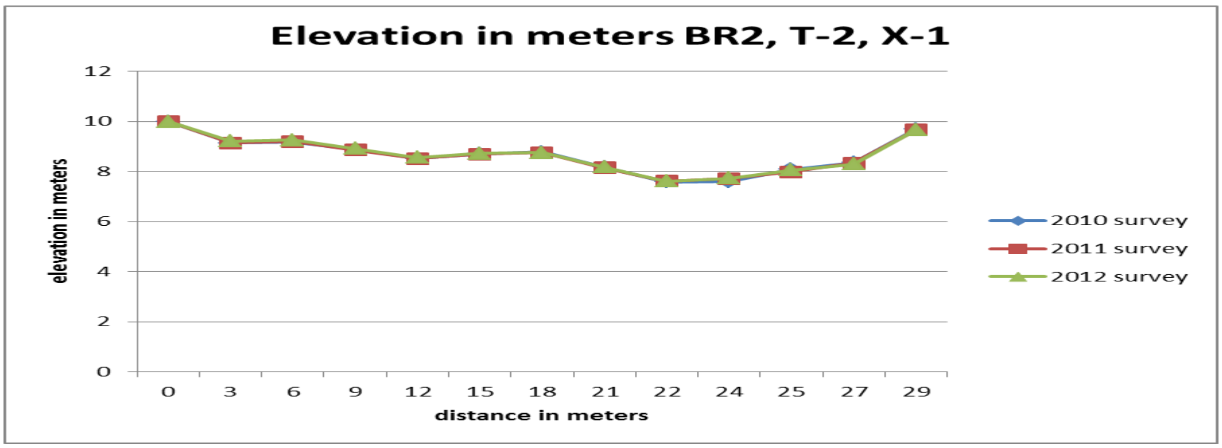
Total tree canopy over all three transects is 60%. Cottonwood and Goodding willow are dominant. Numerous seedlings and saplings of Arizona ash were recorded at this location. Standard error is high for tree canopy cover due to the variability in tree canopy along the stream at this location. The data does however, illustrate the repeatability of the method used to determine tree canopy in this study. There were no significant differences in tree canopy from 2010 to 2013 although apparent trend shows continued recovery from tree canopy lost in the Ryan fire in 2002.

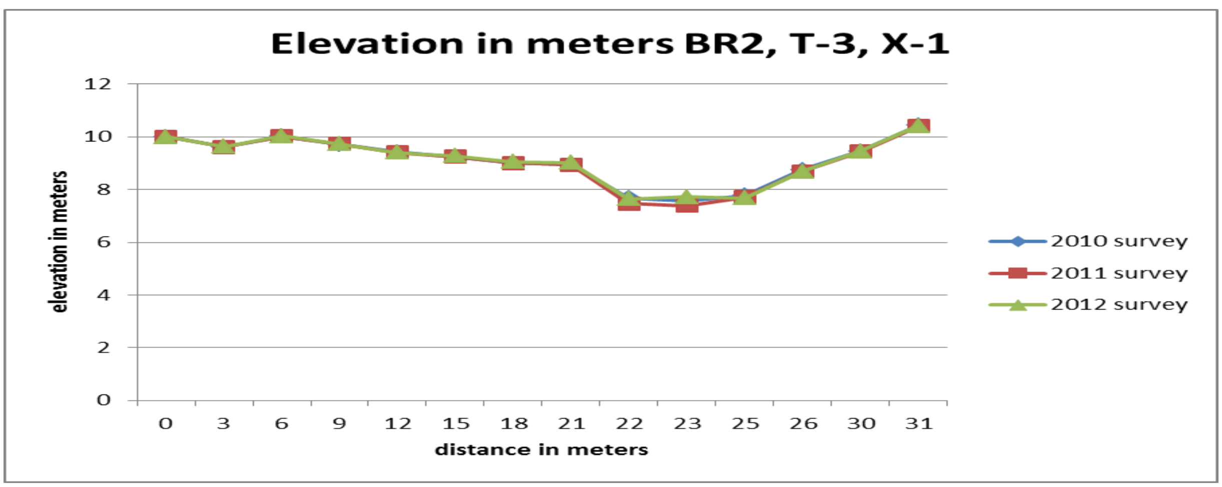
Geomorphic cross sections were surveyed at appropriate intervals and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. Cross sections were re-surveyed in 2012 and showed no change in dimensions from surveys in 2010 or 2011. There were no floods through this cross section in 2013 and they were not re-surveyed. The cross sections at all three transects shows filling in of the pool areas with mud and silt as a result of lack of flooding through the transect area in the past several years.

BR #2 Transect #1 looking west, the cross section at T-1 is in the foreground. Winter streamflow, 1-4-14

Figure 36.







BR #3 Babacomari River Farm Crossing

This location begins in the spillway channel just north of the irrigated land and runs downstream from the road crossing. This portion of the Babacomari River was part of a small pasture north of the farm which had a lane to allow cattle in the Lyle Canyon sacaton pasture or on the farm to have access to water. It was re-fenced and included into the new Bridge pasture in 2009 and will managed by grazing in the winter and spring each year. This location is immediately below the large CCC era dam at the Babacomari Ranch headquarters and lacks an outside source of sediment. The channel here has few riparian trees and a shallow stream confined to the spillway channel of the large CCC structure at the Babacomari Ranch headquarters. It appears to have potential for rapid tree recruitment with the change in livestock grazing management and alternative water development outside of the stream. It was grazed in 2009 May through July. It was not grazed in 2010. It was grazed in May and June of 2011. The pasture was open to cattle in the Lyle canyon pasture from December through the end of May in 2012. It was not grazed during the spring – summer growing season in 2013.

The monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long, along both banks. Plants species composition is recorded by canopy cover in quadrats (plot frames) placed every two meters along the green-line on both banks. At each interval quadrats are read both on the bank and another partially submerged in the water. At each green-line transect 40 quadrats are read on both stream banks and another 40 quadrats are read partially submerged in the water. This technique helps sample the plant community for both the aquatic species and stream-bank species. Cover data are presented separately for bank and water quadrats. Herbaceous vegetative data are presented as average canopy cover by species summed for all six transects in the cluster. Frequency is aggregated for all 240 quadrats in the six transects in the cluster.

BR #3, Babacomari Farm Crossing, collecting riparian plants species for identification, 6-8-2010

BR #3, Transect 1 looking west. 6-9-10

BR #3, Transect 1 looking west. 6-14-11

BR #3, Transect 2 looking east. 6-9-10

BR #3, Transect 2 looking east. 6-14-11

BR #3, Transect 3 looking east. 6-9-10

BR #3, Transect 3 looking east. 6-14-11

BR #3, Transect 1 looking west. 5-30-12

BR #3, Transect 1, S. Russell. looking W. 5-18-13

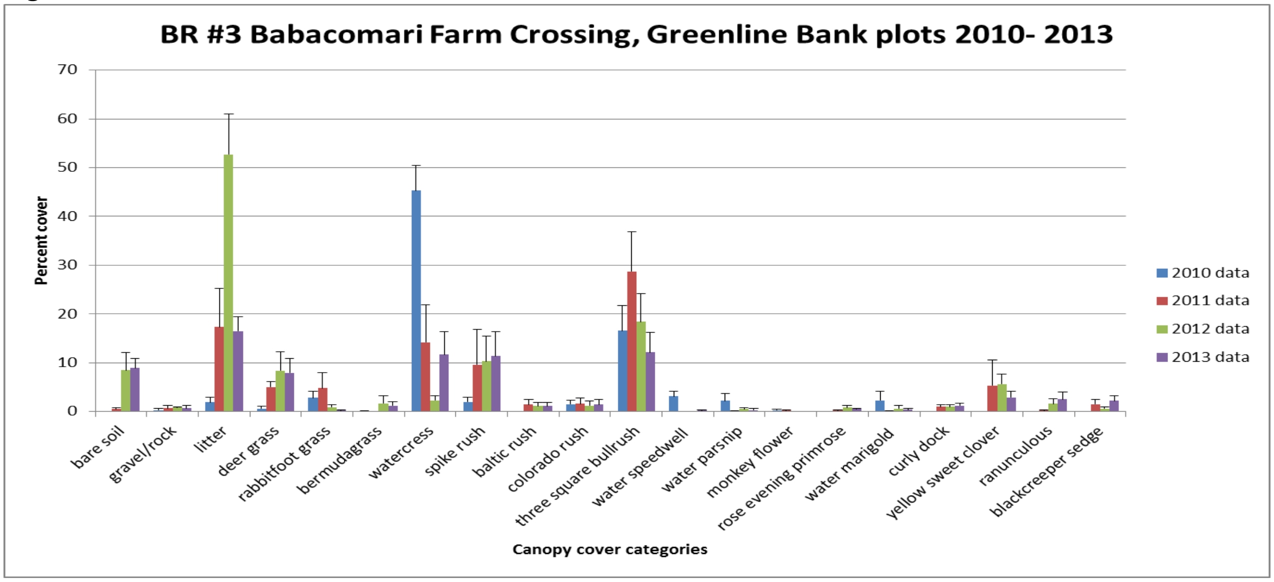
BR #3, Transect 2 looking east. 5-30-12

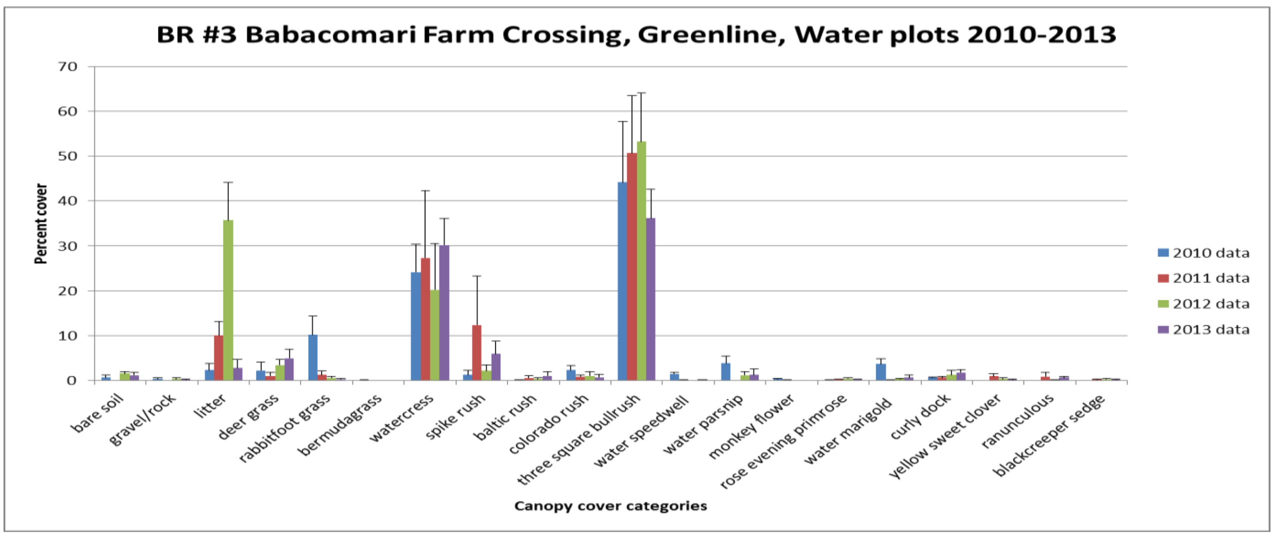
BR #3, Transect 2, S. Russell. looking E. 5-18-13

BR #3, Transect 3 looking east. 5-30-12

BR #3, Transect 3, S. Russell. looking E. 5-18-13

Figure 37.



