Longitudinal Variation in the Vegetation Community on the San Juan River

A classic cobble bar and mix of native and nonnative vegetation can be seen in a section of the San Juan river (Photo by Ramya Chandrasekaran)

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1 July 2022
Ecogeomorphology 2022
University of California, Davis

ABSTRACT

In this paper, we analyze the longitudinal changes in vegetation composition along a 76-mile stretch of the San Juan River in southern Utah. The San Juan River woody canopy community is dominated by two primary invasive species competing with two primary native species. The two primary invasive species, Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix spp.*), have flourished in the San Juan River, perhaps due to the altered hydrological regime from management of Navajo Dam (1962) and the sediment accumulation upstream of Glen Canyon Dam, which have placed the native willow (*Salix exigua*) and cottonwood (*Populus fremontii*) at a competitive disadvantage. In this study we conducted line-intercept vegetation surveys in mid-June 2022 at four separate locations along the San Juan river in an effort to document changes in the vegetation composition moving downstream along the five sites sampled from Sand Island to Oljeto Wash. We suggest that shifts from coyote willow to seepwillow and tamarisk reflects sediment accumulation from Glen Canyon dam transforming the downstream sites' floodplains into sandy ones, and that invasion of the primary nonnative species at the upstream sites are more reflective of historic establishments persistent with hydrological conditions set by Navajo Dam.

INTRODUCTION

Riverine vegetation is a critical component of watershed ecosystems. Vegetation performs many important ecological services such as stabilizing banks, increasing water quality, and supporting biodiversity (Cho et al., 2019). Vegetation also provides habitat and a food source for birds and other animals.

In the San Juan River Basin, native riverine plants, such as coyote willow (*Salix exigua*) and cottonwood (*Populus fremontii*), are adapted to an unregulated flow regime. Peak spring flows from snow melt and low summer flows likely were not crucial for their growth and seedling recruitment. The San Juan River originates as snowpack in the San Juan mountains of Colorado and flows 383 miles westward through New Mexico and Utah, into Lake Powell. Since 1962, though, the construction of the Navajo Dam in the upper part of the San Juan basin has resulted in a much more regulated flow regime.

Dams create physical changes to the hydrology, sediment regime, and channel morphology of the river, which impacts aquatic and floodplain species through modification of habitat and indirect interactions within the food web (Rood et al., 2005). Broadly, the impacts of Navajo Dam can be summarized as follows:

- Reduction in flood peaks caused by storms higher in the basin
- Increases in minimum flows
- Storage and accumulation of sediment above the dam
- Changes in seasonal flow patterns (Webb et al., 2001)

Managed flows from Navajo Dam reduce peak annual discharges downstream, and sustain moderate flows throughout the summer. The largest flood post-Navajo Dam yielded a discharge of around 38,500 cfs, whereas pre-dam, the largest recorded flood occurred in 1927 with a discharge of about 70,000 cfs (Webb et al., 2001). In the absence of natural flooding events, invasive tamarisk (*Tamarix spp.*) and Russian olive (*Elaeagnus angustifolia*) have become abundant at the expense of the native plant species. Willow and cottonwood have life histories which depend on the natural seasonality of San Juan flows, and regulated releases from Navajo Dam may have negatively impacted native species, opening the door for invasive vegetation encroachment (Hughes, 2015).

We can see the transformative impact of regulated flows from dams and the shift from native vegetation species towards a landscape dominated by non-native, invasive tamarisk and Russian olive (*Woody Invasive Species Management Plan*, 2008). Through comparing historic before and after photographs at several sites along the San Juan River from Bluff, NM, to the upper portions of the San Juan Canyon, we can see the change in river morphology (Webb et al., 2001). The channel shifts from a wide floodplain channel scattered with trees to a narrower, densely vegetated channel dominated largely by invasive Tamarisk and Russian olive, as well as some native Cottonwood and Coyote Willow. The San Juan still receives sediment supply from its tributaries downstream of Navajo Dam, such as the Animas River, but has a reduced ability to transport the sediment downstream due to the reduced peak flows and discharge (Webb et al., 2001). This dynamic has caused a gradual narrowing of the river channel. Side-channel and backwater habitats tend to fill in with sediment and organic debris without high peak flows to push the organic material downstream, enabling the Russian olive to flourish and form dense canopy monocultures (Bissonette, 2021).

The San Juan River has had a regulated flow regime since the construction of the Navajo Dam in 1962. This change in hydrology is critical to understanding the current vegetation community and what changes are expected in the future. Seedling establishment of tamarisk, cottonwood, and willow needs moist sediment and soil in both high and low flow years (Scott and Friedman, 2018). Therefore, climate change and a reduction in flows in the San Juan River could reduce the potential habitat for all plant species. Cottonwoods require a minimum flow volume and timing to set seed and compete with non-native encroaching species, such as tamarisk, and this equilibrium range is known as the cottonwood “recruitment box” (Rood et al., 2005). The flow requirements to support the life history of cottonwoods are rare under a regulated flow regime, giving year-round seeding tamarisk a competitive advantage over cottonwood (Hughes, 2005). The later peak flows support tamarisk, and the tamarisk establishment zone extends closer to the river relative to the willow because it continues to release seed much later in the season (Scott and Friedman, 2018). Thus, a common sight on the river is in the sections of the river without tamarisk, there are new shoots of willow close to but not lining the water’s edge, and then when tamarisk is present, it will form thick patches right along the bank of the river at the exclusion of willows.

