Lateral Analysis of Vegetation Communities Along River Channel Cross Sections in Lower San Juan River

—

Evans, K. & Jordan Pajala, A.

GEL136 Ecogeomorphology

Dr. Nicholas Pinter & Dr. Sarah Yarnell

July 7, 2022

I. Abstract

In the American southwest, water availability is becoming an increasingly scarce resource; consequently, the patterns of vegetation are anticipated to change as well. As a result, this report aims to examine the relationship of the vegetation communities to elevation and distance from the edge of a river. The study region of this report consists of 76 longitudinal river miles of the Lower San Juan river basin, which is a drier desert environment in comparison to the upper San Juan's more precipitated dendritic headwaters. At 5 different study sites along the 76 miles, a cross section of the river channel was measured and at 4 of those sites a vegetation transect was taken parallel to the line of the cross section. We expected that there would be distinctive transitions between vegetation communities that correspond with changes in elevation and water availability. The first assumption was generally consistent with what we observed, being that vegetation communities do change over space laterally. However, the predictability of which plants would be present at a certain proximity was variable. This seems to reveal that although the existence of vegetation gradients are universal, the specific factors acting on vegetation and creating the gradient are variable by location, and not primarily dependent on current surface water supply.

II. Introduction

The San Juan River traverses through the variable terrain of the Four Corners region. Its large range covers 14 subwatersheds primarily in Arizona, New Mexico, Utah, and Colorado, consisting of 1.2 million acre feet of water (Ewers 2005). Beginning in the 4,292m tall San Juan Mountains in southwestern Colorado, the river ends 1130m above sea level at Lake Powell in Utah (Heil & O'Kane 2003). Within this large change in elevation from headwaters to its terminal point comes an elevational gradient that also extends laterally. The erosive forces of the river in conjunction with geologic time and uplift– making popular features like the Goosenecks– created tall canyon walls along much of the river, entrenching it primarily between sedimentary rock.

These geologic structures along the river are able to accommodate an array of vegetation within them. The San Juan River Basin is dominated by Pinyon-Juniper, with over 2253 vascular plant species described (Heil & O'Kane 2003). This diversity in the landscape and plant biology situates the region to answer the following question: how has the basin morphology of the San

Juan River impacted the distribution of vegetation along the banks? As the elevation changes away from the water, does the vegetation community change laterally?

It is well documented in prior research that the sections of a riparian zone are largely differentiable based on its distance to and elevation from the water (Auble 2005). These sections are believed to have distinctive vegetation patterns universally, though the section size and specific species in each of these sections vary based on the river dynamics. This is because riparian areas act as the ecologically valuable interface between the land and water; each portion is assumed to interact with the water in a unique way and is directly affected by changes in this dynamic.

Riparian zones can experience much variation in their vegetation makeup based on the water, making it increasingly pertinent to understand the current state of these dynamics in the San Juan River. The San Juan has not been the exception to water scarcity issues that are becoming increasingly precarious as a result of damming, climate change, and rights allocations that will continue to alter the river dynamics over time. In fact, despite only holding 1.2 million acre-feet of water, the San Juan river has allocated 1.7 million acre-feet per year for its stakeholders (Ewers 2005). Water in the San Juan Basin is used for irrigation of crops in the area and there are many stakeholders involved with water usage in the area, including farmers and the Navajo Tribe (Rondeau 2017). Due to activities such as this, studies estimate that 70-90% of historic riparian zones have been lost because of anthropogenic activities (Stevens, n.d.). Thus, the vegetation present in one area is subject to be highly altered over time as the river dynamics ignite change upon this interface.

This uncertainty is not only concerning due to the water itself, but from the possible effects trickling down to the ecological environment which depends on the river's dynamics. Though natural variation had played a substantial role in discharge in the past, long term averages have been increasingly smaller and more homogeneous. Understanding the river dynamics and how vegetation is impacted will have major implications for the animal species that utilize the basin, who have evolved to a completely different snowmelt regime than what we now see today.

While analyzing potential historical trends in conjunction with primary data, we anticipate that the vegetation along the San Juan River will showcase a shift in the dominant cover in each defined riparian zone. Likewise we expect that between different sites, species with similar drought tolerances will occupy similar spatial configurations, particularly in regards to proximity to the water. This gradient is expected to be primarily driven by increased accessibility to water closer to the river.

III. Methods

2.1 Study sites

Our study takes place in the lower section of the San Juan River, entirely contained within the state of Utah. By studying this area, our research incorporates more consistency in habitat and climate, while also being able to be collected within a relatively short period of time.