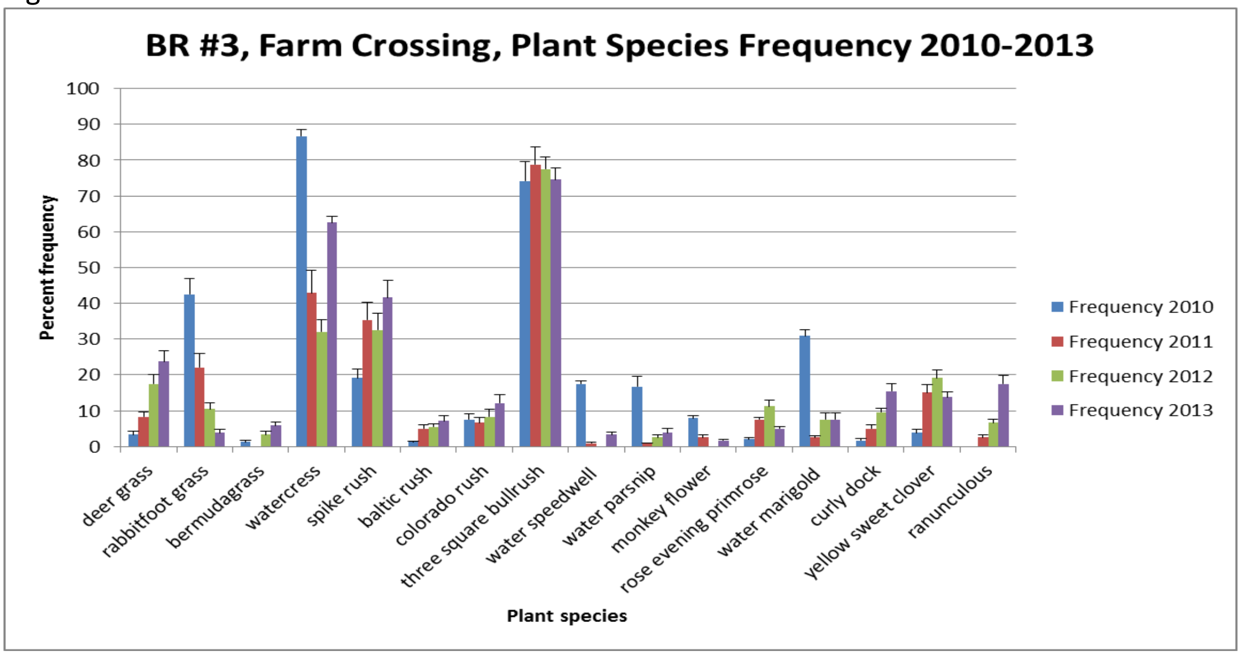


Watercress is common in both bank and water plots at this location. The stream here is shallow and lacks defined banks. Tree canopy is very low and the stream is nearly in full sunlight. Three square bull-rush is co-dominant with Colorado rush (*Juncus confusus*) and spike rush. Important native aquatic forbs include water speedwell, water parsnip and water marigold. Weedy species at this location include rabbitfoot grass, foxtail barley (*Hordeum jubatum*) and yellow sweet clover.

From 2010 to 2012 watercress declined in the bank plots due to unknown reasons. It recovered somewhat during 2013. Litter cover is variable and percent bare soil remains very low from 2011 to 2013 in both stream-bank and water plots. All other species appear to be unchanged in cover from 2010 to 2013. Standard error is quite high for cover of major greenline plant species at this location due to variability in the plant community from one transect to the others. This makes it difficult to establish trends.

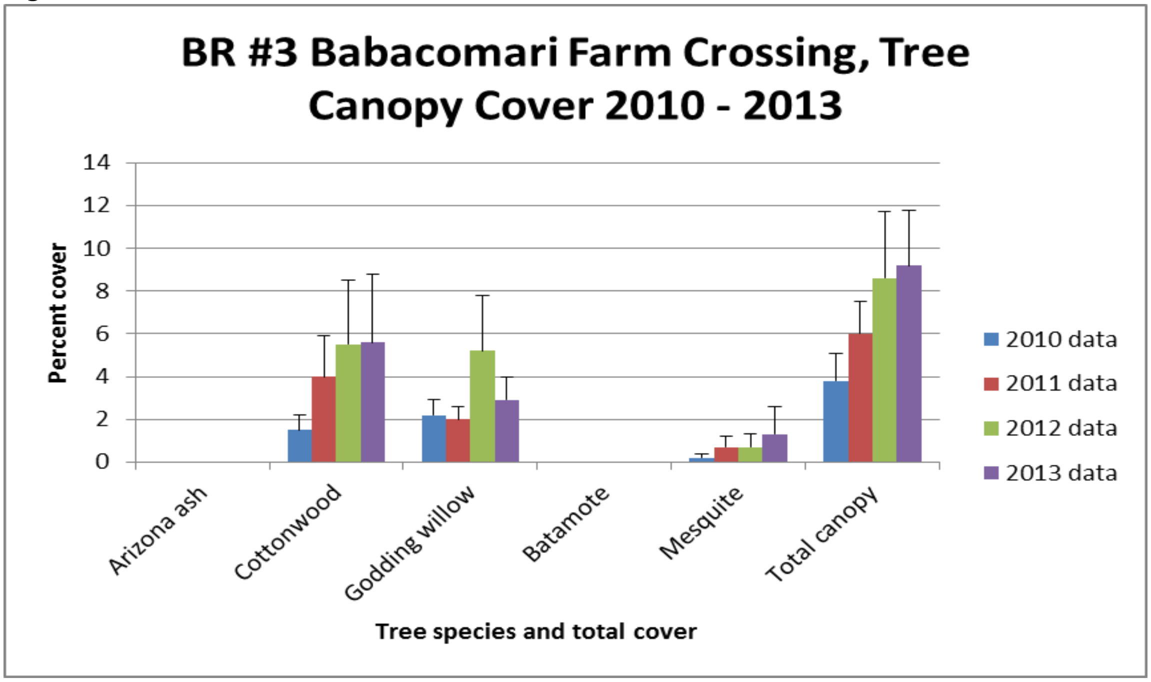
Frequency data for major plant species were calculated from the data-set to help sort out vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at location BR #3. Frequency data are presented in the table below. Although standard error is moderate for major species the data seems to show a stable or upward trend for the greenline plant community for this site over the course of the study. Note the increasing figures for frequency of deer grass, spike rush, Colorado rush, Baltic rush and some of the aquatic forbs. Further analysis would help sort out trends when at least ten years of sampling has occurred.

Figure 38.



BR #3 Babacomari Farm Crossing, large western diamondback rattlesnake on transect T-1, 5-18-13

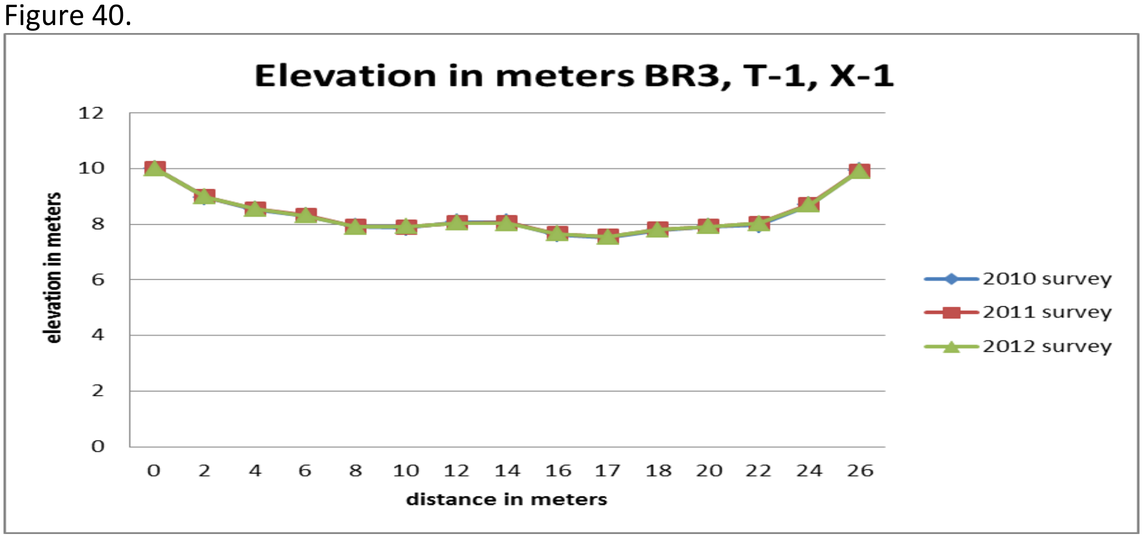
Figure 39.

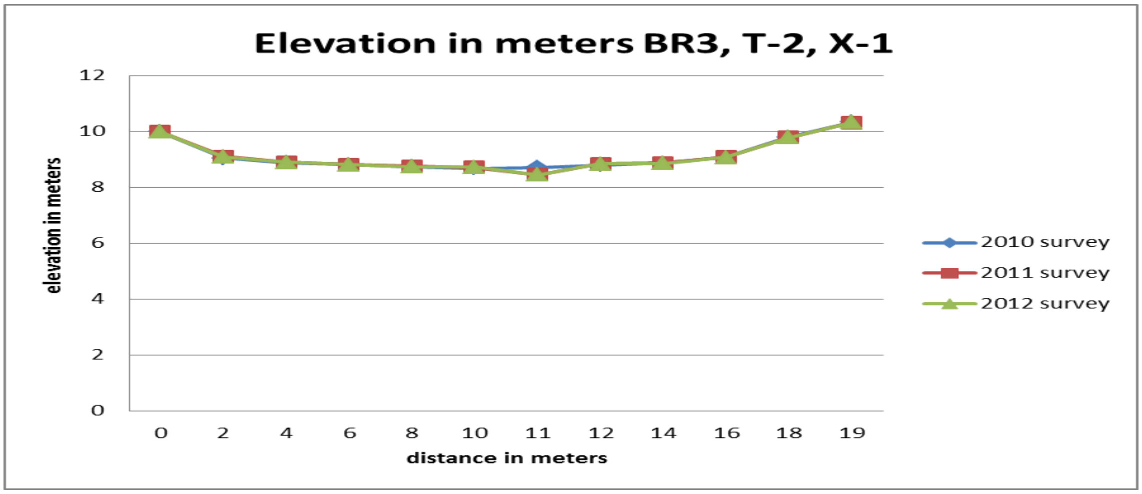


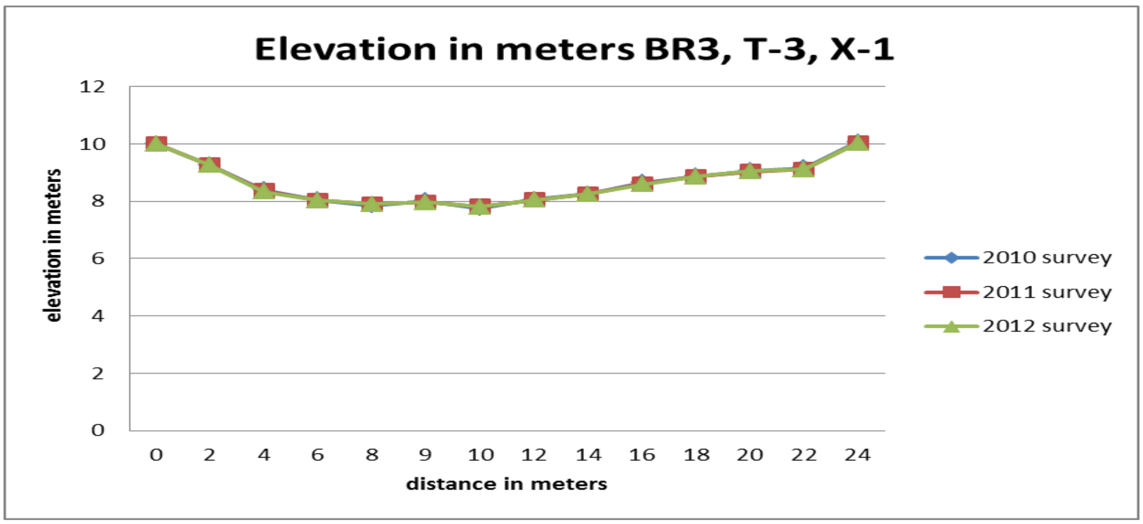
Tree canopy cover is low on the site with cottonwood and willow dominant. Total tree canopy has increased (2010 to 2013) from 4% to 9%. Riparian tree species are expected to recruit into this area with the change in grazing management.

Geomorphic cross sections were surveyed at appropriate intervals and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. Re-survey of the three cross sections in 2012 shows slight to no change in channel morphology since 2010. There were no floods through this area in 2013 and the cross sections were not re-surveyed.

Figure 40.







Cross section at BR #3, transect 3, Richard Chasey assisting on 6-7-2010

TRR #1 Turkey Creek Dry Riparian

This location begins just north of the USFS boundary on the Audubon property in Turkey creek. This area has prolonged stream flow during the winter with a shorter period during the summer monsoon. The western stream bank consists of bedrock hillside; the eastern bank is a floodplain of deep loamy soils with sacaton and other native perennial grasses. The stream channel is rocky and confined by tall banks (> 1 meter). Few trees occur in or along the stream channel although at one time in the past several large sycamore trees occurred at this location. Only one large sycamore remains and it was heavily damaged by fires in 2002 and 2009.

The monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long, along both banks. Plants species composition is recorded by canopy cover in quadrats placed every two meters along the green-line. At each interval quadrats are read both on the bank and another partially submerged below the line of normal water flow. At each green-line transect 40 plots are read on both stream banks and another 40 plots are read in the water area. This technique helps sample the plant community for both the aquatic species and bank species. Data are presented separately for bank plots and water plots. Herbaceous vegetative data are presented as average canopy cover by species summed for all three transects in the cluster. Frequency data are aggregated for all 240 quadrats in the six transects in the cluster at TRR #1. Tree vegetative data are presented as average canopy cover by species and total canopy cover for the area of the belts along both banks and summed for all three transects. Total cover is less than the sum of individual tree species cover as canopies often overlap. Geomorphic monitoring includes three survey cross sections, one perpendicular to the stream channel at the midpoint of each transect in the cluster.

TRR #1 Turkey Creek after the Canelo fire in May of 2009. This location also burned severely in the Ryan fire in April of 2002. Linda Kennedy on 5-10-09.

TRR #1 Transect 1, looking west, 5-13-10

TRR #1 Transect 1, looking west, 6-2-11

TRR #1 Transect 2, looking north, 5-13-10

TRR #1 Transect 2, looking north, 6-2-11

TRR #1 Transect 3, looking north, 5-13-10

TRR #1 Transect 3, looking north, 6-2-11


TRR #1 Transect 1, looking west, 5-10-12


TRR #1 Transect 1, looking west, 5-15-13

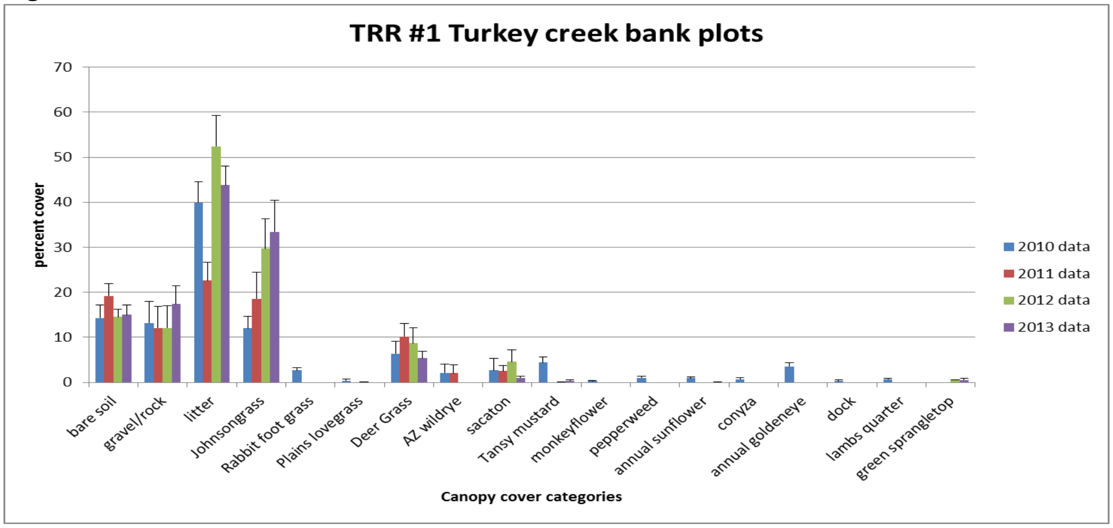

TRR #1 Transect 2, looking north, 5-10-12


TRR #1 Transect 2, looking north, 5-15-13


TRR #1 Transect 3, looking north, 5-10-12


TRR #1 Transect 3, looking north, 5-15-13

Figure 41.



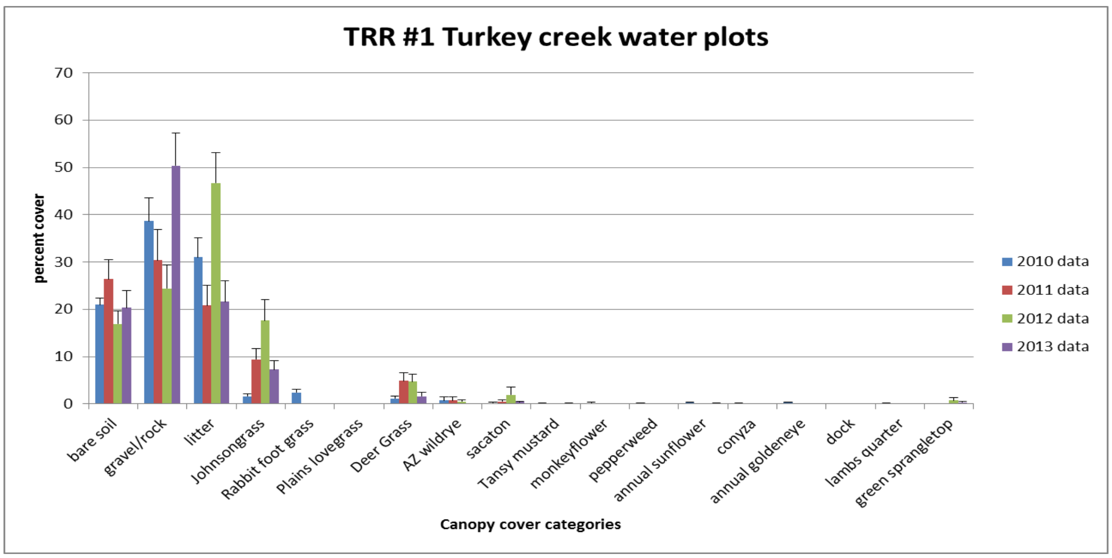
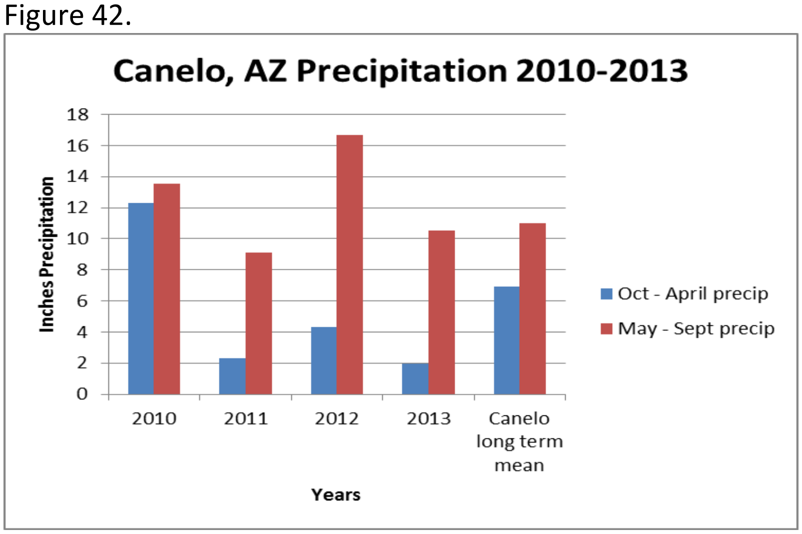


Figure 42.



This area experienced heavy runoff after the Canelo fire in both 2009 and 2010. Very high rainfall in the summer of 2012 caused channel and bank scouring through the transect area (see table above from the Canelo weather station, I mile southwest of this location). Both bank and water plots are low in vegetative cover. Percent bare soil is high and soil cover of litter is moderate, unchanged during the course of this study. The dominant herbaceous species are native perennial grasses like deergrass, Canada wild rye, sacaton and the non-native, invasive species Johnson grass. Deergrass, Canada wild rye and sacaton have all decreased in cover and frequency from 2010 to 2013 possibly due to channel and bank scouring after the Canelo fire. Channel scour can be seen in the transect photos taken in May 2013. Johnson grass has increased significantly from 2010 to 2013. The abundant annual forbs present in 2010 were almost non-existent in 2011, 2012 and 2013 due to extremely below average amounts of winter-spring precipitation in all three years. Standard error is high for cover of major greenline plant species at this location due to variability in the plant community from one transect to the others.

Frequency data for major plant species were calculated from the data-set to help sort out vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at location TRR #1. Frequency data are presented in the table below. Although standard error is moderate for major species, both the frequency and the cover data seem to show a downward trend for the green-line plant community for this site over the course of the study. Further analysis would help sort out trends when at least ten years of sampling has occurred.

Figure 43.

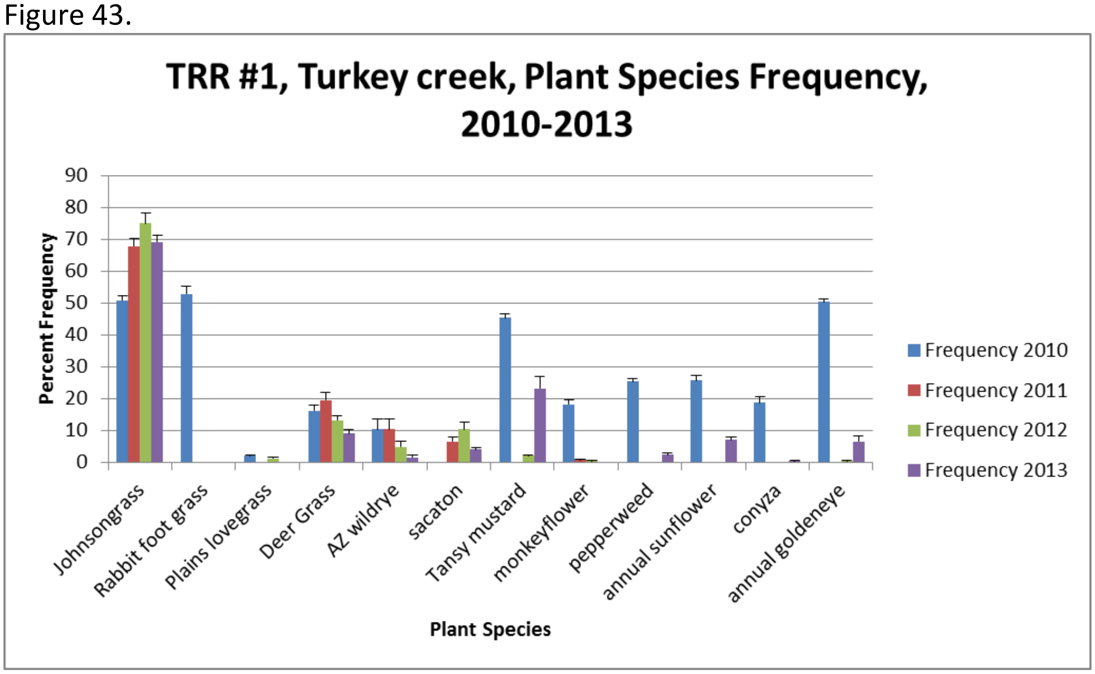
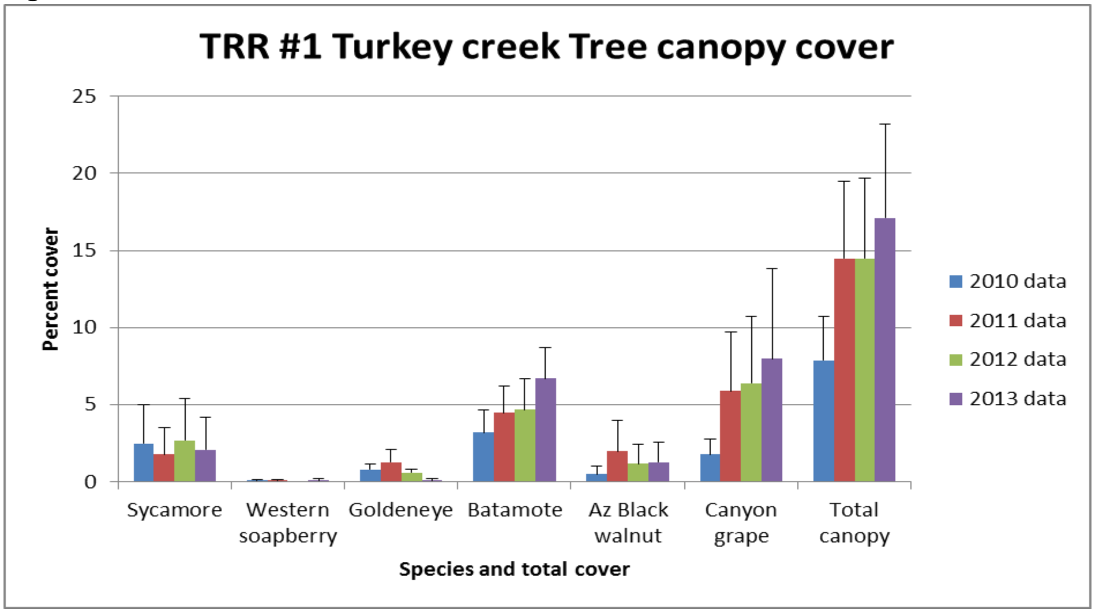


Figure 44.



