Flaming Gorge Dam Effects on Amphibian, Reptile, and Mammal Populations

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ABSTRACT

The construction of Flaming Gorge Dam has modified the flow of the Green River, causing decreased flooding and altering the surrounding riparian vegetation. There are many species of animals relying on this habitat, but the effects of the habitat alterations on amphibians, reptiles, and mammals are not well known. Amphibians may suffer due to a decreased floodplain but reptiles and mammals are most likely either benefited or not affected at all. Alterations to the vegetation composition and their food source are factors determining the populations' response to the regulated river. These populations may revert to their historic structure and function as the distance from the dam increases, in accordance with the serial discontinuity concept.

INTRODUCTION

Construction of Flaming Gorge Dam on the Green River in Utah was completed in 1962 with operation beginning in 1967. The dam's construction has altered this river system into a regulated river. Stanford and Ward (1983a cited in Stanford and Ward 2001) devised the Serial Discontinuity Concept which states that rivers will revert back to their natural conditions with increasing distance downstream of the dam. They considered a dam to be a discontinuity in the natural continuum of the river that causes environmental responses in relation to what they term the "discontinuity distance" (Stanford and Ward 1983a cited in Stanford and Ward 2001). In this paper I discuss some of the known amphibian, reptile, and mammal species inhabiting the riparian ecosystem of the Green River and suggest how their populations are impacted by the Flaming Gorge Dam. Additionally I discuss how impacts to population compositions by the dam may decrease farther downstream.

While there is limited information available on the populations of amphibians, reptiles, and mammals along the Green River, it can be inferred that the dam has impacted them indirectly through changes in their habitat and food source. They appear to be neglected in studies dealing with dam environmental consequences perhaps as a result of the limited direct effects river regulation has on them especially when compared with the present dwindling native

fish populations. However, amphibians, reptiles, and mammals are a fundamental component of the ecosystem and their population changes should be considered as well.

Regulated rivers have their channels separated from their floodplains, causing loss of the interactions between them (Ward and Stanford 1995). Often a new shoreline will form to match the new water levels which may then be colonized by riparian species depending on the interval, length, and rate of occurrence of these water levels, substrate movement, and interactions with other species (Nilsson and Berggren 2000). For example, movement of riparian vegetation can influence the movement of animals as new usable habitat is either created or destroyed. Naiman et al. (1993) describes riparian habitat as a "corridor [that] encompasses the stream channel and that portion of the terrestrial landscape from the high water mark towards the uplands where vegetation may be influenced by elevated water levels or flooding" with high biodiversity. Unfortunately, river regulation is known to reduce biodiversity (Stanford and Ward 2001). I will examine various species known to inhabit area along the Green River and possible changes to their populations as a result of the dam. Specifically, in this paper I investigate the following questions: (1) is the serial discontinuity concept applicable to amphibian, reptile, and mammal populations? And (2) what changes in amphibian, reptile, and mammal populations would be expected as the distance downstream from the dam increases?

VEGETATION CHANGES

In order to discuss changes to amphibian, reptile, and mammal populations it is necessary to consider what has happened to the riparian vegetation with river regulation. Habitat plays an important role in the life of mammals, as it serves as their home and source of food. The riparian habitat along the Green River appears to be experiencing change as a result of the flow regulation (see Bowen 2006, this volume). One well studied species of the area is the cottonwood (*Populus* species), as well as its exotic competitor, the tamarisk (*Tamarix ramosissima*). Cooper et al. (1999) states that cottonwood establishment would occur in the beginning of summer. They suggest that changing dam releases to incorporate peak flows in the beginning of summer would allow cottonwood establishment over the tamarisk, whose seeds do not disperse until later in the summer. However, tamarisk was present along the river before the construction of the dam, but flow regulation results in a more suitable habitat for the species (Cooper et al. 2003).

There are several aspects to the change in vegetation composition found after dam completion. According to Cooper et al. (1999) “free flowing western rivers with large (> 2m) annual stage changes and large fine-textured suspended sediment loads, such as the Yampa, create environmental opportunities for, and place constraints on, cottonwood establishment fundamentally different from those on (1) regulated rivers with (> 1m) stage changes (2) regulated or unregulated rivers with low sediment loads, or (3) river reaches with primarily coarse-textured substrates,” as fine-textured sediment retains more water for plant use (van Genuchten et al. 1989 cited in Cooper et al. 1999). Since it is not possible to add fine-textured sediment to replace that trapped behind the dam and with flows determined by the needs of native fish with constant variability between the years, cottonwood establishment is restricted due to incompatible soils (Cooper et al. 1999).