In total, our collection spans 76 river miles, including the Sand Island, River House, Pontiac Wash, Honaker, and Oljeto campsites. These stations were chosen because they are easily accessible by commercial raft, allowing researchers to have sufficient access to them. Upstream of the study sites is a major tributary, the Animas river, which acts as a main supplier of sediment to the Lower San Juan, accompanied by smaller tributaries such as Los Pinos and La Plata. The study area is below the Navajo Dam and ultimately flows into Lake Powell which is dammed by Glen Canyon Dam.

Data collection occurred from June 17, 2022 through June 21, 2022. Sampling during summer coincides with low water levels, exposing more banks that may be covered in other times of the year, such as in early spring when snowmelt occurs. Additionally, sites had relatively similar weather conditions at time of data collection (warm, windy, and sunny). This promotes accurate data, as well as an increased degree of consistency between sites. Daily air temperature highs at sample sites ranged from 82 to 94 degrees, while measured water temperatures ranged from 21.5 to 30 degrees Celsius at time of sampling (Accuweather 2022). Flows during the study period, however, ranged from a low of 500 cfs to a high of almost 2,000 cfs after consecutive days of rainfall (USGS).

2.2. Vegetation data collection

Vegetation data was collected by three groups of researchers, each given standardized data collection technique. A single transect was conducted parallel to the cross section, and the location along the river bank was randomly chosen. No official transect was conducted at San Island, however general trends were noted. At River House a total of 100m was measured for the transect, and at all remaining sites the transect was 50m long. All transects began at the water's edge, at 0m. Researchers then walked along a tape measure noting the intervals that any plant species were directly under the tape measure. This method is used to be able to calculate percent cover of each species, and be able to assess how vegetation communities change laterally as distance from the river's edge increases. A singular transect was done at each site since there was not sufficient time to do multiple, and this transect was used to extrapolate the percent cover of the general study area. % cover was calculated by adding up the total distance (m) that a species was found in the given 10m interval, and then dividing by the total meters sampled which was 100 m for River House and 50 m for the rest of the study sites. This was done for the two species which covered the most distance (m) per 10m intervals of 0-10, 10.1-20, 20.1-30.0, and 30.1+.

2.3 Cross Section Survey data collection

Cross section surveys were completed in rotations by three groups of researchers, each given standardized surveying technique. The elevation change measured along a 50m line perpendicular to the river was measured at each aforementioned location. Using a depth rod, level tripod, and scope, researchers walked along the 50m tape and noted the distance along the tape (station in meters) and then measured the change in elevation at that point by viewing the height of the depth rod from the stationary level scope. Researchers chose the station to reflect significant changes in the topography and points that characterized the topography such as edges of cobble bars and the edge of the water. Due to safety concerns related to crossing the river in moving current, only partial cross sections of the topography underwater were measured.

2.4 Data processing

All cross sections were analyzed through excel by plotting the elevation change (m) against the station (m). To create continuity between the cross sections and vegetation transects the elevation at the edge of the water was set to a standard of 100 m in all cross sections. Percentage of Total Cover for the vegetation transects was calculated in 10-meter intervals up to 30 meters (0-10.0, 10.1-20.0, and 20.1-30.0 and 30.1+).