Overall, the San Juan River riparian vegetation is primarily coyote willow (*Salix exigua*), cottonwood (*Populus fremontii*), tamarisk (*Tamarix spp.*), and Russian olive (*Elaeagnus angustifolia*), with some smaller native shrubs, such as rabbitbrush (*Chrysothamnus nauseosus*) and netleaf hackberry (*Celtis reticulata*). The sediment accumulation due to Glen Canyon Dam and Lake Powell and the lack of peak flows post-Navajo Dam to flush sediment downstream has homogenized vegetation in the upstream reaches closer to Bluff, UT, and created three different vegetation zones from river miles 46-84, due to the variation in sediment deposit regimes (Gianniny et al., 2019). Vegetation composition and how it changes along a river provide context for the health of the broader ecosystem. Therefore, motivating questions for our research and data collection are:

- How does vegetation vary along the San Juan River longitudinally between Sand Island (site 1) and Oljeto Wash (site 5)?
- Does the variation in vegetation from upstream to downstream agree with the results of previous studies on the vegetation community?

METHODS

Study Site

This study was conducted from June 16-22, 2022 along the 76-mile stretch of the lower San Juan River. Five sites were sampled: Sand Island, River House, Pontiac, Honaker, and Oljeto at approximate river miles 0, 6, 36, 46, and 76, respectively.

We chose sample sites that were depositional zones of the river's bends, including cobble and sand bars, sometimes extending into upland habitats (e.g., with rabbitbrush). We also typically sampled on the side of the river that was most accessible. Within the study area, the southern bank of the river (river left) is on Navajo Reservation land. The northern side (river right) is managed by the Bureau of Land Management (BLM) land until near mile 50, where Bears Ears National Monument begins, and land management transitions to the National Park Service.

Vegetation Survey Procedures

We worked under the guidance of Dr. Truman Young, of the University of California, Davis, to conduct line-intercept vegetation surveys at five sites (Table 1). At each site, we ran a single, 50m transect tape (100m for River House) perpendicular to the flow of water, sometimes roughly parallel to topographic cross-section surveys, which were conducted simultaneously. We set the water's edge to be 0m on the transect. A brief description of each sampling location was recorded. We recorded the start and end of the interval of each type of plant that fell upon a vertical plane created by the tape measure. We recorded both plants on the ground as well as plant canopies that extended over the tape from above. Dead vegetation was also recorded on our transects across sites.

Table 1. Vegetation survey site locations along the San Juan River

Name of Survey Site	River Mile	Sampling Location
Sand Island (site 1)	0	Bank on river right adjacent to cobble bar downstream of Sand Island Boat Ramp
River House (site 2)	6	Downstream of sandy beach at River House 2 campsite on river right
Pontiac (site 3)	36	Downstream of Pontiac campsite on the bank on river left adjacent to cobble bar
Honaker (site 4)	46	Upstream of Honaker campsite on river left
Oljeto (site 5)	76	Vegetation patch and sand bar between the back channel and mainstem on river left at the Oljeto Wash campsite

* Sand Island was a qualitative analysis, quantitative data was acquired for the other four sites

Data Analysis

To analyze the line-intercept data, the intervals of each plant's presence along the transect were organized by plant species. These intervals were then summed and totaled for each plant species. The summed intervals for each plant species were divided by the transect length to estimate the aerial vegetative cover acrossg the longitudinal transect stretch sampled. This value was expressed as a percent total vegetation coverage.

The dominant species at each site in terms of percent coverage was determined, to analyze the changes in the dominant species in the community moving from upstream to downstream. We compared our vegetation transect data with existing reports of vegetative communities along the same stretch of the San Juan River.

RESULTS

Species Found Across Sites

Analysis and comparison of species at each site, moving from upstream to downstream between Sand Island (site 1) and Oljeto (site 5), reveals that certain plant species were consistently found at several locations while some species appeared or disappeared as we moved downstream. Coyote willow was observed across all 5 sites, with the exception of River House (Site 2). Tamarisk was observed at every site sampled in this study. Cottonwood, Russian olive, side sedge, camelthorn, knapweed, low grass, snakeweed, and sonchus were all absent from our transects downstream of River House. Perennial grass and Indian rice grass appeared on our River House transect and reappeared on our transects at the downstream sites. Seep willow and sumac were observed at Pontiac (Site 3). Mallow, skeleton weed, biological soil crust, ephedra, and prickly pear cactus were sampled at Honaker (Site 4). Seep willow, flat dwarf grass, and thistle appeared on the Oljeto (Site 5) transect (Table 2). Controlling for a variation in transect length, at Honaker (Site 4), the greatest number of plant speciess were recordeded (10 spp.). Honaker was followed by River House (site 2), Sand Island/Oljeto (Site 1/Site5), and Pontiac (Site 3), with 7, 6 and 5 plant species recorded, respectively.

Table 2. List of species and the sites where they were found on the line-intercept transects. An X indicates the species was found on the transect line setup at the site and a blank cell indicates that the species was not found at the site.

	Site				
Species	**1. Sand Island, Mile 0**	**2. River House, Mile 6**	**3. Pontiac, Mile 30**	**4. Honaker, Mile 46**	**5. Oljeto, Mile 76**
Coyote Willow	X		X	X	X
Cottonwood	X	X			
Russian Olive	X	X			
Side Sedge		X			
Tamarisk	X	X	X	X	X
Rabbit Brush	X	X		X	
Knapweed	X	X	X		
Perennial Grass		X		X	X
Camelthorn		X			
Low Grass		X			
Indian Rice Grass		X		X	
Snakeweed		X			
Sonchus		X			
Seep Willow			X		X
Sumac			X		
Mallow				X	
Skeleton Weed				X	
Biological Soil Crust				X	
Ephedra				X	

Prickly Pear Cactus				X	
Flat/Dwarf Grass					X
Thistle					X

Sand Island (Site 1)

We were unable to conduct a quantitative analysis at our first sampling site and acquire data on total vegetation coverage and vegetation diversity; however, we did make some observations regarding the vegetation community and the dominant vegetation types for the different habitat types present. Moving inland away from the river, we observed a gradient of seedlings to older Coyote Willows. There was also a progression of cottonwood seedlings and saplings to more mature and older coyote willows while Russian olive. It is also important to note that we observed tamarisk, knapweed, and rabbitbrush at this site that were not included in the qualitative transect (Table 3).