Merritt and Cooper (2000) note that some areas of Browns Park (located downstream of the dam) are constantly flooded while others are left dry resulting from the constant stage as well as water table levels of the regulated flow. They find that this is not the case on the unregulated Yampa River where there is what they describe as a continuum for the amount of wetness. These conditions in Browns Park should cause a difference in the vegetation composition between Browns Park and Deerlodge Park (located along the Yampa River), but with park water conditions approaching those of Deerlodge Park farther downstream of the dam. They determined that Browns Park had shrubs dominating since the dam closure. Another aspect of their study demonstrated that while the river channel through Browns Park once compared to the Yampa’s in Deerlodge Park, it has since narrowed by vegetation (especially tamarisk) encroachment because of limited high flows (Merritt and Cooper 2000).

AQUATIC INVERTEBRATE CHANGES

As with riparian vegetation, aquatic invertebrates are an important component in the lives of various amphibians, reptiles, and mammals as a food source, and their population changes as a result of the dam should also be considered. The Green River once sustained a large aquatic invertebrate diversity with 21 genera with similar species compositions upstream and downstream of the confluence with Red Creek (Vinson 2001). However, since the dam was completed, Vinson (2001) has found notable changes in the invertebrate assemblages with regard to their location, either upstream or downstream of the Green’s confluence with Red Creek (see

also Brenneis 2006, Leong 2006, this volume). Upstream of Red Creek he finds a decrease from about 30 species of mayflies (Ephemeroptera) before the dam to only 3 afterward but with an enormous increase in abundance of macroinvertebrates. The downstream reach was found to be more diverse than the upstream one, with density increasing after the dam and eventually reaching a level close to those upstream. Vinson (2001) suggests that the increase in winter water temperatures (2-3ºC) by river regulation hinders an increase in diversity but is not likely to affect the amphipods (*Hyallela azteca*) who have recently (1993-1999) accounted for the majority of invertebrates upstream of Red Creek. He found that floods increased insect numbers while decreasing amphipods and that the confluence with tributaries, such as Red Creek, increases diversity (Vinson 2001; see also Brenneis 2006, Leong 2006, this volume).

AMPHIBIANS

Amphibians generally use slow or non-moving water sources for reproduction, the eggs and larvae needing to live in water to survive until they metamorphose into adults. Changes in Green River flow have changed the availability of floodplains for amphibian reproduction. While amphibians are dependent on water for reproduction, and in some cases as resting areas, they are affected by the microenvironments created by vegetation (Hammerson 1999). As a consequence, their distributions may change in response to the changes in vegetation distribution resulting from flow regulation. They prey on invertebrates, and changes in the invertebrate abundance and distribution due to flow changes might also impact them.

There is no information available in the literature directly addressing the effects of the Flaming Gorge Dam and Green River regulation on amphibians or recording change in their distribution, abundance, or diversity in different reaches along the river. The United States Fish and Wildlife Service (USFWS) documents five species to be present in Browns Park and Ouray National Wildlife Refuges (located along the river): tiger salamander (*Ambystoma tigrinum*), Great Basin spadefoot toad (*Scaphiopus intermontanus*), Woodhouse's toad (*Bufo woodhousei*), northern leopard frog (*Rana pipiens*), and boreal chorus frog (*Pseudacris triseriata maculata*; see Table 2). I choose to discuss only the first four species as they will be representative of the area of the Green River (Flaming Gorge Dam to Split Mountain) discussed here.

Tiger salamanders (Fig.1) live in any habitat up to 3,660m where there is water nearby, usually in the form of pools or ponds available for breeding (Hammerson 1999). They tend to

live near rodent populations whose burrows they will use for the winter (Hammerson 1999). After breeding, they move to bodies of water depending on availability of food, especially in response to fairy shrimp populations (Hammerson 1999). According to the information presented in the following mammal section on rodents that many rodent populations may experience an increase in abundance with river regulation, this would increase the number of available burrows for the tiger salamanders' use, thus benefiting the species.

The Great Basin spadefoot toad (Fig. 1) makes use of floodplains, dry basins, and rocky canyons within habitats of sagebrush and piñon-juniper woodlands (Hammerson 1999). They breed in temporary or permanent pools or floodwaters, while consuming invertebrates, or plant material when in the larval stage (Hammerson 1999). The spadefoot toad family, in general, lives in arid conditions, spending most of their time buried underground while using pools only for breeding (Hammerson 1999). The increase in invertebrate population abundance following dam completion would provide more food sources and might prompt an increase in spadefoot toad abundance.