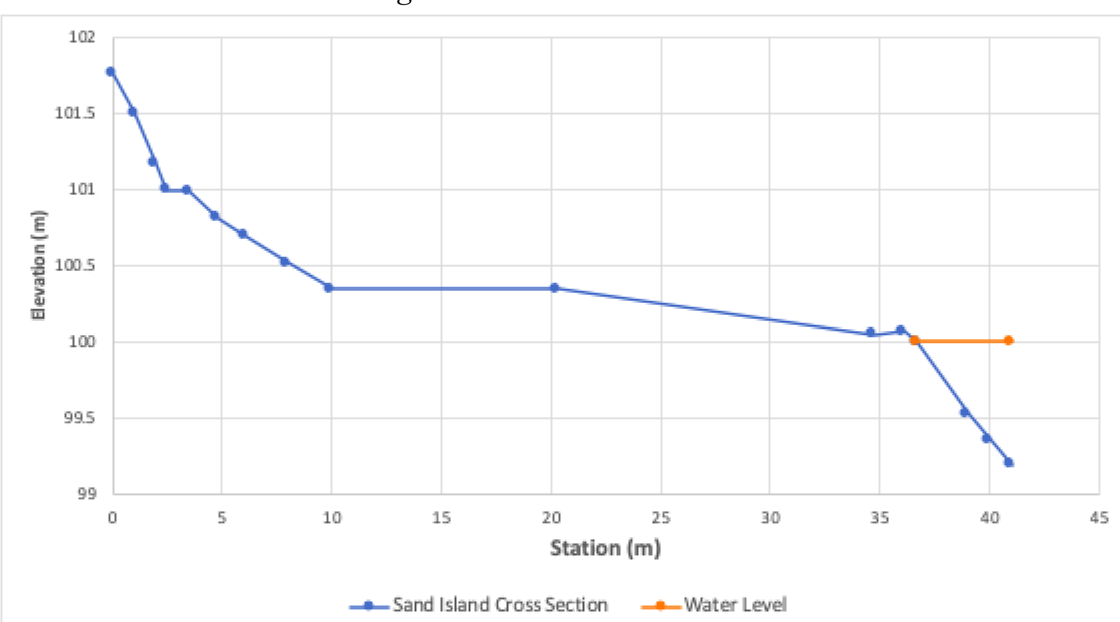
IV. Results

3.1.1 Sand Island (River Mile 0)

Of those observed, Sand Island consisted of 3 different species. These included Willow, Cottonwood, and Russian Olive. Within the cross section, the highest point is 1.76m above the river over 36.7m (*Figure 3.4.3)*.

General observations were a tendency for certain species to occur as elevation increases. In the wet bar area closest to the river's edge there were seedling willows. Moving farther away onto the dry sand bar there were young willows and cottonwoods, and beyond that on the current floodplain there were mature willows and a few 8ft tall cottonwoods. Lastly, at the highest elevation on the historic floodplain there were old willows and russian olives.

Figure 3.1.1 Sand Island Cross Section



The water level is set to a standard elevation of 100m, and the other points represent each station that was measured. The vegetation transect begins at the water level at the 0m interval and then was measured away from the water's edge for 100 m. The vegetation transects extend to a higher elevation than the cross sections do, so in the summary table the vegetation above the 30.1 m interval was grouped into one category.

3.2.1 River House (River Mile 6)

River House consisted of 11 different species detected by the transect (*Table 3.2.1)*. Of these, the highest percent cover included Russian Olive, Side Sedge, Tamarisk, and Cottonwood (*Table 3.2.2*). Within the cross section, the highest point is 1.415m above the river over 24.7 m (*Figure 3.2.3)*.

Table 3.2.1 River House Vegetation Transect Data

Species/Substrate Found	**Intervals (m)**
Side Sedge	2.0-3.8
Russian Olive	5.0-13.0, 14-22, 23.5-26.5, 36.0-39.0
Tamarisk	22.0-22.5, 29.0-34.0
Rabbit Brush	22.5-23.0
Vernonia	23.0-23.5
Grass	41.0-41.1
Cottonwood	40.1-44.5, 47.5-53.0, 55.7-56.0, 57.5-64.5
Green Spiny Herb	52.4-53.2
Indian Rice Grass	94.4-94.6, 97.7-98.0
Snakeweed	98.5-99.0
Sonchus	99.9-100.0

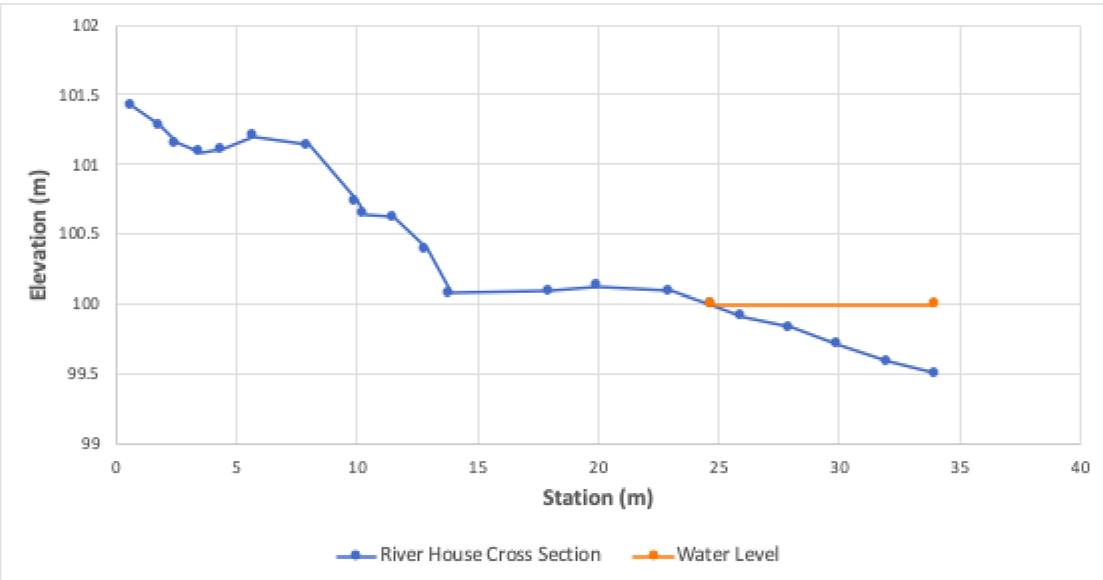
Table 3.2.2 River House Summary Table

Dominant Species	**Interval (m)**	**% of Total Cover**
Russian Olive, Side Sedge	0-10	5%, 1.8%
Russian Olive	10.1-20	8.9%
Russian Olive, Tamarisk	20.1-30	3.9%, 1.5%

