Going with the Flow:
Relationship Between Sediment Deposition and Vegetation Establishment Along the Yampa and Green Rivers

Students in the UC Davis Ecogeomorphology class collecting topographic, fish, and aquatic insect surveys in Dinosaur National Monument

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INTRODUCTION

Alteration of freshwater systems has paved the way for advances in agriculture, transportation, and urbanization for centuries. Today, only around one-third of the world's long rivers (over 1,000 km long) remain free-flowing. In North America, 75 percent of long rivers are either dammed or disrupted (Lovgren 2019). This rearrangement of freshwater movement has resulted in mass changes in river flow and sediment regimes. Alterations of natural flow regimes pose risks to important ecosystem functions, especially when flow regimes fail to trigger functional ecological processes (Yarnell et al. 2015). Many riparian wildlife and plant species have adapted to specific temporal and physical requirements of flow and sediment movement. As flow regimes sustain alluvial river ecosystem health and diversity, the implications of flow and sediment regime change are necessary for societies to understand.

Hydroelectric dams create a management dilemma where industrial and agricultural agendas are often at odds with ecosystem needs. In the western United States, Flaming Gorge Dam's regulation of the Green River tells a story familiar to many river systems. As the longest tributary of the Colorado River (Allred and Schmidt 1999) and part of the Upper Colorado River Basin, the Green River provides hydropower electricity and water storage to Wyoming, Utah, Colorado, New Mexico, Arizona, Nebraska, and Nevada (USBR). Many of the flows released from the Flaming Gorge Dam are 'peaked' flows that increase during the day and decrease at night. Such high diurnal variability limits functional ecological processes for native vegetation and wildlife.

In alluvial rivers (rivers shaped by flow-induced changes in mobile sediments and soil), high flows rework river channels and shape suitable habitats through vegetation removal, scouring, and sediment erosion and deposition. Ecological processes and fluvial processes, therefore, are inherently linked and provide an opportunity for a more holistic ecological management understanding when studied in tandem (Cooper et al. 1999, Scott and Friedman 2018). Promoting vegetation colonization on river bars allows dense vegetation to establish which slows water velocities and promotes further sediment deposition. Some native species, such as Fremont cottonwood, rely on accessible sediments, soil moisture, and complete inundation in order to spread and establish seedlings. Studies have shown hydropeaking, where flows are peaked frequently to generate hydropower, can dramatically change sediment deposition and bar formation and in turn, will influence overall habitat resiliency and local occurrence of vegetation and organisms (Yarnell et al. 2015).

The Yampa and Green Rivers provide an excellent study system to characterize bar morphology, sediment, and local plant communities to better understand how conditions might change with different sediment loads or flow regimes. The lightly regulated Yampa River meanders through narrow canyons, debris fan-affected areas, and channelized sections (Scott and Friedman 2018), while the Green River introduces a drastic change in sediment transport due to regulation by Flaming Gorge Dam.

This observational study explores how differing flow regimes and sediment deposition manifest in bar morphology and vegetation diversity during high Yampa River flows and lower hydropeaking Green River flows. The goal of the study is to provide a solid foundation for future research questions relating to bar morphology and local vegetation distributions along river bars. By analyzing local trends in vegetation and sedimentation, we aim to identify potential interactions between bar morphology, river flows, sediment deposition, and vegetation. We explore four main questions:

1) How do sediment type and size change longitudinally between the lightly regulated Yampa River and the highly regulated Green River?
2) How does bar morphology change longitudinally between the lightly regulated Yampa River and the highly regulated Green River?
3) How does riparian vegetation change with sediment type and size?
4) How does riparian vegetation change with bar topography?

METHODS

Study Area

We surveyed five bars on the Yampa and Green Rivers within Dinosaur National Monument and the Upper Colorado Basin. The first three survey sites were along the Yampa River downstream of the put-in at Deerlodge Park. The fourth survey site was at the confluence of the Yampa and Green River. The fifth survey site was along the Green River before the take-out at Split Mountain (see Table 1). Due to high flows, we opportunistically selected bars that had a width of about 40 meters or more and were accessible by raft. The bars were composed of either sand, cobble, gravel, or a combination of sediment types. Some bars had a variety of riparian and mixed woodland vegetation depending on the bar's connection to canyon slopes or riverside channels.

Table 1. Survey site locations along the Yampa and Green Rivers.

Name of Survey Site	Site Location
Harding Hole	Bar between Harding Hole 1 and 2 campsites along the Yampa River.
Signature Cave	Bar on side channel near Signature Cave with Yampa River along the right bank.
Box Elder	Upstream of Box Elder 2 campsite with Yampa River along the right bank.
Confluence	Bar at the confluence of Yampa and Green Rivers.
Jones Hole	Upstream of Jones Hole 5 campsite with the Green River on the right side of the bar.

Research design

Sediment Grain Size

We measured sediment grain size at patches near cross-section transects using the pebble count method (USFWS 2004) and a gravelometer. We used grain size data to find cumulative percentages of the sediment class sizes. The data was also used to find the median grain size (D50) and the 84th percentile grain size (D84), which represents the coarse grain fraction (Attal 2011).

