Dear Friends and Family of Charlie Blumenstein,

As I look back on my summer, virtually commuting to Northern Colorado all the way from Sherborn, Massachusetts, the greatest thing that comes to mind is gratitude. As we all struggled to adapt to a rapidly changing world, I was lucky enough to work each day with a wonderful group of people all working on pressing conservation issues.

Throughout the summer, I was able to gain a greater understanding of how conservation functions on the ground (despite being virtual myself). It was especially interesting to be involved in the process of finding a new lessee to run the agriculture portion of the ranch. This process included conversations on the Conservancy's goals for the ranch, and how to best use it so the ranch can serve as a template for ecologically responsible ranching, with management practices that are applicable to other Colorado ranches. With climate change a looming threat to all conservation, and COVID-19 standing in the way of normal operation, these conversations about the core goals for the property (and the larger Colorado chapter) seemed especially important. The Nature Conservancy is committed to keeping Carpenter a working ranch; however, they have a number of research interests they hope to address relating to responsible and sustainable grazing, haying, and water use, and finding a lessee who can be a long term partner in these goals is incredibly important. It was very rewarding and informative to be involved with this process throughout the summer. I also spent time looking at maps of elk habitat corridors, to see where on the ranch the elk are passing through during their migration.

While the virtual nature of this internship definitely had its limitations, it also had certain benefits, and I was able to come away from this summer having learned a lot, and made many great connections. I was lucky enough to be able to focus my independent project on a subject

that greatly interests me: the interaction between human activity, river flow, and ecological systems in the Yampa and the larger Colorado River Basin, culminating in a longer paper on the subject. Many of the accounts and studies I used in researching this project were based at the Carpenter Ranch, and even though I was across the country, I was able to develop both a strong sense of place for the ranch, and understanding of the riparian ecology that it encompasses. The conversations I had within the conservancy were also super helpful throughout this project, with my weekly meetings with Jennifer Wellman particularly essential in broadening my understanding of the region, its hydrology, and its culture, and were also great times to mull over some of the larger questions about the nature of conservation. Since I left, they have had conversations with marketing about using the paper, and hopefully it will find a home on their website for public viewing.

It was also very nice to engage with the interns from other schools on a weekly basis, and meet professionals working on very different projects throughout the Colorado chapter of the Nature Conservancy. The changes brought by the pandemic were particularly turbulent in the beginning of the summer for the Colorado chapter, but despite several large changes, everybody on the staff worked hard to support interns however possible, and regularly made time to share their experiences, career paths, and advice. One of the silver linings to working remotely: I was able to talk with people from all over the state of Colorado that I likely would not have been able to engage with had I spent the summer on the ranch.

I was also lucky enough to visit the ranch at the end of this summer on my way to school, and meet with Sally and Matt, who I was working with virtually throughout the summer. Seeing the Carpenter Ranch (and Deerlodge Park further downstream in Dinosaur) as the leaves were just starting to turn was absolutely special. This (my second) visit to the property absolutely

confirmed what a special place it is, and I undoubtedly would have loved to be able to spend more time there, had this summer come under different circumstances.

This summer has also helped me better understand my interests for the future, particularly in investigating and communicating the intersection of human activity and our surrounding ecology (which in Colorado especially relates directly to our water use). Conservation groups like the Nature Conservancy work right at this intersection, attempting to increase community commitment to preserving the natural systems that surround us. A major step towards such a commitment is promoting a broader understanding of the extent that we both affect, and rely on, these ecological systems. These themes were at the core of all the work I did for the Nature Conservancy, my independent project, and will hopefully be central to what I try to accomplish moving forward.

Thank you again for all your support, it really means the world. This internship was an amazing opportunity for me, and I am sure the knowledge I gained throughout it will help me chart my path moving forward.

All the best,

Jon Lamson

# The Confluence of Ecology, Flow, and Human Activity on the Yampa River

Jonathan Lamson

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There is a clear difference between the Yampa and Green Rivers when they meet in Echo Park, in the heart of Dinosaur National Monument in Northwest Colorado. They join at the start of a horseshoe bend, flowing around a sheer, sandstone monument named Steamboat Rock that towers over the confluence. Cottonwoods, willows, and red osier dogwood line the sandy outside shore along the bend, surrounded by another vertical canyon wall. Coming from the east, flowing into the outside of the bend, the Yampa is a muddy brown, completing its 250-mile journey into the Green. Throughout the late summer and early autumn, it is warm enough to swim without much mental fortitude. Along the inside of the bend, the Green is cool, clear, dark, and lacking the sediment that gives the Yampa its color. As they meet and flow around Steamboat Rock, a hybrid river is created, running unobstructed to Canyonlands National Park where it joins with the Colorado River.