Cottonwood, Tamarisk	30.1+	17.2%, 3.9%

The dominant species refers to the species which covered the most distance in that respective interval, and their respective % of the total cover is listed in the right most column.

Figure 3.2.3 River House Cross Section



3.3.1 Pontiac Wash (River Mile 30)

Pontiac Wash consisted of 5 different species detected by the transect (*Table 3.3.1)*. Of these, the highest percent cover included Coyote Willow, Coyote Brush, Knap Weed and Tamarisk (*Table 3.3.2*). Within the cross section, the highest point is 3.2m above the river over 48.6m (*Figure 3.3.3)*.

Table 3.3.1 Pontiac Wash Vegetation Transect Data

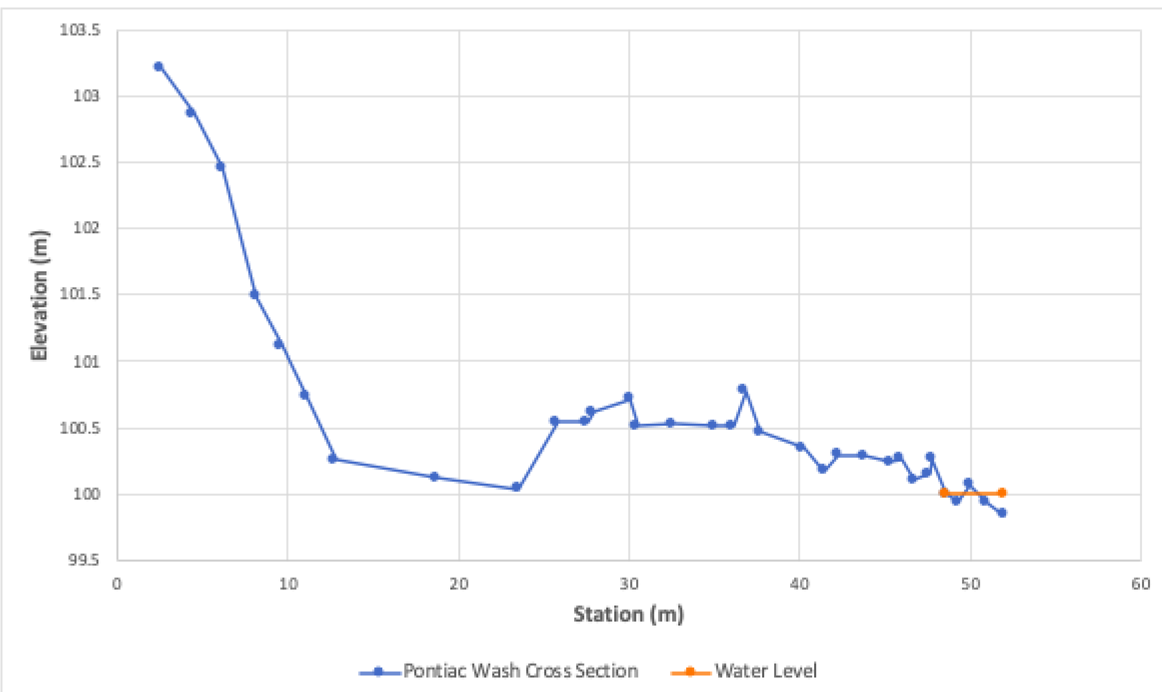
Species/Substrate	**Intervals (m)**
Coyote Willow	8.2-8.6, 12.9-13.5, 36.0-36.2, 37.0-38.7
Coyote Brush	27.7-28.2
Knap Weed	43.4-44.8
Tamarisk	44.0-45.4

Sumac	51.6-52.2

Table 3.3.2 Pontiac Wash Summary Table

Dominant Species	**Interval (m)**	**% of Total Cover**
Coyote Willow	0-10	.8%
Coyote Willow	10.1-20	1.2%
Coyote Brush	20.1-30	1%
Coyote Willow, Knap Weed/Tamarisk	30.1+	3.8%, 2.8% (for both)

Figure 3.3.3 Pontiac Wash Cross Section



3.4.1 Honaker (River Mile 46)

Honaker consisted of 10 different species detected by the transect (*Table 3.4.1)*. Of these, the highest percent cover included Tamarisk, Willow, Rabbit Brush, and Ephedra (*Table 3.4.2*). Within the cross section, the highest point is 4.50m above the river over 30m (*Figure 3.4.3)*.

