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# Riparian and Wetland Ecosystems of the Ashley National Forest: An Assessment of Current Conditions in Relation to Natural Range of Variation

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## Abstract

We conducted this assessment to provide information on the current conditions of riparian and wetland ecosystems in reference to their natural range of variation on the Ashley National Forest during Forest Plan revision. We determined that riparian and wetland ecosystems have experienced numerous stressors that have influenced their current conditions, including reduced beaver activity, altered flow regimes, dams and diversions, livestock and wild ungulate grazing, and climate change. Some ecosystem characteristics, particularly channel and floodplain dynamics, appear to be more resistant to stressors with the majority of units classified as trending toward or within their natural range of variation. Changes to groundwater and surface water dynamics, as well as resistance to invasive and encroaching species, have been impacted the most by stressors, particularly in the Flaming Gorge National Recreation Area. Our results have been incorporated in the Forest Plan and will continue to be useful to resource managers and planners during efforts to restore and/or maintain riparian and wetland ecosystems on the Ashley National Forest.

**Keywords:** riparian, wetland, ecosystem, Ashley National Forest, natural range of variation, Forest Plan

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## Cover photos

Clockwise from left: Wetland and riparian vegetation along Rock Creek in the Uinta Mountains (photo by Max Smith); narrowleaf cottonwoods and other riparian plants in Indian Canyon on the Tavaputs Plateau (photo by Alan Huber); beaver pond complex in the Lodgepole Creek drainage of the Flaming Gorge National Recreation Area (photo by Sheryl Goodrich).

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# Introduction

## Background and Objectives

We conducted this assessment as part of an agreement between the Forest Service, U.S. Department of Agriculture Intermountain Region (Region 4) and the Rocky Mountain Research Station (RMRS). The initial objective of the agreement was to assist with the revision of National Forest management plans by evaluating current conditions of riparian and wetland ecosystems in reference to their natural range of variability. After meeting with staff from the regional office and several national forests, we decided to evaluate riparian areas, wetlands, and groundwater-dependent ecosystems (GDEs) in a separate assessment for each national forest. We conducted this assessment of the Ashley National Forest (ANF) by synthesizing information obtained through literature review, data compilation, and site visits. The first draft of this report was completed in July of 2016. We incorporated comments from the regional office and the ANF into the current draft. Here we report results for riparian and wetland ecosystems. GDE results will be presented in a separate document.

## Definitions and Characteristics

Riparian ecosystems occur at the interface of aquatic and terrestrial zones and are influenced by dynamics of surface water and groundwater (Gregory et al. 1991). Physical, chemical, and biotic interactions between terrestrial and aquatic processes shape riparian ecosystems across a three-dimensional continuum, with one dimension extending from the headwaters of a stream to its mouth, the second dimension extending from the groundwater zone to the canopy of vegetation, and the third dimension extending from the stream bed to the outer extent of the floodplain (Stanford and Ward 1988, 1993; Vannote et al. 1980). Influential dynamics include volume and timing of stream flows, extent of area inundated by surface water, fluctuations in depth to groundwater, evapotranspiration, and fluvial influences such as sediment deposition (Gregory et al. 1991; Naiman and Décamps 1997; Naiman et al. 2005). Intermittent and perennial stream channels have surface flows and groundwater connections adequate to support riparian vegetation. Ephemeral channels, with surface flows limited to periods of precipitation or snowmelt runoff and little to no connection with the water table, do not typically support riparian vegetation (BLM 1993; Meinzer 1923).

Wetland ecosystems are defined and distinguished in several ways, but in general contain three characteristics: frequent to permanent inundation or saturation, vegetation typically adapted for life in saturated soil conditions, and the presence of hydric soils (FICWD 1989; USACE 1987). In the Intermountain West, wetlands form in areas fed by surface water or groundwater. These natural wetland types include lakes, ponds, fens, and wet meadows. Reservoirs, stock ponds, and other anthropogenic features create wetlands as well (USFWS 2016).

Given the above definitions, there is clearly overlap between riparian and wetland ecosystems and there is room for discretion in how they can be defined and differentiated. For this report, however, we assess the riparian ecosystems associated with perennial and intermittent streams and wetland ecosystems associated with lakes and ponds. Given the importance of springs and subsurface flows to streams and other waterbodies (Lawrence et al. 2014; Winter 2007), many if not most riparian areas and wetlands can also be considered groundwater-dependent ecosystems.

# Methodology

## Scale of Assessment

We conducted this assessment at two spatial scales within the ANF. At the broadest scale, we focused on three geographically distinct areas that differ in ecology and management. These areas are the Uinta Mountains and Flaming Gorge National Recreation Area (FGNRA) in the north unit of the national forest and the Tavaputs Plateau in the south unit (fig. 1).

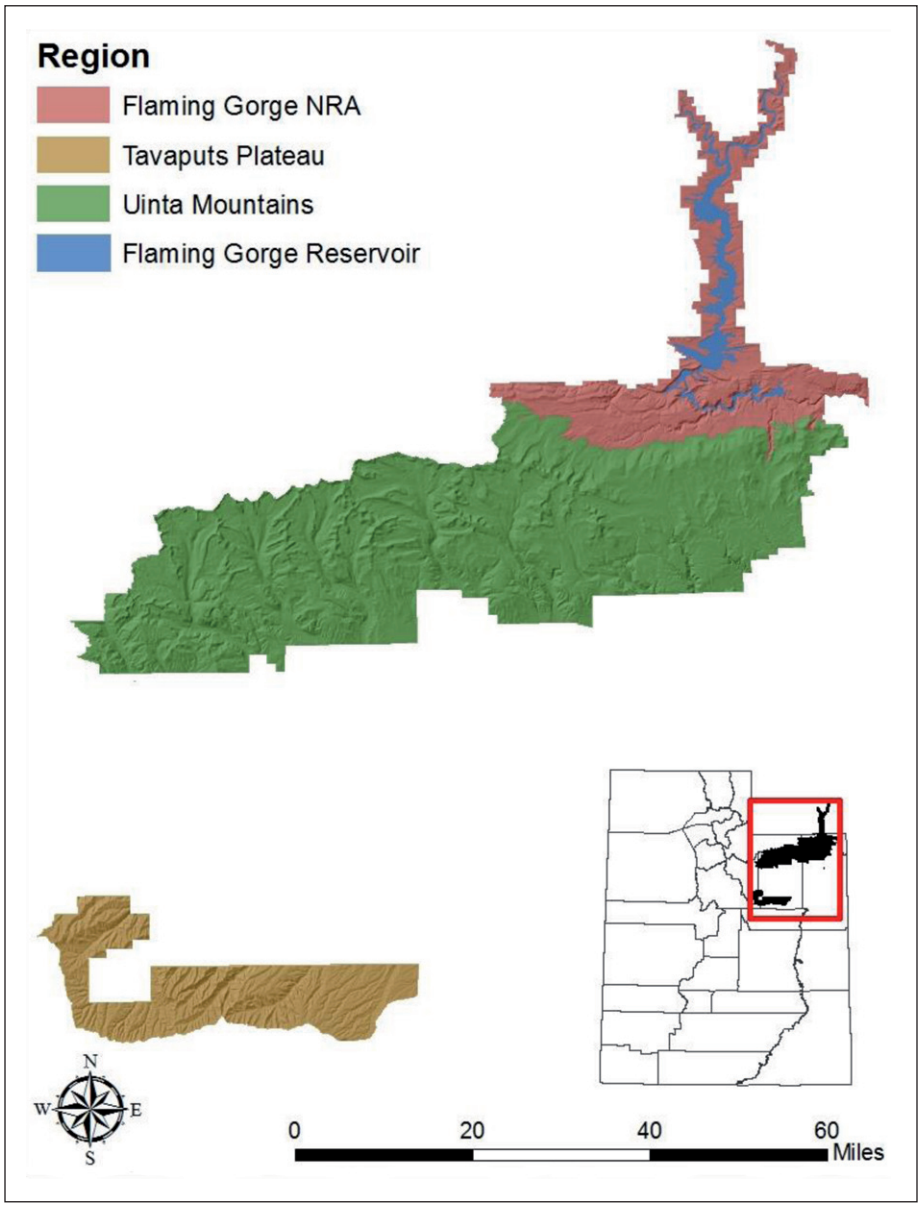


**Figure 1**—Geographic area designations for assessment of riparian and wetland ecosystems in the Ashley National Forest, Utah.

At a finer scale, we assessed riparian and wetland ecosystems within landtype associations (LTAs), which the ANF uses for ecosystem evaluation and planning (ANF 2009a). Each LTA is a collection of smaller landtype units distinguished by processes of geology, geomorphology, soils, and climate. These processes influence the structure and composition of vegetation types, including riparian and wetland communities (Padgett et al. 1989), which vary among the LTAs (ANF 2009a). There are three LTAs in the Tavaputs Plateau area, six in the FGNRA, and 15 in the Uinta Mountains area. Within each LTA we assess key ecosystem characteristics (KECs) for riparian and wetland ecosystems.

## Information Sources

We relied on several geographic information system (GIS) layers to inventory riparian areas and wetlands in the ANF. We used the National Wetland Inventory (NWI) layer to identify the types, area, and distribution of wetland ecosystems in the national forest. This layer was developed using aerial imagery and digital datasets including soil surveys (USFWS 2016). We excluded wetlands classified as riverine by the NWI because this designation includes all stream channels, including ephemeral channels, which we feel over represents their actual distribution. We used the National Hydrography Dataset (NHD) to describe the distribution of perennial and intermittent/ephemeral streams.

We used the ANF field-sampled vegetation layer (ANF 2016) to describe the distribution of riparian ecosystems. This layer was developed with aerial imagery and ground-based surveys. Most of these ecosystems followed vegetation type descriptions by Padgett et al. (1998). Because of the large number of vegetation types in some LTAs, we created riparian and wetland vegetation type groupings based on dominant growth forms (deciduous tree-dominated, coniferous tree-dominated, herbaceous-dominated, non-willow shrub-dominated, and willow-dominated). We also created a grouping of types in which growth forms are not described (unclassified, other, and irrigated). Where possible, we describe the vegetation present in unclassified/other/irrigated riparian areas and wetlands.

To evaluate condition of riparian and wetland ecosystems, we compiled information and data from four general sources (1) scientific literature consisting of peer-reviewed publications and U.S. Forest Service reports; (2) data in the Ashley National Forest Range Study Database, which includes photo points and site visits; (3) vegetation measurements collected with greenline composition and multiple indicator monitoring (MIM) protocols (Burton et al. 2008; Winward 2000); and (4) spatial data compiled by other agencies and research groups described below. We did not assess KECs in LTAs where we felt there was inadequate information about distribution and condition of riparian and wetland ecosystems. Unless otherwise specified, the current conditions we report are drawn from the Range Study Database, which is where we obtained most of our information.

We obtained results from the Riparian Condition Assessment Tool (R-CAT), which was developed by MacFarlane et al. (2017) to quantify changes in riparian ecosystems by using geospatial data. Among the products available within R-CAT are the riparian condition (RC), riparian vegetation departure (RVD), and riparian vegetation conversion type (RVCT) procedures. The RVD procedure uses results from the LANDFIRE vegetation mapping project to identify reaches of perennial streams where riparian vegetation is expected but no longer present. The RVCT procedure uses LANDFIRE data to identify the causes of departure from natural conditions. The RC procedure determines floodplain condition as a function of modeled change in riparian vegetation and observations of stream confinement and connectivity (Wheaton 2009). Because R-CAT results currently exclude intermittent and ephemeral streams, these methods give an incomplete picture of changes in riparian ecosystems. However, we feel that results can add to the evidence we collected in evaluating KECs.

To address aquatic invasive species, we reviewed the Utah Department of Wildlife Resources aquatic invasive species program report (UDWR 2012) and a USFS Region 4 GIS shapefile (USFS 2013). We used the WRDAMS and WRPOD layers from the Utah Division of Water Rights (UDWR 2016) to quantify dams and diversions in each LTA.

## Key Ecosystem Characteristics

In accordance with the 2012 planning rule guidelines (USFS 2015), we selected KECs that reflect the features of riparian areas and wetlands in the ANF. We developed the list of KECs from a review of studies conducted on the forest and our own experience with riparian and wetland ecosystems. We selected KECs that both represent ecosystem integrity and could be evaluated using information available. For each KEC, we identified drivers and stressors that are influenced by natural processes and/or forest management activities. Below we describe the components of each KEC.

### Groundwater and Surface Water Fluctuations

Depth to groundwater, volume of surface water, and timing and magnitude of their fluctuations influence the survival, growth, and composition of riparian and wetland plant communities (Auchincloss et al. 2013; Horton et al. 2001; Stromberg et al. 1997). A stream's natural flow regime includes the timing, frequency, magnitude, rate of change, and duration of flooding events (Poff et al. 1997). High flows are critical disturbances that maintain diverse aquatic and terrestrial habitats, allow for the exchange of material and energy between a stream and its floodplain, and recharge hyporheic and groundwater systems (Junk et al. 1989; Poff et al. 1997; Stanford et al. 2005). The life histories of many plant and animal species have evolved with natural ground and surface water cycles and rely on reliable and predictable fluctuations (Stanford et al. 2005). Groundwater systems depend on infiltration from rainstorms and snowmelt to recharge aquifers that slowly release discharge to surface water systems, maintaining base flows and aquatic habitats throughout the year.

The topographic and geological settings of the ANF result in widespread variation among the natural dynamics of groundwater and surface water. The forest's water resources have also been heavily managed for industrial, agricultural, and municipal purposes. Natural and anthropogenic fluctuations, therefore, have considerable influence on the composition, structure, and function of riparian and wetland ecosystems in this forest.

### Channel, Floodplain, and Sediment Dynamics

The structure of floodplain plant and animal communities is a result of patterns and processes occurring at various scales such as flooding, channel avulsion, cut and fill alluviation, wood recruitment, and regeneration of riparian vegetation (Stanford et al. 2005). Natural rates of these processes vary among geomorphic and climatic settings and are influenced by a variety of factors including instream wood (Lienkaemper et al. 1987). Sedimentation is a key component of floodplain and wetland dynamics in the ANF. Among these dynamics are the establishment of riparian vegetation and the conversion of lakes and ponds into wet meadows and fens. Upland slopes are natural sources for sediment, particularly in the marine geology and climate of the Tavaputs Plateau, but rates of sedimentation are also influenced by recreation and forest management. Assessment of these interrelated processes is critical to understanding current conditions along streams.