Such a visible distinction between the two rivers is a relatively recent phenomenon: 65 miles up the Green River from Echo Park stands the Flaming Gorge Dam, 502 feet tall, pushing a reservoir 91 miles back up the river, blocking sediment, high spring runoff, and flood surges. The dam was completed in 1962 as part of the Colorado River Storage Project, which also authorized the construction of an even larger dam in Glen Canyon, downstream on the Colorado River in Arizona. These two dams function primarily for the purposes of generating electricity and storing water to ensure consistence of downstream river flows.

The merits of construction, particularly of the Glen Canyon Dam, have since been heavily debated. The flooding of Glen Canyon gained fame as one of the great cultural and environmental tragedies of American history, galvanizing the environmental movement. In the words of writer Edward Abbey, who was one of the

few to float the canyon before it was flooded, and later wrote about it in his 1968 book, *Desert Solitaire*:

> Here was an Eden, a portion of the earth's original paradise. To grasp the nature of the crime that was committed imagine the Taj Mahal or Chartres Cathedral buried in mud until only the spires remain visible. With this difference: those man-made celebrations of human aspiration could conceivably be reconstructed while Glen Canyon was a living thing, irreplaceable, which can never be recovered through any human agency. (p. 152)

The Yampa has so far been lucky enough to escape such a fate. Aside from a few smaller upstream reservoirs, the river runs 250 miles largely unimpeded from the Flat Tops Wilderness to Echo Park. While human activity has undeniably had its impact, the Yampa remains wild. The clear, visible differences between the Green and Yampa Rivers at their confluence hints at the key role the Yampa river plays in supporting what is left of the natural systems within the Green River, and within the larger Colorado River Basin. As Colorado economies grow and water stress increases, a complete understanding of our impacts is essential for preserving both the Yampa River and all the life that it supports.

While modern human impacts on the Yampa began in the late 1800s with European colonization and removal of Native Americans from this landscape, humans have inhabited Colorado for over 10,000 years. Throughout Dinosaur National Monument, there are tools, clothing, jewelry, and petroglyphs dated from 400-800 C.E., attributed to a group known as the Uinta Freemont. The Eastern Shoshone and Cheyenne tribes also used areas around the Yampa river, and most recently the Yampa River Valley was inhabited by the Yamparika, part of the White River Band of Utes. They resided throughout the Yampa and White River Valleys until the late 1800s, when they were forced onto a Utah reservation by the U.S. military and their native land sold to settlers.

American empire has a history of attempting to wipe out Native American cultures and place-based knowledge. When Europeans first came to the Yampa River Valley, they tried to force the White River Utes into an agricultural way of life, to ensure their compliance within the ever-expanding European system. When the Utes resisted, U.S. agents resorted to starvation, killed Ute horses, and eventually summoned the U.S. Army. Fighting broke out, and by the early 1880s, nearly all of the White River Utes were forced out of Colorado, onto a reservation of land considered undesirable by the Mormons in Northern Utah. Once on this reservation, U.S. government rations were withheld in order to force Ute children to attend boarding schools that focused on removing their traditional language, culture, and livelihoods. The resulting loss of knowledge, culture, and connection between Yampa River valley's native inhabitants and the region today is a great tragedy, and a detriment to our modern understanding of water use and sustainable living with the valley.

**Interconnected Systems**

The patterns of flow in the Yampa River, still resembling the historical conditions, help set the river apart within the Colorado River Basin. The Yampa river system is characterized by high levels of salinity and sediment (particularly in its lower reaches after it is fed by the Little Snake, which provides the majority of the Yampa's sediment load), as well as large swings in water temperature, ranging from 0 to 30 °C. Patterns of flows vary greatly based on time of year, with water running high in the spring due to snowmelt runoff. From late summer into the winter, low flow conditions persist, with occasional, intense surges and flooding due to large rainstorms and summer monsoons. The seasonal fluctuation is significant: since 2000, average monthly flows at Steamboat Springs have been about 17 times higher in May than in December.