Bar Morphology and River Gradient

At each bar, we selected representative cross-sections perpendicular to the mainstream river flow. Survey teams set a transect running from the water's edge across the chosen bar. Preferably transects crossed local terraces or valley walls unless accessibility or visibly was limited by high flows or thick vegetation. Using an auto-level and stadia rod, teams measured relative elevation changes of the bar cross-section. Each data point represents a transect location where we observed a change in bar slope. We used this data to characterize the cross-section topography of each bar relative to an elevation of 100 meters. We adjusted elevational data to be relative to the water's edge for graphical representation and analysis. GPS points were also taken at each location along the river. The GPS points were then used to find the elevation gradient of the Yampa and Green rivers.

Vegetation Survey

Teams recorded the location of plants and substrate along the cross-sectional transects at each site. We identified plant and substrate types, measured vegetation relative abundance, and calculated vegetation percent cover. Harding Hole was the exception, where we estimated percent cover but did not record the location of plants along the transect. Additional information on the vegetation communities observed is discussed in an accompanying paper.

RESULTS

Sediment Grain Size

Of the data collected, there was no trend in sediment size between the lightly regulated Yampa River and highly regulated Green River. Sediments on bars at Harding Hole and at the Confluence were the most sorted with a composition containing larger cobbles. Sediments on bars at Signature Cave and Jones Hole were the least sorted with a more even distribution of cobble sizes. Jones Hole had the most even distribution of sediment sizes and was the least sorted of all four bars. All bars were dominated by high amounts of sand. D50 values (medians excluding particles less than 2mm) of each site are as follows: Harding Hole, 71.42 mm; Signature Cave, 8.00 mm; Confluence, 47.71 mm; Jones Hole, 9.5 mm. At the time of sampling, bars at Harding Hole and Confluence were both located near backwater channels separating the bar from canyon sides. Sediment samples at the Signature Cave site were taken on the outer bars of the study reaches closest to the main river stem. Sediment samples at the Jones Hole site were taken on a bar connected with the canyon sides and only had water flowing on one side of the bar. At the confluence site, we observed a clear visual divide between the two river systems. The Green River was lighter and greener in color, while the Yampa River was brown due to high suspended sediment content (Figure 1).

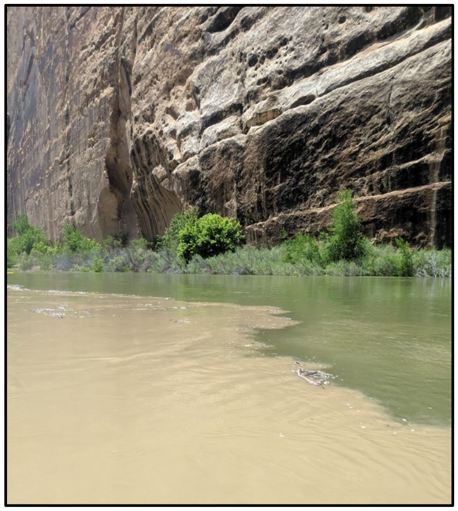

Figure 1. Photograph of the Yampa and Green River confluence taken on day of site survey.

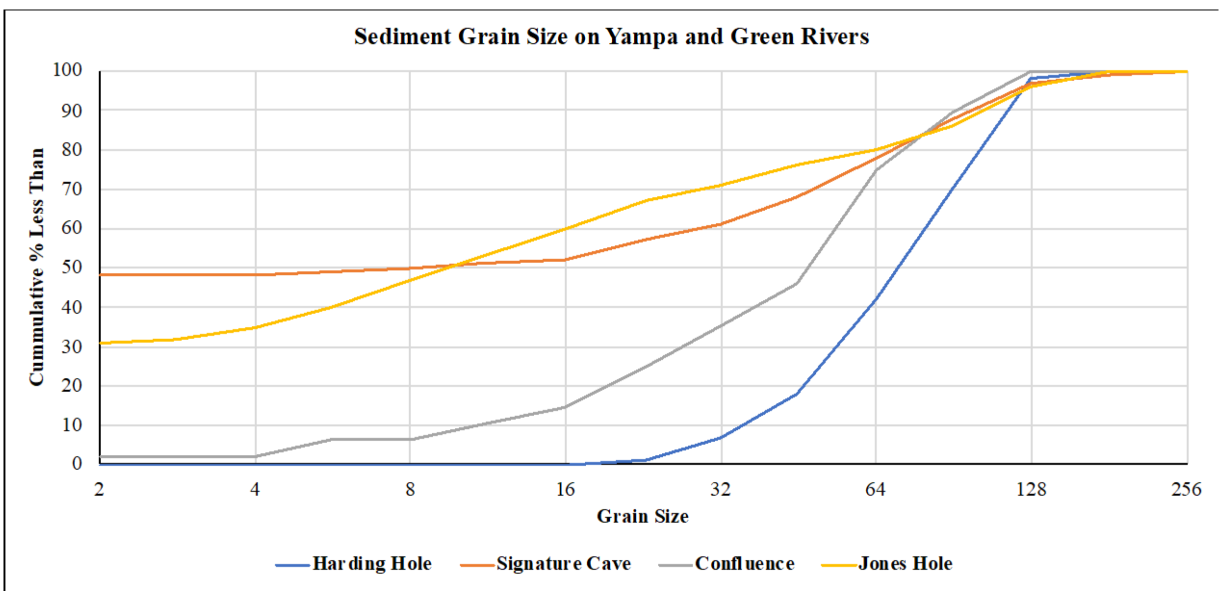

Figure 2. Cumulate distribution of sediment grain sizes at four survey sites.