### Vegetation and Soil Condition

Riparian and wetland vegetation provides physical, hydrological, and biotic services. Among other functions, riparian and wetland vegetation can reduce damage from floods by stabilizing soil, dissipating stream energy, and trapping sediment (Hubert 2004). Riparian and wetland ecosystems also contribute to critical habitat for species of concern and species of interest in the ANF. Large trees and snags in riparian areas are used as nesting sites and perches by northern goshawks (*Accipiter gentilis*), Lewis's woodpeckers (*Melanerpes lewis*), and other birds (Graham et al. 1999; Hollenbeck and Ripple 2008; Saab and Vierling 2001). Fallen logs provide cover, thermoregulation sites, and foraging substrates for terrestrial and aquatic wildlife at streams and wetlands (Brown 2002). Woody and herbaceous vegetation are also used as forage by greater sage-grouse (*Centrocercus urophasinaus*), elk (*Cervus canadensis*), and other herbivores (Atamian et al. 2010; Collins 1977). By stabilizing undercut banks and shading water, riparian and wetland plants help to maintain conditions required for the persistence of Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) and other cold water fishes (Horan et al. 2000). Beavers (*Castor canadensis*) harvest woody vegetation and construct dams and ponds, thereby increasing biodiversity and dynamism of riparian and wetland ecosystems (Parker et al. 1985; Pollock et al. 1995).

Soil exposure and erosion impact riparian and wetland ecosystems in a variety of ways including facilitation of invasive plants and contribution to sediment loads (Belsky et al. 1999; Richardson et al. 2007). Natural disturbances to soil in riparian and wetland zones occur in the ANF, but anthropogenic disturbances can have additive or interactive effects on

ecosystems. This KEC is assessed only within the context of riparian and wetland ecosystems. Upland vegetation and soil conditions are not assessed in this report.

### Resistance to Invasive and Encroaching Species

Due to their dynamic nature and high productivity relative to upland ecosystems, riparian areas and wetlands are especially vulnerable to colonization by invasive plants (Richardson et al. 2007). Invasive plants can damage wildlife habitat, alter disturbance dynamics, and degrade soil and water quality in riparian and wetland settings (Smith and Finch 2014; Vitousek et al. 1996). Nonnative woody and herbaceous plants have been introduced to the ANF or have spread to the forest through natural pathways. Invasive aquatic species, including plants and diatoms, are a concern for riparian and wetland ecosystems as well (Stohlgren et al. 2007). Encroaching species, typically coniferous trees and shrubs, are native to the ANF, but in recent decades these species have increased in cover and abundance in western riparian areas and wetlands (Marlow et al. 2006). Encroachment threatens to displace native plants and animals that specialize in herbaceous-shrub-, or deciduous tree-dominated vegetation types.

## Drivers and Stressors

We developed a list of drivers and stressors for KECs based on literature review of riparian and wetland ecosystems in the ANF and similar areas (table 1). We link the drivers and stressors to the current status of KECs to provide the Ashley National Forest with management strategies.

**Table 1**—Drivers and stressors associated with each key ecosystem characteristic of riparian and wetland ecosystems in the Ashley National Forest.

| KEC | Drivers | Stressors |
|---|---|---|
| 1. Groundwater and surface water fluctuations | Beaver activity; geological setting; groundwater discharge; irrigation waste; soil infiltration; landslides; temperature and precipitation | Beaver removal; canals; dams; debris flows; diversions; floods; pond construction; reservoir fluctuations; spring development; timber harvest |
| 2. Channel, floodplain, and sediment dynamics | Beaver activity; geological setting; instream wood; riparian vegetation; temperature and precipitation; wildfire | Dams and reservoirs; diversions and canals; livestock grazing; recreation; roads; trails; wild ungulate use |
| 3. Vegetation and soil condition | Geological setting; riparian vegetation; wild ungulate use; beaver activity; flood disturbance; groundwater depth; precipitation; soil conditions | Canals; development; livestock grazing; recreation; roads and trails; wild ungulate use; irrigation waste; insects; wildfire |
| 4. Invasive and encroaching species | Beaver activity; native vegetation; soil conditions; wildfire | Beaver removal; fire suppression; irrigation waste; livestock grazing; nonnative plantings; reservoir fluctuation; soil disturbance; wildfire |

## Natural Range of Variation Status

The 2012 planning rule mandates the use of an ecological reference model to evaluate the integrity of forest ecosystems. The natural range of variation (NRV) is used as a metric to judge the status of KECs. If possible, the NRV is described for a reference period ending prior to Euro-American settlement of the area. A variety of information, such as historical data, paleo-ecological data, or data from undisturbed reference sites, is used to quantify this NRV (USFS 2015).

Assessments using the concepts of NRV or the historical range of variation (HRV) have recently been conducted in and near the ANF. In their HRV assessment of National Forests in Wyoming, Dillon et al. (2005) and Meyer et al. (2005) used several methods to quantify the HRV of conifer and aspen forest characteristics. They determined whether characteristics were within, beyond, or trending toward the HRV at the scale of forest stands and forest landscapes to aid the development of sustainable forest management practices. The ANF also used the HRV concept to evaluate forest characteristics in their ecosystem diversity evaluation (ANF 2009a). At the LTA scale, they described departure from historical disturbance regimes for elements of several ecosystem types. In their analysis of HRV of riparian and wetland ecosystems in the Forest Service's Rocky Mountain Region (Wyoming, Colorado, South Dakota, Nebraska, and Kansas; Region 2), Gage and Cooper (2014) reviewed the types of riparian areas and wetlands in the region and discussed anthropogenic changes. Based on this information, they determined whether the various types of riparian and wetland ecosystems were within or outside of their HRV. The ANF (2009a) and Gage and Cooper (2014) considered a historical reference period, but they did not quantify the NRV or HRV of ecosystem elements.

The riparian and wetland ecosystems we assessed cover a small percentage of the national forest and vary in their structure and composition. In addition, many riparian and wetland ecosystems are unique to the Forest, making it difficult to find reference sites for comparison. For these reasons, it was not possible to quantify the NRV of KECs at scales that are useful to forest planning. We instead describe the types of riparian and wetland ecosystems currently present in each management area, along with anthropogenic changes. We use this information, combined with literature from the ANF or similar locations, to infer whether each KEC is within, outside, or trending toward its NRV in each LTA. This approach is similar to that used by the ANF (2009a) and Gage and Cooper (2014). To standardize our determination of NRV status, we answered the following questions, adapted from the forest planning handbook (USFS 2015):

1. Are the KEC and associated processes no longer functioning in a way that contributes to long-term integrity of ecosystems and provides conditions for species adaption to a changing climate?
2. Have the KEC and associated processes been altered or eliminated, or are they declining or increasing in extent and/or quality, or have they declined or increased in the past, including changes in the spatial pattern?

3. Are the KEC and associated processes rare in the plan area or otherwise clearly vulnerable to future environmental change?
4. Are changes to the KEC and associated processes widespread in the area of interest?
5. Would projects or activities be necessary to maintain or restore the KEC and associated processes?

We determined that the KEC was **outside** its NRV if four or five questions received a *yes* answer, **trending toward** its NRV if two or three questions received a *yes* answer, and **within** its NRV if fewer than two questions received a *yes* answer.

## Distribution and Composition in the Uinta Mountains

For the purposes of our assessment, we define the Uinta Mountain management area as a collection of 15 LTAs located on the north and south slopes of the Uinta Mountains. The Uinta Mountains are an east-west trending range that contain the highest point in Utah. This range is composed of a bedrock of quartzites and shales surrounded by sedimentary formations (Hansen 1969). The highlands are characterized by peaks, moraines, and cirques shaped during Pleistocene glaciation (Atwood 1909). Streams draining the south slope of the Uinta Mountains are generally grouped into two types: west side streams that occupy U-shaped glaciated valleys and east side streams that occupy narrow, stream-carved canyons (Carson 2007; Hansen 1986). Non-glaciated streams on the south and north slopes are influenced by karst systems associated with Mississippian limestone deposits (Godfrey 1985).

Lentic ecosystems in the upper portions of Uinta Mountain drainages include glacial lakes, potholes, kettle ponds, and beaver ponds. Wet meadows, fens, and willow fields surround many of these bodies, forming expansive aquatic, riparian, and wetland ecosystems. The expansive wet meadows around lakes and streams can be herbaceous-dominated or willow-dominated, depending on soil conditions. Riparian areas associated with streams are present throughout the range as well. The three largest riparian and wetland vegetation types mapped in the Uinta Mountains region by the ANF were herbaceous-, willow-, and deciduous tree-dominated.

Herbaceous-dominated ecosystems are typically characterized by a mix of graminoids such as water sedge, Nebraska sedge, beaked sedge, tufted hairgrass, and wiregrass (scientific names of plants are listed in the Appendix) that occur across elevations. The plane-leaf willow/water sedge association is ubiquitous along streams and in meadows in high-elevation LTAs. Fields of grayleaf willow occur in some wet meadows and on drier upland sites.

Deciduous trees of lower elevation riparian forests include narrowleaf cottonwood, box elder, and bigtooth maple. These forests also contain coniferous trees including ponderosa pine, lodgepole pine, Douglas-fir, blue spruce, and Rocky Mountain juniper. Drummond's willow, Geyer willow, and other tall willows are found across a range of elevations. Other widely distributed shrubs include mountain alder, river birch, red-osier dogwood, and shrubby cinquefoil (ANF 2009b).

## Distribution and Composition in the Flaming Gorge National Recreation Area

The Flaming Gorge National Recreation Area (FGNRA) is the northernmost area of the ANF. Six LTAs in this region contain streams that drain the north slope of the Uinta Mountains into Flaming Gorge Reservoir or the Green River below Flaming Gorge Dam. Streams are influenced by Pleistocene glaciation, erosive sedimentary substrates, and a series of east-west trending faults (Carson 2003).

A variety of lentic and lotic settings support numerous species of riparian and wetland vegetation. Most riparian and wetland vegetation is herbaceous-dominated, followed by irrigated/other/unclassified types. Woody species include narrowleaf and Fremont cottonwood, willows, boxelder, and chokecherry. Ponderosa pine, blue spruce, and other conifers are found in floodplains as well. Riparian and wetland ecosystems in the northern portion of the area are largely dominated by herbaceous species such as wiregrass, sedges, and a mixture of native and introduced grasses. Invasive herbaceous and woody species are a significant component of the vegetation along the lower sections of streams entering Flaming Gorge Reservoir.

## Distribution and Composition in the Tavaputs Plateau

The Tavaputs Plateau lies south of the Uinta Mountains and is composed of sedimentary rocks in the Uinta and Green River formations. This highly erosive substrate is dissected by numerous stream channels, most of which are intermittent or ephemeral (ANF 2009a; Knight 2011). The portion of the plateau within the ANF contains streams flowing northeast into the Uinta Basin. These streams transition from steep, narrow canyons in their upper reaches to low gradient alluvial floodplains at lower elevations.

The area of riparian and wetland ecosystems is relatively small in the Tavaputs Plateau, with riparian and wetland vegetation largely limited to streams with perennial reaches. In these streams, upper reaches contain Booth's willow, aspen, and some narrowleaf cottonwoods. Lower sections have floodplains stabilized by wiregrass, sedges, and other graminoids, with scattered shrubs and trees including cottonwood, boxelder, coyote willow, and graybark willow. Most field-sampled riparian and wetland vegetation types are classified as irrigated/unclassified/other.

## Physical Processes

Groundwater and surface water dynamics are driven by snowmelt throughout much of the area (Carson 2007). Baseflows of perennial streams are maintained by runoff from persistent snow beds and/or groundwater discharge from springs and talus slopes. Peak flows of perennial and ephemeral streams typically occur during periods of heavy snowmelt runoff but can also result from rain on snow events or summer thunderstorms (ANF 2009a). Depending on geological setting, water movement occurs through surface flows in streams, subsurface flows, or overland flows. Riparian and wetland ecosystems rely on surface water and groundwater connections maintained, in some areas, by beaver dams. Along some intermittent streams, riparian vegetation is limited to stream sections where baseflows are supported by spring discharge. Along other intermittent streams, riparian vegetation is maintained by a shallow groundwater table. Karst systems are strong drivers of surface flows and groundwater dynamics at several streams,

particularly on the east end of the Uinta Mountains (ANF 2009a; Godfrey 1985). In these systems, limestone sinks, caves, and springs transfer flows within and across drainages. Surface flow is absent at several reaches in this area unless sinks are filled by heavy runoff from snowmelt or thunderstorms. Perennial baseflows of other reaches are produced by discharge out of karst systems.

In their natural state, Uinta Mountain lakes receive input from sources including streams, seepage, and groundwater upwelling. Amount of through-flow varies among lakes, with greater volumes of water moving through higher elevation lakes that are in proximity to ice, snow, and rock (Munroe 2007; Squire 2012). The depth of lakes and ponds changes as a result of climate and sedimentation. Potholes and pools in upper basins show high variation in surface water conditions (i.e., ephemeral, perennial, emergent vegetation, open water), thus maintaining richness of wetland plant communities (Matyjesic et al. 2015). Ephemeral pools, ponds, and potholes collect runoff in meadows and fluctuate year to year in depth.

High-elevation streams are bedrock-controlled or stabilized by meadow vegetation and have low rates of dynamism. Width-to-depth ratios of these streams are largely determined by gradient and bed substrate (Carson 2003). Streams associated with talus slopes and cobble-bedded channels have higher rates of dynamism. Floods occur annually at cobble-bedded, valley bottom streams, rerouting channels, and activating and deactivating channels (Schmidt et al. 2008). Debris dams form during high spring flows and help to reroute active channels.

Wider valley bottoms contain ponds created by depressions, debris dams, and beaver dams. Where present, beaver dams slow streamflow, diminish channel capacity, allow for more frequent floodplain inundation, resist headcuts and channel incision, and widen channels. Additionally, beaver dams mitigate both flooding and droughts by reducing flood peaks as they migrate downstream and by slowly releasing water and augmenting baseflows during drier periods. Following failure of dams, exposed mudflats are colonized by early seral vegetation (ANF 2009a) and water storage capacity is reduced.

Sedimentation sources include red pine shale, pocket gopher (*Thomomys* spp.) activity, nivation from snowfields, and streams emerging from bollies and talus slopes. As lakes accumulate sediment from natural sources, they transition to wet meadows and fens (Munroe et al. 2013). Storms and runoff deposit sediment in floodplains, creating conditions resembling grazing damage. Mudflows, debris slides, and avalanches deposit sediment and debris into floodplains and channels.

## Vegetation Dynamics

Reproduction of cottonwoods, willows, and other pioneering species occurs following disturbances such as floods that scour vegetation and litter and/or deposit sediment. Narrowleaf cottonwoods establish on floodplains with bare substrates during years with heavy precipitation and spring runoff (Baker 1990). High-severity wildfire results in above-ground mortality of trees and shrubs, but deciduous species can quickly recover from fire by producing basal sprouts and root suckers (Dwire and Kauffman 2003; Smith et al. 2009). Clonal sprouting of willows and narrowleaf cottonwood is also triggered by disturbances such as floods and beaver activity (Wilding et al. 2014).

