Vegetation Characterization on the Yampa and Green Rivers

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Photo courtesy of Sam Winter, UCDavis Ecogeo 2019

PREFACE

The University of California Davis Ecogeomorphology course consists of an interdisciplinary group of undergraduate and graduate researchers. While this paper focuses on plant community composition and flow regimes within Dinosaur National Monument, the greater forces that alter landscapes, hydrology and communities are worth considering. The purpose of the research conducted on the Yampa and the Green River was in part, to gain a better understanding between the processes of geology, hydrology and ecology. Geology sets the stage providing the base material for hydrologic processes to mold, carve and shape into habitat for ecological communities to emerge and inhabit. Ecological communities in turn alter hydrologic processes, which in turn alter geologic structures. The interdisciplinary lenses used in this research lead to insights throughout and are the background that lead to the understanding of topics within this paper.

ACKNOWLEDGEMENTS

We would like to express our immense gratitude to the National Park Service for allowing us to study what has become extremely rare and precious in the modern day: a natural flowing river. This opportunity gave us great insights not just into baseline conditions of a natural flow regime, but into what kinds of impacts we as human beings have on our natural world. We would also like to extend our gratitude to the University of California Davis for creating this research opportunity as well as our donors who made its execution possible. Last but not least, we appreciate our instructors who have guided us through this interdisciplinary process, leading us to our learning outcomes and so much more.
Thank you.

DEFINITIONS

Flow regime: the complex pattern, magnitude, and timing of river flows.

Native: a species that has evolved in the area and is adapted to the natural forces within it.

Exotic or Non-native: a species that has evolved elsewhere under similar conditions such that it can proliferate in a different environment when transported there.

Graminoid: an herbaceous plant with grass-like characteristics.

Forb: an herbaceous plant that is not a graminoid.

Disturbance: a force in the environment that produces noticeable change within it.

Type Conversion: the change of a plant community from one type to another (due to disturbance).

Fire Return Interval: the (mean) time between fires in a given area.

Ecotype: the distinct and characteristic genotype that occur in a particular habitat.

Geomorphic: the form of earth's surface or a specific landscape.

Riparian: Relating to river habitats.

Snowmelt Recession: the naturally occurring gradual decrease in spring and summer flows in snowmelt-fed rivers.

Succession: the process by which biotic community tend to recover following disturbance.

INTRODUCTION

UC Davis researchers traveled to the Yampa and Green rivers in June 2019 to assess the relationships between differing flow regimes and vegetation communities. The focus of this paper is to explore how the differing flow regimes of the Yampa and Green rivers related to the percent coverage of different plant communities with a focus on native versus exotic species.

The Yampa river is a largely unimpaired, primarily snowmelt-fed river that erodes, transports and distributes sediments along the corridors and banks of the canyons (Elliott, 1984). The Yampa river joins with the regulated Green river downstream and contributes important sediments to the flow of the regulated Green (Siegfried, 2014). Since the construction of Flaming Gorge Dam, the channels of the Green river have narrowed and sediment transport has decreased, leading to an alteration in the distribution of plant communities by favoring exotic plant species over native species (Allred, 1997). Human activity in the form of ranching, trail building, and general use and visitation have introduced many exotic graminoid and forb species to the Yampa and Green rivers, upsetting and altering the ecological balance of the native plant community (NPS, 2015). Populations of leafy spurge (*Euphorbia esula)*, cheatgrass (*Bromus tectorum)*, common mullein (*Verbascum thapsus),* and smooth brome (*Bromus inermis)* are among the exotic forb and graminoid species within the Dinosaur National Monument (EDD, n.d.).

Cheatgrass in particular is of concern due to its ability to create a connective fuel load through sagebrush and juniper communities where fire has been historically rare, and native plants are not adapted to fire (Pilliod, 2017). Decreased fire return intervals in an ecosystem where fire historically occurred infrequently can create a type conversion from pinon pine and juniper woodland ecotypes to grassland communities, which pose a higher risk of future fires (Pausas, 2009).