Table 3. Sand Island, Mile 0: Qualitative Assessment of Vegetation.

Habitat Type	**Species**
Wet bar	Coyote willow seedlings
Edge of the bar	Young coyote willow and young cottonwood
Flood terrace	Mature/larger coyote willows
Old historic floodplain (dry)	Older coyote willow and Russian olive
-	Tamarisk, knapweed, rabbit brush

River House (Site 2)

Aerial cover of the plant species along the River House (Site 2) transect, in order of decreasing abundance, were Russian olive (40.9%), cottonwood (32.0%), side sedge (11.2%), and tamarisk (10.2%) (Figure 1). Side sedge and Russian olive primarily occupied the river bank, followed by tamarisk and cottonwood moving inland along the transect. River House was the only site where willows were absent from our transect. This site had the greatest species richness with 12 unique species, but importantly a 100m transect was used, whereas 50m transects were conducted at the other sites. River House presents a more complete view of the vegetation community at the site but must be adjusted when comparing between sites. In the first 50m of the transect, the species richness was 7 instead of 12. Five novel species (camelthorn, low grass, Indian ricegrass, snakeweed and Sonchus) were observed in the last 50-100m of the transect. Adjusting this data to represent the first 50m for comparison to the other transects, we see the same order of abundance in our dominant species: 53.0% Russian olive, 16.6% cottonwood, 14.5% side sedge, and 13.3% tamarisk. (Figure 2).

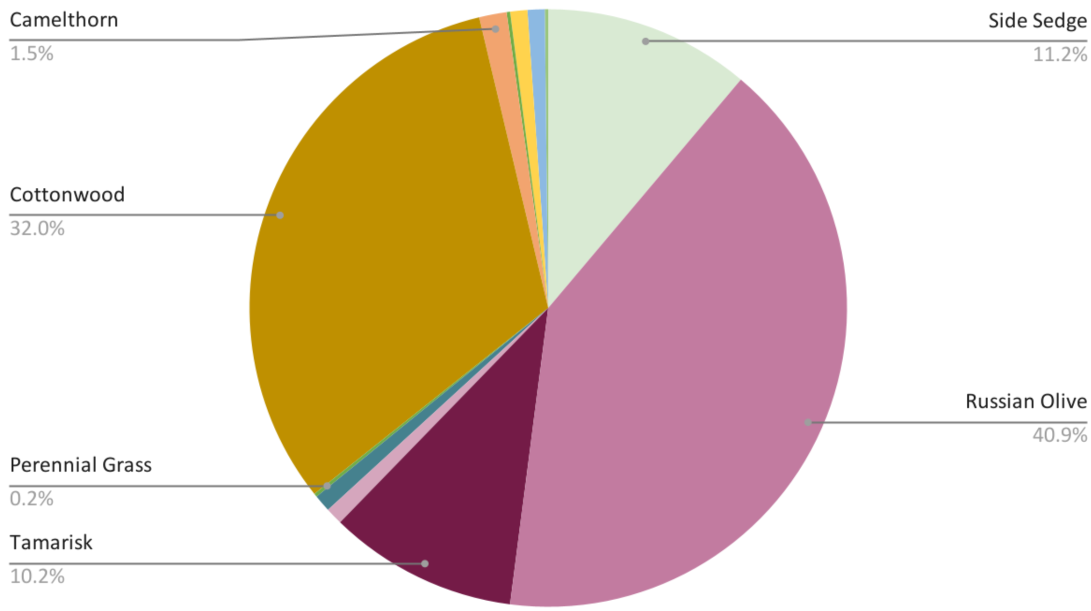

Figure 1. River House, Site 2: Relative cover by species for 100m transect

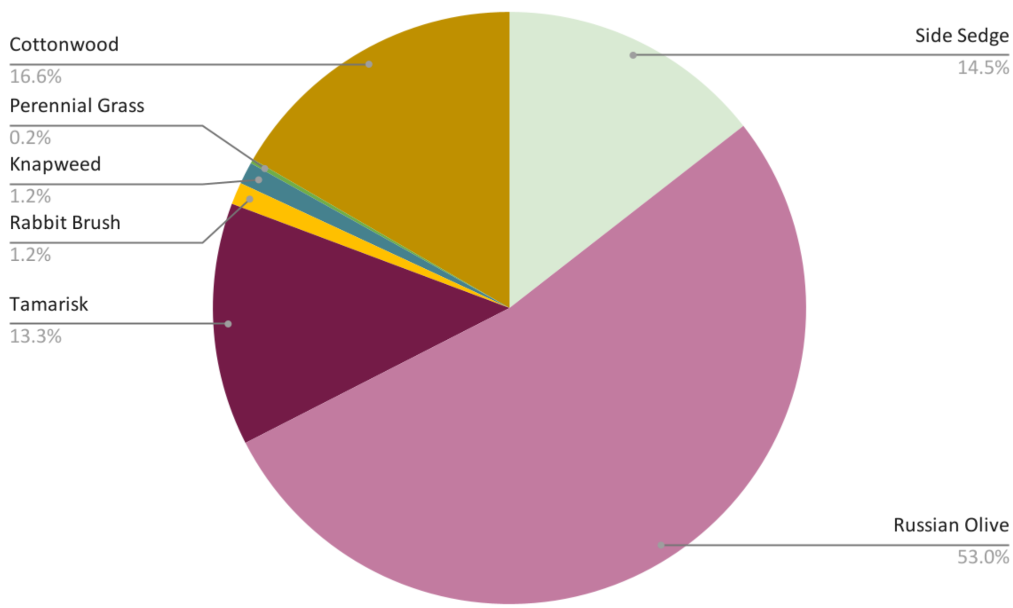

Figure 2. River House, Site 2: Relative cover by species for first 50m of the 100m transect.