Growth and survival of cottonwoods, willows, and other phreatophytic species is limited by groundwater availability. Growth of willows and other woody plants is controlled by wild ungulate browsing, beaver herbivory, and flooding behind beaver dams. Increased depth of groundwater can result in dieback or mortality.

Herbaceous wetland vegetation is the dominant growth form where the soil is too saturated to support woody plants. Herbaceous plants are resilient to grazing by wild ungulates if hydrological conditions are ideal. Water sedge, beaked sedge, Nebraska sedge, and other late-seral riparian graminoids stabilize streambanks along reaches flowing through meadows. Dry meadow plant communities provide lower stability. Water sedge can recolonize and repair streambanks that are damaged by flood or ungulates. Willows stabilize banks, colonize sandbars and levees, and trap sediment. Narrowleaf cottonwood, aspen, and other deciduous trees stabilize soil on streambanks, floodplains, and adjacent slopes.

## Anthropogenic Changes to Riparian and Wetland Ecosystems

To properly assess the condition of riparian and wetland ecosystems, it is essential not only to evaluate natural processes, but also consider changes to landscapes brought upon by humans. Human influence in the Intermountain Region extends to the Pleistocene epoch when Native Americans altered landscapes through their use of fire and their ability to hunt large herbivores (Nowacki et al. 2012; Simms 2008). Though these activities have obvious impacts on plant communities, it is difficult to determine whether they resulted in meaningful, long-lasting effects on riparian and wetland ecosystems (Gage and Cooper 2013). For several centuries, the Fremont Culture practiced irrigated agriculture in the region (Grayson 1993). This activity had localized impacts on surface flows and riparian and wetland vegetation where floodplains were tilled.

Following the disappearance of the Fremont and prior to the arrival of Europeans, groups such as the Utes lived in small bands that tracked seasonal resources across elevations (Simms 2008). Fire was used to increase production of vegetation resources and to create openings for hunting in low- and mid-elevation forests (Nowacki et al. 2012). These fires would occasionally burn into riparian areas and wetlands, preventing conifer encroachment and encouraging dominance by shrubs and trees capable of

resprouting. Bands extracted resources from riparian areas and wetlands during certain times of the year, but their effects were likely minor relative to those that came with Euro-American settlement (Gage and Cooper 2013).

The earliest Euro-American influence on the Uinta Mountains was likely the arrival of the fur trappers in the early 1820s. Beavers and other furbearers were harvested by Native Americans for food and clothing for thousands of years, but, given the large numbers of furbearers reported by early Euro-American explorers, it is unlikely that intensive trapping occurred in the region until a connection with European markets was established in the early 1800s (Chittenden 1902). European and American fur companies trapped beavers from each of the Green River's tributaries during the 19th century (Chittenden 1902). Though population declines were noted by the mid-1800s, aggressive trapping continued in Utah until 1899 when beaver harvest was outlawed. Effects of beaver trapping were likely greatest at lower to mid elevations where beaver density was high. Beaver populations recovered quickly in the early 20th century and today most suitable habitat is thought to be occupied (UDWR 2010). An open beaver trapping season has been in effect since 1957.

In addition to beaver, elk were nearly eliminated from much of Utah, including the Uinta Mountains, from overhunting in the late-1800s. Elk were transplanted from other States starting in the 1910s and were transplanted among areas in the State through the 1980s (UDWR 2015). Populations in Utah grew rapidly from 1975–1990 and growth slowed in many places from 1990–2005. Despite this slowing, elk herds in the Uinta Mountains have exceeded population objectives during most of the years between 2006 and 2014 (UDWR 2015).

Long-term changes to riparian and wetland ecosystems occurred with the establishment of the Uintah Indian Reservation in 1861 and the settlement of the Uinta Valley by Euro-Americans in subsequent decades. During this period, livestock were introduced to the Uinta Mountains and irrigation systems were constructed to increase the potential for agriculture in the valley (Kendrick 1989). Sheep and cattle have grazed the forest since the 1870s or earlier. Creation of the national forest reduced grazing in some areas. Sheep were the dominant grazers for many decades, with numbers peaking during the first half of the 20th century. Cattle are now more widespread and abundant in the Uinta Mountains. Sheep and cattle grazed the Tavaputs Plateau throughout the 20th century, but numbers were reduced in the latter half of the century in response to deteriorating range and stream conditions. A massive flood in 1960 inspired actions that were completed by 1975 in an allotment near Sowers Canyon: cattle numbers were reduced by 75 percent, the canyon bottom was plowed and seeded with forage grasses, and a rest rotation grazing system was initiated (Goodrich 2004). By the 1990s, conditions had noticeably improved. Springs have been developed for livestock use throughout the forest, but effects of grazing on riparian and wetland ecosystems vary within and among LTAs (ANF 2009a).

In the first decades of the 1900s, reservoirs were constructed at mountain lakes for flood control and water storage. Effects of these modifications include changes to timing, frequency, duration, and magnitude of stream flows, unnatural fluctuations in lake levels, and erosive events caused by the failure of dams and canals (ANF 2009a). Widespread construction of irrigation canals, dams, and transbasin diversions occurred with development of the Moon Lake Project in the 1930s and the Central Utah Project in the 1960s. The Moon Lake Project was initiated to provide water to the Uinta Basin and extend the growing season into the dry summer months. Moon Lake Dam was completed in 1938, raising the volume of the naturally occurring Moon Lake to an active capacity of 35,800 acre-feet, creating Moon Lake Reservoir (Redmond 2000). One of the final components of the Central Utah Project, Stillwater Dam impounds Rock Creek and diverts flows to the Wasatch Front via Strawberry Reservoir. Following completion of Stillwater Dam in 1987, annual flood magnitude in Rock Creek has been reduced by 70 percent (Schmidt et al. 2008).

The dominant anthropogenic change in the FGNRA was construction of Flaming Gorge Dam and Reservoir, the latter of which began filling in December of 1962. The reservoir inundated riparian vegetation along the Green River and several other streams. Operation of the dam has also altered hydrologic and geomorphic processes on the Green River and other streams below and above the dam (Allred and Schmidt 1999). Other bodies of water in the FGNRA include small lakes and ponds that were constructed for livestock, recreation, and wildlife habitat. Smaller dams, diversions, and canals are located throughout the area as well.

On the Tavaputs Plateau, many perennial and ephemeral channels lie in deep gullies. Gullying is a stage of natural incision and aggradation cycles in this setting, but land management practices, such as beaver removal, road building, and grazing, may have increased incision rates (Muir 2008; Pollock et al. 2014). Gully plugs were installed in several streams in the 1970s and 80s to slow or reverse gullying processes by trapping sediment, elevating the streambed and water tables, and expanding riparian and aquatic habitats (Muir 2008). Large dams, reservoirs, and canals are absent in this area, but stock ponds and spring developments have been constructed for livestock use (ANF 2009a).

Timber has been harvested from the Uinta Mountains since the early years of Euro-American settlement. Timber harvests have declined since the 1980s for reasons that include changes in management objective and the designation of 52 percent of the forest as roadless (ANF 2009b). Current timber harvest is limited to the northeast portion of the range (Carson 2007). Relatively little timber harvest has occurred in the rugged slopes and canyon bottoms of the Tavaputs Plateau. Twentieth century fire suppression has likely increased the extent of Douglas-fir, pinyon pine, and juniper in canyon bottoms, leading to conifer encroachment into riparian and wetland communities (ANF 2009a). Fire suppression is ongoing to protect private

property and natural resources and satisfy public opposition to smoke and postfire esthetics. As a result, many processes are occurring outside of their normal range of variation (ANF 2009b).

Recent studies have identified indirect effects of human activity on Uinta Mountain ecosystems. Sediment cores from high-elevation Uinta Mountain lakes show increasing inputs of dust since the 1870s, concurrent with landscape changes in the American West. Amounts of ore-derived elements in sediment have also increased, implicating Wasatch Mountain mining and smelting operations with changes to water and soil chemistry (Reynolds et al. 2010). In addition to ore-derived elements, levels of reactive nitrogen have increased as a result of fertilizers used along the Wasatch Front and other agricultural areas (Hundey et al. 2016). Inputs of nitrogen and other elements have increased primary productivity at five lakes in the Yellowstone River and Whiterocks River basins (Hundey et al. 2014). These changes to lake chemistry and productivity will likely have cascading effects in aquatic, riparian, and wetland ecosystems. Density of oil and gas wells is greater in the Tavaputs Plateau than in the other areas of the forest. Vegetation and wildlife are displaced by construction of roads and drill sites, but long-term effects of these disturbances are addressed through restoration or mitigation.

## Alpine Moraine LTA

### Riparian and Wetland Ecosystems

The Alpine Moraine has the greatest area of wetland (table 2) and riparian (table 3) ecosystems among the Uinta Mountains LTAs (fig. 2). Twenty riparian and wetland vegetation types were mapped by the ANF in the LTA (table 4). These vegetation types are located in two watersheds on the north slope of the Uinta Mountains (Carter Creek and Sheep Creek) and in 10 watersheds on the south slope (Ashley Creek, Dry Fork Creek, Dry Gulch, North Fork Duchesne River, Lake Fork River, Pole Creek, Rock Creek, Uinta River, Whiterocks River, and Yellowstone River). Most riparian and wetland ecosystems are associated with lakes and tributary streams in large compound cirques above 3,000 m in elevation and near or above the current tree line (fig. 3).

**Table 2**—Area of wetland ecosystems in land type associations (LTAs) within the Uinta Mountains management area. Data were obtained from the National Wetland Inventory (USFWS 2016).

| LTA | Freshwater emergent | Freshwater forested/shrub | Freshwater pond | Lake | Total |
|---|---|---|---|---|---|
| | | | *Hectares* | | |
| Alpine Moraine | 5,151.6 | 555.5 | 697.3 | 2,068.7 | 8,473.1 |
| Dry Moraine | 4.3 | 3.0 | 8.2 | 0 | 15.5 |
| Glacial Bottom | 131.1 | 694.7 | 48.0 | 314.2 | 1,188.0 |
| Glacial Canyon | 26.1 | 10.6 | 8.9 | 9.7 | 55.3 |
| Limestone Hills | 14.0 | 3.5 | 1.8 | 0 | 19.3 |
| Limestone Plateau | 4.3 | 0 | 0.4 | 0.7 | 5.4 |
| Moenkopi Hills | 0.1 | 0 | 0 | 0 | 0.1 |
| Parks Plateau | 417.0 | 9.8 | 17.8 | 22.6 | 467.2 |
| Round Park | 222.5 | 40.1 | 1.7 | 0 | 264.3 |
| South Face | 48.1 | 4.6 | 2.9 | 0 | 55.6 |
| Stream Canyon | 41.3 | 32.6 | 4.3 | 0 | 78.2 |
| Stream Pediment | 24.1 | 9.5 | 0.7 | 0 | 34.3 |
| Trout Slope | 936.8 | 47.3 | 16.5 | 261.2 | 1,261.8 |
| Uinta Bollie | 230.7 | 75.7 | 11.0 | 97.1 | 414.5 |
| Wolf Plateau | 7.4 | 0.9 | 0.8 | 0 | 9.1 |
| Total | 7,259.4 | 1,487.8 | 820.3 | 2,774.2 | 12,341.7 |

**Table 3**—Area of riparian and wetland vegetation types in land type associations (LTAs) within the Uinta Mountains area. Data were obtained from the Ashley National Forest field-sampled vegetation layer (ANF 2016).

| LTA | Unclassified/ other/ irrigated | Deciduous tree-dominated | Coniferous tree-dominated | Non-willow shrub-dominated | Herbaceous-dominated | Willow-dominated | Total |
|---|---|---|---|---|---|---|---|
| | *Hectares* | | | | | | |
| Alpine Moraine | 29.9 | 6.0 | 17.8 | 0 | 1,865.6 | 2,890.4 | 4,809.7 |
| Dry Moraine | 10.4 | 32.1 | 0 | 0 | 6.6 | 0 | 49.1 |
| Glacial Bottom | 75.5 | 2,083.9 | 36.2 | 0 | 22.0 | 10.8 | 2,228.4 |
| Glacial Canyon | 0.1 | 174.0 | 1.3 | 0 | 25.3 | 0 | 200.7 |
| Limestone Hills | 0 | 0 | 0 | 0 | 95.5 | 0 | 95.5 |
| Limestone Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Moenkopi Hills | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Parks Plateau | 0 | 0 | 4.3 | 562.4 | 1,358.6 | 9.0 | 1,934.3 |
| Round Park | 0 | 0 | 0 | 0 | 143.8 | 86.7 | 230.5 |
| South Face | 1.8 | 42.6 | 0 | 0 | 19.5 | 7.2 | 71.1 |
| Stream Canyon | 0 | 220.4 | 0 | < 1 | 33.8 | 0 | 254.2 |
| Stream Pediment | 0 | 48.0 | 0 | 0 | 177.6 | 0 | 225.6 |
| Trout Slope | 0 | 0 | 30.2 | 11.1 | 1,723.1 | 22.5 | 1,786.9 |
| Uinta Bollie | 0 | 0 | 0 | 0 | 62.5 | 257.7 | 320.2 |
| Wolf Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Total | 117.7 | 2,607.0 | 89.8 | 573.5 | 5,533.9 | 3,284.3 | 12,206.2 |

Willow-dominated vegetation types comprise the largest area of mapped riparian vegetation, followed by herbaceous-dominated, coniferous tree-dominated, and deciduous tree-dominated types (table 4). Three patches in the upper Rock Creek drainage were unclassified. One of these patches appears to be a subalpine mixed dry and wet meadow complex (based on photos from studies 22-26D and 22-26E). The others appear to be willow-dominated vegetation types containing plane-leaf willow and water sedge (studies 22-8A, 22-7E, and 22-7I).