The floods that occur in the spring and summer after large rainstorms are essential to shaping the Yampa, which is itself always changing, carving new paths within its floodplain. As the river meanders through the valley, particularly through the

wide, low gradient Morgan Bottom and Hayden floodplain (located between Milner and Craig), flooding events and high spring runoff erode the outsides of bends while depositing sediment on the insides, simultaneously widening the path of the river, and creating "point bars" on the inside of curves where sediment is deposited. These widening curves are eventually short-cut, creating "oxbow lakes" as abandoned channels become still backwaters.

As the continual shifting of the river's path creates and destroys habitat, plant communities are quick to take advantage of newly deposited sediment and nutrients. In oxbow lakes, cattails and rushes establish, creating marshes. On the gradually deposited point bars, narrowleaf cottonwoods are the first to arrive, their seeds deposited and aided in germination by spring flooding. As these Cottonwoods mature, box elder (a type of maple tree), and red osier dogwood (a red-stemmed shrub) will typically establish populations, creating the dominant riparian forest plant communities. Box elder and red osier dogwood are late-successional species, meaning that they are slow to appear after disturbance or creation of a new habitat. On the Yampa, they rely on colonization of a habitat by cottonwoods before they can take root. These specific plant communities are globally rare, and today are only found in a few locations throughout Colorado, especially prominent in the Morgan Bottom and Hayden area. In 1996, the Nature Conservancy acquired the Carpenter Ranch, including three miles of riverfront property, largely to ensure the protection of these plant communities and their larger riparian ecosystem.

Clear-cutting and overgrazing present immediate threats to these plant communities. One study, looking at a period from the late 1800s to the early 1900s when the Yampa River Valley was treated as open cattle range, found that there was essentially no new growth of young cottonwoods over the long term. While these immediate threats must be mitigated, cottonwood survival is also likely contingent on historical flood patterns. Along with creating the habitats that allow for the existence of these plant communities, floods limit the available oxygen for plant life, and are a selecting force on the species present, killing plants that have not adapted to these

conditions. Without floods to help spread the seeds and create the wet environment needed for germination, sexual reproduction for Cottonwoods becomes nearly impossible. In an ecological model created for the Nature Conservancy by researchers Brian and Holly Richter, without natural flooding events, cottonwoods eventually disappeared.

The benefits of the forests, aside from aesthetic, historic, and cultural values, extend throughout the larger ecosystem. For many bird species, riparian habitats are essential. Lowland, riparian forests in Colorado have been found to have significantly higher diversity of bird species than upland forests. Two rare, protected, large bird species, bald eagles and greater sandhill cranes, use the lowland forests along the Yampa as breeding habitats. Bald eagles also use these forests as winter habitat, while the Yampa is also an important staging ground for the greater sandhill crane during their fall migrations.

Furthermore, the wetlands and riparian forests along the Yampa help control flooding, recharge groundwater, and improve water quality. Trees along the banks provide shade and help cool the water during hot summer months. The persistence of these forests also helps maintain the shape of the river by slowing processes of erosion, stabilizing critical aquatic habitats, and providing late-season moisture in the high desert environment.

Within its fluctuating currents, the Yampa is also an important refuge for many native fish species, and improves habitat in the Green after their confluence. The Yampa provides the Green with more natural temperatures, seasonal flows, sediment levels, and salinity, and serves as spawning habitat for fish residing in the lower portions of the Green. In the Colorado River Basin, there are four listed endangered species: Colorado pikeminnow, razorback sucker, humpback chub, and bonytail. The lower 50 miles (roughly from Craig to Echo Park) of the Yampa River are designated as critical habitat for these four species. Further up the river serves as habitat for bluehead suckers, flannelmouth suckers, roundtail chub, and mountain whitefish, all rare native

species. However, despite the largely unaltered flow of the Yampa River, the future of these species is hardly secure.

The suckers and cyprinids native to the Colorado River Basin have evolved to utilize the diverse niches created by the constantly shifting river, relying on different food sources, and occupying distinct habitats based on both species and age. Younger fish tend to utilize slow, shallow stretches of river, often close to shore or in a backwater, with vegetation as cover. As they reach maturity, they move to deeper water. Bluehead suckers, flannelmouth suckers, and roundtail chub have all demonstrated a preference for deep, slow moving pools with a variety of river substrates. A large range of habitat is also required for spawning. A 2017 study lead by Jan Boyer on the Madison River in Montana found that on average, mountain whitefish travel 25 kilometers each year to spawn.