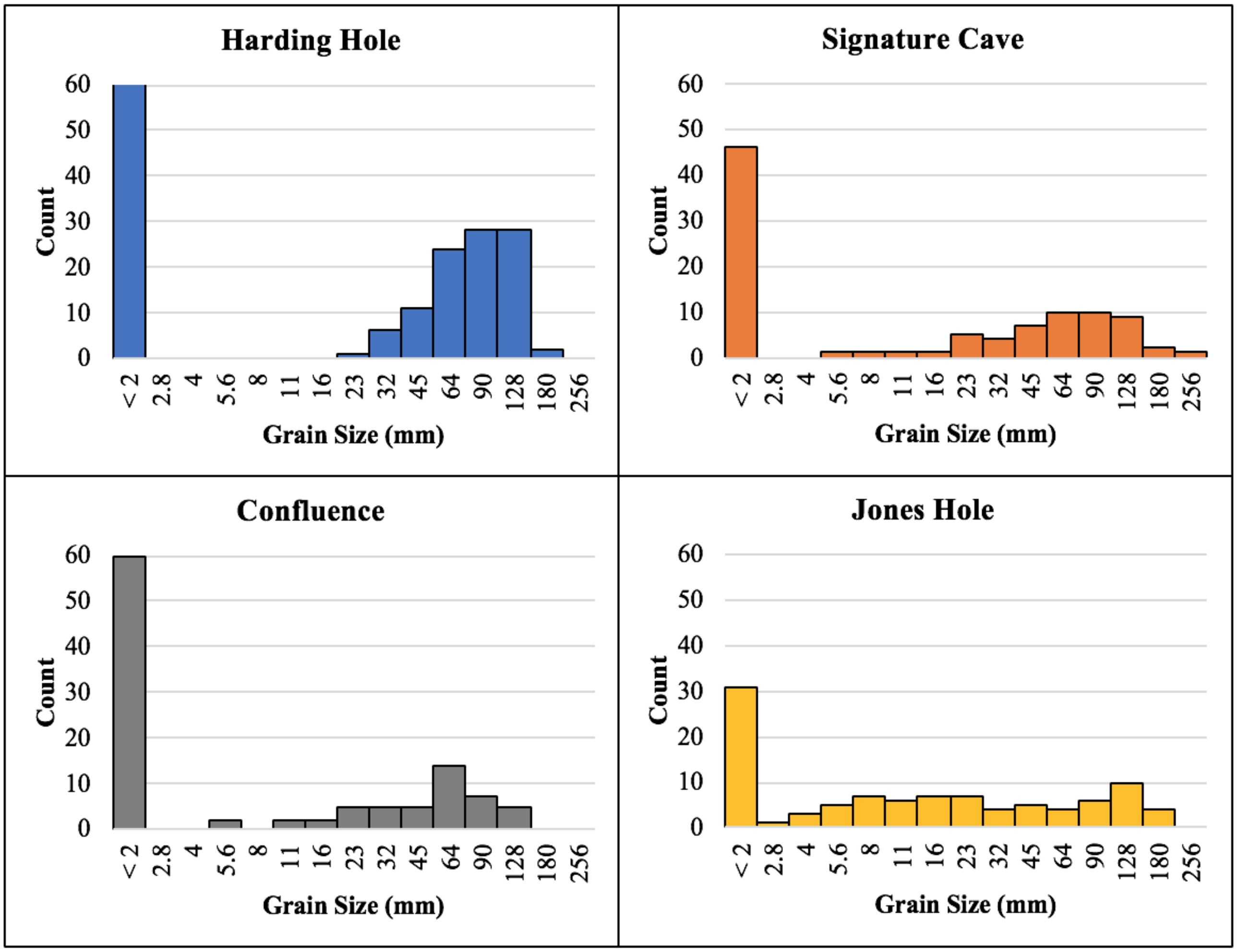

Figure 3. Sediment grain size distribution at each survey site.

Bar Morphology and River Gradient

We examined elevational change one mile below and above each survey site using GPS data collected throughout the river trip. The elevation changes were similar. Though the sites experienced similar local elevation changes along the channel, the elevation of the entire survey trip changed from 1708 meters at Deer Lodge Park to 1468 meters at the Split Mountain rafting take-out. We also used bar survey data (Figures 4 and 5) and observations to generally characterize elevation changes and topographical features of each bar cross-section. While each surveyed bar was characterized by unique local features, overall bar morphology did not substantially differ between the Yampa and Green Rivers based on our five sites.