Loss or replacement of native woody riparian species by exotic forbs and grasses is also of concern because native riparian trees and shrubs provide habitat for birds and mammals, stabilize stream banks, shade and cool water, and act as the foundation of the ecosystem (Rood, 2005). Riparian species of woody plants along the Yampa and Green rivers include cottonwood (*Populus spp.*), boxelder (*Acer negundo)*, willows (*Salix spp.)* and the non-native tamarisk (*Tamarix spp.).* Each of these species has different adaptations and abilities to tolerate conditions along the river corridor and are affected differently by drought, salinity, inundation, flood disturbance, and shade due to differences in seed size, timing of seed dispersal, and ability to form root sprouts (Scott, 2018). These differing abilities, attributes, and tolerances interact with the geomorphic characteristics of the Yampa and Green rivers, resulting in vegetative community patterns that may change downstream as flows vary (Scott, 2018).

A previous study that showed exotic plant species thrive in drier and hydrologically stable banks of regulated rivers, while native plants have life cycles more closely tied to and dependent on the annual fluctuations in water flows of unregulated rivers (Catford, 2011). This study observationally evaluated the hypothesis that the Yampa river would possess fewer exotic plant species than the Green river.

BACKGROUND

Naturally occurring annual flows

Variability of flows and sediment movement within unregulated rivers modify existing streambanks and terraces. High flows create annual disturbances through scouring, erosion, desiccation, and inundation, while subsequent snowmelt recession flows promote sediment deposition and channel bar formation, ultimately producing a variety of habitats (Yarnell, 2010). These processes of disturbance create open, broad areas along the river channel that provide a clean slate for plant colonization. Associated higher water levels provide emerging seedlings a water source as they establish.

The result of annually occurring high flows and subsequent snowmelt recession flows is a patchwork of habitats free of light competition with an availability of water, creating conditions for primary successional species and those limited by competition for light, such as cottonwoods and tamarisk. Cottonwoods are both drought- and shade-intolerant, and seedlings need immediate light sources due to low amounts of energy from the endosperm within their small seeds (Rood, 2005). Cottonwood seedlings are thus dependent on floods or high flows occurring shortly before seed dispersal and a gradual recession flow after seed deposition to successfully establish (Yarnell, 2010).

Native species are not only adapted to natural flows but dependent on them. Natural timing of peaks and recessions of flows throughout the growing season are related to native plant cycles of establishment, growth, flowering, and seed dispersal (Yarnell, 2010). Cottonwoods and willows tend to release their seeds during peak flows earlier in the season, whereas tamarisk releases its seeds later in the season giving it a potential competitive seed establishment edge over natives (Scott, 2018).

Regulated flows

Variability within regulated rivers is typically greatly reduced in comparison to unregulated rivers. Regulation of flows by dams results in lower annual peak flows and higher annual low flows, reducing seasonal differences. This can lead to the establishment and abundance of exotic plants, which are not adapted to or dependent on seasonally varying hydrologic conditions (Scott, 2018). Regulation of flows by dams has been shown to decrease the population size and distribution of native species that are dependent on annually occurring fluvial disturbances (Scott, 2018). Unnatural sudden and sharp fluctuations in the flows of rivers due to hydropeaking can also kill newly established native seedlings and favor nonnative tamarisk, which are more tolerant of salt, flood, and drought (Scott, 2018).

River habitats in canyons tend to have fewer channel bars and habitats available for seedling establishment, as they are a zone of sediment transport rather than a zone of deposition. As a result, cottonwoods generally tend to be absent in such reaches of the river or observed only on older flood terraces (Scott, 2018). However, in regulated systems, tamarisk can be observed in canyon reaches as well as on terraces. During high flows, tamarisk in canyon reaches can

promote local sediment deposition, which further narrows the channel and creates local patches of habitat for additional colonization.