Pontiac (Site 3)

Aerial cover of the plant species in decreasing order of abundance observed at Pontiac was coyote willow (42.6%), tamarisk (20.6%), and knapweed (20.6%), and the species richness of our sample was 5 (Figure 3). This site had the lowest total vegetation coverage of 13.6% of the total 50m sampled, but the greatest percentage of coyote and seep willow, which occupied the river bank habitat from 8.0-38.7 meters from the river's edge. From 38.7-50.0 meters, knapweed, tamarisk and sumac dominated in successive order.

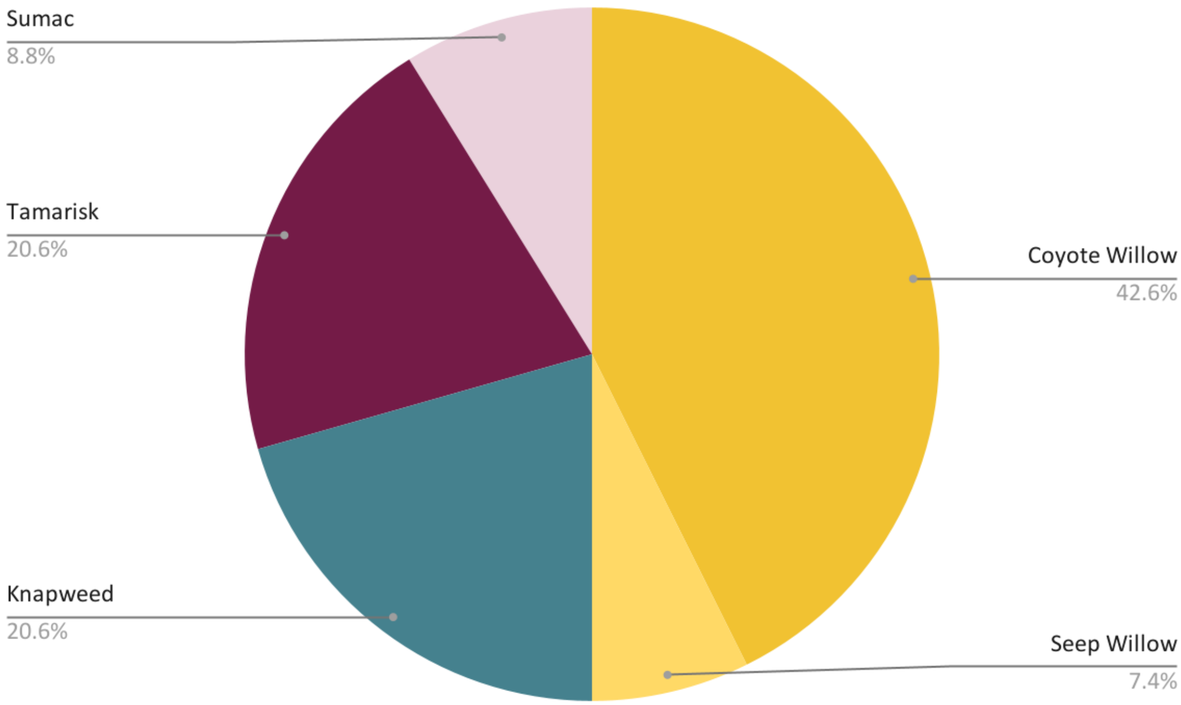

Figure 3. Pontiac, Mile 30: Relative cover by species.

Honaker (Site 4)

Aerial cover of the plant species in decreasing order of abundance at Honaker included rabbit brush (29.9%), biological soil crust (18.18%), tamarisk (16.88%), and coyote willow (14.29%), and we observed 10 unique species (Figure 4). Perennial grasses and tamarisk made up the river bank habitat from 5.0-5.1 meters and 9.2-10.5 meters, respectively. Of the 50-meter transect sampled, the total vegetation coverage was only 15.4%. This site's vegetative community was mainly of native plants, with the exception being tamarisk.