Figure 1. Tiger salamander (left) and Great Basin spadefoot (right). (State of Utah Natural Resources: Division of Wildlife Resources, http://www.dwrcdc.nr.utah.gov/ucdc)

The woodhouse's toad needs floodplain habitat and dams are assumed to have decreased essential breeding habitat, thereby negatively affecting the toads (Hammerson 1999). They are not, however, limited to floodplains and also use marshes, temporary or permanent pools, lakes, or any shallow water with little to no current, they spend their winter buried underground (Hammerson 1999). If other pools or water sources are not available nearby, a decreased floodplain caused by controlled releases on the Green River will negatively impact this species.

The northern leopard frog also breeds in floodplains and reduction and/or loss of those due to dams or water diversions have presumably had negative impacts on the species (Hammerson 1999). They generally remain near the water of marshes, ponds, lakes, reservoirs, or streams (Hammerson 1999). Rather than burying themselves underground, this species lives at the bottom of its water source for the winter (Hammerson 1999). A decreased floodplain on the Green River would therefore be harmful to this species by decreasing potential breeding habitat as well as a place for them to spend the winter.

While regulation of the Green River has decreased floodplain habitat there may be other bodies of water within the land adjacent to the river where these amphibians can still reproduce (see Figures 2 and 3). Their distribution may have been affected by changes in riparian vegetation and invertebrate populations. As distance from the dam increases and as the vegetation and invertebrate populations become more representative of their pre-dam abundance and diversity, amphibian populations will more resemble their previous pre-dam state. The benefit of additional food from increased invertebrate abundance may not outweigh the cost of the reduction of floodplain habitat, making it difficult to determine if their populations are increasing since flow regulation began. Figures 2 and 3 show the availability of open water in Browns Park and Ouray National Wildlife Refuge, respectfully, demonstrating that there are more water sources for amphibians in Ouray.

Figure 2. Areas with open water in Browns Park. (United States Fish and Wildlife Service (USFWS), Browns Park National Wildlife Refuge comprehensive conservation plan)

The Ouray National Wildlife Refuge, located along the Green River 30 miles south of Vernal, states the presence of only four amphibian species: Woodhouse's toad (*Bufo woodhousei*), Rocky Mountain toad (*Bufo woodhousei woodhousei*), Boreal chorus frog (*Pseudacris triseriata maculata*), and northern leopard frog (*Rana pipiens*), only two of which are also present in Browns Park (Woodhouse's toad and northern leopard frog; USFWS). However there is no information available in the literature on whether these changes in species or small number of amphibians are related to flow regulation. The land they inhabit is subject to more flooding due to the removal of levees and thus they may have more available habitat for reproduction than those in Browns Park (USFWS). It may be possible that amphibians just naturally have a low diversity for the area.

