Brief history of the site: The BEMP BioPark site was cleared of exotics in 2006 and trails cleared to increase public access. It is adjacent to the created wetlands, but does not overlap with the wetlands or wet meadow areas.

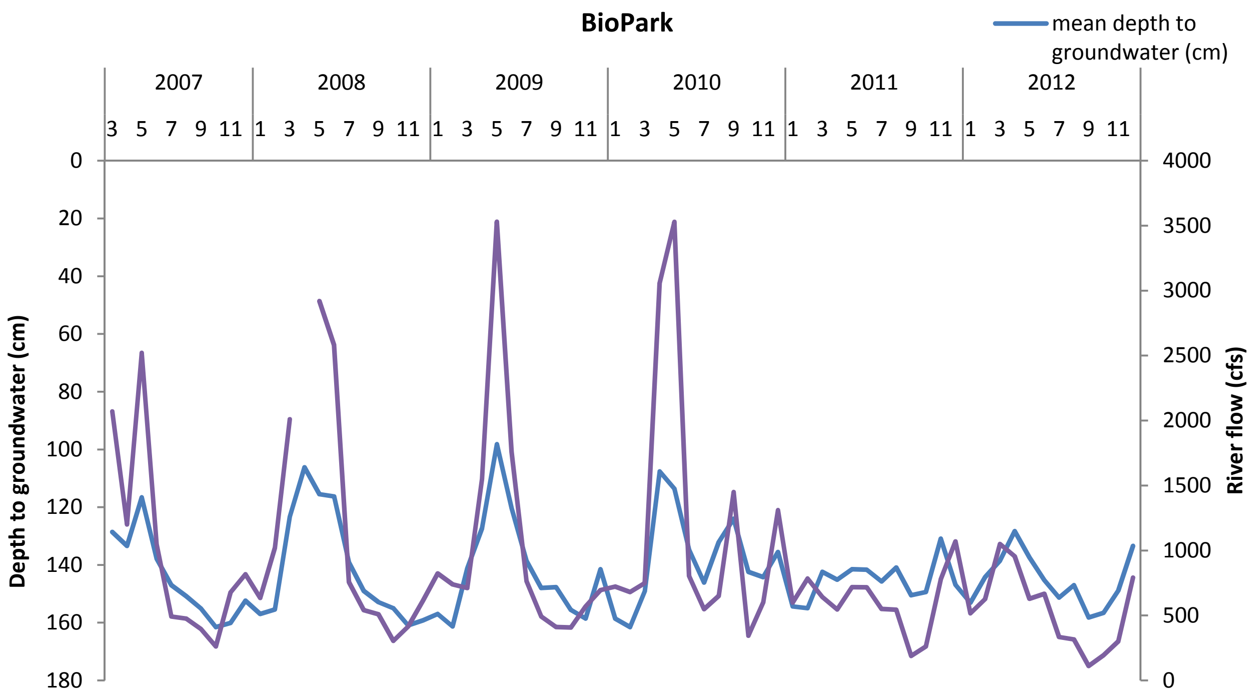

Figure 1. Response of depth to groundwater (cm) to river flow (cfs) at BioPark.