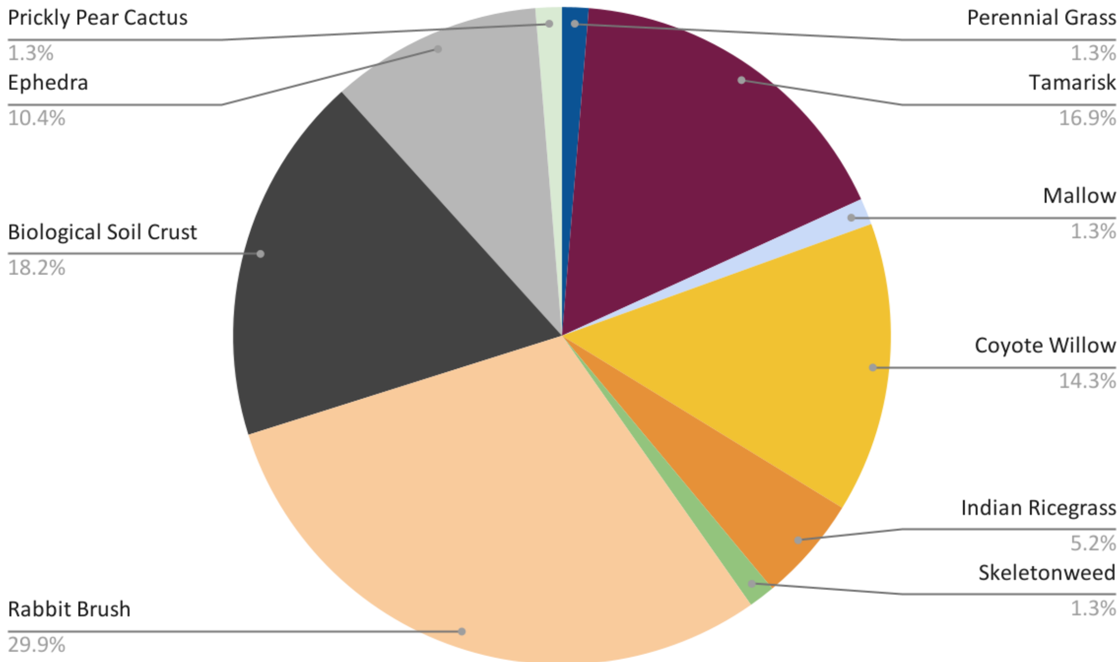

Figure 4. Honaker, Mile 46: Relative cover by species.

Oljeto (site 5)

Aerial cover of the plant vegetation in decreasing order of abundance at Oljeto was coyote willow (48.7%), perennial grasses (30.2%), and tamarisk (18.1%), and we found 6 different species on our transect (Figure 5). This substrate of this site was primarily fine-grain sand. The first 23 meters of the transect had a small patch of flat/dwarf grasses just off the river bank, the middle section was primarily bare ground, and a community of willows and tamarisk made up the vegetation cover close to the end of the 50m.

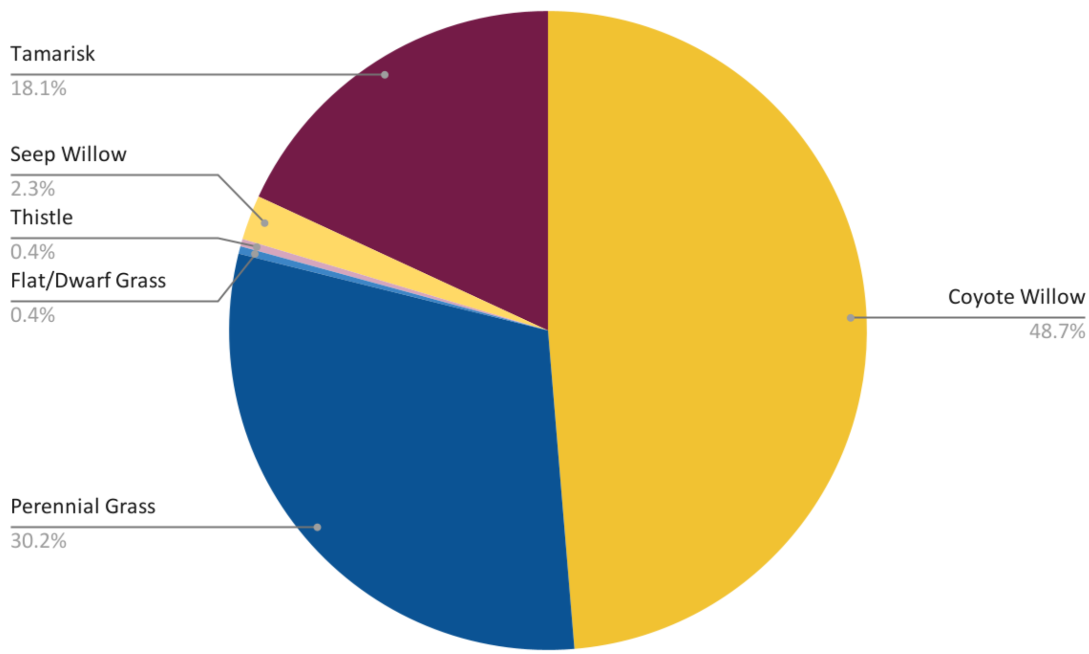

Figure 5. Oljeto, Mile 76: Relative cover by species.

<u>Summary of Vegetation Cover and Species Composition Across Sites</u>

Combining the vegetation cover and the relative abundance of each species for the four sites where we conducted line-intersect sampling, we see that River House has the highest vegetation density, followed by Oljeto, Honaker, and finally Pontiac, respectively. Russian olive composed over half of the vegetation found along the transect, Pontiac and Honaker had relatively low abundances of all species observed, and coyote willow and tamarisk were dominant at the Oljeto site (Figure 6).

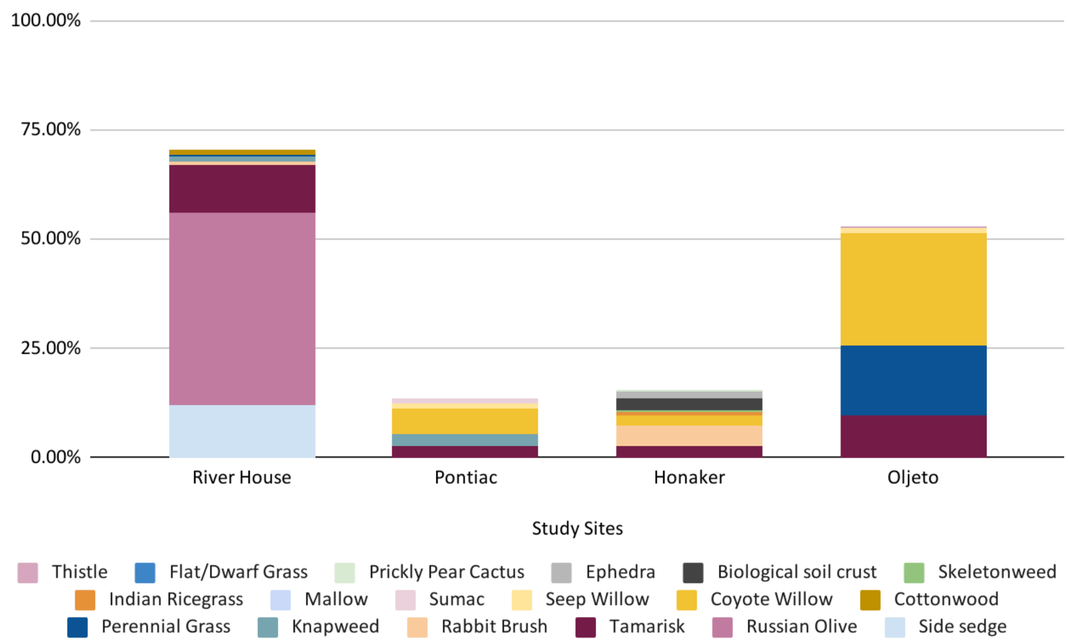

Figure 6. Cumulative species coverage and relative coverage per species across study sites.