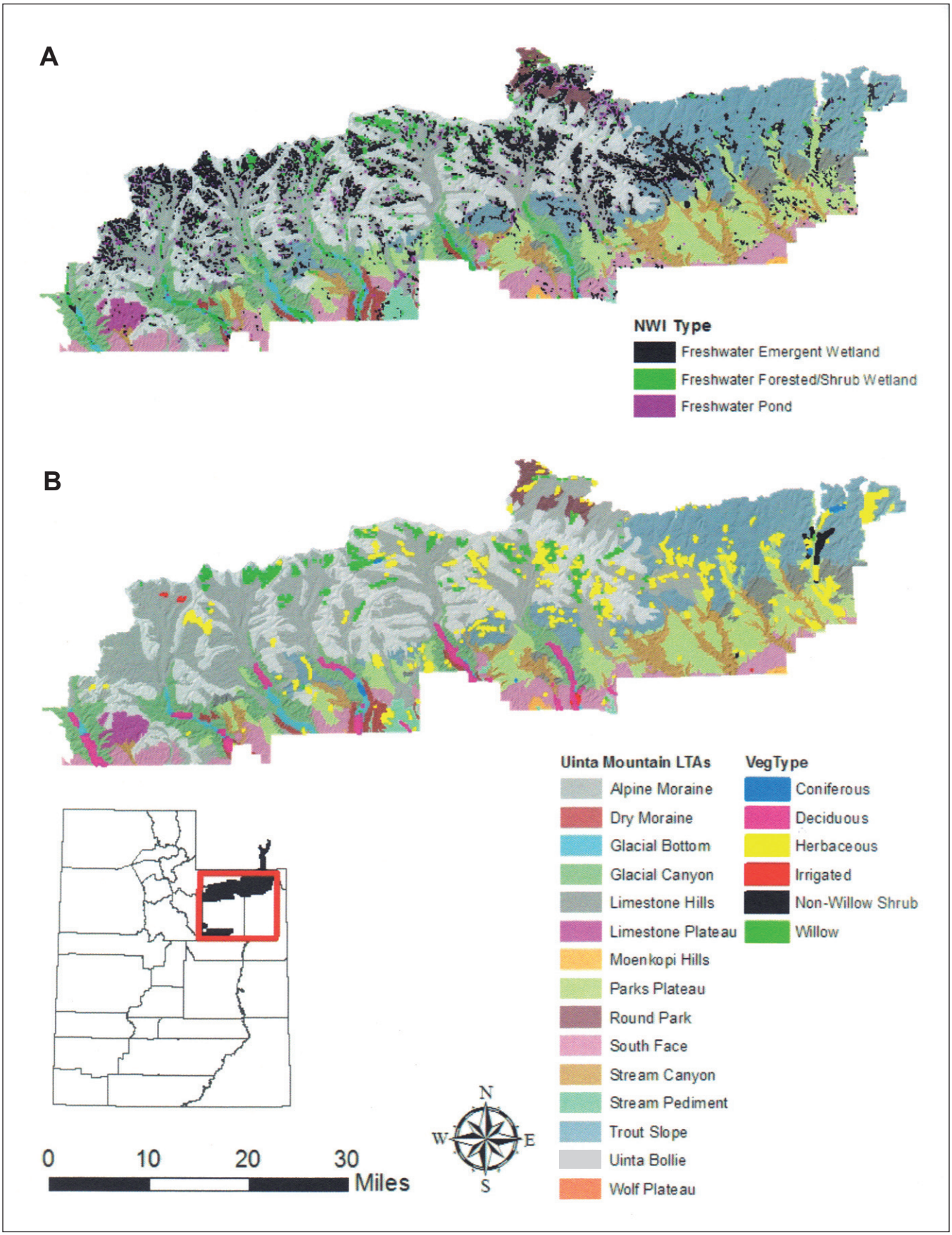


**Figure 2**—(A) Wetland ecosystems and (B) riparian vegetation types in the Uinta Mountain management area.

**Table 4**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Alpine Moraine land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 29.9 |
| Coniferous tree, unclassified | Coniferous tree-dominated | 17.8 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 6.0 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 1,488.8 |
| Riparian meadow with conifer displacement | Herbaceous-dominated | 8.7 |
| Wet meadow undifferentiated | Herbaceous-dominated | 67.1 |
| Water sedge | Herbaceous-dominated | 271.1 |
| Mud sedge | Herbaceous-dominated | 1.1 |
| Cottongrass | Herbaceous-dominated | 1.3 |
| Timber oatgrass | Herbaceous-dominated | 27.5 |
| Bluejoint reedgrass/single-spike sedge | Herbaceous-dominated | 26.1 |
| Willow/meadow complex | Willow-dominated | 33.5 |
| Low willow | Willow-dominated | 392.2 |
| Plane-leaf willow | Willow-dominated | 39.4 |
| Plane-leaf willow/water sedge | Willow-dominated | 980.3 |
| Plane-leaf willow/bluejoint reedgrass | Willow-dominated | 5.8 |
| Low willow/wet and dry meadow complex | Willow-dominated | 1,338.4 |
| Tall willow | Willow-dominated | 1.3 |
| Coyote willow | Willow-dominated | 73.0 |
| Geyer willow | Willow-dominated | 0.4 |

**Figure 3**—Alpine Moraine landscape featuring lakes, streams, and expansive willow- and herbaceous-dominated vegetation types (photo by Mark Muir, USFS).

## Current Conditions of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

Density of dams in this LTA is among the highest in the Uinta Mountains. Numerous dams (table 5) and diversions and canals (table 6) are in multiple basins, disconnecting or altering natural networks of snowmelt, lakes, streams, and groundwater. Several dams in the Yellowstone and Lake Fork watersheds were reconstructed in 2009 to replicate pre-dam lake levels at reservoirs. Reservoir levels in other drainages, however, remain altered from reference conditions. Despite widespread alteration of lakes and streams in the LTA, we did not find evidence that ecosystem integrity has been affected as a result. We determined the status of groundwater and surface water fluctuations in this LTA to be **trending toward** the NRV (table 7).

**Table 5**—Number of dams in each code and density of dams in land type associations of the Uinta Mountains management area. Data were obtained from the Utah Division of Water Rights.

| LIA | Code[a] | | | | | | | | Total dams/km$^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 7 | 200 | 300 | 307 | 500 | 800 | 900 | |
| Alpine Moraine | 0 | 0 | 12 | 10 | 1 | 1 | 6 | 0 | 0.03 |
| Dry Moraine | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Glacial Bottom | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 2 | 0.02 |
| Glacial Canyon | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.003 |
| Limestone Hills | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| Limestone Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Moenkopi Hills | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Parks Plateau | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| Round Park | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South Face | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.03 |
| Stream Canyon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stream Pediment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Trout Slope | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| Uinta Bollie | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.003 |
| Wolf Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 17 | 18 | 10 | 2 | 1 | 7 | 2 | |

[a] Dam codes are: 0 = Small regulating, or insignificant dams that impound more than 20 acre-feet of water; 7 = Small regulating, or insignificant dams that impound 20 acre-feet of water or less; 200 = Inspected dams that are neither flood control or industrial and impound more than 20 acre-feet of water; 300 = Inactive dams that are neither flood control or industrial and impound more than 20 acre-feet of water; 307 = Inactive dams that are neither flood control or industrial and impound 20 acre-feet of water or less; 500 = Never-been-inspected (needs investigation); 800 = Inspected by other agency/inspection report must be submitted to Dam Safety Office; 900 = Federally inspected dams.

**Table 6**—Number of diversion types and density of diversions in land type associations of the Uinta Mountains management area. Data were obtained from the Utah Division of Water Rights.

| LTA | Diversion type | | | | | | | Total diversions/ km² | Canal (km) |
|---|---|---|---|---|---|---|---|---|---|
| | Abandoned well | Point to point | Rediversion | Return | Spring | Surface | Underground | | |
| Alpine Moraine | 0 | 230 | 15 | 0 | 2 | 144 | 3 | 0.36 | 21.1 |
| Dry Moraine | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0.11 | 0.2 |
| Glacial Bottom | 2 | 0 | 11 | 12 | 2 | 216 | 117 | 5.44 | 10.5 |
| Glacial Canyon | 0 | 0 | 0 | 0 | 9 | 61 | 5 | 0.26 | 0.5 |
| Limestone Hills | 0 | 56 | 0 | 0 | 3 | 18 | 5 | 1.07 | 0.6 |
| Limestone Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0.13 | 0 |
| Moenkopi Hills | 0 | 3 | 2 | 0 | 0 | 7 | 0 | 1.38 | 0 |
| Parks Plateau | 0 | 209 | 0 | 0 | 4 | 168 | 27 | 1.04 | 17.9 |
| Round Park | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0.14 | 0 |
| South Face | 0 | 43 | 1 | 0 | 17 | 89 | 9 | 0.80 | 0 |
| Stream Canyon | 0 | 125 | 8 | 0 | 1 | 45 | 13 | 1.08 | 1.1 |
| Stream Pediment | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0.18 | 0 |
| Trout Slope | 0 | 222 | 1 | 0 | 2 | 103 | 5 | 0.57 | 4.7 |
| Uinta Bollie | 0 | 57 | 2 | 0 | 1 | 12 | 7 | 0.11 | 0 |
| Wolf Plateau | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0.12 | 0 |
| Total | 2 | 952 | 40 | 12 | 43 | 873 | 196 | | |

**Table 7**—NRV status of KECs in LTAs in the Uinta Mountains management area.

| KEC | AM[a] | GB | GC | LH | PP | RP | SF | SC | SP | TS | UB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Groundwater and surface water fluctuations | TT | Out | In | TT | TT | In | TT | TT | In | TT | In |
| 2. Channel, floodplain, and sediment dynamics | In | TT | In | In | TT | In | TT | In | TT | TT | In |
| 3. Vegetation and soil condition | In | In | In | TT | Out | TT | TT | In | TT | TT | In |
| 4. Invasive and encroaching species | TT | TT | Out | In | TT | TT | Out | In | TT | TT | In |

[a] Abbreviations refer to LTAs: Alpine Moraine, Glacial Bottom, Glacial Canyon, Limestone Hills, Parks Plateau, Round Park, South Face, Stream Canyon, Stream Pediment, Trout Slope, and Uinta Bollie.

### *Channel, Floodplain, and Sediment Dynamics*

This LTA has the most perennial stream miles on the ANF and the most intermittent/ephemeral of the Uinta Mountain region (fig. 4). Total length of perennial streams is greater than the length of ephemeral/intermittent streams. Most perennial stream segments are classified as confined and unimpacted in the riparian condition analysis (table 8). In some locations within the Uinta River and Whiterocks River watersheds, failure and reconstruction of beaver dams create dynamics in channel morphology and plant communities in what are otherwise relatively static environments. Trails, gullies, and headcuts resulting from recreation and livestock grazing are anthropogenic sources of sediment that are unlikely to exceed natural sources. High loads of sediment create bars in channels and levees on streambanks, which can support willow stands. Most streams appear stabilized by riparian and wetland vegetation. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 7).

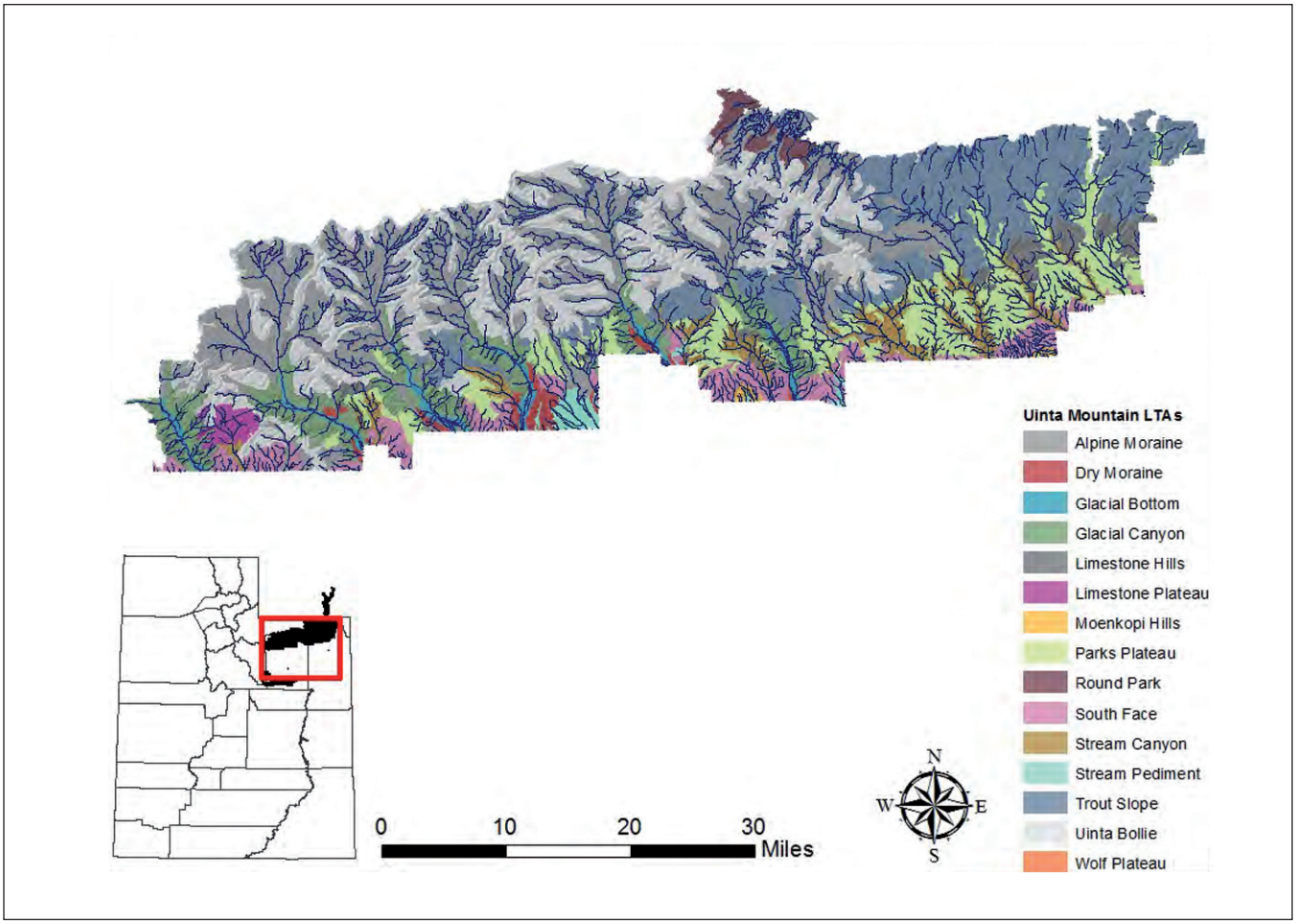


**Figure 4**—Location of perennial, intermittent, and ephemeral stream channels in the Uinta Mountains management area.

**Table 8**—Length of stream types and riparian condition assessment classifications of perennial streams in land type associations (LTAs) in the Uinta Mountains area.

| LTA | Streams | | Perennial stream riparian conditions | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Intermittent/ ephemeral | Perennial | Percent confined-impacted | Percent confined-unimpacted | Percent floodplain intact | Percent floodplain in good condition | Percent floodplain in moderate condition | Percent floodplain in poor condition |
| | km | | | | | | | |
| Alpine Moraine | 292.1 | 962.1 | 1 | 87 | 3 | 3 | 5 | 0 |
| Dry Moraine | 17.4 | 0.8 | 13 | 66 | 7 | 15 | 0 | 0 |
| Glacial Bottom | 40.2 | 104.8 | 2 | 13 | 41 | 38 | 7 | <1 |
| Glacial Canyon | 167.7 | 60.8 | 1 | 96 | 1 | 2 | 1 | 0 |
| Limestone Hills | 27.7 | 9.8 | 5 | 87 | 5 | 2 | 0 | 0 |
| Limestone Plateau | 24.8 | 1.9 | 0 | 100 | 0 | 0 | 0 | 0 |
| Moenkopi Hills | 19.8 | 0 | -- | -- | -- | -- | -- | -- |
| Parks Plateau | 223.2 | 39.3 | 16 | 67 | 3 | 7 | 6 | 1 |
| Round Park | 10.9 | 22.7 | 2 | 82 | 0 | 9 | 7 | 0 |
| South Face | 239.6 | 17.1 | 27 | 70 | 2 | 0 | 1 | 1 |
| Stream Canyon | 238.5 | 131.2 | 6 | 81 | 3 | 6 | 3 | 1 |
| Stream Pediment | 44.7 | 6.8 | 2 | 72 | 5 | 18 | 3 | 0 |
| Trout Slope | 192.3 | 133.4 | 11 | 77 | 4 | 4 | 3 | 0 |
| Uinta Bollie | 66.6 | 34.6 | 1 | 99 | 0 | 0 | <1 | 0 |
| Wolf Plateau | 17.9 | 1.9 | 0 | 100 | 0 | 0 | 0 | 0 |

### *Vegetation and Soil Condition*

Under currently prescribed stocking rates, cattle graze on dry and seasonally wet meadows, but allowable use is rarely exceeded. In some areas, stunted willows are a legacy of heavy sheep grazing, but increases in size and cover are noted in many others. Wild ungulates are the primary users of willow-dominated vegetation types, with browsing of plane-leaf willows attributed to elk and moose (*Alces alces*; fig. 5). Willows grow large enough to shade streams if soils are not perennially saturated and browsing pressure is low. Herbaceous vegetation is the dominant growth form where the soil is too saturated to support willows.