Tree and shrub canopy is low (17%) at this location. Batamote (*Baccharis glutinosus*) and Canyon grape (*Vitis arizonica*) dominate the shrub component. There is one large Arizona sycamore, one small black walnut and a few small western soapberry along the channel through the transect area. Canopy cover of canyon grape, batamote and total canopy increased from 2010 to 2013 showing continued recovery from the Canelo fire in 2009. Large standard error is due to the variability and low canopy cover of trees and riparian shrubs on the site.

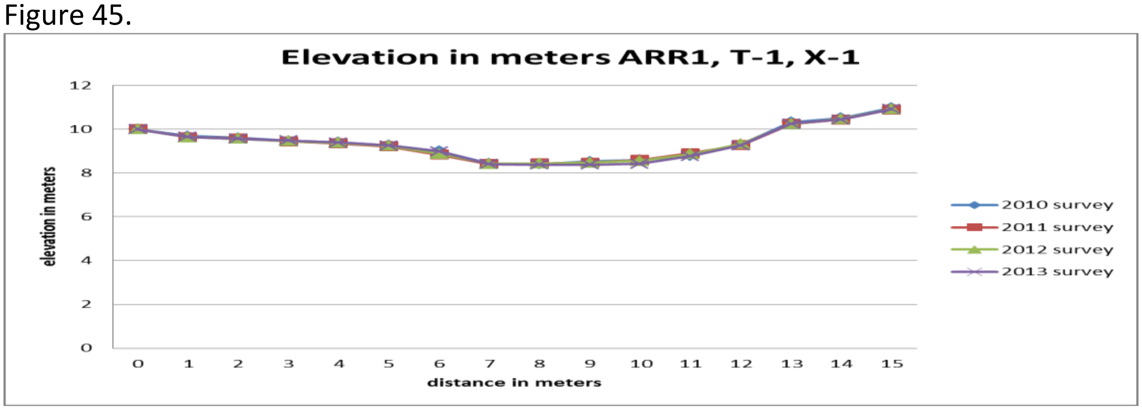
TRR #3 Turkey Creek dry riparian cross section at transect 1. Note the channel scour due to large rains and runoff in the summer of 2012. Picture taken 5-15-13

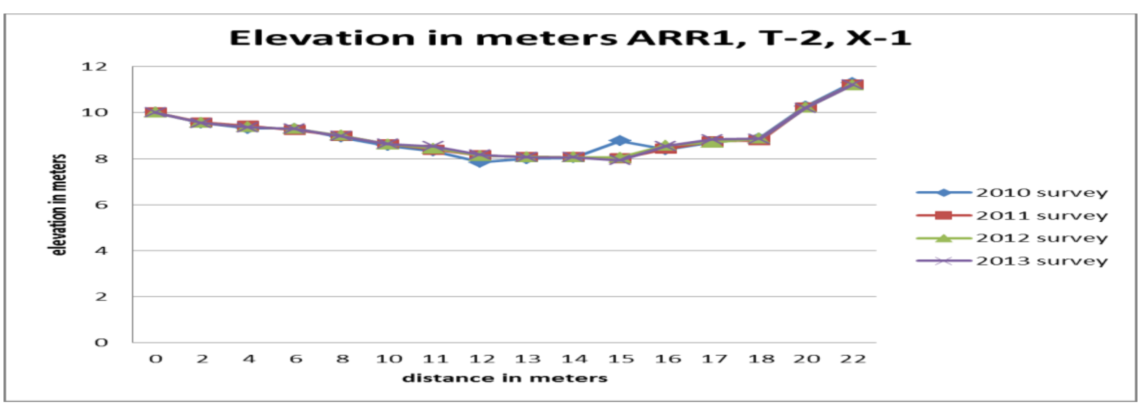
TRR #3 Turkey Creek dry riparian cross section at transect 1. Note the lack of any runoff in the summer of 2013. Picture taken 1-11-14

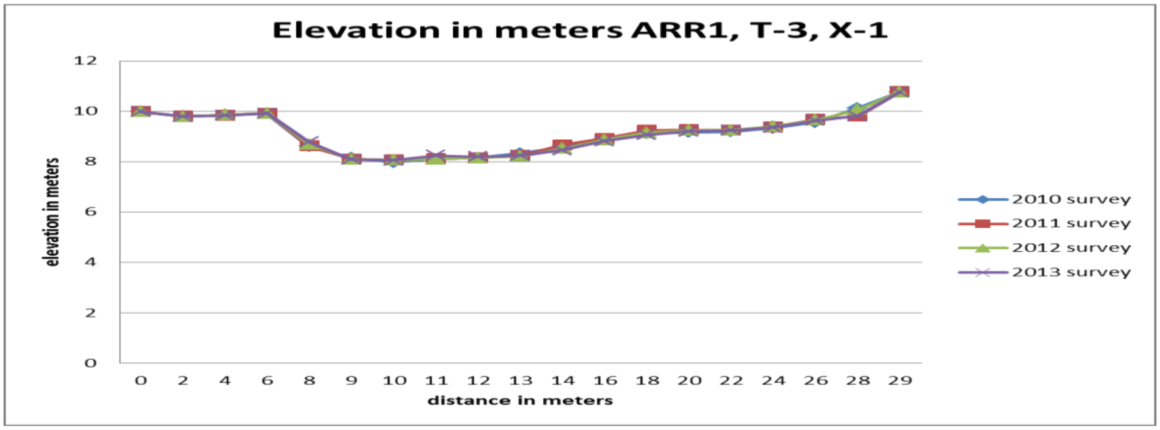
Geomorphic cross sections were surveyed at appropriate intervals and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. Re-survey of the geomorphic cross sections show continued erosion of the stream channel at cross sections #1 and 2. Cross section #3 appears to be stable over the duration of the study. Heavy summer rainfall in 2012 caused scouring of the stream channel and some bank erosion through the monitoring location. Pictures taken on 1-11-14 showed almost no water flow in the channel during the summer of 2013.

TRR #3 Turkey Creek dry riparian cross section at transect 2. Richard Chasey assisting on 5-10-2010

Figure 45.





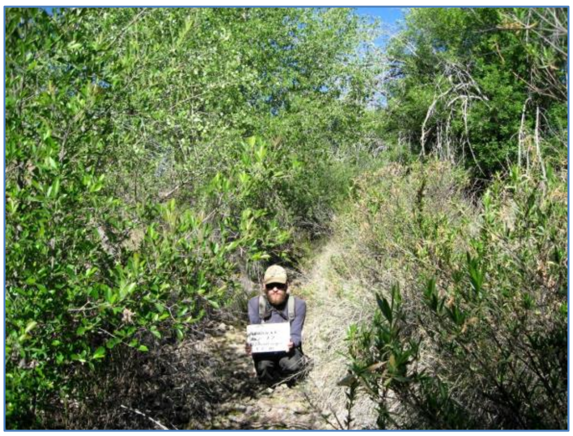


TRR #2 O'Donnell Canyon Dry Riparian

This location begins about a mile south of the Audubon headquarters in O'Donnell canyon. This area has prolonged stream flow during the winter with a shorter period during the summer monsoon. The southern stream bank consists of a bedrock hillside; the northern bank is a high stream terrace of deep loamy soils with sacaton and other native perennial grasses. The stream channel is rocky and confined. An excellent stand of riparian trees occur in or along the stream channel. This location burned severely during the Ryan fire in 2002. In the Canelo fire (May, 2009) this area burned only on the southern bank and few trees were affected by the fire.
The monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long, along both banks. Plant species composition is recorded by canopy cover in quadrats placed every two meters along the green-line. At each interval quadrats are read both on the bank and another partially below the line of normal water flow. At each green-line transect 40 plots are read on the stream bank and another 40 plots are read in the water area. This technique helps sample the plant community for both the aquatic species and bank species. Data are presented separately for bank plots and water plots. Herbaceous vegetative data are presented as average canopy cover by species summed for all three transects in the cluster. Frequency data are aggregated for all 240 quadrats in the six transects in the cluster at TRR #2. Tree vegetative data is presented as average canopy cover by species and total canopy cover for the area of the belts along both banks and summed for all three transects. Total cover is less than the sum of individual tree species cover as canopies often overlap. Geomorphic monitoring includes three survey cross sections, one perpendicular to the stream channel at the midpoint of each transect in the cluster.

TRR #2 transect 1, looking west, 5-12-10

TRR #2 transect 1, looking west, 6-3-11



TRR #2 transect 2, looking west, 5-12-10

TRR #2 transect 2, looking west, 6-3-11

TRR #2 transect 3, looking west, 5-12-10

TRR #2 transect 3, looking west, 6-3-11

TRR #2 transect 1, looking west, 5-16-12

TRR #2 transect 1, looking west, 5-16-13

TRR #2 transect 2, looking west, 5-16-12

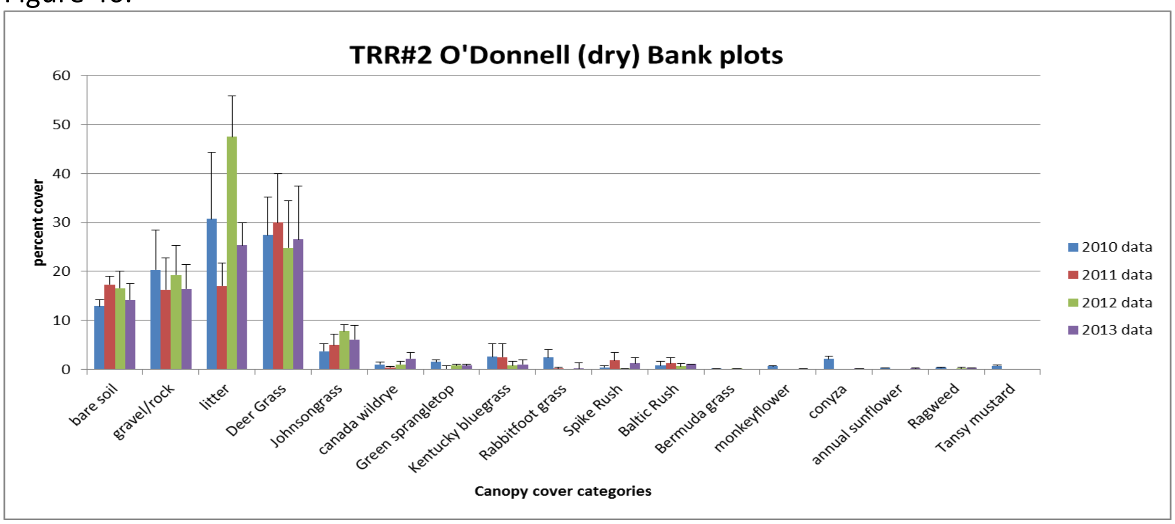
TRR #2 transect 2, looking west, 5-16-13

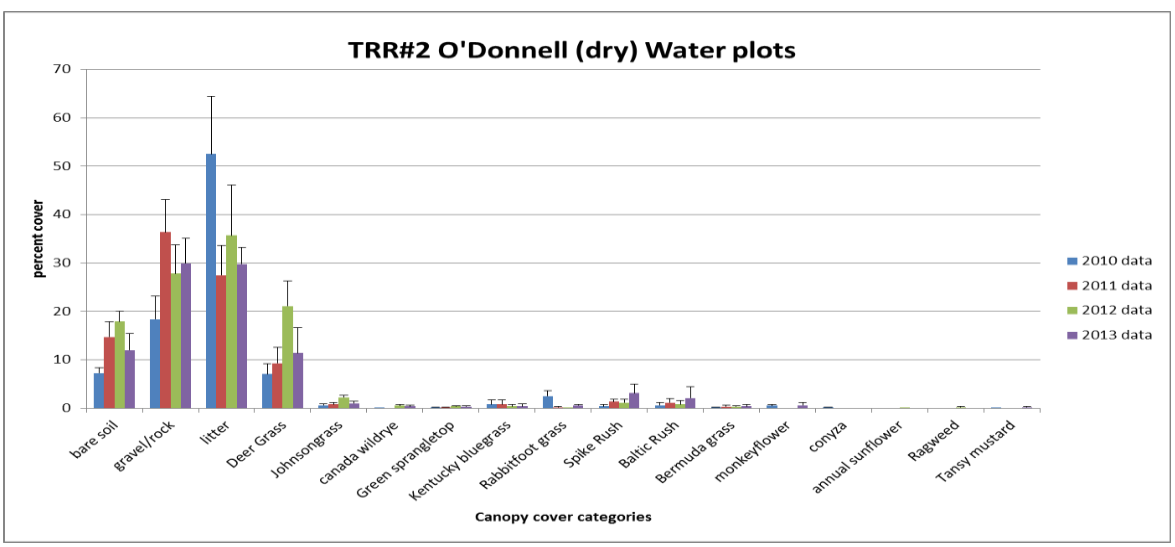
TRR #2 transect 3, looking west, 5-16-12

TRR #2 transect 3, looking west, 5-16-13

BR #2, O'Donnell (dry) riparian greenline and tree, Transect #1, winter runoff on 1-11-14

Figure 46.