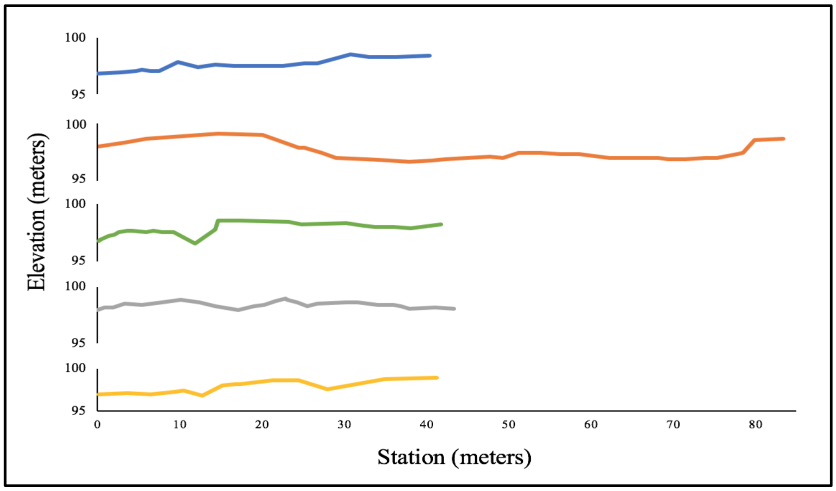

Figure 4. Elevation change along each site transect relative to 100 meters, where station 0 m is the water's edge; blue line represents Harding Hole, orange line represents Signature Cave, green line represents Box Elder, grey line represents Confluence, yellow line represents Jones Hole (Note: Signature Cave transect was reversed so that all cross-sections begin at the main channel water's edge). The Confluence transect starts at the Green River water's edge andends at the Yampa River water's edge.

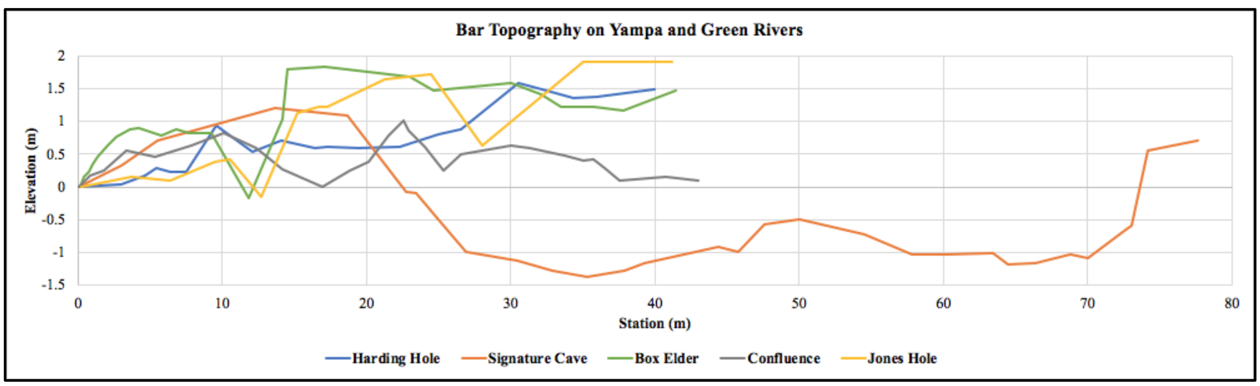

Figure 5. Elevation change of the five survey transects relative to each site's water's edge (water's edge set to zero meters in elevation).

Due to elevated river flows, the bars were largely flooded and water inundated portions that would likely be exposed at times of the year experiencing lower flows. This high flow throughout surveying resulted in overflow channels on portions of several of the bars, including Harding Hole, Signature Cave, and the Confluence. Overall, the five bars showed gradual slopes between the water's edge and inland with slight depressions from high flow channels typically filled with debris or cobbles. The Signature Cave site was the only exception. There, we observed a larger sand bar right next to the water's edge followed by a decrease in elevation where the bar surface remained relatively flat until the terrace. Along each of the transects, we observed sediment deposition in the form of sand and cobble bars in portions of the site closer to mainstream flow. This alluvium included mud, sand, gravel, and cobbles. Elevation change from the water's edge to the highest point ranged from about one to two meters, and we observed terraces at 0.56, 1.84, and 1.96 meters above the water's edge at the Signature Cave, Box Elder, and Jones Hole sites. Below are more detailed descriptions of the five sites on the Yampa River, Confluence, and Green River bars.

Harding Hole was located on the river left bank of the Yampa River and bordered by several overflow channels and a terrace. We set a transect along a bar area near the water's edge, but the transect ended before the back channels and terrace due to limited survey visibility and accessibility. Along the 40-metertransect, we observed a shallow, increasing slope from the water's edge up to thickening vegetation. Two mounds occurred along the bar transect: a 0.2 m tall sand bar (relative to the elevation of the water's edge) from station 4.5-6.5 m, and a more vegetated sand bar one meter in height above the water elevation from station 7.5-12.1 m along the transect. There was a cobble bar from station 17.3-19.4 m in a slight depression following the sand bars. After the cobble bar, we observed an elevation increase up to 1.59 meters above the water elevation starting at transect station 23 m where vegetation thickened into dense willows. Overall, bar elevational range of this site was up to 1.59 m above the elevation of the water's edge.

The Signature Cave survey site was located further downstream along the Yampa on river right. Our 80 m transect also featured a vegetated sand/cobble bar with several overflow channels flowing parallel to the mainstream flow. Cross section data showed that the bar's highest points were inundated by overflow. Near the mainstream water's edge, a 1 m high bar was located from station 5.5-26.9 m along the transect and a flatter bar was located between overflow channels from station 45.8-54.4 m along the transect. We observed that regions submerged by overflow channels also included sand and cobbles and would create a large sand/cobble bar over a large portion of the transect during lower flow conditions. A local terrace occurred at station 73 m from the water's edge. The terrace was about 1 m in height from its base but about 0.56 m in height relative to the elevation of the water's edge. The highest points of the transect were at the top of the larger bar 1.2 m in hieght above the elevation of the water's edge and at the top of the terrace 0.56 m above the elevation of the water's edge.