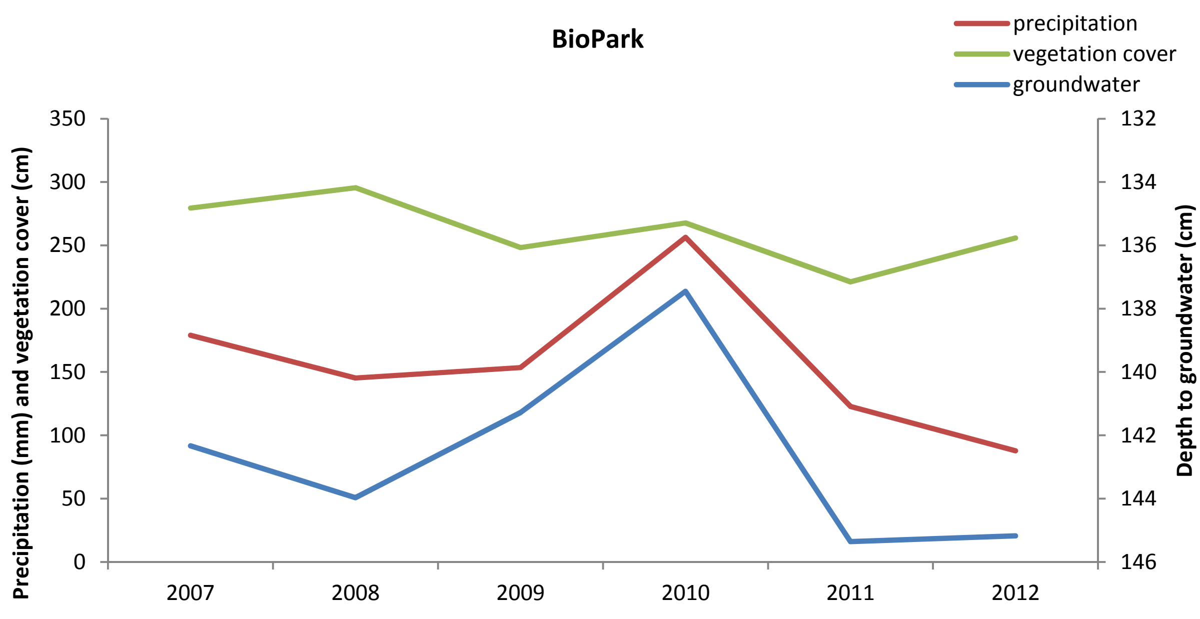

Figure 2. Mean annual depth to groundwater (cm), mean annual precipitation (mm), and sum of vegetation cover (sum intercept length) (cm) at BioPark. Increase in vegetation cover from 2011 to 2012 is mostly tumbleweed.

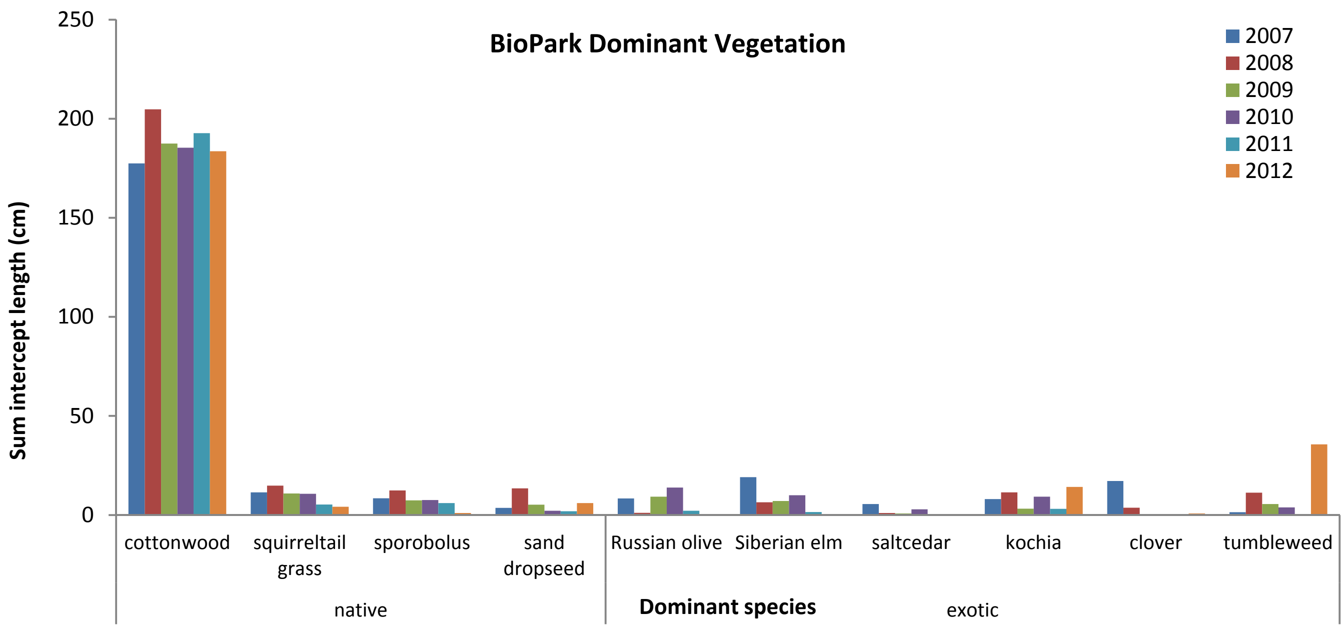

Figure 3. Sum of native and exotic dominant (not all) plant species at BioPark.

Table 1. List of species on ten 30 m transects for each year at BioPark. Green fields are native plants, purple are exotic.