The understory plant community is dominated by deergrass with lesser amounts of native perennial species like green sprangletop (*Leptochloa dubia*), Arizona wild rye, spike rush and Baltic rush. Non-native grass species like Johnson grass, Bermuda grass and rabbitfoot grass are also common in the understory plant community. Amounts of bare soil are low and stream-banks are well covered with rocks and gravel, litter and vegetation. There were no significant changes in the understory plant community from 2010 to 2013 with the possible exception of Johnson grass, a non-native, invasive perennial. Johnson grass has increased slightly since 2010 on the transect area. There has been below average amounts of winter-spring precipitation throughout the study. Standard error is high for cover of major greenline plant species at this location due to variability in the plant community from one transect to the others.

Frequency data for major plant species were calculated from the data-set to determine vegetative trends. Frequency is the percentage of times a plant species occurs in a quadrat. For example if a species has 50% frequency it means that species occurred in 120 out of the 240 total quadrats sampled (in the six transects) at location TRR #2. Frequency data are presented in the table below. Although standard error is moderate for major species, both the frequency and the cover data seem to show a stable trend for the green-line plant community for this site over the course of the study. Johnson grass made a large increase in both cover and frequency in 2012. Further analysis would help sort out trends when at least ten years of sampling has occurred. Note the high frequency for cool season annual species like tansy mustard and conyza in 2010, the only year during the study where winter moisture received was average.

Figure 47.

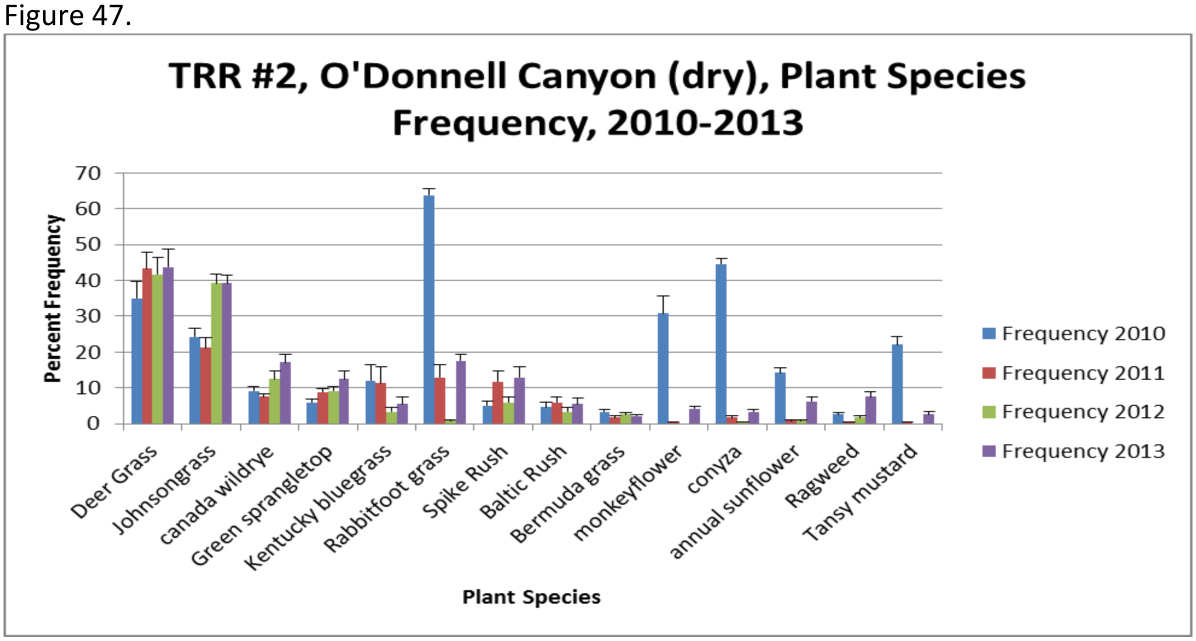
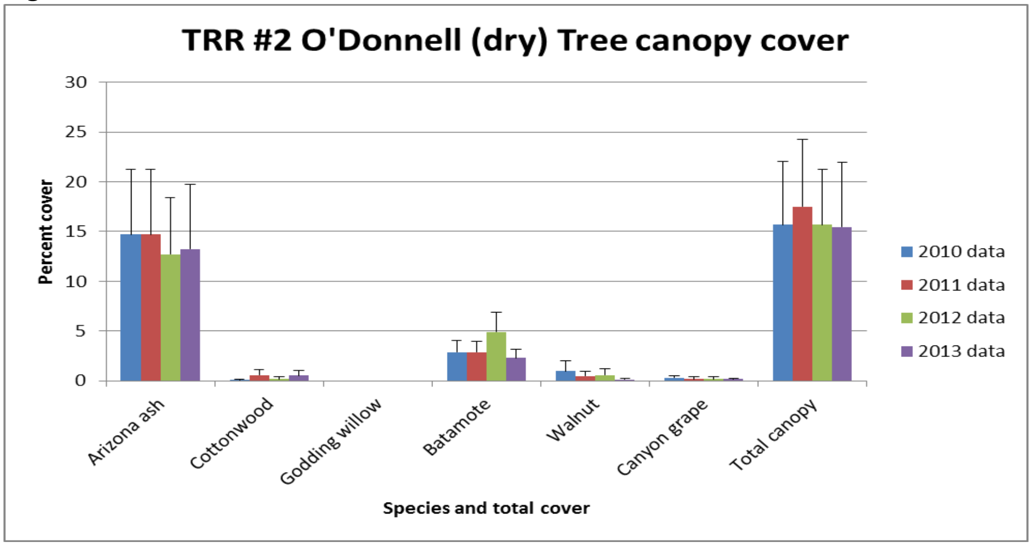


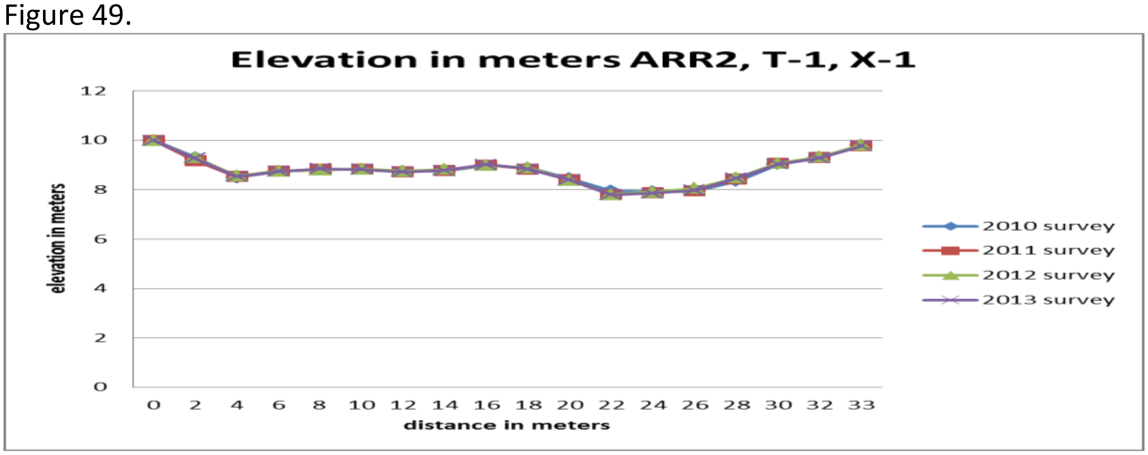
Figure 48.

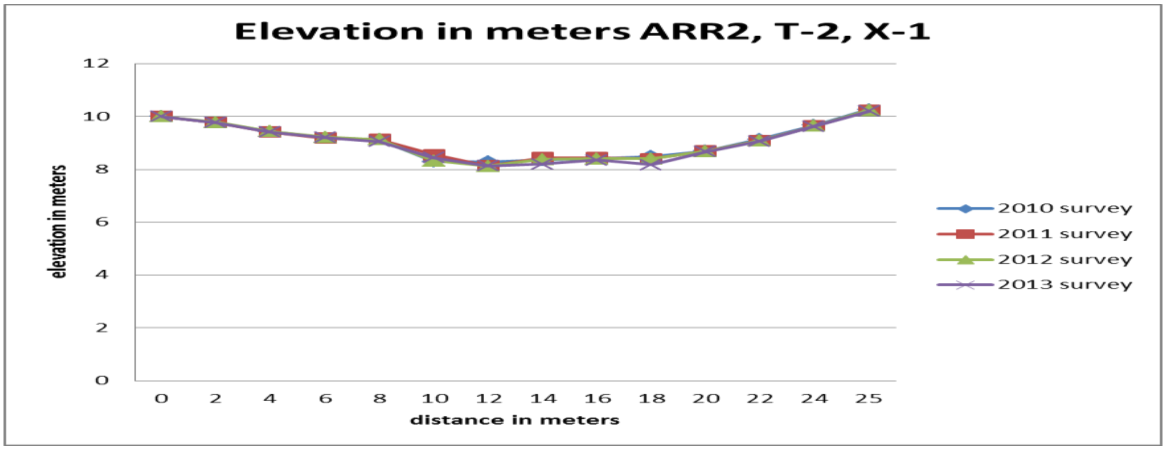


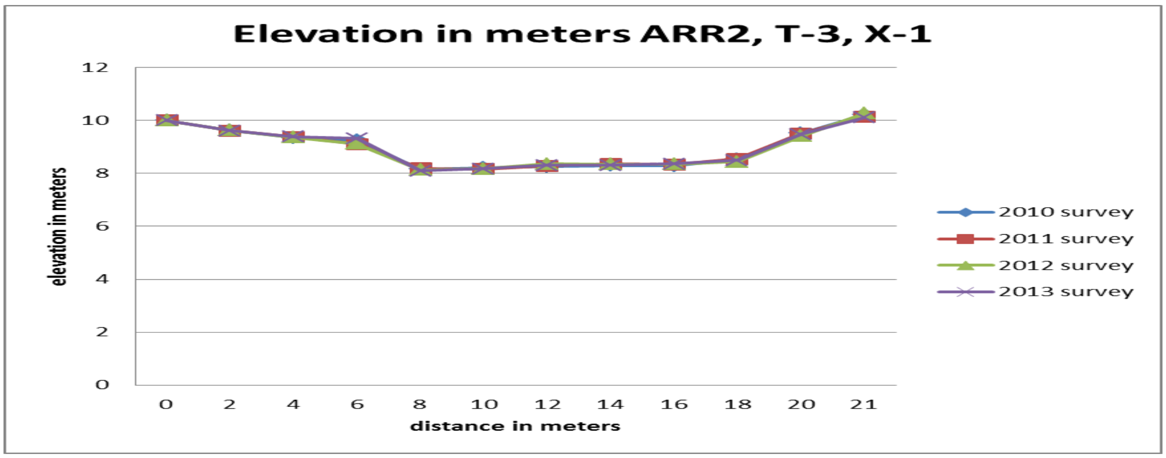
Tree canopy is moderate at this location at nearly 15% cover. Most of this canopy is Arizona ash with lesser amounts of walnut and cottonwood. Batamote and canyon grape are the dominant shrubs in the belt transects along the green-line. Tree cover appears to be still recovering from the effects of the Ryan fire in April 2002 and the Canelo fire in 2009. There was no change from 2010 to 2013. Tree canopy data does however show the repeatability of the monitoring techniques used in the study.

Geomorphic cross sections were surveyed at appropriate intervals and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. One cross section had minor erosion in the stream channel due to heavy runoff in the summer of 2010 after the Canelo fire of May 2009. The cross section below this one had minor filling in the stream channel in 2011, perhaps as a result of upstream erosion. The cross section surveys in 2012 showed no change from those done in 2011. The cross sections were surveyed in the spring of 2013 and showed no change at Cross sections 1 and 3. Cross section #2 showed some channel cutting possibly due to heavy summer rainfall and runoff in 2012.

Figure 49.