Further downstream on the Yampa, we surveyed the Box Elder site over a 41.4 m transect. We found that the bar generally sloped upwards away from the water's edge until it met a local terrace at station 17 m on the cross-section. The terrace's highest point was 1.84 meters above the elevation of the water's edge. There was a sand bar from the water's edge to station 10 m, and its highest point occurred at station 4.2 m along the transect. We observed a dry channel from station 9.2-14.2 m that likely filled and channelized during higher flows. The channel was about 0.2 m below the elevation of the water's edge. Vegetation thickened after the overflow channel and up onto the terrace. Overall, elevation along the Box Elder transect ranged up to 1.84 meters above the elevation of the water's edge.

At the confluence of the Yampa and Green Rivers, we surveyed a 43-m transect from the river left side of the Green River to the river right side of the Yampa. The cross-section included several midway depressions containing woody debris and vegetation, in addition to a side channel cutting across the area between the Yampa and Green Rivers, likely active during high flows. A large depression occurred at station 12.3-20.1 m from the Green River and was filled with various grasses and forbs. Another depression occurred from station 20.1-25 m that was mostly filled with large woody debris. We measured elevation on top of the debris, with the highest point located at 1.78 m above the elevation of the Green River water's edge. There was a bar containing mud, pebbles, and cobbles from station 35 m to the end of the transect at the Yampa River's right edge. Along this transect, elevation was about 1 m higher than the elevation of the Green River water's edge, with the highest point located at station 22.6 m along the transect on top of the woody debris.

The Jones Hole site was on the river right side of the Green River. We set a 41.2 m transect from the water's edge up to thickening vegetation behind a local campsite path. Along the transect, we observed reeds from station 0-4 m, cobbles in a slight depression from station 4-6 m, woody debris from station 5-8 m, and sand from station 6-20 m. Along this sandy bar, there was a slight depression from station 10.5-15.2 m where woody debris was deposited. A terrace was located at about station 20 m that reached an elevation of 1.752 m above the elevation of the water's edge before decreasing slightly from station 24.5-35 m along the cross-section. The depression contained various grasses and forbs and transitioned into larger vegetation near the end of the transect. Elevation ranged up to 1.92 m above the elevation of the water's edge, with th highest point occurring on the terrace at the end of the transect.

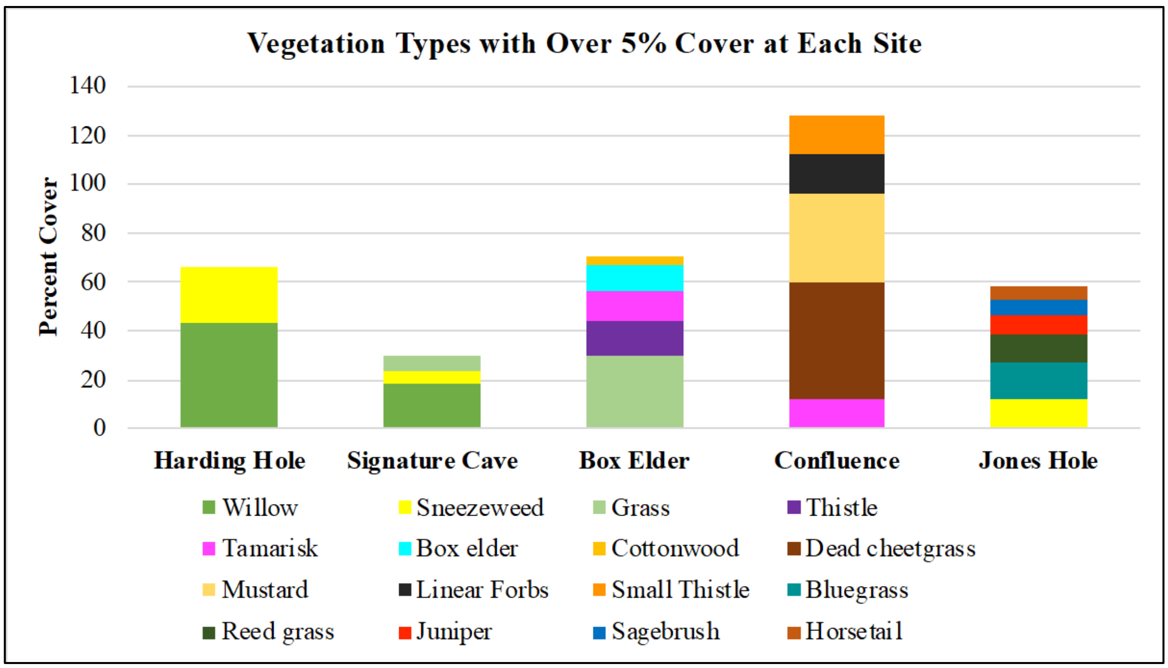

Figure 6. Percent cover of vegetation greater than 5% for each site. Cover included plants and other substrates such as bare ground and sediment. The percent cover of all cover types observed at each bar site is in Appendix A.

Table 2. Location of vegetative cover (>5%) along cross-section transects. Point zero corresponded to an inland point and the transect ends at the water's edge. Transect stations were approximated from the topographic survey transects and show how vegetation varied with bar elevation and slope. In some cases, the cover types were more densely spread across these station ranges, and in some cases, they had gaps (usually around 1 m) within these station ranges. Site 1 at Harding Hole is excluded from the table because a vegetation transect location was not recorded. *Note: Sneezeweed in site 5 was the most sparsely spread out throughout the entire cross-section.