In some areas, soil has been left exposed following decades of sheep grazing, with effects visible as trails, adjacent upland bedding areas, and trampled banks at stream crossings. Other effects of grazing include bank slumping, bank cutting, and headcuts. Recreational activities such as camping, horse use, and off-highway vehicle use result in trailing, headcuts, and gully formation. Soil near reservoirs was disturbed by excavation of fill for dam construction throughout the 20th century. In recent decades, areas damaged by grazing, dam construction, and recreation have been repaired through restoration and stabilizing vegetation. Over the years of 1997 to

**Figure 5**—Wet meadow in Dry Fork Watershed with plane-leaf willows that have been browsed by wild ungulates (photo S. Goodrich, and G. Brown, USFS).

2013, streambank stability was evaluated at 12 greenline transects and two MIM areas. Greenline transects were dominated by communities with plane-leaf willow, water sedge, and bluejoint grass. This vegetation gave all but one of these transects a stability rating of 8.9 or higher (out of 10). The lowest stability rating was 7.5 at Fish Creek in 1997. At the MIM area along Dry Fork Creek, nearly 70 percent of greenline plots were dominated by late-seral sedges, 1 percent of the plots were altered by ungulate hooves, and 35 percent of the plots showed signs of fracture, sloughing, or slumping. At the area near Wigwam Lake, 60 percent of the plots were dominated by late-seral sedges, less than 1 percent of plots were altered by ungulates, and 38 percent of the plots showed signs of fracture, sloughing, or slumping. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 7).

### *Resistance to Invasive and Encroaching Species*

Cheatgrass was observed growing below the high water line of the dam at Cliff Lake in the Whiterocks River watershed, but it is unlikely to spread because most of this LTA is above 8,500 feet in elevation. Conifer encroachment is observed in willow stands that are surrounded by lodgepole pine and Engelmann spruce forest (fig. 5). Most conifer encroachment, however, is taking place in dry and mesic meadows and has occurred within the mean fire return interval for the LTA. R-CAT results indicated that encroachment by conifers and other upland vegetation has occurred along 6 percent of perennial stream miles (table 9). We determined the status of resistance to invasive and encroaching species in this LTA to be **within** the NRV (table 7).

**Table 9**—Percentage of stream miles classified by conversion from riparian to other cover types for each LTA in the Uinta Mountains area. Data were generated from the Riparian Condition Assessment tool.

| LTA | Conifer encroach-ment | Conversion to ag | Conversion to barren | Conversion to developed | Conversion to invasive | Non-riparian to riparian | Upland encroach-ment | No change |
|---|---|---|---|---|---|---|---|---|
| Alpine Moraine | 2 | 0 | <1 | 0 | 0 | 1 | 4 | 94 |
| Dry Moraine | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Glacial Bottom | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 97 |
| Glacial Canyon | 20 | 0 | 0 | 0 | 0 | 0 | 1 | 79 |
| Limestone Hills | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Limestone Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| Moenkopi Hills | -- | -- | -- | -- | -- | -- | -- | -- |
| Parks Plateau | 2 | 0 | 0 | 5 | 0 | 0 | 7 | 86 |
| Round Park | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 97 |
| South Face | 6 | 1 | 0 | 0 | 3 | 2 | 3 | 85 |
| Stream Canyon | 11 | 1 | 0 | 2 | 0 | 0 | 1 | 85 |
| Stream Pediment | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 95 |
| Trout Slope | 1 | 0 | 0 | 1 | 0 | 0 | 12 | 86 |
| Uinta Bollie | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 95 |
| Wolf Plateau | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |

## Information and Research Needs/Data Gaps

1. *Coniferous tree-dominated riparian vegetation types*. Many streams flow through coniferous forests in this LTA, but little information is available on the extent, function, and composition of coniferous tree-dominated riparian and wetland vegetation, relative to willow and herbaceous types.

2. *Damage by wild ungulates*. Heavy browsing of willows and localized soil disturbance by elk and moose were noted throughout the LTA. Information about the NRV status of their populations is needed determine if this use is sustainable.

3. *Conifer encroachment*. The mechanisms causing encroachment of lodgepole pine and Engelmann spruce must be determined in order to slow or prevent the advance of conifers into willow and herbaceous-dominated vegetation types.

## Dry Moraine LTA

### Riparian and Wetland Ecosystems

The area of wetland (table 2) and riparian (table 3) ecosystems in the Dry Moraine is small relative to other LTAs in the Uinta Mountains (fig. 2). There are three riparian vegetation types mapped (table 10). These types are located in the Lake Fork River, Pole Creek, Rock Creek, Timothy Creek, Yellowstone River, and Whiterocks River watersheds on the south slope of the Uinta Mountains.

Deciduous tree-dominated types comprise the largest area of mapped riparian vegetation, followed by irrigated and herbaceous-dominated types (table 10). Among the herbaceous-dominated types are emergent and wet meadow vegetation associated with McKune Lake in the Yellowstone River watershed (fig. 6).

### Information and Research Needs/Data Gaps

We did not evaluate KECs for this LTA because it contains a small area (<50 ha) of mapped riparian vegetation and few perennial or intermittent streams (table 8). Additional information and research is needed to identify the structure, composition, and condition of vegetation in the irrigated lands along the Whiterocks River. Information and research is also needed to document the composition and condition of herbaceous-dominated vegetation types in the Timothy Creek watershed and deciduous-dominated vegetation types that are found across the LTA.

**Table 10**—Riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Dry Moraine land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type code | Grouping | Hectares |
|---|---|---|
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 32.1 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 6.6 |
| Irrigated lands | Unclassified, other, or irrigated | 10.4 |

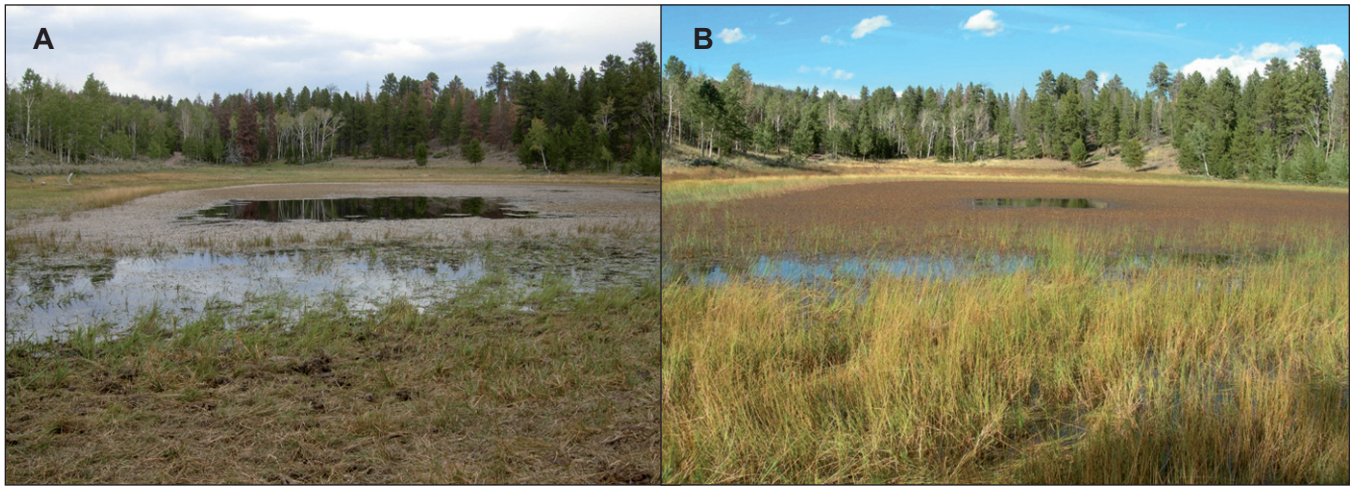


**Figure 6**—Emergent and wet meadow vegetation at McKune Lake (A) following cattle grazing in 2007 and (B) heavy spring and summer precipitation in 2011, (photos by A. Huber, USFS).

## Glacial Bottom LTA

### Riparian and Wetland Ecosystems

The Glacial Bottom contains relatively large areas of freshwater forested shrub wetlands (table 2) and deciduous tree-dominated riparian ecosystems (table 3). In this LTA, eight riparian and wetland vegetation types are distributed along the lower portions of six watersheds (table 11; Duchesne River, Lake Fork River, Rock Creek, Uinta River, Whiterocks River, and Yellowstone River) on the south slope of the Uinta Mountains (fig. 2).

Deciduous tree-dominated stands are by far the largest riparian vegetation types in the LTA (table 3). One patch of irrigated riparian is mapped in the Whiterocks drainage. This patch, a continuation of the irrigated area in the Glacial Canyon LTA, appeared to be a pasture supporting scattered cottonwoods, junipers, and smaller deciduous shrubs and trees, based on photos from studies 42-7, 42-54, and 42-16.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Large dams and reservoirs on Rock Creek and Lake Fork River have altered timing and magnitude of peak flows (table 5; Redmond 2009; Schmidt et al. 2008). A comparison of stream gage data between Rock Creek and the undammed Whiterocks River indicates that timing and magnitude of peak discharge at Rock Creek have been altered by the construction of Upper Stillwater Dam and diversion of water to Strawberry Reservoir (fig. 7). Numerous diversions and canals have altered the hydrology of streams throughout this LTA as well (table 6). Spring and early summer floods remain an annual event at the undammed streams in the LTA. Management activities, such as ecological flow releases, may be necessary to maintain ecosystem integrity in a changing climate. We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 7).

**Table 11**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Glacial Bottom land type association.

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Coniferous tree, unclassified | Coniferous tree-dominated | 36.2 |
| Deciduous tree, unclassified | Deciduous tree-dominated | 332.0 |
| Narrowleaf cottonwood | Deciduous tree-dominated | 5.6 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 1,746.1 |
| Bigtooth maple | Deciduous tree-dominated | 0.2 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 22.0 |
| Willow/meadow complex | Willow-dominated | 10.8 |
| Irrigated lands | Unclassified, other, or irrigated | 75.5 |

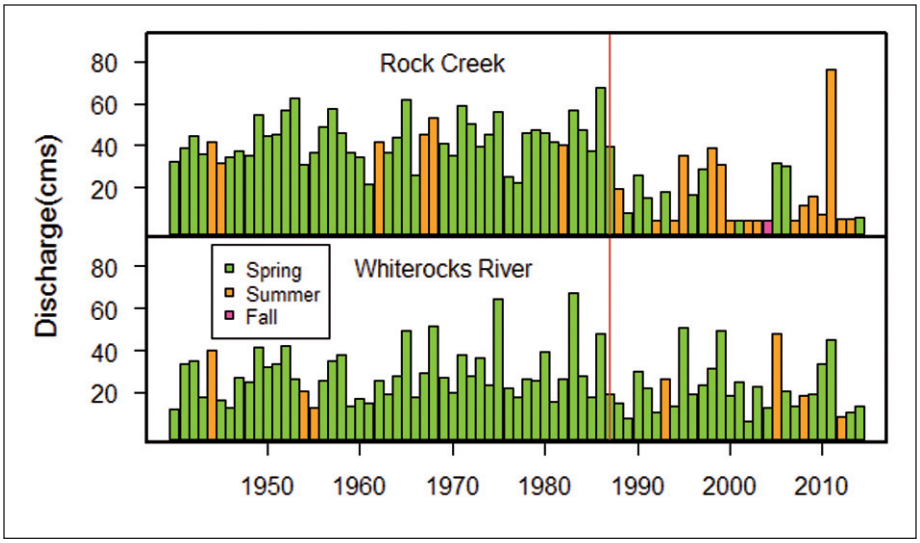


**Figure 7**—Magnitude of peak daily discharge at Rock Creek below Upper Stillwater Dam and at the unregulated Whiterocks River. Season of peak discharge is indicated by bar color. The red line indicates completion of upper Stillwater Dam. Negative trends in peak magnitude were evident at both rivers, but the trend was greater at Rock Creek (Mann-Kendall test; Rock Creek: $Z$ = -3.45, $P$ = 0.00001 and Whiterocks River: $Z$ = -0.16 $P$ = 0.1). Positive trends in peak discharge data were evident at Rock Creek ($Z$ = 0.18, $P$ = 0.01) but not at Whiterocks River ($Z$ = -0.04, $P$ = 0.65).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of perennial streams is greater than length of ephemeral/intermittent streams in this LTA (table 8). Flows above Moon Reservoir are capable of scouring mature willows from banks and transporting large boulders (Schmidt et al. 2008). Erosion and deposition rates affected similar percentage of area at Rock Creek above Stillwater Dam (26 percent) and at Lake Fork above Moon Lake Dam (19 percent). These dams have altered channel dynamics along with levees, roads, and canals in lower sections of streams. Despite these changes, natural hydrologic and geomorphic processes are occurring throughout most of the LTA. Most perennial stream segments occupy floodplains that are intact or in good condition, according to R-CAT results (table 8). Roads, ATV use, and cattle disturbances add sediment to streams. Sediment is trapped and stored behind Upper Stillwater and Moon Lake Dams. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 7).

### *Vegetation and Soil Condition*

Narrowleaf cottonwood and Drummond's willow are ubiquitous on cobble, exposed banks, and hillsides (fig. 8). Willows recently colonized the area excavated below Stillwater Dam. Rapid growth of rushes and sedges and expansion of Drummond's willow are attributed to floodplain beaver ponds. Wet meadow graminoids are grazed by livestock in several canyon bottoms and along tributaries, but recent levels of use have not exceeded 50 percent.