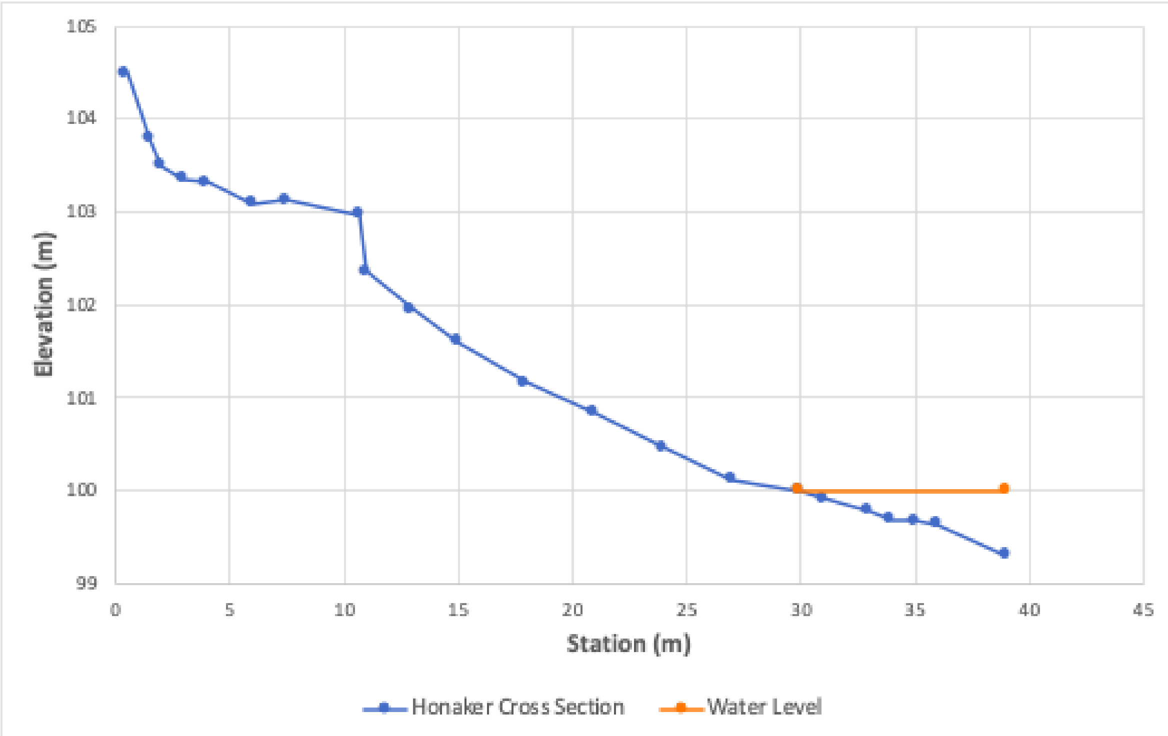
Table 3.4.1 Honaker Vegetation Transect Data (River Mile 46)

Species/Substrate	**Intervals (m)**
Grass	5.0-5.1
Tamarisk	9.2-10.5
Mallow	22.7-22.8
Willow	23.0-23.5, 24.6-25.2
Indian Rice Grass	25.1-25.5
Skeleton Weed	25.5-25.6
Rabbit Brush	29.9-31.2, 32.6-33.2, 34.5-34.9
Crust	43.0-44
Ephedra	45.0-45.8, 46.5-46.7, 49.7-50
Prickly Pear	46.8-46.9

Table 3.4.2 Honaker Summary Table

Dominant Species	**Interval (m)**	**% of Total Cover**
Tamarisk	0-10	1.6%
Tamarisk	10.1-20	.8%
Willow	20.1-30	8%
Rabbit Brush, Ephedra	30.1+	4.2%, 2.6%

Figure 3.4.3 Honaker Cross Section



3.4.1 Oljeto (River Mile 76)

Oljeto consisted of 6 distinct species detected by the transect (*Table 3.5.1)*. Of these, the highest percent cover included Flat/ Dwarf Grasses, Willow, Perennial Grasses, and Tamarisk (*Table 3.5.2*). Within the cross section, the highest point is 0.9m above the river, though this does not occur at the farthest point from the water's edge like the other transects. This high point occurs over a span of 42.8m, while the entire transect totals 57.8m in length (*Figure 3.5.3)*.