TRR #3 O'Donnell Canyon Perennial

This location begins about a mile south of the Audubon headquarters and about one half mile west of TRR#2 in O'Donnell canyon. It begins just upstream of the two concrete dams and runs from east to west. This area has perennial stream flow. The southern stream bank consists of a bedrock hillside. The northern bank has a high stream terrace of deep rocky and loamy soils in places and bedrock in other areas. The stream channel is rocky, sinuous and confined. An excellent stand of riparian trees occur in or along the stream channel. This location burned severely during the Ryan fire in 2002. Many cottonwood trees were killed and sprouting species like Arizona ash, willow and walnut were top killed. In the Canelo fire in May of 2009 this area burned lightly along both banks. A few trees along the banks were affected by the fire.
The monitoring at this location consists of a cluster of three riparian green-line transects for herbaceous vegetation paired with three belt transects (3 meter wide) on both banks to record tree species by canopy cover. Green-line transects are 40 meters long, along both banks. Plant species composition is recorded by canopy cover in quadrats placed every two meters along the green-line. At each interval quadrats are read both on the bank and another submerged partially below the water. At each green-line transect 40 plots are read on the stream bank and another 40 plots are read in the water area. This technique helps sample the plant community

for both the aquatic species and bank species. Data are presented separately for bank plots and water plots. Herbaceous vegetative data are presented as average canopy cover by species summed for all three transects in the cluster. Frequency data are aggregated for all 240 quadrats in the six transects in the cluster at TRR #3. Tree vegetative data are presented as average canopy cover by species and total canopy cover for the area of the belts along both banks and summed for all three transects. Total cover is less than the sum of individual tree species cover as canopies often overlap. Geomorphic monitoring includes three survey cross sections, one perpendicular to the stream channel at the midpoint of each transect in the cluster.

The upper concrete dam in O’Donnell canyon on the Audubon Research Ranch with winter runoff, TRR #3 is 300 meters upstream. 1-11-14

TRR #3, transect 1, looking west, 5-18-10

TRR #3, transect 1, looking west, 6-23-11


TRR #3, transect 2, looking west, 5-18-10


TRR #3, transect 2, looking west, 6-23-11


TRR #3, transect 3, looking west, 5-18-10


TRR #3, transect 3, looking west, 6-23-11


TRR #3, transect 1, looking west, 5-25-12


TRR #3, transect 1, looking west, 5-27-13


TRR #3, transect 2, looking west, 5-25-12

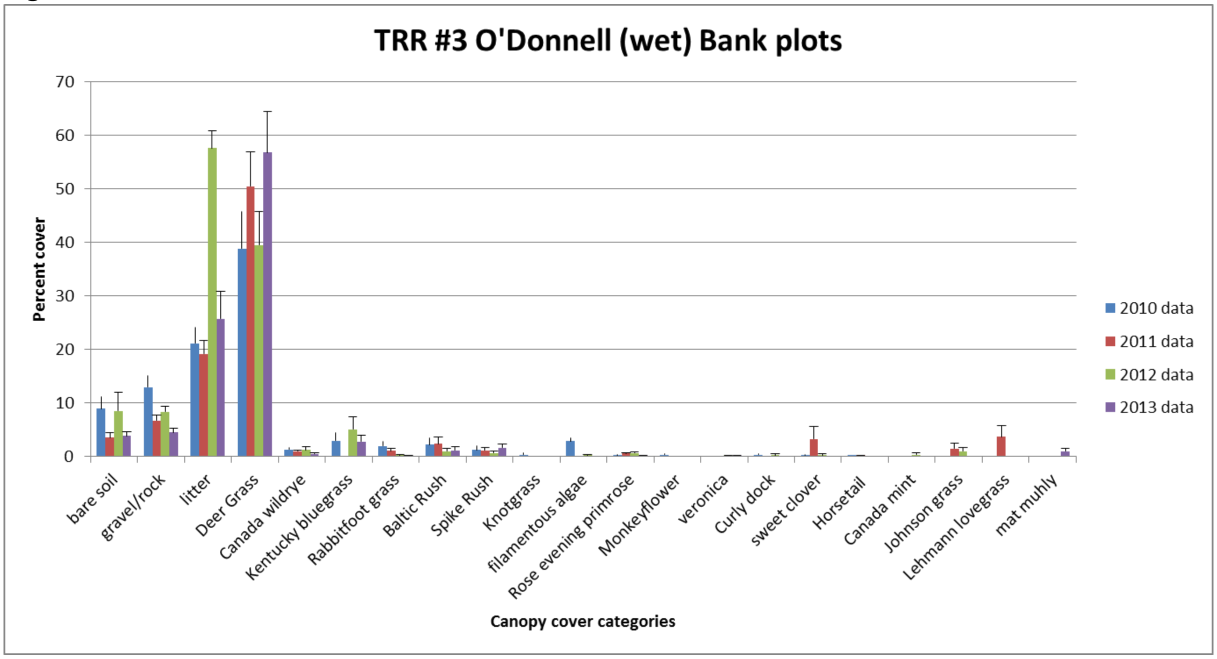

TRR #3, transect 2, looking west, 5-27-13

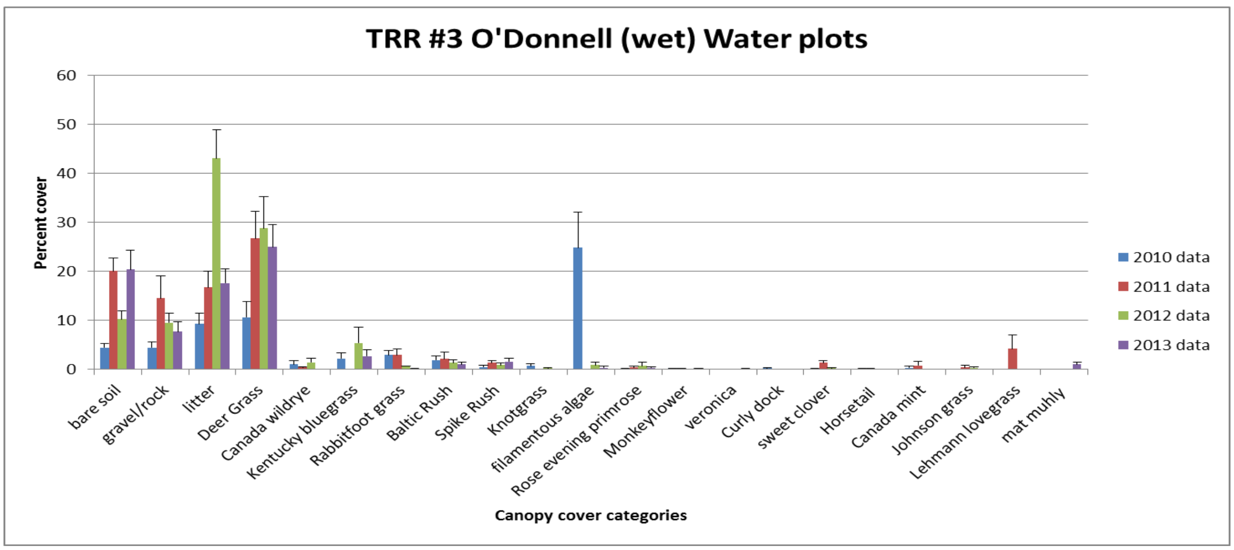

TRR #3, transect 3, looking west, 5-25-12


TRR #3, transect 3, looking west, 5-27-13

Stream-flow was strong at this location in 2010 but very low in 2011 due to very low winter-spring precipitation and below average summer rains. Rainfall in 2012 was much better and stream-flow was present at the time this transect was re-read in late May. Stream flow was strong in the spring of 2013 but the water dried up in June of 2013. Stream flow was good when visited on 1-11-14. This reach of O'Donnell Canyon has been considered to be perennial but has dried to a few small pools in June of the last three years.

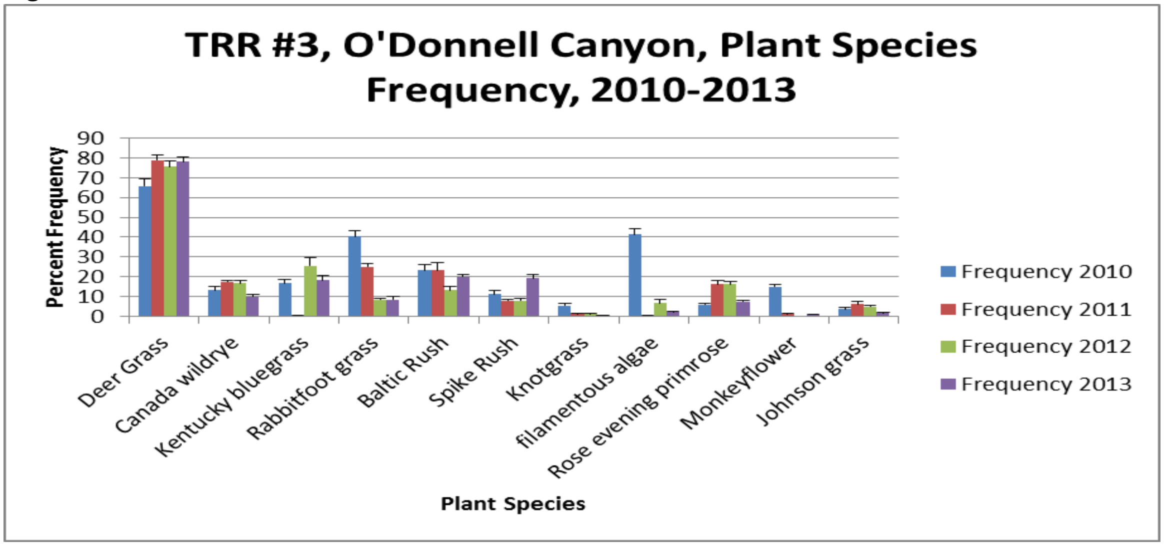
Figure 50.





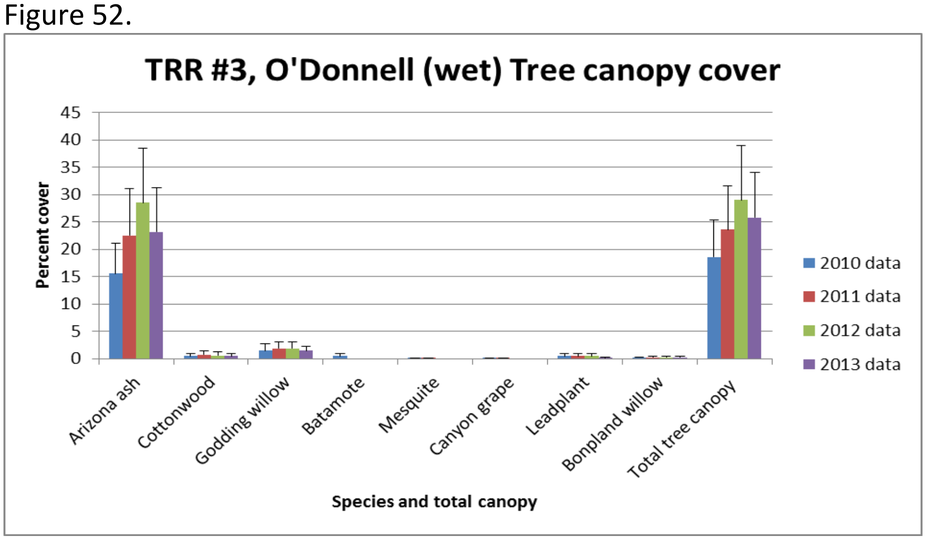
Deergrass dominates the understory plant community on the stream banks. Filamentous algae (C*ladophora glomerata*) dominate the understory of the water plots. Algae cover decreased significantly from 2010 to 2011. High amounts of algae in 2010 may have been due to nutrient rich runoff from the Canelo fire in 2009. Very low amounts in 2011 and 2012 may be due to lack of stream-flow this spring and / or reduced nutrient concentrations in the water. Other plant species appear to be relatively unchanged on this transect since 2010. Native perennial riparian species like Canada wild rye, Baltic rush and spike rush are common. Non-native grasses including Kentucky bluegrass (*Poa pratensis*), tall fescue (*Festuca arundinacea*) and annual rabbitfoot grass are also common in the understory plant community. The stream banks are well protected by covers of rock, gravel, litter and deergrass. The stream channel is very rocky, providing stability in large floods. Both cover and frequency of major plant species at this location indicate very stable trends in the greenline, understory plant community. Johnson grass remains unchanged on this site.

Figure 51.