Despite the competitive advantages of tamarisk, boxelders are shade-tolerant, which gives them a long term competitive edge in river systems, as they can establish under stands of tamarisk in both regulated and unregulated reaches. Boxelder are dependent on regular high flows for water availability, but do not require large scouring events to remove preexisting vegetation in order to establish.

In summary, native plant species in the Yampa and Green rivers in Dinosaur National Monument have life cycles closely tied to naturally occurring seasonal high and low flows, and thus have been observed to occur in fewer numbers relative to exotic species in river reaches where flows have been altered.

METHODS

Study Area

We surveyed five sites 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 from 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 Split Mountain (see Table 1). Additionally, we noted vegetation between each study site as we traveled downstream by raft.

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

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

Vegetation Assessment

Plant community data was collected in two ways. Line intercept sampling, where plants that came into contact with the established transect line (measuring tape) were identified and recorded, was used to determine vegetation cover on channel bars at each of five study sites. The length of line intercepted by each plant type was summed and then divided by the total length of the transect to calculate the percent cover of each plant type. The length of plant intercept segments was measured to the nearest 5 or 10 cm, depending on the identity of the surveyors. The bar topography was also surveyed along each transect using an autolevel (see accompanying paper), and a reach sketch was completed at each study site to aid visual interpretation of the data (see accompanying group data).

Observations of individual cottonwood (*Populus spp.)*, boxelder (*Acer egundo.)*, and willow (*Salix, spp.*) on various river bars and terraces occurring downstream between study sites are denoted in the results section as "from point A to point B". These observations were made from oar boats with visual estimates. Tamarisk were not measured based on visual estimates; however, it was generally noted that tamarisk numbers were seen in greater quantity as distance downstream from Deerlodge Park on the Yampa River increased.
Due to the distances from observer to plant species of interest while in the oar boats, only large easily identified woody plants were noted.

Sources of Error

Due to differences in observation and knowledge of plant species in the region, different plant species were grouped together and/or given an placeholder name depending on which student researchers were collecting data, which leads to possible aggregation error. When unable to identify an individual forb species, plants were grouped into a general category labeled "Forb", which encompassed a wide variety of both native and exotic species. The form and appearance of many forbs were noted before they were grouped, so additional details can be found in the accompanying group data. Aggregation of species into fewer groups may have led to decreased accuracy in evaluation of native versus nonnative plants, as different unidentified plant species were sometimes grouped in the same category. This is especially true for forbs that lacked flowers for identification.

There was also potential error of aggregation with the grouping of different grass species. Similar to forbs, a general "grass" category was created to group unidentified grass species. Cheatgrass (*Bromus tectorum*) was consistently identified and given its own category that was then divided into two subcategories, live or dead. However, the aggregation of other grasses included both native and non-native grass species, which limited a full determination of native versus non-native percent cover.

This observational study was conducted in June 2019, where above average snowfall for the region created high flows on both the Yampa and Green rivers. Many of the bars and habitats that would have been assessed at lower flows were submerged resulting in limited data collection

on the higher elevation bars and terraces only. This high-water sampling may affect the approximate percentages of exotic vs native species percent cover if compared to other years.

RESULTS

From Deerlodge Park to Harding Hole

No visual estimates of woody species were made.

Site 1 – Harding Hole

Two line intercept plant surveys were conducted halfway between Harding Hole 1 and 2 camps on 6/20/2019 in different locations from the Harding Hole channel morphology transect. The line intercepts were completed parallel to shore at 3 meters and 5 meters inland from the water's edge. The total length of each transect was 25.6 meters.

Along the first transect at 3 meters from the water's edge, the percent coverage of grass (primarily *Bromus tectorum)* was 34%, forbs was 7.3%, willow was3.4%, horsetails was 0.1%, lactuca was 0.3%, sneezeweed was 2.3%, showy milkweed was 0.7%, and salsify was 0.7%. Exotic cover was approximately 34.7%, and native cover was approximately 14.1%.