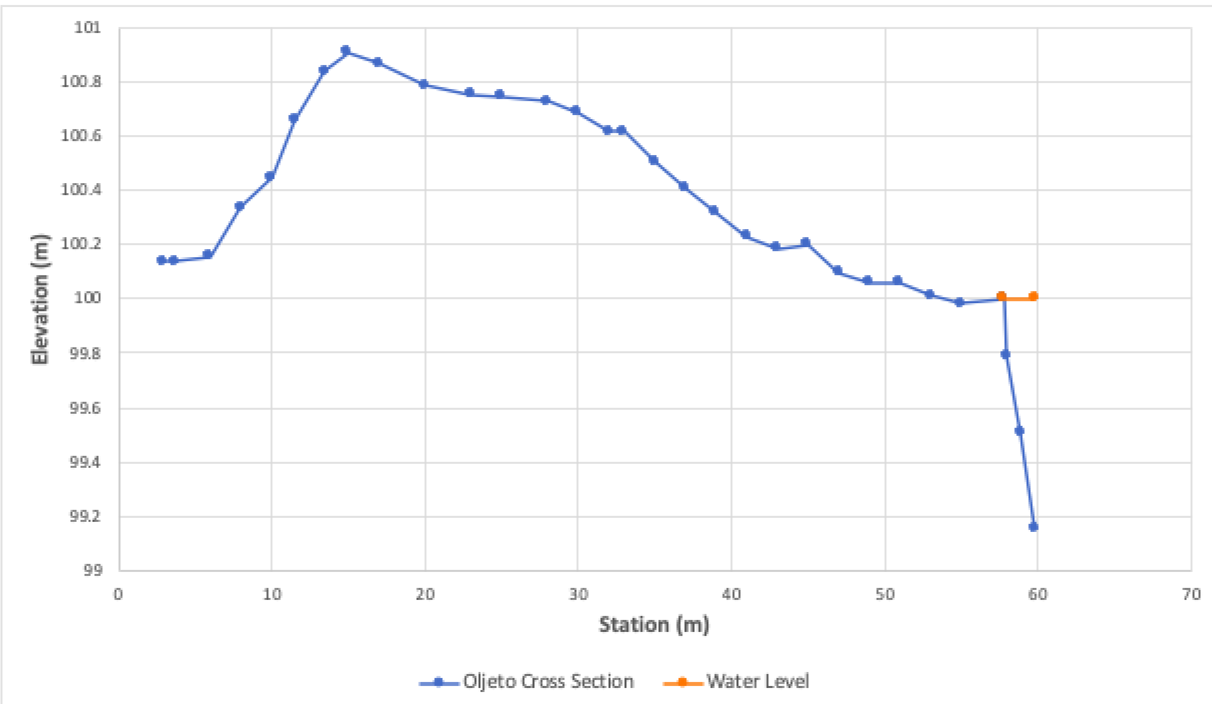
Table 3.5.1 Oljeto Vegetation Transect Data (River mile 76)

Species/Substrate	**Intervals (m)**
Flat/Dwarf Grass	0.8-0.9
Willow	23.8-29.9, 42.7-47.8, 48.3.-49.4
Grass	36.3-36.8, 37.4-37.7, 38.0-45.2
Tamarisk	37.3-42.7
Seep Willow	39.0-39.6
Thistle	44.1-44.2

Table 3.5.2 Oljeto Summary Table

Dominant Species	**Interval (m)**	**% of Total Cover**
Flat/ Dwarf Grass	0-10	.2%
NA	10.1-20	0%
Willow	20.1-30	12.2%
Grass, Tamarisk	30.1+	16%, 10.8%

Figure 3.5.3 Oljeto Cross Section



V. Discussion

3.1 Sand Island

At the Sand Island site, the dominant plant cover closest to the water are willow seedlings. This reveals that this wet bar may be newly uncovered, whereas it had been previously engulfed by water. This is because willows have high water demands, particularly in younger stages, but none of the seedlings had grown large enough to imply that the current wet bar was a historic water level. Likewise, young willows are able to grow very quickly when their roots are in direct contact with water, meaning it would not take long to establish to the degree it was present in (Stevens, n.d.). Comparatively, we see willows of increasing age farther back, revealing a retreat of water over time. Because willows do poorly in dry, upland soils, it means there had to be water closer by when the plants had first established. In addition to young willow on the far edge of the sandbar away from the water, young cottonwood appears. Like willow, young cottonwoods are seen as part of early successional communities, further reaffirming the water level's retreat that revealed a new colonization site (Stevens, n.d.). They tend to decrease in dominance with increasing sediment accumulation and give way to other species, potentially explaining why their presence is sparse farther away in the flood terrace (Stevens, n.d.). Farthest from the river is Russian olive, which is both a drought-tolerant and invasive plant (Nagler 2011). It likely was able to colonize a drier region due to the changes in water levels leaving historic floodplain soils dry.