**Figure 8**—Mix of coniferous trees, deciduous shrubs, and deciduous trees in the wide floodplain of lower Rock Creek (photo by D.M. Smith, USFS).

Soil damage is extensive in some areas, but much of the exposure is natural or has been repaired. Banks and hillsides that are heavily grazed are especially prone to stream cutting. Soil has been exposed by headcuts, cut banks, recreation, development, and cattle damage at stream crossings. The areas excavated during the construction of Upper Stillwater Dam have since been revegetated. We determined the status of vegetation and soil condition to be **within** the NRV (table 7).

### *Resistance to Invasive and Encroaching Species*

Musk thistle and bull thistle have invaded meadows but are not displacing riparian and wetland species. The invasive diatom didymo (*Didymosphenia geminate*) has invaded Rock Creek. Encroachment of blue spruce is widespread in riparian forest stands and floodplains, threatening to displace deciduous species (fig. 9). R-CAT results, however, indicated that encroachment by conifers and other upland vegetation has only occurred along 3 percent of perennial stream miles (table 9). In some areas, encroachment is slowed by flooding behind beaver dams. In addition, fuel reduction projects, such as prescribed fire and lop-and-scatter treatments, have been conducted or are ongoing in the Yellowstone, Rock Creek, and Lake Fork watersheds. We determined the status of resistance to invasive and encroaching species to be **trending toward** the NRV (table 7).

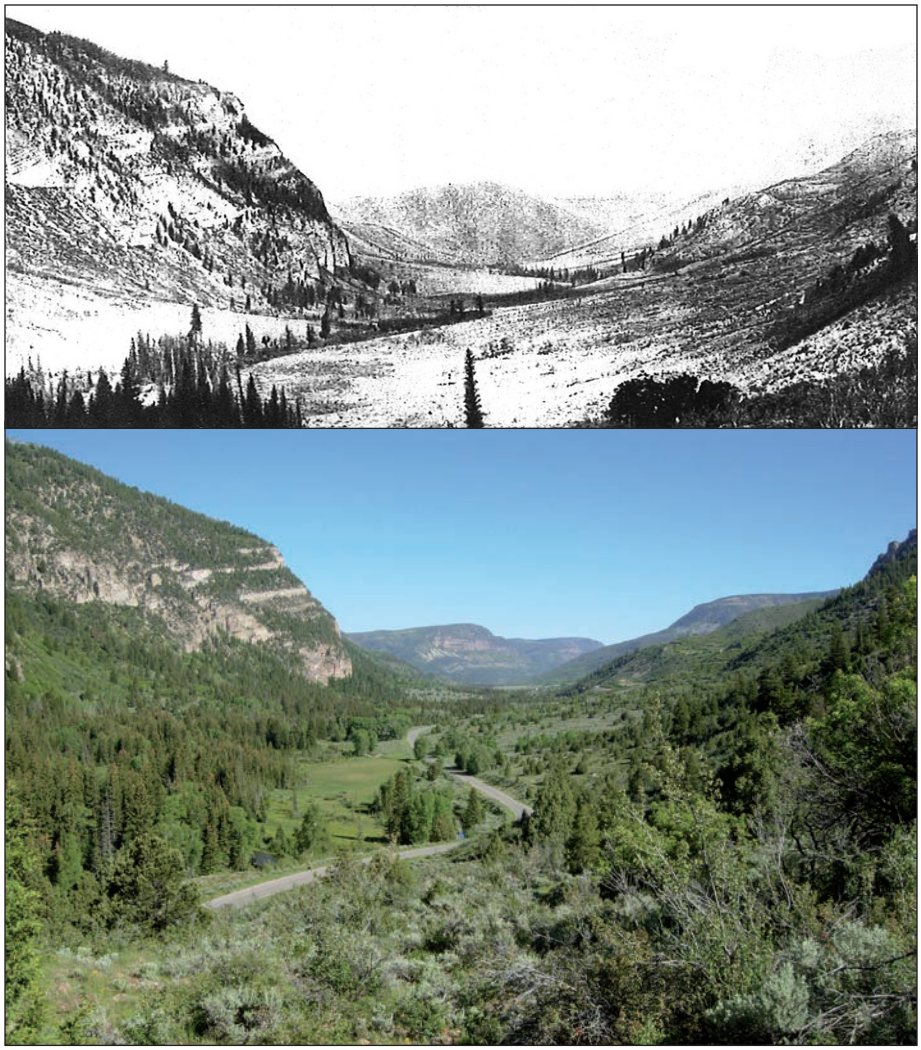

**Figure 9**—Repeat photo comparison showing increase in conifer cover between 1909 and 2009 in lower Duchesne Canyon (photos by W.W. Atwood, S. Goodrich, and A. Huber, USFS).

## Information and Research Needs/Data Gaps

1. *Groundwater dynamics*. Relative to surface water, changes to groundwater dynamics by dams and diversions are poorly understood.

2. *Sediment storage*. Downstream effects of sediment storage in Upper Stillwater Reservoir and Moon Lake Reservoir should be investigated to prevent long-term floodplain damage.

## Glacial Canyon LTA

### Riparian and Wetland Ecosystems

The Glacial Canyon LTA has a relatively low amount of wetland ecosystem acres (table 2), but a moderate amount of riparian vegetation has been mapped (table 3). This LTA contains nine riparian and wetland vegetation types (table 12). These types are located in the Whiterocks, Uinta, Lake Fork, Rock Creek, and Duchesne River Watersheds on the south slope of the Uinta Mountains (fig. 2).

Deciduous tree-dominated riparian vegetation types are the largest group represented, followed by herbaceous-dominated, coniferous-dominated and irrigated types (table 3). One irrigated patch is located in the lower Whiterocks River drainage. There were no studies in or near this patch, so we do not describe the vegetation present.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Springs have been developed for livestock use, but density of dams (table 5) and diversions (table 6) is relatively low in this LTA. Growth, survival, and reproduction of narrowleaf cottonwoods and other riparian trees indicate stable groundwater fluctuations and scouring flows in side canyons. We determined the status of groundwater and surface water fluctuations in this LTA to be **within** the NRV (table 7).

#### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA. The majority of perennial stream segments are classified as confined and unimpacted by the R-CAT (table 8). Channels of perennial streams can be rerouted following flash floods during summer and fall thunderstorms. Floods, mudflows, and avalanches transport sediment and debris from the Glacial Canyon to the Glacial Bottom LTA. Other sediment sources include pocket gophers and red pine shale deposits. New ephemeral stream channels formed following mudslides in 2005, highlighting the

**Table 12**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Glacial Canyon land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type code/name | Grouping | Hectares |
|---|---|---|
| Coniferous tree, unclassified | Coniferous tree-dominated | 1.3 |
| Deciduous tree, unclassified | Deciduous tree-dominated | 77.8 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 83.8 |
| Bigtooth maple | Deciduous tree-dominated | 12.4 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 20.6 |
| Wet meadow with conifer displacement | Herbaceous-dominated | 0.6 |
| Wet meadow, undifferentiated | Herbaceous-dominated | 3.4 |
| Brookgrass | Herbaceous-dominated | 0.7 |
| Irrigated | Unclassified, other, or irrigated | 0.1 |

dynamic nature of this LTA. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 7).

### *Vegetation and Soil Condition*

Woody and herbaceous riparian vegetation is found along low to moderate gradient streams, which are relatively rare in this LTA. Aspen trees have recovered from wildfires, mudflows, and severe avalanches. Mature bigtooth maple, aspen, and narrowleaf cottonwoods are growing in side canyons of several watersheds (fig. 10).

Vegetation helps to stabilize banks in this steep LTA that is prone to erosion. Wet meadow soils are exposed by cattle trailing and pocket gophers. Some canyon bottom streams cut into red pine shale each spring, causing soil to slide. Mature narrowleaf cottonwoods help to stabilize these banks and hillsides. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 7).

### *Resistance to Invasive and Encroaching Species*

Musk mustard has recently invaded the Whiterocks River watershed. Lodgepole pine, Douglas-fir, and juniper are encroaching into some deciduous riparian communities as a result of fire suppression in this watershed. R-CAT analysis indicated that encroachment by conifers and other upland vegetation has occurred along 21 percent of perennial stream miles (table 9). We determined the status of resistance to invasive and encroaching species to be **outside** the NRV (table 7).

## Information and Research Needs/Data Gaps

1. *Beaver activity*. Monitoring of beaver in perennial channels is needed to determine if ecosystem engineering is influencing dynamics of streams that meet at the base of canyons.

**Figure 10**—Bigtooth maple, aspen, and narrowleaf cottonwood stand in Red Pine Canyon (photo by S. Goodrich, USFS).

## Limestone Hills LTA

### Riparian and Wetland Ecosystems

The area of wetland (table 2) and riparian (table 3) ecosystems in the Limestone Hills is small relative to other LTAs in the Uinta Mountains. Two herbaceous-dominated riparian vegetation types, mixed dry and wet meadow complex and Nebraska sedge, are mapped in the LTA (table 13). These types are located in the Big Brush Creek, Little Brush Creek, Jones Hole Creek, and Burnt Cabin Gulch drainages (fig. 2).

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Streams are intermittent due to limestone sinks and limited availability of snowmelt runoff. Anthropogenic stressors include spring developments and irrigation canals. There are no dams (table 5) in this LTA, but the diversion density is relatively high for the Uinta Mountains (table 6). At least one cattle pond is present, which fluctuates in depth from year to year. Leakage from canals has contributed water to springs and streams. Timber harvest has likely increased water yield and peak flows from snowmelt runoff (Burton 1997). Though groundwater and surface water dynamics have been altered, natural fluctuations still occur. We determined the status of groundwater and surface water fluctuations to be **trending toward** the NRV (table 7).

#### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than the length of perennial streams in this LTA (table 8). Channels are mostly bedrock-confined with little dynamism. ATV use contributes to sedimentation near streams, but we did not find widespread evidence of changes to floodplain dynamics or sedimentation. R-CAT analysis classifies the majority of floodplains associated with perennial streams as confined-unimpacted with intact floodplains in good condition. A small percentage of perennial stream floodplains are confined and impacted (table 8). We determined the status of channel, floodplain, and sediment dynamics to be **within** the NRV (table 7).

#### *Vegetation and Soil Condition*

Riparian and wetland vegetation is present in a few riparian stream bottoms and wet meadows. Narrowleaf cottonwood reproduction is occurring along Pothole Creek/East Draw, though saplings are browsed by cattle and/or elk (fig. 11). Alders in a gully near Jones Hole Creek have also been browsed. Grasses and sedges in wet meadows are receiving heavy grazing pressure, especially during drought years where use exceeds 50 percent (fig. 12). Excessive use of riparian graminoids was also noted following unauthorized grazing (trespass cattle, exceeded allotment time). Composition of riparian and wetland plants has not changed despite heavy use. Post-grazing conditions in riparian zones are improved during years when rain is abundant enough to support production of Kentucky bluegrass in drier portions of meadows.

Where present, late-seral riparian vegetation stabilizes streambanks. Banks vegetated with silver sage/Kentucky bluegrass have lower stability and greater rates of incision. Soil disturbances are not widespread, but some wet meadows are affected by vehicle use, camping, cutbanks, wallows,

**Table 13**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Limestone Hills landtype association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Mixed dry and wet meadow complex | Herbaceous-dominated | 92.3 |
| Nebraska sedge | Herbaceous-dominated | 3.2 |

**Figure 11**—Narrowleaf cottonwoods along Pothole Creek/East Draw in 2011 (photo by S. Goodrich, USFS).

**Figure 12**—Herbaceous riparian vegetation along Reader Creek in a grazed meadow, photographed in 2013 (photo by G. Brown, USFS).

cattle trailing, and hoof trampling. Streambank stability was measured at a greenline transect in 2013. This transect was dominated by communities with Nebraska sedge and other herbaceous species, resulting in a stability rating of 8.3. We determined the status of vegetation and soil condition to be **trending toward** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

Blue spruce and Douglas-fir are present along Pothole Creek/East Draw, but are not showing signs of encroachment into riparian vegetation. R-CAT results indicated that no riparian areas have converted to invasive species, conifer, or other upland vegetation (table 9). We determined the status of resistance to invasive and encroaching species in this LTA to be **within** the NRV (table 7).

## Limestone Plateau LTA

### Riparian and Wetland Ecosystems

The area of wetland and riparian ecosystems in the Limestone Plateau is small relative to other LTAs in the Uinta Mountains (fig. 2). Freshwater emergent, ponds, and lakes make up a very small amount of the land cover in this LTA (table 2). Additionally, no riparian vegetation has been mapped in the Limestone Plateau (table 3). Riparian and wetland ecosystems are limited in this LTA because surface water rapidly infiltrates into soil and karst geology and springs are generally absent (ANF 2009). There are no dams located in this LTA (table 5) and there are few underground diversions (table 6). R-CAT analysis indicated there are many more intermittent/ephemeral streams than perennial and that the few perennial miles are confined and unimpacted (table 8). Additionally, there has been no documented conversion from riparian cover to conifer, invasive species, or upland (table 9).

### Information and Research Needs/Data Gaps

We did not evaluate KECs in this LTA because no riparian vegetation types are mapped and we did not find studies of riparian and wetland ecosystems in the Range Study Database. Additional information is needed to document the structure, composition, and extent of riparian and wetland vegetation that is present in this LTA, particularly around the small number of perennial streams.

## Moenkopi Hills LTA

### Riparian and Wetland Ecosystems

The area of wetland and riparian ecosystems in the Moenkopi Hills is the smallest of any LTA in the Uinta Mountains (fig. 2). A very small amount of freshwater emergent habitat (table 2) and no riparian vegetation is mapped in this LTA (table 3). We did, however, find information about riparian vegetation in studies 42-38D, 42-28S2, 42-28S1, 42-38H, and 42-38J. Narrowleaf cottonwood is present in Wild Horse Draw, which was burned by the Neola North Fire in 2007. By 2012, cottonwood resprouts were abundant in the draw. Also in the draw was Nebraska sedge and several small, resprouted Russian olives. There are no dams in this LTA (table 5), but there are several diversions (table 6) that result in a relatively

high diversion density in this small LTA. There are no perennial stream miles in the Moenkopi Hills, but there are some intermittent and ephemeral streams (table 8).

### Research and Information Needs/Data Gaps

We did not evaluate KECs in this LTA because there were no riparian vegetation types mapped and there are no perennial streams. Additional information is needed to document the structure, composition, and extent of any riparian vegetation surrounding intermittent and ephemeral streams. Furthermore, continued monitoring of the riparian zone burned by the Neola North Fire would provide a unique opportunity to document long-term effects of fire on native species including narrowleaf cottonwood and Nebraska sedge, as well as invasive species including Russian olive, Canada thistle, and cheatgrass.