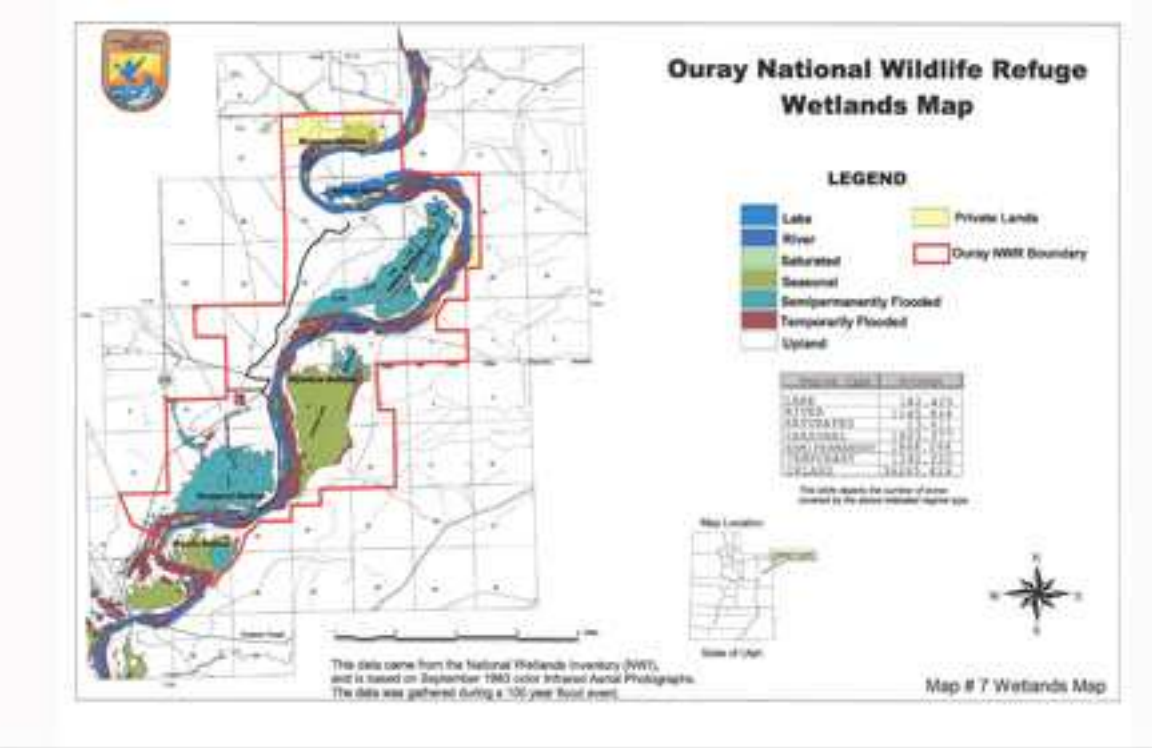

Figure 3. Areas with open water in Ouray National Wildlife Refuge. (United States Fish and Wildlife Service (USFWS), Ouray National Wildlife Refuge comprehensive conservation plan)

REPTILES

Reptiles occupy a wide range of habitats and individual species often can inhabit multiple habitat types. Little research has been done on species along the Green River and none has specifically discussed effects of river regulation on populations or changes in populations downstream of the dam. The USFWS has compiled a list of those present in Browns Park and Ouray's National Park (see Table 3). Here I discuss the Great Basin gopher snakes' (*Pituophis melanoleucus*) characteristics as representative of other snake species present in the area and three lizard species to highlight possible effects on the populations by flow regulation.

The Great Basin gopher snake inhabits a wide range of habitat types from grasslands, riparian areas, and pond/lake edges to canyons and ponderosa pine, piñon-juniper, among other woodlands (Hammerson 1999). Diller and Wallace (1996) found no habitat preference for the gopher snake, with unvaried distribution in different habitats. While they are negatively impacted by humans, through a change in their habitat or the human eradication of members of their populations, they are able to occupy agricultural and residential areas. They spend the winter in a burrow and migrate approximately 500m to where they will spend the summer (Park and Brown

1980, sited in Hammerson 1999). They prey on birds and bird eggs (Diller and Wallace 1996; Eichholz and Koenig 1992, sited in Hammerson 1999), rodents, and small mammals. Diller and Wallace (1996) found 33% of their diet to be mountain cottontail (*Sylvilagus nuttallii*) and 16% to be deer mice (*Peromyscus maniculatus*), although this could change depending on the habitat and habitat preferences of their prey. The western rattlesnake (*Crotalus viridis*, Fig. 4), the western territorial garter snake (*Thamnophis elegans*), the striped whipsnake (Masticohpis taeniatus), and yellow-bellied racer (*Coluber constrictor*) occupy a similar wide range of habitats as the gopher snake (Hammerson 1999). Decreased flooding downstream of the dam would provide more accessible habitat to support a larger population.

The eastern fence lizard (*Sceloporous undulatus*, Fig. 4), tree lizard (*Urosaurus ornatus*), and side-blotched lizard (*Uta stansburiana*) live in rocky habitats including cliffs and canyons with various surrounding vegetation: ponderosa pine, piñon-juniper, or shrublands (Hammerson 1999). In addition to perching on rocks, these lizards may also be found on trees or on the ground (Hammerson 1999). They prey on available invertebrates, generally employing a sit-and-wait strategy (Hammerson 1999). These lizards should be benefiting from river regulation as their invertebrate food source has probably increased in abundance. Therefore, lizard abundance will probably have increased as well.

Figure 4. Western Rattlesnake (left) and eastern fence lizard (right). (State of Utah Natural Resources: Division of Wildlife Resources, http://www.dwrcdc.nr.utah.gov/ucdc)

While reptiles do not seem to be dependent on specific water sources or vegetation types, they are likely to benefit from river regulation indirectly since their prey populations are most likely positively affected by changes to the flow regime. Their populations may not change

dramatically or at all farther along the river at a increased distance away from the dam. The increase in available food for both snakes and lizards should cause an increase in their abundance. There could be some changes in their populations caused by the altered vegetation, but since they tend to use many different vegetation types this should not be a problem for them.