Our water use, particularly for industry and agriculture, has often been destructive of aquatic habitats. Dams and poorly constructed diversions form barriers between populations, restricting genetic exchange and decreasing genetic diversity. The isolation of populations also increases the likelihood of random extinction events and threatens migratory corridors. Water released from dams is also typically cooler, lacking in sediment and nutrients. In the Colorado River Basin, this tends to result in poor habitat for native fish downstream, and reservoirs upstream that are also usually unfavorable for most native species. Water temperature is also an important factor in the timing of reproduction for bluehead suckers, flannelmouth suckers, and roundtail chub, making these species especially vulnerable to changes in their habitat. Channelizing the river, armoring banks to protect infrastructure, and using dams to restrain floods all threaten diversity of river habitats by constraining the natural shifting of river paths and altering cycles of erosion and deposition.

Human recreation accompanying dams, even on the largely unaltered Yampa, has brought an additional factor: introduced, non-native fish species. Of 52 species of fish found in the Upper Colorado River Basin, only 13 are native to the region. Northern pike, initially stocked in the Stagecoach Reservoir, and smallmouth bass, stocked in the

Elkhead reservoir, both escaped downstream and established resident, predatory populations within the Yampa. These two species can have synergistic effects on the native species: smallmouth bass prey on the smaller-bodied fish, while northern pike feed on those that are lucky enough to reach maturity. This intense predation is particularly harmful to the species that have evolved in the Colorado River Basin, which tend to have slower life cycles, meaning they take longer to reach maturity and breed sporadically throughout their lifetimes. This amplifies the effects of added predation, making it more difficult for populations to quickly rebound. However, the conditions on the Yampa have helped limit bass and pike populations, as the water is still cooler than is preferred for bass and pike (though this is likely to change with a warming climate). High spring flow in the Yampa favors recruitment of native species, while smallmouth bass tend to thrive when these conditions abate.

The interactions between the Yampa's flow, riparian forests, and native fish are all very logical at their essence- it is the native species that have evolved to use the natural habitats and resources that exist here in the most efficient ways. In the face of increasing threats, preserving the natural characteristics of the river is essential. As pike and bass have taken root in the Yampa they have depleted native fish populations, disrupting the basic structure of energy flow through the ecosystem and outlining an aquatic shadow of the colonizing settlers that imported them into the Yampa's reservoirs.

## Cycles of Creation and Destruction

The vitality of the Yampa River is dependent on the existence of a dynamic equilibrium within its basin. The seasonal fluctuations between spring floods and late-summer return flows, and the slow meanders and abrupt cutoffs that create and destroy habitat, are the environment upon which the balance of the local ecosystem is built. While floods can threaten existing habitat and human infrastructure alike, they are essential for the plant communities that improve both water quality and aquatic habitat,

and have reverberating effects throughout the entire ecosystem. The lack of permanence within the system is what supports it.

This dynamic equilibrium is often a direct contradiction to how we have interacted with water in the modern times since European colonization. Instead of learning how to live within the world around us, we have strived to dominate it. Our desires for stability, control, and permanence have physically manifested throughout the Colorado River Basin in the behemoth dams that flooded Glen Canyon, Flaming Gorge, and clogged nearly every major river in the American West.

A similar fate nearly came to Echo Park, right in the heart of Dinosaur National Monument, in the early 1950s. The US Bureau of Reclamation had proposed another large dam within Echo Park's high canyon walls in the same legislation that flooded Flaming Gorge and Glen Canyon. The saving grace (but only for Echo Park) was a coalition of 28 conservation organizations, including the Sierra Club, National Parks Association, and Wilderness Society, that formed to keep the dam out of the Colorado River Storage Project.

The decision to defend Echo Park specifically, instead of Glen Canyon or Flaming Gorge, was based on its location within a national monument (along with the fact that they knew little about Glen Canyon at the time of the legislative battle). Conservationists, particularly those in the National Parks Association, were worried about the precedent it would set if dams were allowed to be constructed within protected lands, which were threatened by a number of other proposals, including one within Grand Canyon itself. Their fight was eventually successful, and despite last minute objections from the Sierra Club Executive Director, David Brower, the conservation coalition went so far as to support the final legislation, after the removal of the Echo Park Dam, sealing the fate of Glen Canyon and Flaming Gorge.

Following the passing of the Colorado River Storage Project, but prior to the construction of the Glen Canyon Dam, the Sierra Club sponsored float trips through Glen Canyon. During the same period, Lula Leopold, the chief hydrologist for the U.S. Geological Survey released a report that concluded that the Glen Canyon Dam was

unnecessary for goals of storage and regulation, with the Hoover Dam downstream. For those who were aware, an understanding developed of both what was to be destroyed and the insufficient reasons for its destruction. To this day, Glen Canyon remains a powerful symbol within the American environmental movement.