DISCUSSION

How does the vegetation along the San Juan River vary longitudinally between Sand Island campground to Oljeto Wash?

Dominant Native and Invasive Species Relationship

River House was the only site that had no willows, and was dominanted by Russian olive. This result is consistent with previous evidence that the Russian olive tends to displace native willows in the area (Bissonette, 2021). Russian olive alters ecosystem processes and nutrient cycling through high nitrogen fixation and high levels of decay-resistant leaf litter inputs (Bissonette, 2021). Additionally, in the absence of high peak flows to push material downstream, side-channel and backwater habitats tend to infill with sediment and organic debris. This habitat change allows the Russian olive to flourish and form dense canopy monocultures (Bissonette, 2021). These side-channel and backwater habitat types are utilized by endangered native fishes, such as the Colorado pikeminnow, humpback chub, and razorback sucker.

Additionally, native birds such as the endangered Southwestern Willow Flycatcher and the threatened Yellow-Billed Cuckoo that rely on the native willow and cottonwood trees are being excluded by Russian olive and tamarisk. Willow and cottonwood continue to be replaced by Russian olive and tamarisk, reducing essential habitat for these bird species (Hughes, 2015). Given the problems associated with Russian olive removal efforts have been highlighted in the most recent San Juan River Restoration Plan (Bissonette, 2021). At Oljeto, we found that coyote willow and tamarisk dominated the vegetation composition without the presence of the Russian olive. A similar abundance of tamarisk was found between River House and Oljeto, suggesting that Russian olive impacts native willow negatively but may have little effect on tamarisk

(Figure 6). Sand Island was the only other site where Russian olive was present, in addition to River House, and did have some coyote willow present (Table 2). However, we did not collect quantitative evidence at Sand Island; therefore, we are unable to compare the coyote willow abundances to those found along our other transects to further inform this relationship between invasive Russian olive and native willows.

Cottonwood and Russian olive were not observed along our transects downriver from River House (Table 2). Russian olive's disappearance may be attributed to it needing time to establish downstream, especially with the lower flows not reaching historic floodplains. However, given cottonwood is native to San Juan's riparian habitats, this observation may be more significantly attributed to the decline in scouring flows that create floodplain habitats (Basset, 2015, and T. Young, pers. comm.).

Other Trends and Observations

- We only observed biological soil crust at Honaker, even though two other sites were also positioned on river left. We can infer that this soil crust may have had a localized, non-hydrological mechanism because it was found 43.0-44.4 along the transect far from the river's edge (Appendix A).
- Seep willow appeared on our transects at Pontiac and Oljeto but was not recorded on our Honaker transect, even though coyote willow and tamarisk were found across all three sites (Table 2). Given that we only ran one transect, seep willow could have been present in our system but at a much lower abundance, such that our single transect did not intersect any seep willow individuals.

Does the variation in vegetation from upstream to downstream agree with the results of previous studies on the vegetation community?

Previous studies on the vegetation community of the San Juan River area that we sampled have been focused on the portion of the San Juan River just upstream of Glen Canyon Dam and Lake Powell. Morris (2016) identified three distinct vegetation zones: (1) above the sediment wedge, (2) on the upper sediment wedge, and (3) on the lower sediment wedge. The sediment wedge is a gradient of lake deposits formed from the reduction in flow rate created by the Lake Powell reservoir. These lake deposits are overlain by river deposits as you move upstream, which are a product of the reduction in pulse flows post-Navajo Dam. A recent presentation on these vegetation zones proposed a feedback loop, where a reduction in stream gradient contributes to a reduced ability to transport sediment and a corresponding increase in sediment accumulation, which both further reduce stream gradient, perpetuating the negative feedback loop. This feedback loop subsequently increases streambank vegetation (Gianniny et al., 2019). Areas above the sediment wedge are characterized by sparse vegetation with varying willow density and represents river miles 46 through 66. The Honaker site falls in this vegetation zone, and had one of the lowest total vegetation coverages (15.4%). The lower sediment wedge is from river miles 71-84, incorporating our Oljeto site, and tamarisk and taller plants (1.5 to >2.5 meters) are indicators of this vegetation zone, which we found along our transects.

Morris also observed shifts from coyote willows to seep willows post-dam. This shift may reflect the altered hydrological regime from historically summer monsoon-based high flows to dam-controlled high winter flows. Coyote willows tend to flower from March to May, whereas the seep willows flower from October through March. The sediment accumulation from the Glen Canyon Dam, creating the sediment wedge, may also be creating a sandy floodplain habitat favorable for seep willows (Salix exigua 2019; Baccharis salicifolia 2020).