Overall, this region farther east in the San Juan River reveals a clear difference in the dominant cover based on lateral distance from the river. Likewise, it demonstrates how water dynamics continue to evolve and transform the vegetation communities that exist alongside it.

3.2 River House

Opposite to the observations in Sand Island, River House was dominated by Russian Olive closest to the river. However, these findings are reconciled by the idea of disturbance. Russian olive is tolerant to flood events, potentially indicating more frequent flooding occurring along the banks at River House as opposed to Sand Island (Nagler 2011). The banks along River House are relatively gradual, allowing rising water to easily travel along the land.

In the farther sections of the riparian zone, tamarisk becomes a more common cover type despite there being less overall cover. Similar to Russian Olive, tamarisk notably is able to endure tolerance and has a deeper root system that allows it to outcompete species like willows and cottonwoods (Nagler 2017).

In general, the area has higher amounts of tolerant species. This is likely due to disturbance both in the form of drought in the upland region and flood in the lower elevations close to the river, requiring resilience in order for a plant to establish itself.

3.3 Pontiac

The sections closest to the river consist mostly of Coyote Willow, which prefer gravel bars closer to water (Stevens, n.d.). This being the rockiest site data was collected, the prevalence of this species is not unexpected. Interestingly, though, the topography 20m away from the river decreases in elevation; at the 30m station, however, a steep incline begins. Within the 20-30m range, the Coyote willow is not the dominant cover. Instead, Coyote Brush is more common. After this dip in elevation for 10m, the prevalence of Coyote Willow is once again reasserted alongside tamarisk and Knapweed. This may imply that this area is less prone to disturbance like drought, because its morphology would catch runoff more easily. This could make Coyote brush able to act as a stronger competitor than more drought tolerant species. In the upper reaches, however, the tamarisk, Coyote Willow, and Knapweed are stronger competitors due to a reputation for drought tolerance (Nagler 2017 & Henry 2004).

3.4 Honaker

Unlike other sites, tamarisk dominance occurred in sections of the riparian zone closest to the water. Being a plant that has high water requirements, its occurrence here is logical but has not been observed otherwise within this study. This is largely because it tends to compete through having deeper roots, allowing for it to exist farther from the shore than other plants that also have equally high water requirements. An unexplored explanation could be its ability to endure harsh soil conditions, which tends to be more likely on steeper slopes such as this site (Siswanto 2019). Its dominance in reaches closer to the river may be a signal of erosive forces being at play.

Another surprise is the prevalence of cottonwood farther back. This could show that the area has experienced a large decline in average water levels, similar to Sand Island. As mentioned, cottonwoods require high water levels to establish (Stevens n.d.); thus the presence of cottonwoods farther back in a slope area may mean there had been more water there in the past.

Farthest back in the Honaker site, Rabbitbrush and Ephedra (Mormon tea) are dominant. Rabbitbrush prefers full sun and is an early colonizer; it has additionally been used as a plant that indicates highly degraded sites (USDA 2017). Likewise, Ephedra prefers rocky debris (Solins 2017). Like the section closest to the river, this area is also very steep and likely more easily eroded.

3.5 Oljeto

Though the area was primarily bare ground, enough dwarf and flat grasses were present in order to be captured by the transect. This could be indicative of the sand bar being newly uncovered and early successional communities beginning to grow. Regardless, Oljeto is a region prone to flash floods, meaning this section with a very gradual slope would be prone to disturbance.

Willows are more common farther back, acting either as an indicator of overall declining water levels or a testament to the occurrence of flash floods that may periodically change where the water level rests.

Perennial grasses dominate the area farthest from the stream, but closest to a dried tributary running alongside the San Juan river. Flash floods may encourage these early successional communities here. Slightly farther from the dried tributary, tamarisk again becomes common, likely due to its deep roots allowing for establishment away from the water.

3.6 Trends and Conclusions

Overall, the sites reveal diverse vegetation communities that do change over space laterally. However, the predictability of which plants would be present at a certain proximity varied, particularly in the Honaker site. This seems to reveal that although the existence of vegetation gradients are universal, the specific factors acting on vegetation and creating the gradient are highly dependent on location. Even within the same river, this difference can be quite clear.

Not explicitly analyzed, though worthwhile to note, is the presence of bare ground in data collection. One notable trend is that vegetation was often more sparse closer to the river's edge and percent cover generally increases as elevation and distance from the water's edge increases. This seems to indicate increasingly evolving communities, impacted by the changing base water levels of the San Juan River. Areas closer to the river may be more likely to be an early successional community as a result, while farther reaches may tend to be more established.