In the increasingly dry American west, water is both the painter and the painting. To control water is to control life itself, and there is little room for error. Water shapes the landscape, builds and maintains the ecosystems, supports our culture, ranching, farming, and larger economies, and at the most basic level, keeps us alive. Too frequently, we have failed to use the American West's limited water supply in a way that accommodates all needs. Looking at just one example, California has the largest state share of water rights to the Colorado River, with 4.4 Million Acre Feet per year (MAF). The majority of this allotment, 3.1 MAF, is piped out of the Colorado River to the Imperial Valley, an agriculture epicenter in the Sonoran Desert, which averages less than 3 inches of rain each year. The amount of water allotted to the Imperial Valley is roughly equal to the combined rights of Arizona and Nevada.

While the construction of large dams and reservoirs has helped ensure these state water quotas, any water removed for upstream uses has inevitable downstream impacts, regardless of legal or moral justification. When all quotas are filled, there is usually nothing left for the river. Since the construction of massive river storage projects in the Colorado River Basin in the mid-20$^{th}$ century, the Colorado has only on occasion reached its final destination in the Sea of Cortez, most recently in the spring of 2014 as a result of a historic collaboration between U.S. and Mexico to help improve the delta habitat. The Colorado River delta, formally a thriving, biodiverse wetland, home to thousands of Cocopah Native Americans, is now mostly dry desert.

One enduring theme of our efforts to manipulate and control water here is responsibility. Regardless of legal water "rights," all water users within the Colorado River System have a responsibility to understand the consequences of wasteful water use and to limit these as much as possible, with so much relying on this dwindling

source of life. As climate change stretches the already-limited water resources thin, we must be creative about how we use our water, and act not simply for personal profit, but for mutual survival.

Any history and reflection of human interaction with water and ecology along the Yampa river is vastly incomplete without the insights of the people who lived here for hundreds of years prior to European colonization. The destructive colonization and western expansion, when the White River Utes were forced out of Colorado and intentional efforts made were made to strip them of their culture, has extending negative effects in the present. The losses of culture and collective wisdom are today as incomprehensible as any unseen, canyon wonder flooded in the name of the Colorado River Storage Project.

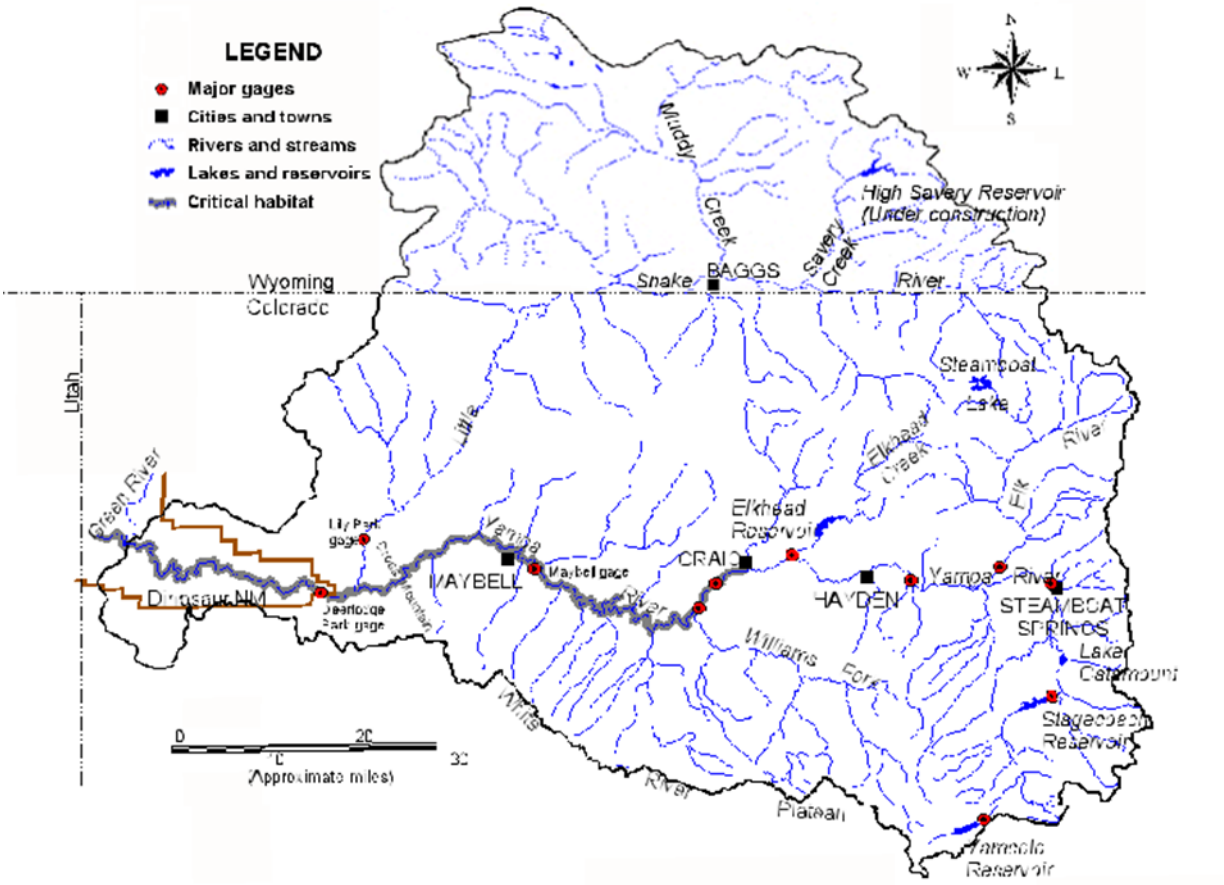
Since this shameful episode of American history, our use of this land, and the water that runs through it, has been incredibly wasteful. Even the outspoken proponent of the Colorado River Storage Project, Arizona Senator Barry Goldwater, came to consider the damming of Glen Canyon a serious mistake, lamenting its lost beauty (and even reportedly agreeing to help former foe David Brower fight for the removal of the dam) prior to his passing. The weight of mistakes, while dealing with water in a desert, our hands holding the levers of life and death, must be spotted at the time of decision making, not decades after, when irreversible damage has already been done. We can no longer afford to ignore the consequences of our actions; our collective responsibility to each other and our surrounding place must be adequately considered. For too long we have stumbled and crashed through the darkness with hardly an idea or an image of what has been broken.