MAMMALS

71 species of mammals are known to be present in one or both of Browns Park and Ouray National Wildlife Refuge along the Green River including: 17 of the order carnivora, 27 rodentia, 4 lagomorpha, 2 insectivora, 14 chiroptera, and 7 artiodactyla (see Table 4). Mammals may experience a variety of affects from river regulation depending on the range of their habitat, food availability, and their dependence on the river. Large mammals such as ungulates or carnivores are able to move on to a new area if a given one does not fit their food, cover, or other basic needs, whereas rodents tend to depend on the vegetation in a given area. Research on mammals in the Green River is mainly limited to the interactions between beaver/rodents and vegetation in the form of a comparison between populations on the Green River (Browns Park and Island Park) and populations on the Yampa River (Deerlodge Park, located downstream of Browns Park, upstream of Island Park; see Andersen and Cooper 2000, Andersen et al. 2000, Breck 2001, Breck et al. 2001, 2002, 2003, Falck, M. 1996). The behavior of the species on the Yampa River provides insight into the species characteristics when inhabiting an area on an unregulated river. By contrast, the behavior of those species on the Green River, reflects the effects of the flow regulation. Following the lesson of the downstream effects predicted by the Serial Discontinuity Concept, the behavior shown on the Yampa River is therefore what would be assumed to occur farther down the Green River as the ecosystem reverts back to a more natural state.

There is some data concerning bats, ungulates, and beavers along the Green River; however there is very little for most of the mammal species that inhabit this area. With the exception of the comparison studies between the Yampa and Green Rivers, little is known about the affects of the Flaming Gorge Dam on mammals or how their distributions, abundance, or diversity may change farther down the river. The USFWS provides a list of species present in Brown's Park and Ouray National Park (see Table 3). These species can be assumed to inhabit

similar habitat along the Green River in terms of park or canyon reaches that provide the type of habitat necessary for the different species.

Beaver

Beavers (*Castor canadensis*, Fig. 5) live in colonies composed of an adult couple and two years worth of offspring (Gurnell 1998). They build burrows in the banks with an entrance below water (Gurnell 1998). Though beavers generally build dams on 1st to 4th-order streams (Naiman et al. 1986, sited in Gurnell 1998) to insure water availability river regulation and a base flow determined by plant capacity, beavers are not dam building in the main channel.

Breck et al. (2001) found five to six colonies along a 10.1 km reach of the Green River (Browns Park) compared to 3 colonies in an 8.6 km reach of the Yampa River (Deerlodge Park) during fall trappings between 1997 and 1999. They discovered that the Green River's regulated flow benefited the beavers. Those living on the Yampa River were found to be close in skeletal size to Green River beavers but with less fat and in inferior condition. River regulation on the Green River resulted in a changed geomorphology that affected the presence and location of willow, allowing beavers to use more willow on the Green River than on the Yampa River despite its greater density of willow and cottonwood (Breck 2001 cited in Breck et al. 2001). This was due to the Yampa River's shift to a smaller flow in the summer with the trees farther away from the water versus the Green River's willow population on islands. 51% of willow inhabited area is on the islands in the Green River and closer to water for the beaver to make more use of, whereas in the Yampa River the area is only 14% (Breck et al. 2003). In another study, Breck et al. (2002) determined that a higher probability of beavers cutting cottonwood saplings exists in places where flooding causes the saplings to be closer to the water. However, due to the availability of an alternate food source, willow, on the Green River, the beavers cut less cottonwood on the Green River than they did on the Yampa River. Further, the decreased flooding on the Green River did not appear to negatively affect them as they had an alternate food source.


Figure 5. Beaver (left) and northern river otter (right). (State of Utah Natural Resources: Division of Wildlife Resources, http://www.dwrcdc.nr.utah.gov/ucdc)

Northern River Otters

The northern river otters (*Lutra canadensis*, Fig. 5) live actively year round in riparian habitats next to a permanent water source containing their necessary prey: fish, crustaceans, amphibians, small birds and mammals (Fitzgerald et al. 1994, Maxfield et al. 2005). They use beaver and other animal dens and as a consequence are probably less dependent on a specific vegetation type. Between the years 1989 and 1992 the Utah Division of Wildlife Resources reintroduced 67 northern river otters into 8 different areas along the Green River as a result of low population levels (Maxfield et al. 2005; see Table 4). These releases allowed the otters to move into Green River tributaries; however there is no current estimate of population size (Maxfield et al. 2005). Findley et al. (1992, sited in Maxfield et al. 2005) found that carp and trout are the otter's main source of food with additional sources including other fish, crayfish, and muskrat.

Due to the limited data on the species within the Green River, it is difficult to determine the effects of the flow regulations on their populations. According to Bich (1988; sited in Maxfield et al. 2005) the otters were not ever abundant in Utah. The low populations seen before the reintroduction efforts began were probably not a result of the construction of Flaming Gorge Dam. The flow regulation will likely affect the otter's prey, thereby indirectly affecting the otter. Since they eat a variety of fish, the type of fish present will also likely have little effect on the population.