Site 2 Signature Cave		Site 3 Box Elder		Site 4 Confluence		Site 5 Jones Hole	
Plant	**Meter**	**Plant**	**Meter**	**Plant**	**Meter**	**Plant**	**Meter**
Willow	16-55 m	Grass	0-14 m	Dead Cheatgrass	6-22 m 29-35 m	Bluegrass	14-17 m 24-40 m
Grass	3-6 m 23-33 m	Thistle	29-42 m 33-42 m	Mustard	3-13 m 21-22 m 36-38 m	Reed grass	2-6 m
Sneeze weed	7-8 m 25-32 m 55-56 m	Tamarisk	4-11 m	Linear Forbs	2-16 m	Sneezeweed	4-23 m 27-34 m
		Box elder	35-40 m	Small Thistle	3-9 m 13-15 m 20-21 m	Juniper	18-22 m
		Cotton-wood	3-5 m	Tamarisk	4-5 m 7-9 m 12-14 m 36-37 m	Sagebrush	20-21 m 25-26 m 36-39 m 40-42 m
						Horsetail	34-39 m

Vegetation Survey

Based on the transect and observational data for the five transects, vegetation generally did not occur in exposed cobble bars. Small non-woody vegetation such as sneezeweed, forbs, and grasses occupied the finer alluvium locations where sandbars tended to be located. Several transects, such as Box Elder and the Confluence, had small depressions (without cobbles) containing various grasses or woody debris. Though woody debris often was found in overflow depressions, it was also deposited in flatter sections near the water's edge at the Jones Hole site. Larger woody vegetation, such as junipers, sagebrush, box elders, and willows, tended to occur in higher elevations on the bars and especially on elevated terraces. For example, the Signature Cave site had juniper and tamarisk at the top of the larger bar close to the water's edge and juniper and sage on the terrace. In addition, there where willows at Harding Hole on the more elevated, stable sediment region. Though woody vegetation tended to be farther from water and on elevated regions such as terraces, there were several exceptions. Willows were also found throughout the overflow channels at the Signature Cave site. Generally, vegetation did not grow on regions of sharp elevation changes, such as on the slopes between sandbars and terraces or in gullied overflow channels. Below are more detailed descriptions of plant cover and vegetation locations along a transect in relation to each site's topography and sediment distribution.

For site 1 at Harding Hole, willow (*Salix spp.*) had the highest percent cover, and sneezeweed (*Helenium spp.*) had the second highest percent cover. There was also a large amount of sand and water in the transect. Additionally, we observed small amounts of grasses, different types of forbs, and cobble that made up 10% of the transect area altogether (see Appendix A). The locations of these types of cover along the transect were not recorded at Harding Hole. From recollection, willow was densely located further inland around 25 meters from the water's edge inland from a cobble bar. The willow was growing throughout the two side channels and slightly inland, where there was larger vegetation such as box elder. Forbs were seen closer to the water's edge on more sandy substrate.

At the Signature Cave site, willows had the highest percent cover, followed by grass, and sneezeweed (see Figure 6). There was also large amounts of bare ground/litter and cobble observed along the transect (see Appendix A). There were small amounts of different types of forbs, horsetail (*Equisetum spp*.), and juniper (*Lomatium spp.*) that made up 5% of the transect area together (see Appendix A). Looking at the reach sketch and the cross-section elevation (Figures 4 and 5), we found willow between the inland terrace and throughout the two side channels. Grasses were found at the base of the inland terrace and overlapping with the cobble bars. Sneezeweed grew at the base of the terrace and on the adjacent bar, and it also overlapped with the grass and cobble observed at these two locations (see Table 2 above and Figures 4 and 5).

At the Box Elder site, grasses had the highest percent cover, followed by thistle (unknown genus), tamarisk (*Tamarix chinensis*), box elder (*Acer negundo*), and cottonwood (*Populus spp.*) (see Figure 6 above). There were small amounts of different types of forbs, such as milkweed (*Asclepias spp.*), sneezeweed, and sagebrush (*Artemisia spp.*), that comprised 8% of the transect length together (see Appendix A). Grass grew next to the water's edge on the bar and also further inland near the end of the transect on the higher elevation terrace. We also found thistle further inland almost overlapping with the grass on the terrace. Tamarisk occurred on the bar a few meters from the water's edge. There was a box elder at the end of the transect further inland on the terrace. Cottonwood was found on the lowest elevation of the transect near the Yampa River's edge, overlapping with grass and tamarisk (see Table 2 above and Figures 4 and 5).

At the confluence survey site, dead cheatgrass (*Bromus tectorum*) had the highest percent cover, followed by mustard (unknown genus), linear forbs, small thistle, and tamarisk (see Figure 6 above). There were small amounts of grass, live cheatgrass, and different types of forbs that totaled 17% of the transect length together (see Appendix A). The dead cheatgrass was located a few meters from the Green River's water edge to the woody debris pile midway across the bar, and also on the Yampa River side of the woody debris pile. Mustard was found overlapping with the dead cheatgrass, but a few meters closer to the Green River's water edge and also on the woody debris. We found linear forbs slightly inland from the Green River to the woody debris. Small thistle was also found overlapping with linear forbs, mustard, and dead cheatgrass a few meters inland from the Green River to within the debris. Tamarisk was located from the Green River to the woody debris, a few meters from the Yampa River, and almost directly inland from the cobble bar adjacent to the Yampa River (see Table 2 above and Figures 4 and 5).