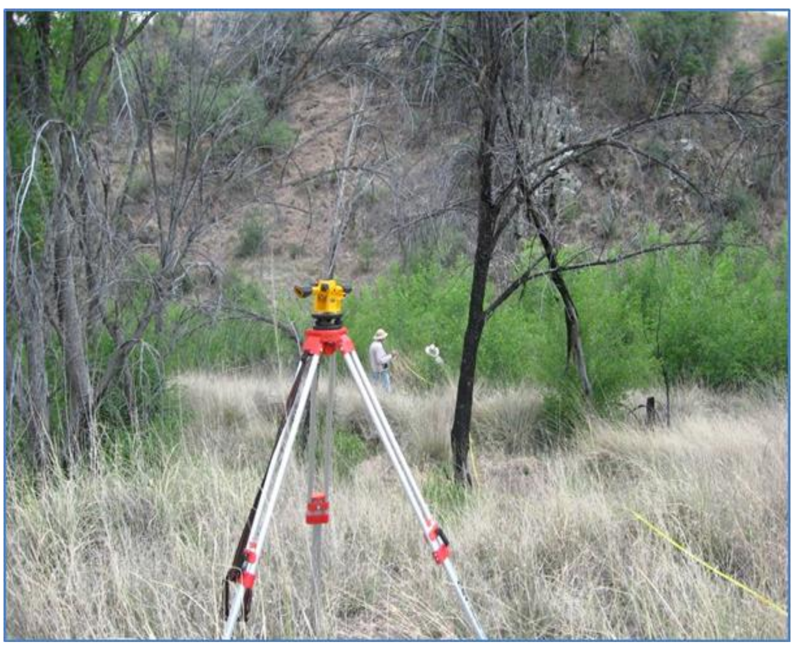
Tree canopy is moderate at this location at 26 % cover in 2012. Most of this canopy is Arizona ash with lesser amounts of cottonwood and willow. Batamote and leadplant (*Amorpha fruticosa*) are the dominant shrubs in the belt transects along the green-line. Tree cover is still recovering from the severe impacts of the Ryan fire in April 2002 and partial burning in the Canelo fire of 2009. Tree canopy remains unchanged the past four years. Note the large standard error on the dominant species, Arizona ash, due to variation in tree cover along the monitoring location. Most of the Arizona ash plants (present along the banks) at this location are coppice sprouts of larger trees top-killed by the Ryan fire. Some were burned again in 2009 by the Canelo fire.

Figure 52.



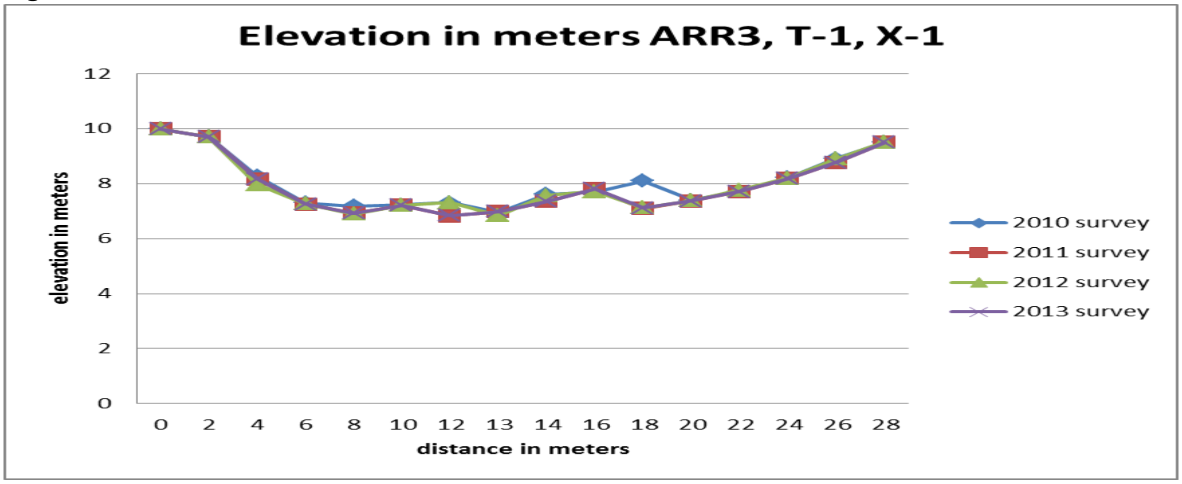
Dan Robinett and Richard Chasey doing three meter belt transects for tree canopy on TRR#3. 5-19-10

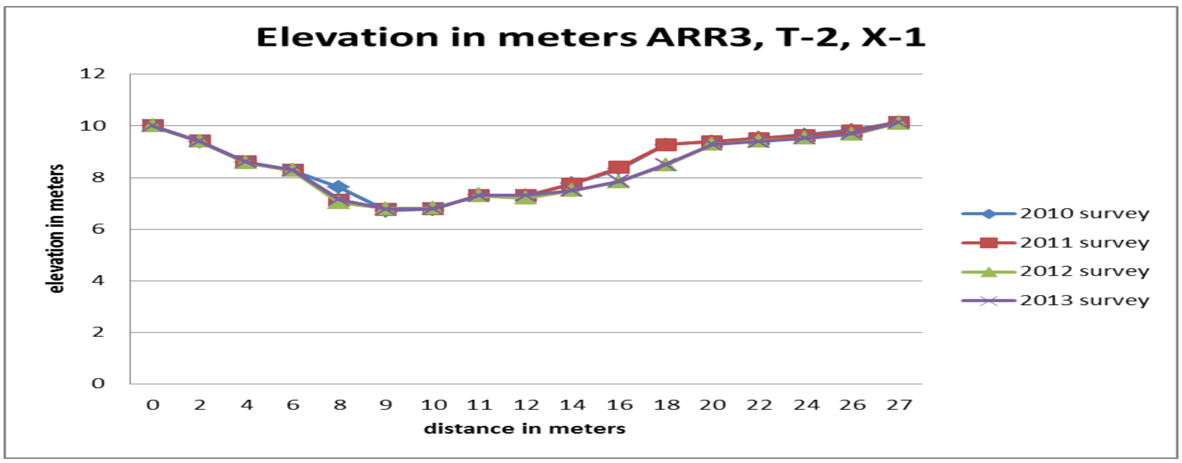
Geomorphic cross sections were surveyed yearly in the spring and perpendicular to the stream at each transect. Cross sections spanned the floodplain and low stream terraces on either side. Re-surveys of the geomorphic cross sections indicate no change in one profile and moderate erosion in the channel area of the other two cross sections. This is due to heavy summer rainfall and stream-flow in the summer of 2011 and 2012 after the Canelo fire in May 2009. Cross section surveys done in 2013 indicate no change from those done in 2012.

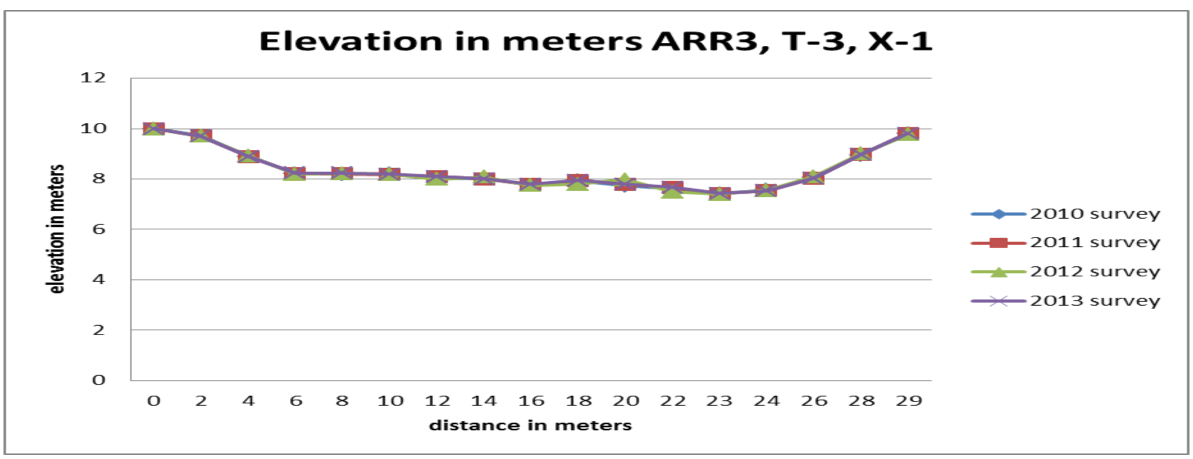


ARR #3, X-section 3, Dan Robinett performing survey on 5-16-12 with Roger Cogan (ARR) and Mark Stromberg (former Research Ranch Director).

Figure 53.



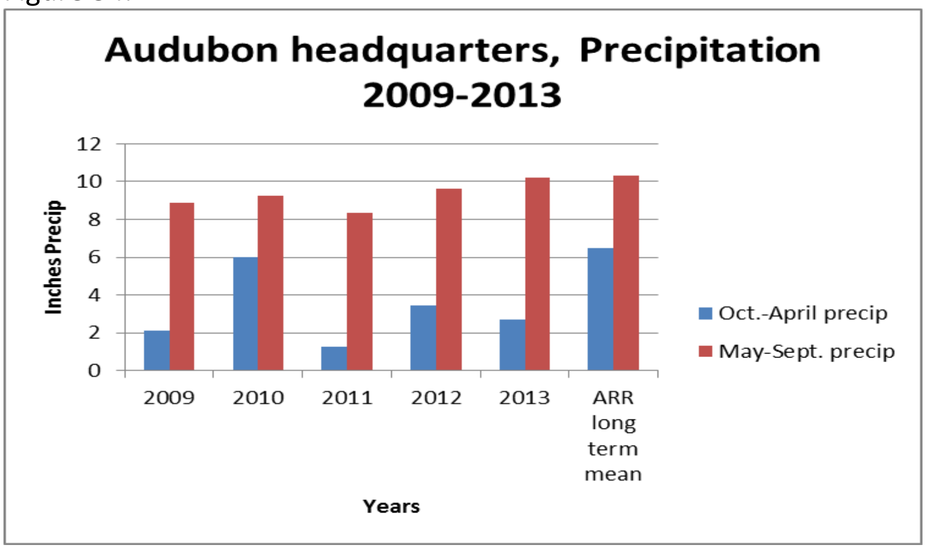




9. Discussion

Riparian (giant sacaton) grasslands on both the Babacomari ranch and the Audubon Research Ranch show very stable trends during the study period. None of the three monitoring sites on the Babacomari Ranch have received extra water from overbank flooding since 2009. All three sites on the Audubon property received overbank flooding caused by local runoff from a large thunderstorm in July of 2012. All six monitoring sites are in high ecological condition and function effectively. Precipitation from the Audubon headquarters shows nearly average amounts of summer rainfall each year since 2009 but below average amounts of cool season precipitation for the same period. The Babacomari Ranch and Audubon property have similar long term average precipitation of about 17 inches annually. About 60% of the average rainfall comes during the summer monsoon season, the remainder, October through April.

Figure 54.



As illustrated in the histograms for sacaton cover for all six sites, live foliar cover of sacaton varies with summer rainfall and live basal cover of sacaton stays nearly the same over the duration of the five year study. Data for the Post canyon/O'Donnell canyon sacaton site show how quickly these plant communities recover from fire. The Hay Canyon/Babacomari sacaton bottom was burned and grazed this spring (2013) in a prescribed fire designed to improve forage quality and availability for livestock as well as wildlife. This transect recovered partially this summer and will be re-read in the fall of 2014 to determine the response with two years of vegetative recovery post-fire.

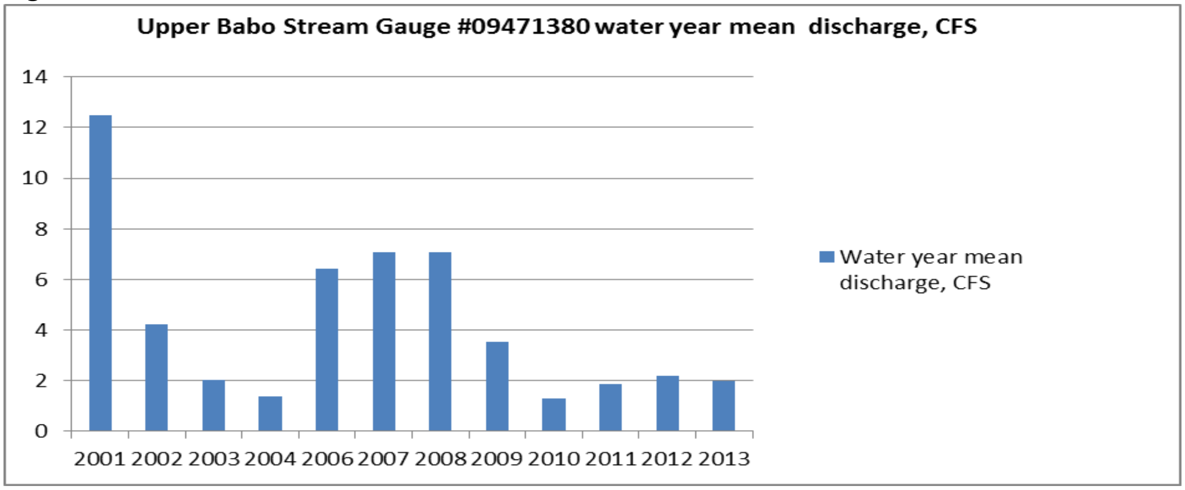
The wetland part of the Babacomari Cienega has a diverse plant community of aquatic grass, grass-like plant species and perennial aquatic forbs. Canopy cover of the major species in this plant community remains high over the course of the study but basal cover has declined for alkalai muhly, blackcreeper sedge, spike rush, Baltic rush and knotgrass in the past four years. These are all good forage species for livestock but the only year when grazing was a significant impact on this site was 2012. The reasons for the decline in basal cover or these species are unknown but may be related to changes in the depth to ground water in this part of the cienega or to the increasing deficit in winter moisture in the same time period or perhaps both. This area last flooded in the September of 2007. We propose to install a 6 meter deep piezometer (monitoring well) to track the depth to groundwater at this location in the spring of 2014.