Bats

Research on bats along the Green River is limited to the spotted bat (*Euderma maculatum*, Fig. 6) although some observations on bats in general were made in the same study (see Navo et al. 1992). However, many species of bats make use of piñon-juniper woodland habitats (Fitzgerald et al. 1994), and presumably that would include those habitats along the Green River. The USFWS provides a list of bat species present in Browns Park (see Table 2) that may also be present in other areas along the river. These bats are insectivorous (Fitzgerald et al. 1994) and the increase in insect abundance resulting from flow regulation should benefit their populations. With increased food abundance their population size could increase.

Bat species within Dinosaur National Monument are more active along the Green River channel than they are inland, indicating the importance of the canyons to the bat populations (Navo et al. 1992). Within Dinosaur National Monument, Navo et al (1992) observed spotted bats to be more common in Echo Park and Gates of Lodore than in Vermillion, Pot, or Limestone Creeks, but they were less abundant than other bat species. They were observed foraging over the various types of habitat available within the park including campgrounds and at a height of over ten feet (Navo et al. 1992). Navo et al. (1992) suggested they were not dependent on specific vegetation or limited by roost sites available within the canyons. While they lacked visual evidence, they assumed from the increased bat activity by the river that they were drinking from the rivers, possibly in eddies (Navo et al. 1992). Wai-Ping et al. (1989) documented spotted bats foraging over many habitats while using the same area and path to it nightly, roosting in cliff faces, consuming a diet of mostly moths, and returning to the same roost each day.

Figure 6. Spotted bat (left) and Ord's kangaroo rat (right). (State of Utah Natural Resources: Division of Wildlife Resources, http://www.dwrcdc.nr.utah.gov/ucdc)

Rodents & Rabbits

Andersen and Cooper (2000) observed two species of cottontail rabbits (*Sylvilagus audubonii* and *S. muttallii*), deer mice (*Peromyscus maniculatus*), pinyon mice (*Peromyscus truei*), bushy-tailed woodrats (*Neotoma cinerea*), western harvest mice (*Reithrondontomys megalotis*), Ord's kangaroo rats (*Dipodimys ordii*, Fig. 6), Great Basin pocket mice (*Perognathus parvus*), and montane voles (*Microtus montanus*) in Island Park on the Green River. They suggest that the vole population there has increased due to an increase of vegetation in the floodplain caused by the river's flow regulation (Grams 1997 cited in Anderson and Cooper 2000). It is possible that other rodent and/or rabbit populations have increased along the Green River as well. Since the Green River below the confluence with the Yampa River has increased flow added to it, it is expected that the flow regulation would have created increased rodent/rabbit habitat nearer the dam (upstream of the Yampa River), with decreasing additional habitat downstream as the river reverts to more normal conditions. However, Island Park's peak flow has decreased by 25% because of Flaming Gorge Dam (Andersen et al. 2000) which suggests the possibility of more habitat past the confluence with the Yampa River. Additionally, an increase in small rodent populations would provide more available food for the snake population, thus allowing an increase in the snake population size.

Some small mammal populations may benefit from a natural flow regime by river regulation, while others may suffer (Andersen et al. 2000). For example, small mammals can be eliminated from an area by natural flooding (Andersen and Cooper 2000). Without natural flooding, these mammals can take advantage of additional habitat. However, this is not the case for at least one species, Ord's kangaroo rat. This species is known to re-colonize riparian areas after flooding events in Deerlodge Park on the Yampa River because of their preference for areas with scattered vegetation due to flood disturbances (Miller et al. 2003). The rats may now have less preferred habitat to use on the Green River because the dam has changed the natural flood regime thereby altering the floodplain vegetation.

Ungulates

The literature contains no studies on populations of ungulates that inhabit areas along the Green River. Information on presence of species is limited to the list provided by the USFWS and observations made during other studies (USFWS, Falck 1996 sited in Andersen and Cooper

2000, Anderson and Cooper 2000, Utah Division of Wildlife Resources: Trend Study 8B-3-00 2004, Utah Division of Wildlife Resources: Trend Study 9-5-00 2004). Since ungulates may only use these areas seasonally (Anderson and Cooper 2000), flow regulation probably has little effect on their populations. That is, flow regulation has changed the vegetation composition but probably not to an extant that would harm their populations. Changes, if any, in these species' populations farther along the Green River away from the dam are more likely caused by factors other than river regulation.