At the Jones Hole site, the highest vegetative percent cover was bluegrass (*Poa spp.*), followed by reedgrass (unknown genus), sneezeweed, juniper, sagebrush, and horsetail (see Figure 6 above). There were small amounts of box elder, cottonwood, sedges, and forbs that totaled 9% of the transect length together (see Appendix A). Sneezeweed grew a few meters from the Green River water's edge and overlapped woody debris. Bluegrass was found further inland than the sneezeweed and also overlapped with woody debris. Reed grass was located on the bar at a lower elevation inland from the woody debris. Juniper trees were found near the center of the cross-section, while sagebrush was located from the center to the end of the transect. Horsetail was also found towards the end of the transect overlapping with woody debris (see Table 2 above and Figures 4 and 5).

DISCUSSION

How do sediment type and size change between the lightly regulated Yampa River and the highly regulated Green River?

The Yampa River appears to transport large and small sediments into the Green River throughout downstream river stretches close to the confluence. At the time of sampling, the Yampa River experienced high flows ranging from 11,500 ft^3s^{-1} (325.64 m^3s^{-1}) to 15,500 ft^3s^{-1} (438.91 m^3s^{-1}) (www.Dreamflows.com, Yampa - At Deerlodge Park), and the Green River upstream of the confluence experienced hydropeaking flows ranging from 2,000 ft^3s^{-1} (56.63 m^3s^{-1}) to 4,500 ft^3s^{-1} (127.43 m^3s^{-1}) (www.Dreamflows.com, Green - Near Greendale). Although the Green River's regulated flows likely transported fewer sediments than the Yampa River, downstream of the confluence continued to receive sediment deposition from the Yampa River's dominating flow during spring runoff. A wide distribution of sediment size classes is important to maintaining diverse bar morphology and habitat (Mueller et al. 2014).

Differences in sediment grain size imply that there are variations in depositional events occurring at each bar. In the case of Jones Hole, sediment grain size samples were taken on a gradual slope of the bar. Hydropeaking brings sudden changes in water velocities along the edges of bars, and in turn, may be a factor contributing to the poorly sorted sediment grain sizes we observed on gradual bar slopes.

How does bar morphology change between the lightly regulated Yampa River and the highly regulated Green River?

Surveyed bar morphology between the Yampa and Green Rivers share similar characteristics of elevated sand and cobble sections creating higher terraces and a total elevation change of around one to two meters above the elevation of the water's edge. Because the surveyed bars were largely flooded due to high flows in the Yampa and Green Rivers, the esurveyed transects were relatively short in length. Portions of the bar submerged during the survey might show greater elevation ranges and more variable depositional trends during low flows.

Cobbles were observed in slight depressions on many of the bars perhaps due to previous higher flow velocities in those regions. We also observed terraces on the Yampa and Green River survey sites. This suggests that the sites had areas not as recently inundated with channel flow. Because sites on both rivers had terraces, they likely experienced similar sedimentation and high flow events at some point in the past. As the river profile elevations upstream and downstream of each transect site were similar, the sediment deposition observed was likely more related to river channel widening than channel gradient changes.

How does riparian vegetation change with sediment type and size? How does riparian vegetation change with bar topography?

Because sediment grain size surveys were completed in opportunistically placed clusters, we were unable to deduce trends in sediment grain sizes classes along the vegetation and bar topographic surveys. The following conclusions relating vegetation types with sediment grain size are based on reach sketches, visual observations, and any notes taken along the transect about sediment type. Across all sites, areas with cobbles and sand had the least amount of vegetation ranging from bare ground to grass with occasional willows. These areas were generally closest to channels and likely received the most disturbance from variable flows with changing flow velocity and sediment deposition. High flows during our reach sampling likely changed the locations where suspended and bedload sediments were transported and deposited along the bar.

Flow variability promotes vegetation establishment for disturbance-dependent riparian species (Scott and Friedman 2018). Tamarisk and cottonwood both rely on the creation of new bars for the establishment of new recruits, explaining why we saw both species on portions of exposed bars closer to the water's edge. Shade tolerant species such as box elder occurred higher up on terraces where flow disturbance was likely less and where they were able to survive with existing vegetation such as sagebrush. Our observations support existing conclusions of relationships between vegetation, bar topography, and sediment types along the Yampa and Green Rivers (Scott 2018; Allred and Schmidt 1999). From our observations, we concluded that sediment load and transport capacity of rivers rework channel shape and bar formation. As a result, vegetation diversity and distribution will likely change with new local environmental conditions.

Notes for Future Studies

The observational nature of our study provides the groundwork for future studies investigating relationships between bar topography, flow, sediment grain sizes, and vegetation. Going forward, researchers should include surveys at different levels of flows to better understand depositional features and differences between bars longitudinally along the river. It is likely that there are differences in slope and bar conditions between the two rivers. Additionally, longer transects should be completed to understand how terraces are positioned and the role they play in vegetation habitat formation. Channel width is an additional factor likely contributing to the observed bar, sediment, and vegetation characteristics. Wide channel areas are typically found to promote diverse habitats due to increased local sediment deposition, bar development, and ranges of sediment types. Examining bars located within similar canyon width and channel width may provide insight into additional physical factors contributing to bar formation that we were unable to capture with this observational study.