BioPark: 2007	2008	2009	2010	2011	2012
# of species: 28	32	27	29	25	26
Indian rice grass	Indian rice grass	Indian rice grass	Indian rice grass	Indian rice grass	Indian rice grass
tree of heaven	tree of heaven	kochia	tree of heaven	pigweed	*Artemisia* sp.
kochia	*Artemisia* sp.	sideoats grama	kochia	kochia	kochia
Bromus sp.	kochia	rescuegrass	rescuegrass	rescuegrass	smooth brome
Canadian horseweed	rescuegrass	Canadian horseweed	sandmat	Canadian horseweed	Canadian horseweed
yellow nutsedge	sandmat	composite	Canadian horseweed	rough barnyardgrass	Russian olive
Russian olive	rough barnyardgrass	rough barnyardgrass	dicot	Russian olive	squirreltail
squirreltail	Russian olive	Russian olive	Russian olive	squirreltail	sunflower
velvetweed	squirreltail	squirreltail	squirreltail	beeblossom	foxtail barley
grass	forb	prickly lettuce	grass	sunflower	prickly lettuce
sunflower	grass	hoary tansyaster	sunflower	prickly lettuce	barberry
prickly lettuce	sunflower	barberry	prickly lettuce	lacy tansyaster	hoary tansyaster
hoary tansyaster	prickly lettuce	scratchgrass	hoary tansyaster	barberry	white sweetclover
lacy tansyaster	rice cutgrass	thicket creeper	barberry	scratchgrass	scratchgrass
barberry	hoary tansyaster	groundcherry	scratchgrass	thicket creeper	thicket creeper
white sweetclover	lacy tansyaster	cottonwood	thicket creeper	cottonwood	cottonwood
witchgrass	barberry	Goodding's willow	groundcherry	tumbleweed	tumbleweed
cottonwood	white sweetclover	tumbleweed	cottonwood	nightshade	threadleaf ragwort
tumbleweed	scratchgrass	alkali sacaton	tumbleweed	copper globemallow	nightshade
threadleaf ragwort	groundcherry	copper globemallow	threadleaf ragwort	sand dropseed	alkali sacaton
copper globemallow	cottonwood	spike dropseed	copper globemallow	dropseed	copper globemallow
sand dropseed	Goodding's willow	sand dropseed	sand dropseed	saltcedar	sand dropseed
dropseed	tumbleweed	dropseed	dropseed	goathead	dropseed
saltcedar	green bristlegrass	saltcedar	white heath aster	broadleaf cattail	goatsbeard
goatsbeard	alkali sacaton	goathead	saltcedar	Siberian elm	broadleaf cattail
cattail	copper globemallow	cattail	goathead		Siberian elm
Siberian elm	sand dropseed	Siberian elm	broadleaf cattail		
mullein	dropseed		Siberian elm		
	saltcedar		mullein		
	goathead				
	cattail				
	Siberian elm				

BEMP
Bosque Ecosystem Monitoring Program

Actively Restoring the Mosaic in the Face of Drought and Climate Change

Clifford Crawford, Anne Cully, Rob Leutheuser, Mark Sifuentes, Larry White, and James Wilber. 1993. Middle Rio Grande Ecosystem: Bosque Biological Management Plan.

"**The river was bordered by a continually changing mosaic of cottonwood and willow (*Salix* sp.) stands of varying ages, sizes, and configurations, interspersed with more open areas of grass meadows, ponds, small lakes, and marshes**."

"Under natural conditions, riparian ecosystems provide a mosaic of habitat components. As a result of floods, other disturbances, varying ground-water levels, and soil conditions, riparian forests become interspersed with a range of plant community successional (seral) stages, marshes, meadows, ponds, and openings. This creates a variety of habitat niches leading to high species diversity. Riparian habitat supports species which are attracted to edges or which require a combination of adjacent vegetation types and habitat features. **For optimal habitat value, a balance must be achieved between large stands of habitat and those with a mosaic of plant communities and structural types.** Habitat types must be large enough and spaced close enough to support viable populations of desired species."

"The presence and depth of ground water determine the composition of plant communities and distribution within the floodplain."

"The erosional-depositional processes of the river promote forest and age diversity on the floodplain and its meandering process creates the distribution of the different communities and age classes. … Stands nearer the river are frequently eroded away and do not attain sufficient age to reach advanced successional states. Those trees near the outer edge of the floodplain, where the erosional effects of the river are less frequent, or stands nearer the river that have escaped removal (perhaps b aggradation within the stand) survive to attain maturity.

"These dynamic effects of flooding created and perpetuated a changing mosaic of cottonwood and willow forest, lakes, marshes, and meadows."