Along the second transect at 5 meters from the water's edge, the percent coverage of grass (primarily *Bromus tectorum)* was 6.5%, sneezeweed was 53.1%, forb was 3.1%, willow was 0.5%, fuzzy pod legumes was 1.3%, and sticky vetch was 0.7%. Exotic cover was approximately 6.5%, and native cover was approximately 58.7%.

Total average exotic cover at this site was measured at approximately 20.6%, and average native cover at approximately 36.4%.

Site 2 – Signature Cave

A line intercept plant survey was collected in conjunction with the channel morphology transect at a study site downstream and around the bend from Harding Hole near Signature cave on 6/21/2019. The transect was oriented perpendicular to the water's edge and was 57.4 meters in length crossing two side channels.

The percent coverage of grass was 7.1%, clover was 0.5%, sneezeweed was 6.4%, willow was 20.9%, melilotus was 2.0%, black-eyed susan was 1.2%, horsetail was 0.5%, forb was 1.2% and juniper was 9.5%. With the assumption that grass was *Bromus tectorum,* exotic cover was approximately 7.1%, and native cover was approximately 42.2%.

From Harding Hole to Laddie Park

A total of 16 individual boxelders, 11 willows, and 3 cottonwoods were noted. Based on these observations of native riparian tree species, cottonwoods appeared at a frequency of 10.0%, willow at 36.7% and boxelder at 53.3%.

An additional observation just upriver of Laddie Park camp included a 35-year old stand of Tamarisk that was in poor condition with many leafless or dead stems and in the apparent state of being gradually shaded out by boxelders and eaten down by tamarisk beetles.

From Laddie Park to Box Elder

A total of 14 individual boxelders, 3 willows, and no cottonwoods were noted. Based on this visual assessment, boxelders appeared at a frequency of 82.3%, willows at 17.7% and cottonwoods at 0.0%.

Site 3 –Box Elder

A line intercept plant survey was conducted along the same transect as the morphological survey upstream of Box Elder 2 camp on 6/22/2019. The transect was oriented perpendicular to the water's edge and extended a total length of 41.4 meters.

The percent cover of grass was 69.8%, forb was 2.1%, cottonwood was 3.6%, tamarisk was 11.5%, sagebrush was 13.0%, horsetails was 0.7%, thistles was 14.0%, sneezeweed was 1.4%, and box elder was 11.0%. Exotic cover (assuming the grass is *Bromus tectorum* and thistles are non-native) was approximately 43.8%, and native cover was approximately 43.3%.

Researchers also observed a small population of stream orchids (*Epipactis gigantea)* (image 1) on a hike upriver on the left bank to the edge of the canyon wall, where a natural seep of water occurred. Though stream orchids are known to occur in Colorado, care should be taken by the National Park Service and visitors to maintain this unique spot along the river to ensure these plants survive as a native North American species of orchid. Coordinates: 40°31'19.2"N, 108°57'14.4"W.

Image 1. *Epipactis gigantea,* Image courtesy of Noelle Patterson, Ecogeo 2019.

From Box Elder to Jones Hole

A total of 18 individual stands of boxelders, 3 of willows, and 6 of cottonwoods were noted. Based on this visual estimate, boxelders were observed at a frequency of 67%, cottonwoods at 22%, and willows at 11%.

Site 4 – Confluence

A line intercept plants was curved was conducted on the same transect as the channel morphology survey at the confluence of the Yampa and Green rivers on 23 June 2019. The transect line was oriented perpendicular to the Yampa and Green rivers across the mid-channel bar with a

length of 43 meters. The percent cover of dead cheatgrass was 47.7% and live cheatgrass was 0.7% for a total cheatgrass coverage of 50.4%. Small thistle had a percent cover of 22.4%, big thistle was 2.9%, forb was 25.3%, mustard 1 was 12.4%, tamarisk was 11.7%, mustard 2 was 4.5%, "other grass" was 3.8%, yellow mustard was 0.7%, sneezeweed was 1.6%, erodium was 0.4%, and clover was 0.5%. Exotic cover, assuming grass was *Bromus tectorum* and mustard, erodium and thistle were non-native, was approximately 100.0 and native cover was 11.1%. Percentages here were greater than 100% due to overlapping plant crowns.