The underlying, ever-present tragedy in the American West is unavoidable, but ought not be paralyzing. There are still people, cultures, and ecosystems left to be fought for. The hope is also very tangible: dams cannot last forever, and our understanding of how these rivers function as dynamic systems is constantly

improving, along with the efficiency of our own water use. On the Yampa, a coalition of town governments, businesses, and NGOs recently launched the Yampa River Fund, an endowment with the goal of preserving flow in the Yampa during the driest periods, restoring habitat, and improving irrigation infrastructure. This type of community collaboration, based on a shared recognition of the value in a healthy Yampa River, is exactly what is needed going forward. At the same time, a new project threatens to build four dams on the Little Colorado River, just upstream of its confluence with the Colorado River in the Grand Canyon. The threats, to sacred land on the Navajo Nation and the encompassed ecology, including critical spawning habitat for the endangered humpback chub, are hardly new.

The image of Echo Park, with the depleted waters of the Green and the hope of the Yampa running into each other, perhaps encapsulates these simultaneous emotional forces better than anything that can put into words. There is much to mourn, yet even more left to save and resuscitate. There is no reason to think that the perseverance of this dynamic river system is incompatible with human prosperity. Instead, these outcomes seem to be inseparable, when thinking beyond our most immediate interests.

At the point where the Yampa and Green meet, the rivers do not initially mix together. The visibly distinct waters are each seemingly intent on running their own course. But now they are just one river, in one canyon, with one final destination that neither has much chance of reaching. Their fates are intertwined, with no choice but to slowly merge into one, traveling toward the sea.




Map of the Yampa River Basin (Roehm, G. W. 2004).

## Scientific Binomials

| | |
|---|---|
| Bald Eagle | Haliaeetus leucocephalus |
| Bluehead Sucker | Catostomus discobolus |
| Bonytail | Gila elegans |
| Box Elder | Acer negundo |
| Colorado Pikeminnow | Ptychocheilus lucius |
| Flannelmouth Sucker | Catostomus latipinnis |
| Greater Sandhill Crane | Grus canadensis |

| | |
|---|---|
| Humpback Chub | Gila cypha |
| Narrowleaf Cottonwood | Populus angustifolia |
| Northern Pike | Esox lucius |
| Razorback Sucker | Xyrauchen texanus |
| Red Osier Dogwood | Cornus sericea |
| Roundtail Chub | Gila robusta |
| Smallmouth Bass | Micropterus dolomieu |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