## Parks Plateau LTA

### Riparian and Wetland Ecosystems

The Parks Plateau has a relatively large area of wetland ecosystems (table 2) and herbaceous-dominated riparian ecosystems (table 3). There are 11 riparian and wetland vegetation types mapped in the Parks Plateau LTA (table 14). Riparian vegetation is mapped in two watersheds on the north slope of the Uinta Mountains (Cart Creek and Gorge Creek) and in at least 14 watersheds on the south slope (fig. 2). Herbaceous-dominated patches comprise the largest area of mapped riparian vegetation, followed by non-willow shrub-dominated, willow-dominated, and coniferous tree-dominated types.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Snowmelt-driven floods are common in north slope streams including Francis Creek. Small lakes are present in depressional areas. Several streams, ponds, and lakes had water in 2011 but were dry in 2012, 2013, 2014, and

**Table 14**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Parks Plateau land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Coniferous tree, unclassified | Coniferous tree-dominated | 4.3 |
| Mountain Silver sagebrush | Non-willow shrub-dominated | 557.7 |
| Shrubby cinquefoil | Non-willow shrub-dominated | 4.7 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 1,045.6 |
| Wet meadow with conifer displacement | Herbaceous-dominated | 135.2 |
| Wet meadow undifferentiated | Herbaceous-dominated | 13.5 |
| Beaked sedge | Herbaceous-dominated | 1.4 |
| Nebraska sedge | Herbaceous-dominated | 12.5 |
| Tufted hairgrass | Herbaceous-dominated | 21.3 |
| Brookgrass | Herbaceous-dominated | 129.1 |
| Tall willow | Willow-dominated | 9.0 |

2015. Beavers augmented a large pond in the Cart Creek watershed by plugging a culvert. There is a low density of dams (table 5) but numerous diversions (table 6) in this LTA. Water from the Big Brush Creek Drainage is diverted to Ashley Creek. Despite these diversions, we did not find evidence of widespread changes in surface water and groundwater dynamics. Timber harvest in this LTA has the potential to increase water yield and peak flows from snowmelt runoff (Burton 1997). We determined the status of groundwater and surface water fluctuations in this LTA to be **trending toward** the NRV (table 7).

#### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA, with the length of ephemeral/intermittent streams one of the highest in the Uinta Mountains (table 8). There is a moderate amount of perennial stream miles in the Parks Plateau, and the majority are classified as confined and unimpacted with intact floodplains in good or moderate condition. However, R-CAT results also indicated a relatively high percentage of confined and impacted floodplains (table 8). Channels are typically bedrock-controlled or stabilized by wet meadow vegetation, resulting in low rates of dynamism. A new channel of Francis Creek was engineered to protect a road in 2012, but it has since blown out, followed by development of a new floodplain. Grazing has led to widening and shallowing of streams in areas of heavy use. Current sediment sources include mineral licks, leakage from irrigation canals, ATV use near streams, and damage from grazing near streams. An upstream limestone mine is a potential source of sedimentation, but effects have not been observed. We determined the status of channel, floodplain, and sediment dynamics to be **trending toward** the NRV (table 7).

#### *Vegetation and Soil Condition*

Stream reaches are generally herbaceous-dominated in the LTA. Where present, woody riparian vegetation includes silver sage (fig. 13), narrowleaf cottonwood, and Geyer willow. A stand of cottonwoods along Reader Creek is used for shade by cattle and there is no sign that the cottonwoods are reproducing. Geyer willow has increased in several meadows in recent decades despite cattle and sheep grazing.

Excessive grazing has occurred in many of the LTA's wet meadows, especially during 2012 and other drought years. Damage was also noted where cattle exceeded their allotment period or breached exclosures. Cattle heavily used riparian graminoids where sediment deposits and shade trees created loafing areas. Post-grazing conditions in mesic areas are improved during years when rain is abundant enough to support production of Kentucky bluegrass (fig. 14). Sedges are grazed near streams late in the season when bluegrass and other preferred grasses are unavailable. Long-term decline of Nebraska sedge and other graminoids could occur following 3 or more years of heavy grazing and drought. Riparian vegetation conversion analysis indicated that replacement of riparian vegetation with developed land has occurred along 5 percent of perennial stream miles (table 9).

**Figure 13**—Wet meadow with silver sage and mesic gramminoids in Bowden Draw (photo by S. Goodrich, USFS).

**Figure 14**—Sedge- and grass-lined stream in the Reader Creek watershed (photo by G. Brown, USFS).

Wet meadow streambanks are stabilized by late-seral sedges and other graminoids. Natural and human-induced soil disturbance is, however, widespread in the wet meadows of this LTA. Disturbances include lingering effects of logging and dam construction, heavy vehicle use, ATV use through wet soil, dispersed camping, stream crossings, pocket gophers, excessive grazing (>50 percent use), canal breakage, mineral licks, headcuts, bank shearing, livestock trailing, and hoof trampling. Some headcuts are a legacy of sheep grazing, which was discontinued in the 2000s. Streambank stability was measured at two greenline transects, one in 2001 and the other in 2013, and at a MIM area in 2011. The greenline transect at Bowden draw was dominated by communities with beaked sedge and other herbaceous species, with a stability rating of 9.0. The other transect, at Francis Creek Station, was dominated by graminoid communities with a stability rating of 7.1. At the MIM area along Basset Creek, nearly 82 percent of greenline plots were dominated by late-seral sedges, 0.1 percent of the plots were altered by ungulate hooves, and 58 percent of the plots showed signs of fracture, sloughing, or slumping. We determined the status of vegetation and soil condition in this LTA to be **outside** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

Small patches of cheatgrass have been observed but do not threaten composition of riparian areas and wetlands. Whitetop patches are present as well but are treated annually. R-CAT analysis indicated that encroachment by conifers and other upland vegetation has occurred along 9 percent of perennial stream miles (table 9). Conifers have advanced on Francis Creek, where lop-and-scatter treatments are planned. We determined the status of resistance to invasive and encroaching species in this LTA to be **trending toward** the NRV (table 7).

### Information and Research Needs/Data Gaps

1. *Conifer encroachment*. The mechanisms causing encroachment of lodgepole pine and Engelmann spruce must be determined in order to slow or prevent the advance of conifers into willow and herbaceous-dominated vegetation types.

2. *Beaver activity*. Additional information is needed to determine whether long-term abandonment of beaver dams resulted from natural loss of aspens or anthropogenic causes.

## Round Park LTA

### Riparian and Wetland Ecosystems

The Round Park LTA contains a moderate area of wetland ecosystems that include freshwater emergent, freshwater forested/shrub, and freshwater pond (table 2). These systems and a small number of perennial streams maintain moderate riparian coverage (table 3). Four riparian and wetland vegetation types are mapped within the Round Park LTA (table 15). Herbaceous- and willow-dominated types are located in the Sheep Creek and Carter Creek watersheds on the south slope of the Uinta Mountains (fig. 2). Much of the riparian vegetation in this LTA is located in meadows and parks (fig. 15).

**Table 15**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Round Park land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Mixed dry and wet meadow complex | Herbaceous-dominated | 143.8 |
| Plane-leaf willow | Willow-dominated | 54.2 |
| Plane-leaf willow/water sedge | Willow-dominated | 16.4 |
| Geyer willow | Willow-dominated | 16.1 |

**Figure 15**—Wet meadow dominated by grasses and sedges in Commissary Park (photo by A. Zobell, USFS).

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

This LTA has a low density of streams due to high rates of soil infiltration. There are no dams in the Round Park LTA (table 5), and there are few diversions (table 6). We found no evidence of change in surface water or groundwater dynamics. We determined the status of groundwater and surface water fluctuations in this LTA to be **within** the NRV (table 7).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of perennial streams is greater than the length of ephemeral/intermittent streams in this LTA, but there is a low total number of stream miles compared to other LTAs in the Uinta Mountains (table 8). The majority of floodplains of perennial streams are classified as confined and unimpacted and good to moderate condition by R-CAT analysis (table 8). The bedrock-controlled and wet meadow vegetation-bound channels have naturally

low rates of dynamism. Natural sediment sources include elk wallows and mineral licks. Cattle grazing contributes to sedimentation, but we found little evidence of additional anthropogenic effects on floodplain dynamics or sedimentation. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 7).

#### *Vegetation and Soil Condition*

Plane-leaf willow has declined in height and canopy cover in some areas and has been eliminated from others. These declines are likely a result of browsing by elk and moose. Browsing of wolf willow is light, possibly because of preference for plane-leaf willow. Damage to riparian graminoids from cattle grazing is localized in this LTA. Fewer cattle were grazed for a shorter period of time than expected in meadows in 2012 because of drought conditions.

Localized soil disturbances include ATV use, dispersed camping, wallows, mineral licks, trailing, headcuts, bank cuts, and stream crossings. Streambank stability was measured at three greenline transects, with the oldest measurement in 2007 and the most recent in 2014. Transects were dominated by water sedge communities. As a result, stability ratings were 8.9 or 9.1. We determined the status of vegetation and soil condition in this LTA to be **trending toward** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

Lodgepole pine and Engelmann spruce are found in willow fields throughout the LTA, but this encroachment has likely occurred during the fire return interval. R-CAT analysis indicated that encroachment by conifers and other upland vegetation has occurred along 2 percent of perennial stream miles (table 9). We determined the status of resistance to invasive and encroaching species to be **trending toward** the NRV (table 7).

## South Face LTA

### Riparian and Wetland Ecosystems

The South Face LTA contains a small area of wetland ecosystems that are primarily classified as freshwater emergent (table 2). A moderate amount of riparian vegetation is supported by these wetland ecosystems and some perennial streams (table 3). Seven riparian and wetland vegetation types are mapped within the LTA. These types are located in the Dry Canyon, Farm Creek, Grouse Creek, Little Water, Mill Canyon, and Whiterocks River watersheds (fig. 2). Deciduous tree-dominated types form the largest area of mapped riparian vegetation, followed by herbaceous-dominated, willow-dominated, and unclassified/other/irrigated types (table 16). A patch of unclassified vegetation located east of Ashley Gorge appears to contain a mix of mature narrowleaf cottonwoods, juniper, and deciduous shrubs, based on photos from study 45-8K.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Most streams are ephemeral in this LTA and riparian vegetation is limited to stream sections where baseflows are supported by springs. Flooding occurs

**Table 16**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the South Face land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Narrowleaf cottonwood | Deciduous tree-dominated | 0.4 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 42.2 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 15.1 |
| Wiregrass | Herbaceous-dominated | 4.4 |
| Tall willow | Willow-dominated | 7.2 |
| Other | Unclassified, other, or irrigated | 1.7 |
| Irrigated | Unclassified, other, or irrigated | 0.1 |

at relatively low frequency. Anthropogenic stressors are localized and include impoundments, diversions, canals, and development of springs. This LTA has the highest dam density in the Uinta Mountains, although all have little impact (table 5). Additionally, there are numerous diversions and a moderate diversion density (table 6). We determined the status of groundwater and surface water fluctuations in this LTA to be **trending toward** the NRV (table 7).

### *Channel, Floodplain, and Sediment Dynamics*

This LTA has a relatively high number of ephemeral/intermittent stream miles compared to the rest of the Uinta Mountains. Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA (table 8). The small number of perennial stream channels support floodplains that are nearly all classified by R-CAT as confined. A large amount is impacted, but the majority of perennial floodplains remain unimpacted (table 8). Most channels are bedrock-controlled and thus have low rates of dynamism. Erosive uplands and natural soil instability, and pocket gopher activity, contribute high loads of sediment to streams. Beaver dams slow streamflow, widen channels, and decrease channel capacity resulting in a stronger connection between the stream and its floodplain. Anthropogenic effects on channels, floodplains, and sediment are localized. Widening of streams has occurred following heavy use by livestock and wild ungulates. Anthropogenic sediment sources include canal breaches and livestock damage to streambanks. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 7).

### *Vegetation and Soil Condition*

A portion of Farm Creek was burned with light to moderate severity by the 2007 Neola North Wildfire. Some mature cottonwoods and ponderosa pines survived the fire, but several narrowleaf cottonwoods were top-killed. Cottonwood sprouted vigorously after fire. Aspen, boxelder, and willows sprouted as well. Large narrowleaf cottonwood snags were present in the postfire riparian forest in 2008. Riparian vegetation along Grouse Creek was

burned with high severity in the spring of 1987 (fig. 16). Bebb's willows resprouted but were later browsed heavily by cattle. Currants and twinberries resprouted as well and were lightly to moderately browsed, respectively. Greater sage-grouse broods were foraging in the postfire riparian site 3 years after the fire. In 1999 logs were abundant and some cottonwood snags were still standing at the Grouse Creek fire sites. Large snags had fallen by 2003 and small snags were still standing in 2005.

Herbaceous vegetation is heavily grazed in meadows within the Little Water watershed. Excessive cattle grazing occurred when cattle entered prior to their allotted period in 2014. Riparian vegetation conversion analysis indicated that replacement of riparian vegetation with agricultural land has occurred along 1 percent of perennial stream miles (table 9). Localized soil disturbance includes cutbanks, gully formation, and hoof trampling at streams. We determined the status of vegetation and soil condition to be **trending toward** the NRV (table 7).

### *Resistance to Invasive and Encroaching Species*

Canada thistle has spread into areas burned by the Neola North Fire. Cheatgrass has spread into riparian zones, becoming a dominant influence on plant communities. R-CAT analysis indicated that replacement of riparian vegetation with invasive species has occurred along 3 percent of perennial stream miles and encroachment by conifers and other upland vegetation has occurred along 9 percent of perennial stream miles (table 9). We determined that the status of resistance to invasive and encroaching species in this LTA is **outside** the NRV (table 7).

**Figure 16**—Narrowleaf cottonwood logs, cottonwood trees, and assorted shrubs near Grouse Creek, photographed in 2008. This area was burned by wildfire in 1987 (photo by S. Goodrich, USFS).

## Stream Canyon LTA

### Riparian and Wetland Ecosystems

The Stream Canyon LTA contains a small amount of wetland ecosystems including freshwater emergent, freshwater forested/shrub, and freshwater pond (table 2). These systems combined with a large number of perennial stream miles support a moderate amount of riparian vegetation (table 3). Four riparian and wetland vegetation types are mapped within the Stream Canyon LTA. These types are located in the Ashley Creek, Big Brush Creek, Dry Creek, Dry Fork, Farm Creek, Hole in the Wall Canyon, and Pole Creek watersheds on the south slope of the Uinta Mountains (fig. 2). Deciduous tree-dominated types form the largest area of mapped riparian vegetation, followed by herbaceous-dominated and non-willow shrub-dominated types (table 17).