Site 5 – Jones Hole

A line intercept plant survey was conducted along the same transect as the channel morphology survey upstream of Jones Hole camp 4 on 24 June 2019. The transect line was oriented perpendicular to the water's edge and had a length of 41.2 meters. The percent cover of reed grass was 2.7%, sedge was 3.6%, white vetch was 3.4%, sneezeweed was 8.1%, false milkweed was 0.5%, melilotus was 0.2%, cottonwood was 0.2%, grass was 14.6%, juniper was 7.9%, big thistle was 0.7%, sage was 6.1%, horsetail was 0.7%, and boxelder was 0.2%. Exotic cover, assuming grass was *Bromus tectorum* and thistles and melilotus were non-native, was approximately 15.5%, and native cover at 33.4%.

From Jones Hole to Island Park

A total of 12 individual stands of boxelders, 4 of willows, and 9 of cottonwoods were noted. Based on this visual estimate, boxelders were found at a frequency of 48%, cottonwoods at 36%, and willows at 16%.

From Island Park to Split Mountain

A total of 13 individual stands of boxelders, 5 of willows, and 17 of cottonwoods were noted. Based on this visual estimate, cottonwoods were found at a frequency of 49%, willows at 14%, and boxelder at 37%.

DISCUSSION

The percent coverage of exotic species within the reaches of Dinosaur National Monument changed from the Yampa river to the Green river. Exotic percent cover was observed to increase after initial evaluation at Signature Cave (Site 2) and peaked at the confluence of the Yampa and Green rivers (Site 4). However, the percent cover of exotics was smaller at Jones Hole (Site 5), which was the last transect evaluated. Jones Hole had a narrow sandbar with sparse coverage and a terrace that may have proven to be a significant barrier to exotics attempting to colonize from the streamflow at that particular reach (Figure 1). The National Park Service's Weed Warriors were also present upstream of the site and may have removed many of the herbaceous exotics which could have affected the evaluation of percent coverage. Jones Hole was also very sandy and may not have held enough moisture and nutrients to allow exotic establishment.

Researchers noted that a well-established beaver dam was located at the downstream end of Jones Hole Creek near its confluence with the Green River. Beavers have been shown to reduce numbers of terrestrial exotic forbs near their dens (Parker, 2006) and may have contributed to a lack of exotic coverage coupled with park intervention at the site. Jones Hole was an exception to the observed trend of increasing exotic coverage downstream. In general, exotic species coverage increased downstream, while native species community cover remained approximately consistent.