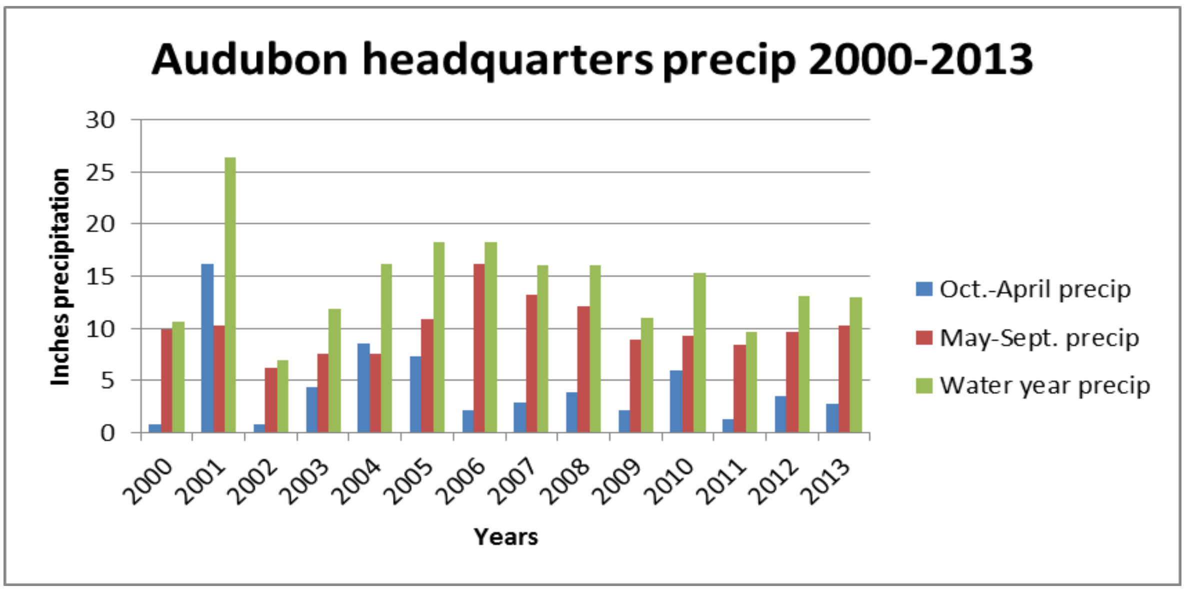
Notable for the Audubon giant sacaton sites was the high cover of cool season annual forbs as a result of the wet winter / spring in 2010. These species including annual sunflower, annual goldeneye, lambsquarter and goldentop produce large quantities of seed for native wildlife species, especially birds and small mammals. From 2011 to 2013 there were few annual forbs except warm season species like pigweed and New Mexico copperleaf, due to much below average winter rainfall. The tables showing depth to groundwater from the piesometers at Post/O'Donnell canyons and Turkey/O'Donnell canyons show how flooding (7-18-12) can recharge the water table, raising water levels to within a few feet of the surface by September, 2012. They also show how this provides the recharge to the Babacomari River below by moving downstream through the aquifer to the Babacomari Cienega. By November water levels dropped to 16 feet below the surface at the same two wells showing the subsurface flow downstream towards the Babacomari River.

Riparian greenline plant communities at three monitoring locations on the Babacomari River all appear to have stable or upward trends in both cover and frequency of major understory plant species along the stream. Riparian understory plant communities at both the Farm Crossing (BR #3) and the Railroad Bridge (BR#2) have stable or upward trends since the new fencing to complete the Bridge Pasture was completed in 2009. Watercress, a non-native perennial aquatic species, and spike rush have decreased in cover at both locations during the study. The reasons for these declines are not apparent. Spike rush is a forage species and has been grazed at both locations the past two years but not excessively. Watercress is not a forage species. Geomorphic monitoring at both of BR #2 and BR #3 locations show very stable conditions with no erosion of banks or stream channels and with fine sediment accumulation in pool areas. There have been no floods through these two sites during the duration of the study.

The plant community at the USGS stream gage (BR#1) remained in good ecological condition through the duration of the study. Little Blacktail and Javalina canyons ran in 2010 and deposited much new soil material into the stream to be re-worked through the transect area. Geomorphic cross sections #1 and 2 show sediment accumulation on the floodplain at this location. These valley side drainages did not carry flood waters in 2011, 12 or 13 and the lack of flooding in the past three years seems to be the cause of siltation of the pool areas in this reach of the Babacomari River. The riparian greenline understory vegetation at BR #1 has a stable or upward trend for cover and frequency of major species. Horsetail, a palatable forage species, declined in 2012 in cover due to moderate grazing use in the spring of that year. It recovered partially in the spring of 2013 with less grazing use. The USGS stream gage at BR #1 provides water flow measurements which can help interpret the geomorphic and vegetative data. Mean daily discharge at this location has been less than 2 cubic feet per second (CFS) for the last four years. In addition there has not been a significant flood since a 10,000 CFS flood in August of 2006 which scoured the channel and banks and left large debris dams in the creek.

Figure 55.





Note how closely the water year, mean daily discharge at the USGS stream gage on the Upper Babacomari site (BR#1) tracks precipitation in the watershed above at the Audubon Research Ranch headquarters. This illustrates the strong relationship between watershed and stream and the importance of managing all parts of the system (including the catchment area, the transport zone and the deposition zone) together. Also note the lack of winter precipitation since 2005 at the Audubon headquarters. The average annual cool season precipitation at Audubon is 6.6 inches. This area has received about half of that amount for 7 out of the last 8 years.

Riparian tree plant communities at two monitoring sites along the Babacomari River (BR#1 and BR#2) are in excellent condition, dominated by Fremont cottonwood and Goodding or black willow. Total tree canopy at both sites are 65% and 60% respectively. The tree canopy data over the past five years illustrate the repeatability of the methods used in the study. Arizona ash appears to be increasing under the dominant tree canopy at both sites with numerous seedlings and saplings recruiting into the plant community. This phenomenon has been documented nearby in riparian monitoring on Bureau of Land management property at Las Cienegas National Conservation Area (K. Simms, BLM, pers. communication). The tree community at the Farm Crossing site (BR#3) has an upward trend increasing from 4 to 9 percent canopy over the past five years since the river was fenced to establish the Bridge Pasture. This monitoring location was chosen as the area had been a water access point and had very little riparian tree cover to begin with. It had potential to make rapid improvement.

Riparian greenline plant communities on the Audubon property in Turkey Creek have a downward trend in major species due to severe fire in 2002 and 2009 and heavy summer rains and runoff for several years afterwards. Native grass species like deergrass, sacaton and Canada wild rye are decreasing in both cover and frequency possibly due to channel and bank scouring after the Canelo fire in 2009. Johnson grass, a non-native and invasive perennial, is increasing at this location each year and may come to dominate the understory of this dry riparian site. The geomorphic monitoring at this location shows continued channel erosion at cross sections #1 and 2. The third cross section appears to be stable.

The dry riparian site in O'Donnell canyon (TRR#2) is in much better condition with a healthy tree canopy and a diverse understory plant community. The riparian greenline understory at this location has a stable trend in both cover and frequency for all major species. Johnson grass has increased at this location in both cover and frequency since 2012. The geomorphic cross sections #1 and 3 are very stable with no erosion or sedimentation since the study began. Cross section #2 had some minor channel erosion in 2012.

The perennial stretch of O'Donnell canyon at TRR#3 has an excellent understory plant community dominated by deergrass, other perennial grass species with good diversity of sedge and rush species. Trends in both cover and frequency are stable for all major plant species in the riparian greenline. Johnson grass is present but not increasing at this location. The geomorphic cross sections at this location show some channel erosion at cross sections #1 and 2 since 2012 and with stable conditions at cross section #3.

Riparian tree plant communities on the Audubon property show the effects of two wildfires in the past 12 years. The Ryan fire in April 2002 burned during one of the worst droughts in recent history and top killed (Arizona ash and black willow) or killed (cottonwood) most of the trees along Turkey and O'Donnell Creeks.

Along Turkey Creek at TRR #1 the 2002 fire top killed all of the riparian shrubs and the few trees along the banks. Canyon grape and batamote have recovered since the fire but trees have not. This site should be able to support a modest tree cover (10-15% canopy). Species like Arizona ash, black walnut and western soapberry are in the area but none have recruited into the area during the study period.

At TRR #3, the wet site in O'Donnell Creek the tree canopy is moderate and appears to still be in recovery from the 2002 and 2009 wild fires. Most of the tree canopy at this location is Arizona ash and all of the plants are coppice sprouts from larger trees top killed by the 2002 fire. The apparent trend is towards increasing canopy cover during the duration of the study.

10. Recommendations

The line-point monitoring technique used to monitor changes in sacaton plant communities is robust and repeatable. These are difficult transects to read as the grass is often head high and very dense, badgers holes, sinkholes and discontinuous gullies can cause injury and large rattlesnakes prey on cotton rats in these plant communities from April through November.
In the first year of the study we recorded 1000 points of cover on the sacaton transects (ten lines of 100 points each). In the subsequent year we recorded 500 points of cover (ten lines of 50 points each) with no loss in precision. This saved time and physical effort.

Five years of data on all six sacaton monitoring sites provides an excellent baseline for change (or the lack of change) into the future. We recommend yearly activities at all six locations in the riparian grasslands including photographs, collecting precipitation information and plant species collection. We recommend re-reading these transects as indicated by natural events like flooding, fire and/or severe drought to determine when an area has recovered to baseline conditions. Late fall (Nov.-Dec.) is the recommended time to re-read these transects.
Geomorphic cross sections span the sacaton floodplains (300 -500 meters in width) and are very difficult to re-survey for the same reasons. We recommend that cross section be re-surveyed only after major flood events result in obvious erosion or sedimentation. Re-surveying after burning can also save considerable time and effort and may result in more accurate information as the grass is much easier to traverse in the year after fire.

The modified Daubenmire method used to monitor trend in the understory plant communities of the riparian greenline is cumbersome and requires considerable judgment in ranking species into canopy cover classes. It appears to be repeatable with the same observers over time. This method does have the advantage of sampling aquatic plant species as well as species which occur on stream banks but has disadvantages as well. The method involves one person wading in the river to carry out the measurements. This limitation means that pool areas greater than chest deep cannot be included in monitoring. The method requires two people as a recorder needs to remain out of the water and keep the record dry and legible. Six transects may not be enough to reduce sampling error to reasonable amounts but to do more would require two full days at each site each year, a luxury no one seems to have these days. In addition vegetative composition along these small streams is so diverse that finding uniform areas to monitor is nearly impossible and standard error will remain high even with 10 or more transects.

We also record plant species frequency along the greenline and this may be a more appropriate measure of trend in major species over time as standard error is less than with cover measurements. Spring (May-June) is the recommended time to read these transects as most of the aquatic plant species along the greenline are in flower then and easy to identify.
Four years of data on all six riparian greenline monitoring sites provides an excellent baseline by which to measure change (or the lack of change) into the future. We recommend yearly

activities at all six locations in these riparian communities including photographs, collecting precipitation information and plant species collection. We recommend re-reading these transects (frequency) as indicated by natural events like drought, flooding and fire (and disturbance by beaver should they migrate up from the San Pedro River) to determine when an area has recovered to baseline conditions.

The belt transect, cover class method used to monitor trend in the riparian tree plant communities is relatively easy and requires minimal judgment in ranking species into canopy cover classes. Monitoring data over the last four years shows the repeatability of the method. We recommend re-reading these transects whenever the riparian greenline is monitored.

Geomorphic cross sections span these small floodplains (10 -30 meters in width) and are very easy to re-survey. We recommend that cross section be re-surveyed after major flood events result in obvious channel or bank erosion or sedimentation.

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13. List of Figures