Cliff Crawford and Sterling Grogan. 2004. Bosque Landscape Alteration Will Reduce Fires and Conserve Water: A Proposal.

"[Restoration should] resemble … the much wilder active floodplain of the past. Stands separated by open areas of native grasses and shrubs over distances up to, say, half a mile, will delay the movement of fire and enable firefighting equipment to be brought in rapidly. The open spaces will therefore act as firebreaks. [This will] **result in a savanna-like architecture of mostly native, uneven-aged stands that are much less vulnerable to combustion and more restrictive of water loss than is the gallery forest that constitutes the present bosque**."

Yasmeen Najmi, Sterling Grogan, and Cliff Crawford. 2005. Bosque Landscape Alteration Strategy

"Objectives: 1. To reorganize the Rio Grande bosque's landscape to retain, within current constraints, including institutional and water supply constraints, its historical processes and wildlife communities. 2. **To recreate**, by doing this, **its former patchy mosaic of native trees and open spaces along the present-day river's narrow floodplain**, while containing the distribution of invasive species. 3. To reduce, by having created this mosaic, the intensity of bosque wildfires both at the wildland-urban interface and within the rest of the bosque, and water depletion by the bosque landscape."

Matt Schmader. 2005. Environmental Enhancement Plan for Rio Grande Valley State Park.

"It focuses on establishing and maintaining a mosaic of habitat types and vegetation/plant communities within the Park. Establishing a mosaic is a widely held restoration goal and will improve overall conditions … for a broad spectrum of animal species, including the Southwestern Willow Flycatcher. … Evaluation of existing site conditions included the following factors: distribution and density of native trees and plants; size and extent of cleared areas; site topography; soil conditions; depth of water table; potential for overbank flooding or high flow channels; edge characteristics and transitions between plant communities; proposed patch sizes and distributions; and other management considerations such as fire-breaks, public safety needs, and public access."

Jean-Luc Catron, David Lightfoot, Jane Mygatt, Sandra Brantley, and Timothy Lowrey. 2008. A Field Guide to the Plants and Animals of the Middle Rio Grande Bosque.

"Where saltcedar and Russian olive are removed with no follow-up effort to plant native vegetation, weeds such as kochia (*Kochia scoparia*) can become established in very high densities."

James Cleverly. 2013. Water Use by Tamarix. Tamarix

"*Tamarix* stands should be replaced by xeroriparian or upland species. Conversion of *Tamarix* thickets into sparse mosaics that mimic prehistoric plant communities will likewise benefit the water budget. Any change in ET due to restoration activities will be modest in either case, but carefully implemented management strategies are an improvement over continuously increasing water use by the current vegetation or by restoration activities that increase *Tamarix* presence or water consumption (Shafroth et al. 2005)."

"**Rather than planting dense stands of high-water-using native trees**, restoration activities that will maximize water salvage operate with the goal of **regenerating the prehistoric sparse mosaic** of individual and widely spaced *Populus* trees within a grass and shrub matrix."

Anna Sher. 2013. Introduction to the Paradox Plant. Tamarix

"Such monospecific vegetation structure was unknown in North America riparian zones before the arrival of the species, and it is a dramatic departure from historic conditions along western rivers, which ranged from nearly empty (e.g., shifting sand bars) to mixed-species riparian forests with two or three canopy layers that were for the most part restricted to the riparian fringe (Webb et al. 2007)."

Some recommended plant species based on water availability:

Mature cottonwood forest with understory riparian shrubs	Ephemeral or perennial standing water; wetlands and marshes	High water table; wet meadow	Open area with medium or variable water table; grassy meadow	Low water table; xeric
Cottonwood	Seepwillow	Saltgrass	Saltgrass	Four-wing saltbush
Coyote willow	Coyote willow	Scratch grass	Dropseed (spike, sand)	Sand sage
Seepwillow	Sedges	Foxtail barley	Grama (blue, black, sideoats, six-weeks)	Screwbean mesquite
False indigo bush	Bulrushes	Alkali mallow	Alkali sacaton	Alkali sacaton
New Mexico olive	Rushes	Yerba mansa	Globemallow	Indigo bush
Goodding's willow	Cattails	Rushes	Asters	Grama
Torrey's wolfberry	Yerba mansa	Sedges	Primrose	Dropseed
Screwbean mesquite	Horsetail	Reeds	Indian ricegrass	Apache plume
Three-leaf sumac	Bearded sprangletop		Galleta	
Golden currant	Scouring rush		Vine mesquite	
Peachleaf willow	fern (*Marsilea*)			

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