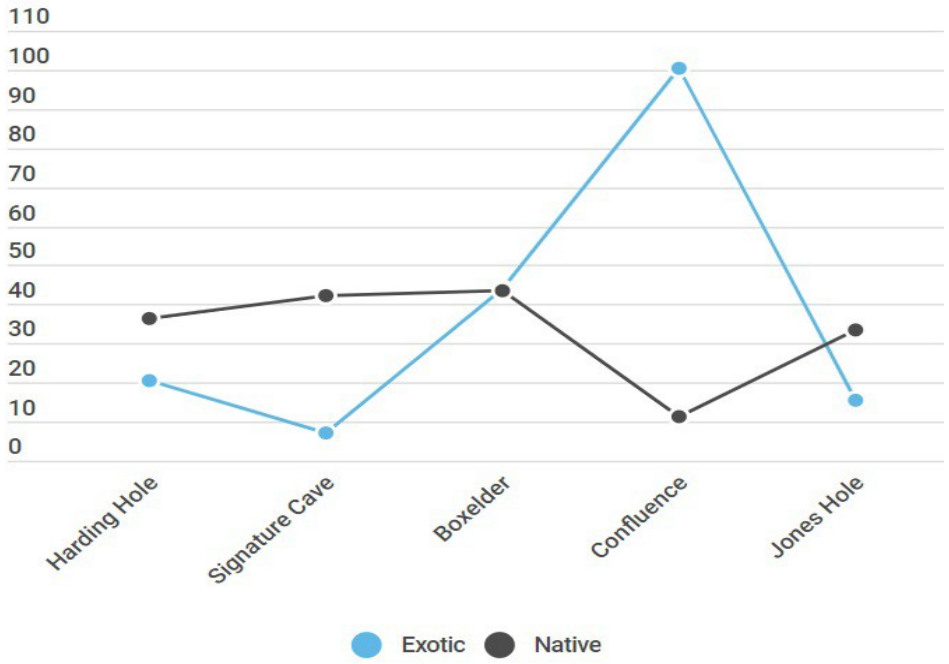

Figure 1. Changes in percent cover of exotic and native species at each study site on the Yampa and Green Rivers.

Changes in the abundance of individual cottonwood, willow, and boxelder were also observed to shift from the Yampa to the Green River (Figure 2). Boxelder observations along the river increased from Harding Hole to Box Elder and decreased after Box Elder Camp. Cottonwoods decreased from Laddie Park to Box Elder and increased from Box Elder to Split Mountain. These cottonwoods were observed to be larger, therefore older, and probably came from a time where natural high flows still occurred on the Green river, allowing them to establish at higher elevations on the river bank. Few small cottonwoods were observed. Willows steadily decreased from Harding Hole to Jones Hole, slightly increased from Jones Hole to Island Park, and then decreased from Island Park to Split Mountain. Decreases in both willow and cottonwood may be due to a lack of scouring and sediment transport to create new sandbars.