Seep willows composed 7.4% and 2.4% of the vegetation cover at the Pontiac and Oljeto sites, respectively (Figures 3 and 5). Given that Navajo Dam was constructed in 1962, we would expect to see more seep willows in our transects, meaning their absence from the Honaker site is unexpected (Table 2). If we were to increase our sampling effort (see below), we might have captured seep willow at Honaker. In addition to the shift in willows, Morris noted a shift from cottonwood and coyote willow-based riparian communities to tamarisk, Russian olive, and native shrub-based riparian communities (including rabbitbrush and netleaf hackberry). Russian olive was present, and willow was absent at River House (Figure 2), while willow was most abundant at Oljeto, where Russian olive was not recorded (Figure 5).

However, we didn't encounter netleaf hackberry on our transects (although it did occur in our lower sites), and rabbitbrush was abundant only at the Honaker site, composing 29.9% of the vegetation (Figure 4). Similar to the rationale for seep willows, we expect to see more of these species as shrubification occurs in this system. This shift towards woodier vegetation creates a feedback loop, acting as a catchment for sediment and benefiting invasive species. Although the initial time of establishment is unclear, the Russian olive was introduced to stabilize river banks for settlement and agricultural development (pers. comm., T. Young). Although willows are effective at stabilizing banks and providing native habitat, the less woody nature of these plants allows the banks to ebb and flow with the river, which would not align with permanent anthropogenic establishments.

Sources of Error

One limitation of this study was that only one transect was conducted per site. While a low number of transects likely still reflect the general composition of riverine vegetation communities, when considering species diversity, more transect replicates could likely have captured a more accurate number and cover of species.

Categorizing certain grasses and sedges as "perennial," "dwarf," and "side" may have helped to paint a general picture of the vegetation community at the sampling sites, but these generic classifications were insufficient during data analysis to determine whether these species were native or non-native. Additionally, our visually-based assignments of plant species could have been incorrect since we did not have other forms of identification to back up the classifications, and had to rely on the field expertise of Dr. Young.

At the beginning of our study period, the flows were low at about 500 cfs relative to the historic median of about 4000 cfs recorded at the Bluff USGS site in the same time period. However, on 18 June, the basin experienced a heavy storm, which resulted in higher flows in the following days, peaking at about 2000 cfs on 21 June (Figure 7), representing an increase in water levels of 2-3 feet. The bars and habitats we surveyed were absent of vegetation for the first 2.0-8.2 meters. Morris (2016) used a vegetation survey method similar to ours–100m transects were drawn at the third division of the quartered stream bank running perpendicular to the direction of flow–however, Morris began the transects at the start of vegetation near the river, whereas we started the transect at the water's edge. Changes in the channel width via higher flows would naturally change the extent inland of our set 50-meter transect; therefore, the percentages of vegetation coverage found. The consistency of Morris's transect selection process could establish a more reliable comparison between sites since the reach of a river bend's flow varies along the curvature.

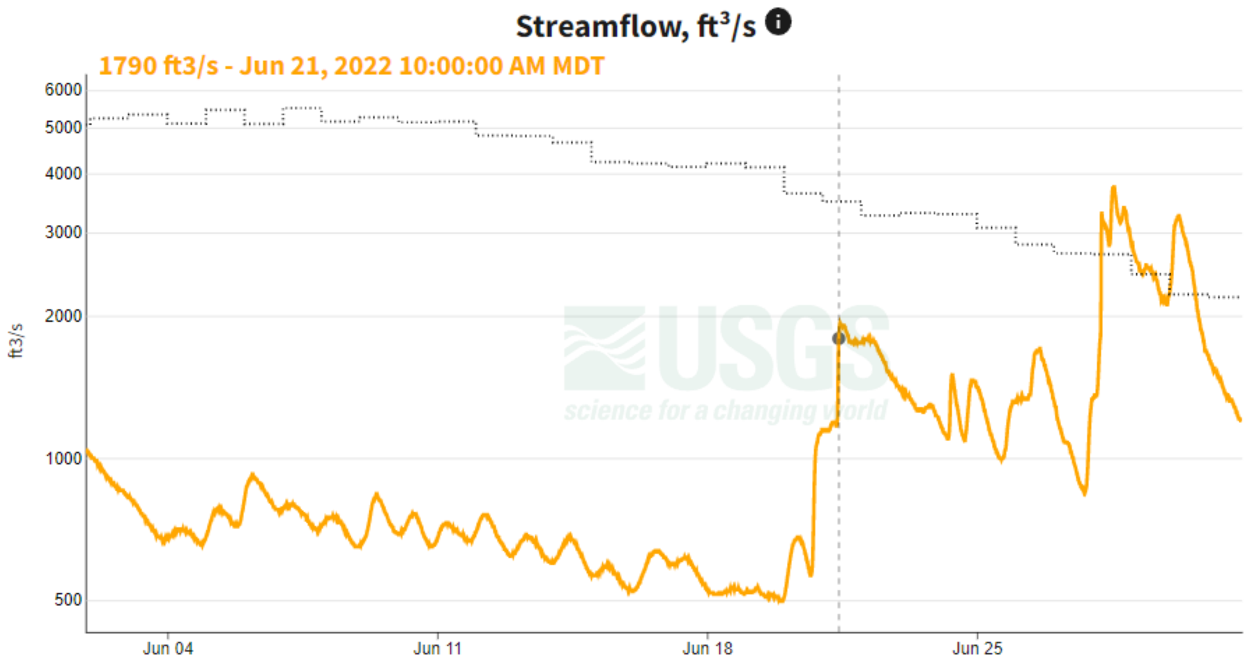

Figure 7. Discharge data at USGS site 09379500 at Bluff, UT for June 2022 (USGS 2022).

We conducted our samples using single line-intercept transects at each site, which can be a limited representation of the natural variation in vegetation. Methods to obtain more complete representations of the vegetation community include running several transects at each study site and supplemental drone or satellite imagery to analyze canopy cover vegetation. Random determination of each transect meant that some of the less abundant vegetation species may have been absent from our transect line; however, our goal was to determine the dominant vegetation species at each site to reasonably compare the dominant species and draw conclusions based on their presence and abundance. The location of our vegetation survey transects was decided on a spatial basis to be near cross-sections, rather than trying to encapsulate the community of the site.