Mule deer (*Odocoileus hemionus*, Fig. 7) and elk (*Cervus elaphus*) both use the habitat in Island Park as part of their winter range, with observations of deer crossing the river (Andersen and Cooper 2000). Moose (*Alces alces*) and pronghorn (*Antilocapra americana*) are also likely to use habitat in Island Park (Falck 1996 sited in Andersen and Cooper 2000). Antelope (assumed to be pronghorn), mule deer, elk, and bighorn sheep (*Ovis canadensis*) are known to use the sagebrush-grass habitat present on Bear Top Mountain near Flaming Gorge Reservoir (Utah Division of Wildlife Resources: Trend Study 8B-3-00 2004). There is a higher usage of Island Park by mule deer than elk (Utah Division of Wildlife Resources: Trend Study 9-5-00 2004). Ungulates have smaller sized areas to graze upon in Island Park as the river regulation has limited the area where new cottonwoods can grow (Andersen and Cooper 2000). Mule deer, elk, and moose consume cottonwood (Anderson and Cooper 2000), so a decrease in cottonwood establishment would provide less available food which may limit the number of individuals who can graze in a given area and thus negatively affect the species.

Figure 7. Mule deer (left) and mountain lion (right). (State of Utah Natural Resources: Division of Wildlife Resources, http://www.dwrcdc.nr.utah.gov/ucdc)

Large Carnivores

As with most other mammal groups, little is known about large carnivore populations along the Green River. The USFWS mammal species list confirms their presence (see Table 2), but no studies in the area have taken them into consideration. One species, the mountain lion (*Felis concolor*, Fig. 7), inhabits a variety of areas including shrublands, piñon-juniper woodlands, and montane forests (Fitzgerald et al. 1994). Deer are their main prey item but they will also feed on smaller mammals. They have a wide range and roam long distances seeking prey. It is doubtful that river regulation has any effect on mountain lions or any other large carnivores. They could possibly be indirectly affected by changes in their prey populations, but again, ungulates probably are not too negatively affected and smaller mammals probably have benefited from flow regulation. However it is not known to what degree ungulate or small mammal populations are changing or what benefits they may have for large carnivores. If the ungulate populations are decreasing and the small mammal populations are increasing then the carnivores will have an alternative food source.

CONCLUSION

More research needs to be done to fully understand the amphibian, reptiles, and mammal populations inhabiting the riparian areas of the Green River. It is likely that many reptiles and mammals are indirectly affected by flow regulation through changes in vegetation and prey populations. Some species such as the beaver or small mammals may benefit from the increased area of vegetation that is no longer flooded. For other larger species with a longer range or migratory behavior these vegetation changes may have little to no impact. Amphibians, however, are more directly affected as they have presumably lost some of the floodplains necessary for reproduction. There may be sufficient alternative water sources for them to maintain their populations, but there is a lack of evidence to prove this. The information available on these various species inhabiting regions of the Green River suggests that the Serial Discontinuity Concept may only be true for some of them. The Serial Discontinuity Concept likely applies to amphibians, snakes, small rodents, and beavers, but not to lizards, bats, ungulates, and large carnivores.

Species	Predicted change caused by river regulation in reaches immediately below the dam	Predicted change caused by river regulation in reaches farther downstream of the dam
Amphibians	Decrease	No change or increase
Snakes	Increase	No change
Lizards	Increase	Increase
Beaver	Increase	No change or increase
River otter	Increase	Increase
Small mammals	Increase	No change or increase
Bats	Increase	Increase
Ungulates	No change or decrease	No change
Carnivores	No change or decrease	No change

Table 1. Predictions of trends in abundance of amphibians, reptiles, and mammals from Flaming Gorge Dam to Split Mountain.

Common Name	Scientific Name
Tiger salamander	*Ambystoma tigrinum*
Great Basin spadefoot toad	*Scaphiopus intermontanus*
Woodhouse's toad	*Bufo woodhousei*
Northern leopard frog	*Rana pipiens*
Boreal chorus frog	*Pseudacris triseriata maculata*

Table 2. Amphibians of Browns Park and Ouray National Wildlife Refuges. (http://ouray.fws.gov/generalBrochure.htm and http://mountain-prairie.fws.gov/planning/States/Colorado/brownspark/finalccp/brcpccpfinal.pdf)

Common Name	Scientific Name
Eastern fence lizard	*Sceloporous undulatus*
Side-blotched lizard	*Uta stansburiana*
Short-horned lizard	*Phrynosoma douglassii*
Western whiptail	*Cnemidophorus tigris*
Sagebrush lizard	*Sceloporous graciosus*
Tree lizard	*Urosaurus ornatus*
Yellow-bellied racer	*Coluber constrictor*
Smooth green snake	*Opheodrys vernalis*
Great Basin gopher snake	*Pituophis melanoleucus*
Western rattlesnake	*Crotalus viridis*
Striped whipsnake	*Masticophis taeniatus*
Western terrestrial garter snake	*Thamnophis elegans*