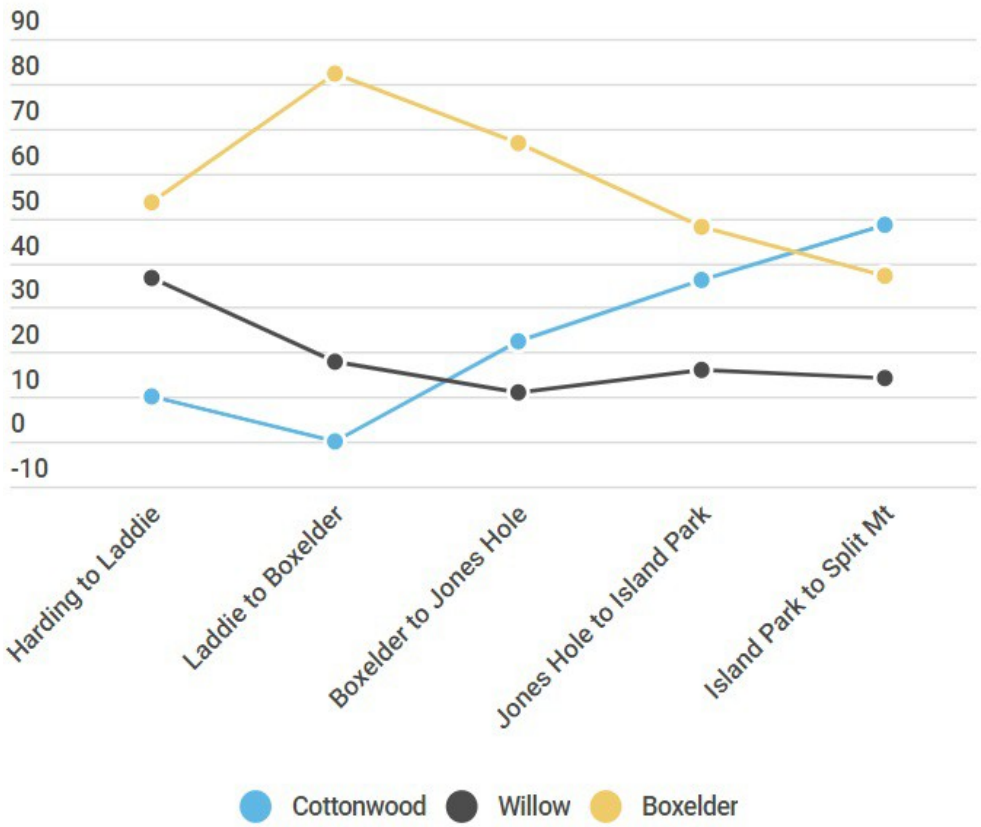

Figure 2. Percentages of individual woody species observed from floating along the Yampa and Green Rivers.

Distributions and habitat preferences of cottonwoods, willows, and boxelders were noted along with the individual visual observations (Figure 3). Willows were observed to be in higher percentages on sandbars. Cottonwoods were observed in higher percentages on sandbars and to a lesser extent on terraces. Boxelders were observed in higher percentages on rocky cobbles and outcroppings in canyons and to a lesser extent on terraces. The ability of cottonwoods and boxelders to survive to a reproductive size on both sandbars and terraces may explain why their abundance (based on percent observed) was greater than willows, which predominantly prefer sandbars.

Researchers also generally noted that the cottonwoods seen along terraces were significantly larger and therefore older than those along sandbars; few if any middle-aged cottonwoods were noted. Presumably, the large cottonwoods seen on terraces indicate the presence of high flows decades ago. A lack of cottonwood recruitment has serious implications for future habitat in the monument, particularly for birds who rely on large old cottonwood trees or other vegetative structure.

Downstream of the confluence of the Yampa and Green rivers, the number of sandbars along the corridor of the river decreased steadily. This is most likely due to a lack of sediment supply and alterations of flows caused by the operation of Flaming Gorge Dam on the Green

River. On some sandbars downstream, including that at Jones Hole and a larger sandbar at Island Park, an abundance of willows and a few small cottonwoods were noted. Inputs of sediment from the confluence with the Yampa river is likely a significant contributor to the sediment in the Green river, and helps to promote cottonwood recruitment when flow conditions are suitable.

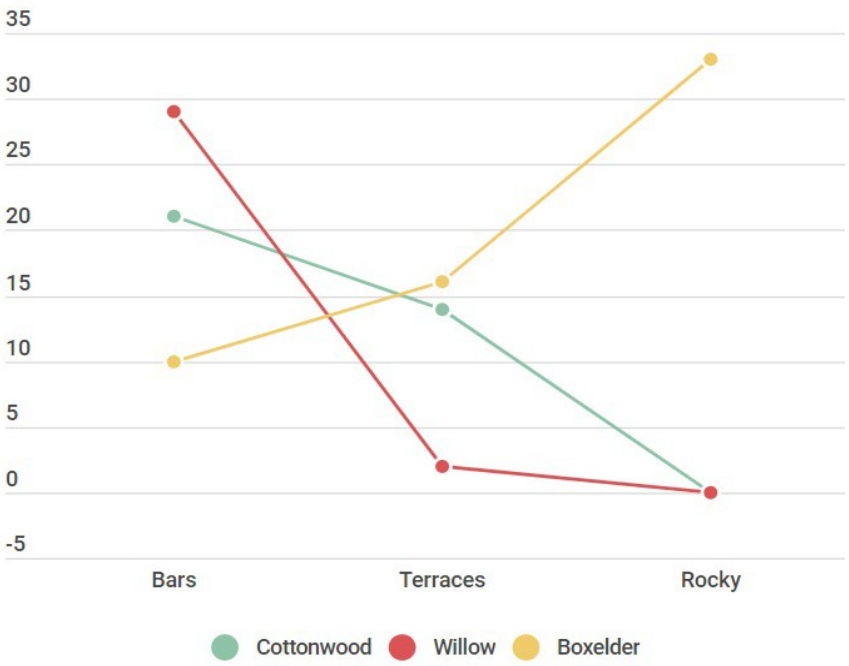

Figure 3. Percentages of woody species on bars, terraces and rocky cobbles and outcroppings showed species distribution within habitat throughout the river corridor.