Finally, we saw varying diversity across sites in terms of the number of unique species. However, we sampled a diversity of habitats, each supported by different sediment compositions, making a diversity comparison moving downstream unrealistic given our small sample size. Characterization of the sedimentary habitats could give us an idea of what substrates are present at each site and allow us to consider how that impacted the vegetation community we were able to measure on our transect lines. We could use this characterization to explain why we observed seep willow at Pontiac (site 3), which is further upstream of Morris (2016)'s sediment accumulation zone. It could also provide clues as to why we did not observe any seep willow at Honaker (site 4), which is also above the sediment accumulation zone, but between Pontiac (site 3) and Oljeto (site 5), where seep willow was present (Table 2).

ACKNOWLEDGEMENTS

This study was made possible thanks to both the University of California, Davis, Center for Watershed Sciences and the Department of Earth and Planetary Sciences. We would like to thank the donors who made this research possible and the Prescott College team, who helped facilitate logistics to make this project a reality. Most importantly, we appreciate our instructors for their unmatched interdisciplinary teaching and support, mentorship, and guidance throughout this course.

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APPENDIX

Appendix A. Vegetation Survey Raw Data from River House, Pontiac, Honaker, and Oljeto Sites

Site	**Plant**	**Lower Limit (meters)**	**Upper limit (meters)**	**Interval Totals (meters)**	**Sum of Intervals (meters)**
River House Mile 6	Side Sedge	2	8	6	6
River House Mile 6	Russian Olive	5	13	8	22
River House Mile 6	Russian Olive	14	22	8	
River House Mile 6	Russian Olive	23.5	26.5	3	
River House Mile 6	Russian Olive	36	39	3	
River House Mile 6	Tamarisk	22	22.5	0.5	5.5
River House	Tamarisk	29	34	5	

Mile 6					
River House Mile 6	Rabbit Brush	22.5	23	0.5	0.5
River House Mile 6	Knapweed	23	23.5	0.5	0.5
River House Mile 6	Perennial Grass	41	41.1	0.1	0.1
River House Mile 6	Cottonwood	40.1	44.5	4.4	17.2
River House Mile 6	Cottonwood	47.5	53	5.5	
River House Mile 6	Cottonwood	55.7	56	0.3	
River House Mile 6	Cottonwood	57.5	64.5	7	
River House Mile 6	Camelthorn	52.4	53.2	0.8	0.8
River House Mile 6	Low Grass	82.3	82.4	0.1	0.1
River House Mile 6	Indian Ricegrass	94.4	94.6	0.2	0.5
River House Mile 6	Indian Ricegrass	97.7	98	0.3	
River House Mile 6	Snakeweed	98.5	99	0.5	0.5
River House Mile 6	Sonchus	99.9	100	0.1	0.1
River House Mile 6	Sonchus				53.8
Pontiac, Mile 30	Coyote Willow	8.2	8.6	0.4	2.9
Pontiac, Mile 30	Coyote Willow	12.9	13.5	0.6	
Pontiac, Mile 30	Coyote Willow	36	36.2	0.2	
Pontiac, Mile 30	Coyote Willow	37	38.7	1.7	
Pontiac,	Seep Willow	27.7	28.2	0.5	0.5

Mile 30					
Pontiac, Mile 30	Knapweed	43.4	44.8	1.4	1.4
Pontiac, Mile 30	Tamarisk	44	45.4	1.4	1.4
Pontiac, Mile 30	Sumac	51.6	52.2	0.6	0.6
Pontiac, Mile 30	Sumac				6.8
Honaker, Mile 46	Perennial Grass	5	5.1	0.1	0.1
Honaker, Mile 46	Tamarisk	9.2	10.5	1.3	1.3
Honaker, Mile 46	Mallow	22.7	22.8	0.1	0.1
Honaker, Mile 46	Willow	23	23.5	0.5	1.1
Honaker, Mile 46	Willow	24.6	25.2	0.6	
Honaker, Mile 46	Indian Ricegrass	25.1	25.5	0.4	0.4
Honaker, Mile 46	Skeleton Weed	25.5	25.6	0.1	0.1
Honaker, Mile 46	Rabbit Brush	29.9	31.2	1.3	2.3
Honaker, Mile 46	Rabbit Brush	32.6	33.2	0.6	
Honaker, Mile 46	Rabbit Brush	34.5	34.9	0.4	
Honaker, Mile 46	Biological Soil Crust	43	44.4	1.4	1.4
Honaker, Mile 46	Ephedra	45	45.8	0.8	0.8
Honaker, Mile 46	Prickly Pear Cactus	46.8	46.9	0.1	0.1
Honaker, Mile 46	Prickly Pear Cactus				7.7
Oljeto, Mile	Coyote Willow	48.3	49.4	1.1	12.9

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Oljeto, Mile 76	Coyote Willow	42.1	47.8	5.7	
Oljeto, Mile 76	Coyote Willow	23.8	29.9	6.1	
Oljeto, Mile 76	Perennial Grass	38	45.2	7.2	8
Oljeto, Mile 76	Perennial Grass	37.4	37.7	0.3	
Oljeto, Mile 76	Perennial Grass	36.3	36.8	0.5	
Oljeto, Mile 76	Flat/Dwarf Grass	0.8	0.9	0.1	0.1
Oljeto, Mile 76	Thistle	44.1	44.2	0.1	0.1
Oljeto, Mile 76	Seep Willow	39	39.6	0.6	0.6
Oljeto, Mile 76	Tamarisk	37.3	42.1	4.8	4.8
Oljeto, Mile 76	Tamarisk				26.5