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Appendix A

Table 3. Percent Cover at each survey site. Site 1 corresponds to Harding Hole, Site 2 corresponds to Signature Cave, Site 3 corresponds to Box Elder, Site 4 corresponds to the confluence, and Site 5 Corresponds to Jones Hole. A dashed line indicates that there was no data for the cover type.

Cover Type	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**
	Percent Cover (%)	**Percent Cover (%)**	**Percent Cover (%)**	**Percent Cover (%)**	**Percent Cover (%)**
Bare Ground/Litter	-	9	-	-	-
Black-Eyed Susan	-	1	-	-	-
Blue Grass	-	-	-	-	15
Box Elder	-	-	11	-	0
Buttercups	4	-	-	-	-
Cheatgrass (dead)	-	-	-	48	-
Cheatgrass (live)	-	-	-	1	-
Clover	-	1	-	0	-
Cobble	4	8	-	12	-
Cottonwood	-	-	4	-	0
Erodium	-	-	-	0	-
False Milkweed	-	-	-	-	1
Forb	-	-	1	3	-

Forb (linear)	-	0	1	16	-
Forb (lupine-like)	2	-	-	-	-
Forb (other)	-	1	-	-	-
Forb (pointy leaf)	-	-	-	4	-
Forb (wide leaf)	-	-	-	0	-
Forb (yellow)	0	-	-	-	-
Grass	1	6	30	3	-
Horsetail	-	1	0	-	5
Juniper	-	0	-	-	8
Lamb's Ear	-	-	-	1	-
Melilotus	-	2	-	-	0
Mustard	-	-	-	36	-
Mustard (serrated)	-	-	-	5	-
Mustard (yellow)	-	-	-	0	-
Reed Grass	-	-	-	-	12
Sage	-	-	0	-	6
Sand	13	-	-	-	-

Sedge	-	-	-	-	4
Sneezeweed	23	6	1	2	12
Tamarisk	-	-	12	12	-
Thistle	-	-	14	-	-
Thistle (Big)	-	-	-	3	1
Thistle (small)	-	-	-	16	-
Water	12	-	-	-	-
White Vetch	-	-	-	-	3
Willow	43	18	-	-	-
Woody Debris	-	-	-	-	16
Woody Debris (large)	-	-	-	25	-
Total % of small cover (values below 5% summed)	10	5	8	17	9

Appendix B

Table 4. Start and end station locations were recorded for the cover types along the cross-sectional transect at each survey site. Point zero corresponds to an inland point and the transect ends at the water's edge. In some cases, the cover types were more densely spread across the relative ranges, and in some cases there were gaps (usually around 1 m) within these ranges. Sites 1-5 correspond to the survey locations as described in Table 3 (Appendix A).

Cover Type	Site 1	Site 2	Site 3	Site 4	Site 5
	Range Across Transect (m)	Range Across Transect (m)	Range Across Transect (m)	Range Across Transect (m)	Range Across Transect (m)
Bare Ground/Litter	-	3-6, 53-66	-	-	-
Black-Eyed Susan	-	25-31	-	-	-
Blue Grass	-	-	-	-	14-17, 27-40
Box elder	-	-	35-40	-	42-43
Buttercups	-	-	-	-	-
Cheatgrass (dead)	-	-	-	6-22, 29-35	-
Cheatgrass (live)	-	-	-	21-22, 32-33	-
Clover	-	6-7, 27-28	-	34-35	-
Cobble	-	7-8, 26-32	-	37-43	-
Cottonwood	-	-	3-5	-	9-10
Erodium	-	-	-	31-32, 34-35	-

False Milkweed	-	-	-	-	4-5
Forb	-	-	0-2, 12-13, 40-41	3-4, 33-35	-
Forb (linear)	-	26-27	0-1	2-16	-
Forb (lupine-like)	-	-	-	-	-
Forb (other)	-	55-62	-	-	-
Forb (pointy-leaf)	-	-	-	15-18, 35-36	-
Forb (wide-leaf)	-	-	-	1-14, 25-31	-
Forb (yellow)	-	-	-	-	-
Grass	-	3-6, 32-33	0-14, 29-42	16-17, 31-36	-
Horsetail	-	26-29	27-28	-	34-39
Juniper	-	58-63	-	-	18-22
Lamb's Ear	-	-	-	14-17	-
Melilotus	-	24-25, 54-55	-	-	8-9
Mustard	-	-	-	3-13, 21-22, 36-38	-
Mustard (serrated)	-	-	-	6-7, 11-12, 19-22	-
Mustard (yellow)	-	-	-	21-22	-

Reed Grass	-	-	-	-	-2-6
Sagebrush	-	-	5-13, 27-22	-	20-21, 25-26 36-39, 40-42
Sand	-	-	-	-	-
Sedge	-	-	-	-	1-4
Sneezeweed	-	7-8, 25-32, 55-56	40-41	31-37	4-23, 27-34
Tamarisk	-	-	4-11	4-5, 7-9, 12-14, 36-37	-
Thistle	-	-	33-42	-	-
Thistle (big)	-	-	-	1-5, 20-21	32-34
Thistle (small)	-	-	-	3-9, 13-15, 20-21	-
Water	-	-	-	-	-
White Vetch	-	-	-	-	2-6
Willow	-	16-55	-	-	-
Woody Debris	-	-	-	-	5-21, 31-40
Woody Debris (large)	-	-	-	14-31	-