We noted throughout the trip that the cottonwoods closest to the water's edge on both the Yampa and Green rivers were very small and therefore assumed to be very young. Upon later and closer inspection, it was observed that these "small" cottonwoods were usually coppiced and resprouting shoots from larger and older trunks. It was noticed at the Harding Hole site, that beavers are also a substantial force on the river and an additional possible reason for the lack of cottonwood growth. Cottonwoods are softwood deciduous trees, which lends them the ability to bend instead of break during high flows, or alternately break and resprout from broken branches and shoots further downstream (Karrenberg, 2002). It would be beneficial to learn more about the effects of beavers, peak flows, and flow alterations on limiting cottonwood recruitment and growth.

In general, we observed as we traveled downstream that the Yampa River had considerably less woody exotic species, such as tamarisk, than the Green River, and where tamarisk did occur, they were in lower population numbers and smaller colonies than those observed on the Green River. The Yampa River also had a large quantity of mobile woody debris observed after the flash flood on 22 June 2019 that may later contribute to instream sediment accumulation and habitat formation along the banks of the river for all vegetative species.

Tamarisk were observed on all terrestrial levels including sandbars, rocky cobbles, and terraces. This is likely due to their later seed dispersal as well as their ability to resist drought and flooding once established.

This 2019 season in particular was very wet in the North American West. Colorado had a snowpack 751% above normal, which lead to significantly higher water levels on the Yampa and Green Rivers (Samenow, 2019). Many of the areas that would have been likely candidates for surveying were underwater. Due to the late seeding dispersal of tamarisk and the normal westerly winds, it seems possible that wind dispersed tamarisk seeds may be blown back upstream and colonize these newly exposed banks after peak flows subside and spring snowmelt recession occurs. Care and observation should be made by river visitors (including weed warriors?) after spring snowmelt recessions along sand bars to reduce establishment of tamarisk along the reaches of the Yampa River.

CONCLUSION

Unregulated rivers such as the Yampa River in Dinosaur National Monument erode, carry, and deposit sediments with naturally variable flows that native plants and animals have adapted their life cycles to. Boxelders are dependent on naturally occurring high flows for adequate water. Species such as cottonwoods and willows prefer sandbars that are created from scouring at high flows followed by sediment deposition as flows decrease. These annually scoured and redeposited sandbars are also prime habitat for colonial plant species that depend on disturbance to limit competition for light. Sand bars in general were more prevalent on the Yampa river than on the Green river, though the higher than normal water levels during this study made evaluation of bars extremely difficult.

Regulated rivers such as the Green river in Dinosaur National Monument have altered erosion, sediment transport, and deposition regimes as sediments are captured upstream of Flaming Gorge Dam. This leads to less sediment deposition downstream and less open habitat for disturbance dependent vegetative species. Willows were observed to have the greatest preference for sandbars, which decreased in quantity downstream of the confluence. The decreased presence of bars was likely affected by the lack of sediment in the Green river downstream of Flaming Gorge Dam. Due to regulation of flows on the Green river, a lack of annual disturbances that scour and deposit new sediments favors exotic species, which were observed to generally increase after the confluence.

The data collected indicates that there was a decrease in native species percent cover and an increase in percent cover of exotic species downstream of the confluence on the Green river. Jones Hole represented a shift in this trend, possibly due to the presence of bank beavers and Weed Warriors as a force of disturbance in the area that benefited native rather than exotic species. Efforts to continue supporting native species and their habitats should continue.

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