Table 3. Reptiles of Browns Park and Ouray National Wildlife Refuges. (http://ouray.fws.gov/generalBrochure.htm and http://mountain-prairie.fws.gov/planning/States/Colorado/brownspark/finalccp/brcpccpfinal.pdf)

Common Name	Scientific Name
Merriam's shrew	*Sorex merriami*
Montane shrew	*Sorex monticolus*
California myotis	*Myotis californicus*
Western small-footed myotis	*Myotis ciliolarbrum*
Long-eared myotis	*Myotis evotis*
Little brown myotis	*Myotis lucifugus*
Fringed myotis	*Myotis thysanodes*
Long-legged myotis	*Myotis volans*
Yuma myotis	*Myotis yumanensis*
Hoary bat	*Lasiurus cinereus*
Silver-haired bat	*Lasionycter noctivagans*
Western pipistrelle	*Pipistrellus hesperus*
Big brown bat	*Eptesicus fuscus*
Spotted bat	*Euderma maculatum*
Townsend's big-eared bat	*Plecotus townsendii*
Pallid bat	*Antrozous pallidus*
Desert cottontail	*Sylvilagus audubonii*
Mountain cottontail	*Sylvilagus nuttalii*
Black-tailed jackrabbit	*Lepus californicus*
White-tailed jackrabbit	*Lepus townsendii*
Cliff chipmunk	*Tamias dorsalis*
Least chipmunk	*Tamias minimus*
Hopi chipmunk	*Tamias rufus*
Yellow-bellied marmot	*Marmota flaviventris*
White-tailed antelope squirrel	*Ammospermophilus leucurus*
Wyoming ground squirrel	*Spermophilus elegans*
Golden-mantled ground squirrel	*Spermophilus lateralis*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
White-tailed prairie dog	*Cynomys leucurus*
Northern pocket gopher	*Thomomys talpoides*
Olive-backed pocket mouse	*Perognathus fasciatus*
Great Basin pocket mouse	*Perognathus parvus*
Ord's kangaroo rat	*Dipodimys ordii*
American beaver	*Castor canadensis*
Western harvest mouse	*Reithrodontomys megalotis*
Canyon mouse	*Peromyscus critinus*
Deer mouse	*Peromyscus maniculatis*
Pinyon mouse	*Peromyscus truei*
White-footed mouse	*Peromyscus leucopus*
Northern grasshopper mouse	*Onychomys leucogaster*
Bushy-tailed woodrat	*Neotoma cinerea*
Long-tailed vole	*Microtus landicaudus*
Montane vole	*Microtus montanus*
Meadow vole	*Microtus pennsylvanicus*

Sagebrush vole	*Lemmiscus curtatus*
Common muskrat	*Ondatra zibethicus*
Common porcupine	*Erithizon dorsatum*
Coyote	*Canis latrans*
Red fox	*Vulpes vulpes*
Kit fox	*Vulpes macrotis*
Gray fox	*Urocyon cinereoargenteus*
Black bear	*Ursus americanus*
Ringtail	*Bassariscus astutus*
Raccoon	*Procyon lotor*
Long-tailed weasel	*Mustela frenata*
Black-footed ferret	*Mustela nigripes*
Mink	*Mustela vison*
American badger	*Taxidea taxus*
Western spotted skunk	*Spilogale gracilus*
Striped skunk	*Mephitis mephitis*
Northern river otter	*Lutra canadensis*
Mountain lion	*Felis concolor*
Bobcat	*Lynx rufus*
Lynx	*Lynx canadensis*
American elk	*Cervus elaphus*
Mule deer	*Odocoileus hemionus*
White-tailed deer	*Odocoileus virginianus*
Moose	*Alces alces*
Pronghorn	*Antilocapra americana*
Bison	*Bison bison*
Bighorn sheep	*Ovis canadensis*

Table 4. Mammals of Browns Park and Ouray National Wildlife Refuges. (http://ouray.fws.gov/generalBrochure.htm and http://mountain-prairie.fws.gov/planning/States/Colorado/brownspark/finalccp/brcpccpfinal.pdf)

Year	Number Released	Release Location
1989	9	Red Creek (confluence with Green River)
1990	14	Little Hole (along Green River)
1991	11	Island Park (Dinosaur NM)
	6	Rainbow Park (Dinosaur NM)
	9	Ouray NWR
	6	Pariette Wetlands
1992	2	Flaming Gorge Reservoir
	10	Sand Wash (along Green River)
Total	67	

Table 5. Northern river otter reintroduction in Utah. (Maxfield et al. 2005)

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