3.7 Shortcomings of the Experimental Design

Our experimental design, though attempting to be inclusive, does also contain potential faults. First, only one transect had been randomly chosen per site, meaning it may not be as representative compared to doing multiple randomly chosen transects. Likewise, since species were only counted if they were directly under the tape measure, this means it was a narrow window. Regardless, we deemed this to be the overall most representative choice for this study.

Additionally, the data collection crews varied by site. Though there were some standardization processes that were attempted (i.e., team data collection technique practice prior to study), each group may have incorporated small differences in technique that could have subtle effects on the overall result, particularly regarding transect placement and survey pole placement.

3.8 Future Research

Based on the findings in this study, future research should attempt to describe which factors are most important for determining the distribution of individual plants in the lower San Juan River basin riparian zones. Though we have been able to show a relatively strong gradient that exists laterally, the mechanisms for vegetation spread in each area are assumed to be different. Alongside this, model predictions of future distributions can be very useful for determining how the basin will change over time, and what this means for the basin's ecological viability in further years.

Works Cited

Accuweather Inc. (2022). *Bluff, Utah* [Weather data]. https://www.accuweather.com/en/us/bluff/84512/june-weather/336146

Auble, G. T., Scott, M. L., & Friedman, J. M. (2005). Use of individualistic streamflow-vegetation relations along the Fremont River, Utah, USA to assess impacts of flow alteration on wetland and riparian areas. *Wetlands*, *25*(1), 143-154.

Ewers, M. (2005, July). Combining hydrology and economics in a system dynamics approach: modeling water resources for the San Juan Basin. In *Proc., 23rd International Conference of the System Dynamics Society, July* (Vol. 1721).

Heil, K. D., & O'Kane Jr, S. L. (2003). CATALOG OF THE FOUR CORNERS FLORA VASCULAR PLANTS OF THE SAN JUAN RIVER DRAINAGE ARIZONA, COLORADO, NEW MEXICO AND UTAH. *Harvard Papers in Botany*, 321-379.

Henry, C. (2004). Russian Knapweed Management in Riparian Areas Improves Wildlife Habitat. *Techline*.

Nagler, P. L., Glenn, E. P., Jarnevich, C. S., & Shafroth, P. B. (2011). Distribution and abundance of saltcedar and russian olive in the western united states. *Critical Reviews in Plant Sciences*, *30*(6), 508–523. https://doi.org/10.1080/07352689.2011.615689

Nagler, P. L., Nguyen, U., Bateman, H. L., Jarchow, C. J., Glenn, E. P., Waugh, W. J., & van Riper, C. (2018). Northern tamarisk beetle (*diorhabda carinulata*) and tamarisk i(*tamarix* spp.)nteractions in the Colorado River basin: Northern tamarisk beetle and tamarisk interactions. *Restoration Ecology*, *26*(2), 348–359. https://doi.org/10.1111/rec.12575

Rondeau, R., Bidwell, M., Neely, B., Rangwala, I., Yung, L., & Wyborn, C. (2017). *Pinyon-juniper landscape: San Juan Basin, Colorado Social-Ecological Cimate Resilience Project* (Doctoral dissertation, Colorado State University. Libraries).

Siswanto, S. Y., & Sule, M. I. S. (2019, December). The Impact of slope steepness and land use type on soil properties in Cirandu Sub-Sub Catchment, Citarum Watershed. In *IOP Conference Series: Earth and Environmental Science* (Vol. 393, No. 1, p. 012059). IOP Publishing.

Solins, J. (2017). Riparian vegetation in the Grand Canyon: Multiple priorities influence management options.

Stevens, M., Fenchel, G., & Hoag, C. (n.d.). *Coyote Willow*. USDA & NRCS. Retrieved July 6, 2022, from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.369.2586&rep=rep1&type=pdf

USDA. (2017). *Field Guide for Managing Rabbitbrush in the Southwest* . USDA Forest Service. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd563029.pdf

USGS. (2022). *National Water Information System: Web Interface* [Government Hydrological Provisional Data]. USGS 09379500 SAN JUAN RIVER NEAR BLUFF, UT; USGS. https://waterdata.usgs.gov/ut/nwis/uv?cb_00010=on&cb_00020=on&cb_00035=on&cb_00036=on&cb_00045=on&cb_00052=on&cb_00060=on&cb_00065=on&cb_00095=on

&cb_00300=on&cb_00400=on&cb_63680=on&cb_75969=on&format=gif_default&site_no=09379500&period=&begin_date=2022-06-17&end_date=2022-06-24