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Karst systems are strong drivers of surface flows and groundwater dynamics at many streams (Godfrey 1985) in this LTA. Portions of the Dry Fork and other streams are intermittent due to periods when sinks are exceeded by heavy runoff from snowmelt or thunderstorms. Perennial baseflows of certain streams are produced by discharge out of karst systems. There are no dams in this LTA (table 5), but springs are developed for livestock and Ashley Creek flows are augmented by a canal from Big Brush Creek in the Parks Plateau LTA. Additionally, this LTA has a relatively high diversion density (table 6). We determined the status of groundwater and surface water fluctuations in this LTA to be **trending toward** the NRV (table 7).

#### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams, but there are many of both stream types in this LTA. The majority of stream segments are classified as confined and unimpacted, according to the R-CAT analysis (table 8). Spring and summer snowmelt floods are regular events that deposit alluvium, activate and deactivate channels, and realign channels in valley bottoms. Floods from summer thunderstorms realign channels as well. Valley bottoms also contain ponds created by depressions, debris dams, and beaver dams. Geomorphic and

**Table 17**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Stream Canyon land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Narrowleaf cottonwood | Deciduous tree-dominated | 119.2 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 101.2 |
| Shrubby cinquefoil | Non-willow shrub-dominated | 0.02 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 33.5 |
| Timber oatgrass | Herbaceous-dominated | 0.3 |

hydrologic processes are in their natural state at most of the streams. Roads along Dry Fork and Pole Creek limit channel migration, but other streams are unaffected by roads, given their remote canyon settings. Anthropogenic sources of sediment include roads on uphill slopes and stream crossings, ATV use, and dispersed camping. Sediment washed into streams following the Neola North Wildfire in 2007. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 7).

### *Vegetation and Soil Condition*

Natural establishment of narrowleaf cottonwoods and Drummond's willow occurs on cobble and boulder floodplains of the Dry Fork (fig. 17). The Neola North Wildfire burned a portion of riparian vegetation along Farm Creek with high intensity in 2007 (fig. 18). Herbaceous vegetation along the incised stream was not burned by the fire. Large narrowleaf cottonwoods, aspen, and conifers were top-killed by the fire. Cottonwood and aspen recovered vigorously by producing root sprouts. Sprouted saplings were in good condition 9 years after the fire amidst cattle grazing and drought. Dense shrubs including red-osier dogwood had recovered along the stream channel as well. Loose-bark cottonwood snags were standing 1 year post-fire, clean snags were standing in 2011, and few snags were left standing in 2015. The area around a beaver dam was severely burned by the 2007 Neola North Fire, but herbaceous vegetation near the pond was unburned.

Though condition of woody vegetation appears good, herbaceous vegetation is excessively used by livestock in several locations. Use of pasture near Farm Creek by Forest Service horses exceeded 50 percent in

**Figure 17**—Narrowleaf cottonwoods and conifers growing near Dry Fork channel downstream from limestone sinks (photo by S. Goodrich, USFS).

**Figure 18**—Beaver dam and pond constructed after the 2007 Neola North fire along Pole Creek (photo by A. Huber, USFS).

2012. A wet meadow in Hole in the Wall Canyon was excessively grazed in 2013 and 2014. R-CAT analysis indicated that replacement of riparian vegetation with agricultural and developed land has occurred along 3 percent of perennial stream miles (table 9).

Natural soil disturbances include pocket gopher activity. Anthropogenic soil disturbances such as livestock trailing, hoof trampling, and sod-cuts were present but not widespread in this LTA. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

R-CAT analysis indicated that encroachment by conifers and other upland plants has occurred along 12 percent of perennial stream miles (table 9). Conifers, however, are a natural component of the woody plant community in non-glaciated canyons. We determined the status of resistance to invasive and encroaching species to be **within** the NRV (table 7).

### Information and Research Needs/Data Gaps

1. *Beaver activity*. Little information is available about distribution of beaver in this LTA. Such information is needed to evaluate their interactions with karst systems.

## Stream Pediment LTA

### Riparian and Wetland Ecosystems

The Stream Pediment LTA contains a small amount of wetland and aquatic ecosystems (table 2). However, these systems support a moderate amount of riparian vegetation (table 3). There are four riparian and wetland vegetation types mapped within the Stream Pediment LTA (table 18). Herbaceous-dominated and deciduous tree-dominated types are mapped in the Dry Gulch, Mill Canyon, Pole Creek, Timothy Creek, and West Fork Dry Gulch watersheds on the south slope of the Uinta Mountains (fig. 2). Riparian and wetland vegetation is found in meadows (fig. 19) and along streams in this LTA (fig. 20).

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Streams entering the LTA lose water to soil infiltration and become intermittent. Flooding occurs in Timothy Creek but is not as widespread

**Table 18**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Stream Pediment land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type code/name | Grouping | Hectares |
|---|---|---|
| Aspen | Deciduous tree-dominated | 15.5 |
| Narrowleaf cottonwood | Deciduous tree-dominated | 21.1 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 11.4 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 177.6 |

**Figure 19**—Wet meadow near Burnt Mill Spring in the Timothy Creek watershed (photo by A. Huber, USFS).

**Figure 20**—Shrubs and trees along Mill Creek in the Stream Pediment landtype association (photo by G. Brown, USFS).

and important in the LTA as it was in the geological past. Surface water and groundwater connections are maintained, in part, by beaver activity. There are no dams in this LTA (table 5) and the diversion density is low (table 6). There is, therefore, little evidence of widespread, anthropogenic changes to surface water and groundwater dynamics. We determined the status of groundwater and surface water fluctuations in this LTA to be **within** the NRV (table 7).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA, but there is a limited number of both stream types (table 8). The floodplains for the few perennial streams were classified by R-CAT analysis as mostly confined and unimpacted and in good condition (table 8). Streams are typically bedrock-controlled or stabilized by wet meadow vegetation and have low rates of dynamism. High erosion rates contribute to sedimentation of streams during summer thunderstorms. Roads constructed along perennial streams contribute sediment as well. Livestock damage has widened and shallowed several streams and contributed to sedimentation. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 7).

### *Vegetation and Soil Condition*

Willows in the west fork of Dry Gulch decreased in cover from 2001 to 2011. Cottonwoods recently established near a canal in Mill Canyon. In 2007 the Neola North Fire burned aspens near a beaver dam but the pond protected riparian and wetland vegetation. At least one dam remained active during the year following the fire. Beavers harvested both mature aspens and postfire

aspen sprouts for building material and food. Excessive grazing was noted in wet meadows in 2013 and 2014. Production of graminoids was high during the wet year of 2011.

Soil disturbances include cattle and elk wallows near springs and troughs, pocket gophers, and headcuts. We did not find evidence of widespread, anthropogenic soil disturbance and there are examples such as a gully in the Dry Gulch allotment that has been stabilized by wet meadow vegetation. We determined the status of vegetation and soil condition to be **trending toward** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

Canada thistle has invaded the area around a beaver dam, as is often noted in the Uinta Mountains. R-CAT analysis indicated that encroachment by upland vegetation has occurred along 5 percent of perennial stream miles (table 9). We determined the status of resistance to invasive and encroaching species to be **trending toward** the NRV (table 7).

### Information and Research Needs/Data Gaps

1. *Beaver activity*. Additional stream surveys are needed to determine if the influence of beaver activity is as strong in other streams in this LTA as it is on Pole Creek.

## Trout Slope LTA

### Riparian and Wetland Ecosystems

The Trout Slope LTA has relatively large areas of emergent wetlands (table 2) and herbaceous-dominated riparian (table 3) ecosystems. There are nine riparian and wetland vegetation types mapped within the meadows of the Trout Slope LTA. These types are located in the Cart Creek, Carter Creek, Gorge Creek, and Pipe Creek watersheds on the north slope of the Uinta Mountains and in the Ashley Creek, Big Brush Creek, Dry Fork, Dry Gulch, Lake Fork, Little Brush Creek, Pole Creek, Uinta River, Whiterocks River, and Yellowstone River watersheds on the south slope (fig. 2). Herbaceous-dominated has the largest area of riparian vegetation types, followed by coniferous tree-dominated, non-willow shrub-dominated, and willow-dominated (table 19).

**Table 19**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Trout Slope land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Coniferous tree, unclassified | Coniferous tree-dominated | 30.2 |
| Mountain silver sage | Non-willow shrub-dominated | 11.1 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 1,509.3 |
| Wet meadow with conifer displacement | Herbaceous-dominated | 8.3 |
| Wet meadow, undifferentiated | Herbaceous-dominated | 55.1 |
| Timber oatgrass | Herbaceous-dominated | 150.4 |
| Willow/meadow complex | Willow-dominated | 0.1 |
| Plane-leaf willow/water sedge | Willow-dominated | 6.6 |
| Low willow/wet and dry meadow complex | Willow-dominated | 15.8 |

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

Several meadow streams are dependent on springs. Ephemeral pools, ponds, and potholes collect runoff in meadows and fluctuate year to year in depth. Several streams were modified in the previous century to operate now-defunct mills and fish hatcheries. There are few dams and reservoirs located in this LTA (table 5). Numerous diversions and canals alter surface water dynamics of lakes, streams, and groundwater (table 6). Peak flows and water yield from snowmelt runoff have likely increased following timber harvests (Burton 1997). We determined the status of groundwater and surface water fluctuations in this LTA to be **trending toward** the NRV (table 7).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA. However, this LTA has the second largest amount of perennial stream miles in the Uinta Mountain region (table 8). Streams are typically bedrock-controlled or stabilized by wet meadow vegetation and so have low rates of dynamism. R-CAT analysis indicated the majority of floodplains associated with perennial streams are confined and unimpacted with floodplains in good and moderate condition. A small percentage of floodplains were classified as confined and impacted (table 8). Large wood is present in streams within the Little Brush Creek and Pole Creek watersheds. Livestock damage has widened and shallowed portions of streams passing through wet meadows. Sedimentation sources include roads, road crossings, ATV use, shale soils, and livestock damage. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 7).

### *Vegetation and Soil Condition*

Water sedge and other wet meadow plants were heavily grazed by cattle during the drought years of 2012 and 2013. Wet areas with wiregrass were avoided by cattle along the north fork of Ashley Creek. In addition to grazing, precipitation and soil type heavily influence herbaceous production. During the drought year of 2012, ungrazed areas appeared in better condition than grazed areas (fig. 21). Plane-leaf willows are browsed by elk and moose. Caudate willows were not as heavily browsed as nearby plane-leaf willows. Elk have become the dominant herbivore where sheep were removed from allotments on the Cart Creek watershed. Evidence of old beaver dams was found in a meadow in the Pipe Creek watershed. These dams were likely abandoned after aspen had been depleted. Riparian vegetation conversion analysis indicated that replacement by development has occurred along 1 percent of perennial stream miles (table 9).

Soil disturbances include ATV use, primitive roads, salting for elk in red pine shale, pocket gophers, headcuts, cutbanks, licks, wallows, logging, bank shearing (natural when sod gets too heavy), trampling at stream crossings and springs by cattle and elk, ice flows, and old reservoir spillway cuts. Late-seral sedges and a variety of woody species are capable of stabilizing soil damaged by natural and anthropogenic processes. Bank cutting is more severe where streams are adjacent to dry meadow communities. Streambank stability was

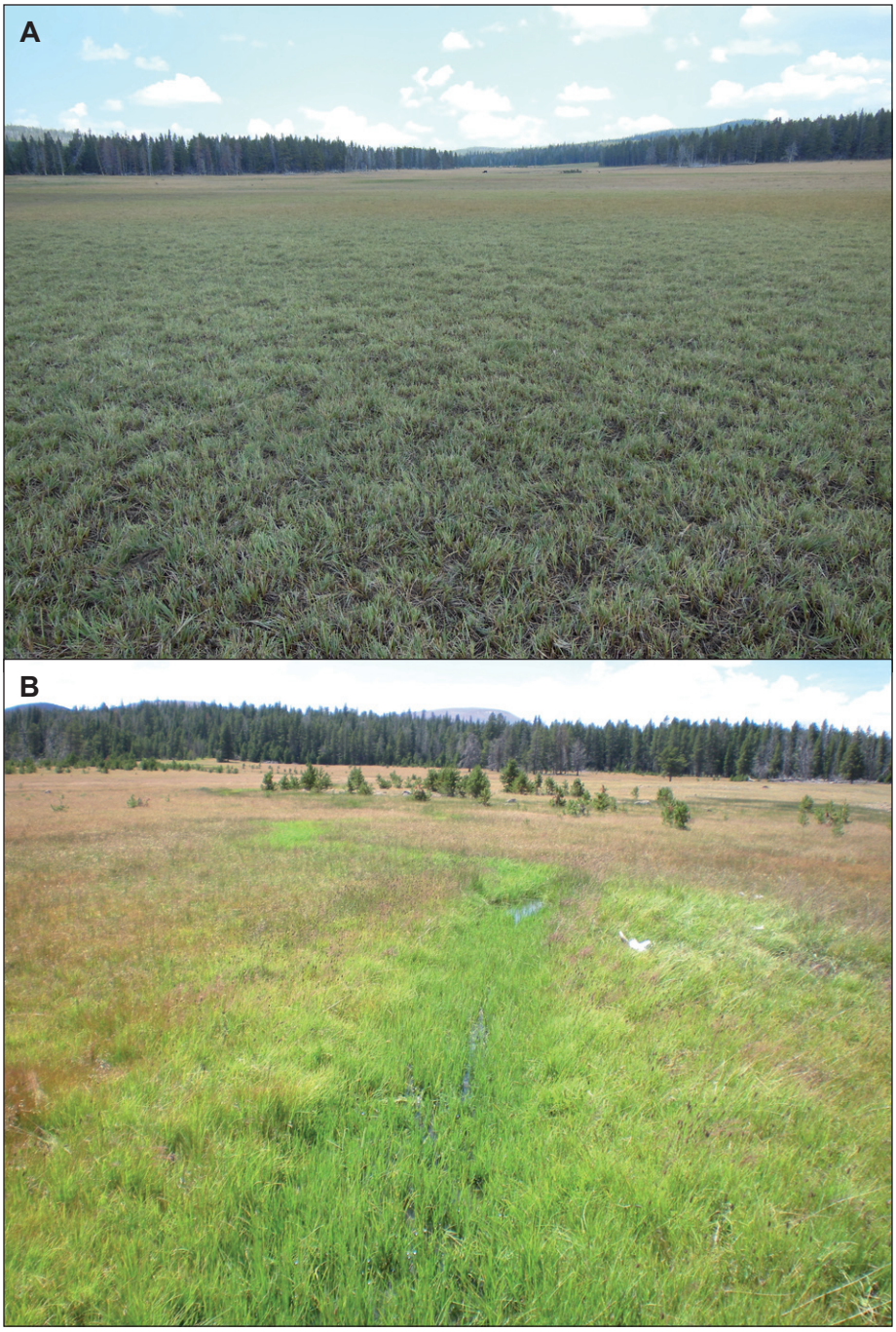


**Figure 21**—(A) Water sedge meadow in the Ashley Creek watershed. This photo was taken while the meadow was grazed by cattle during the drought year of 2012 (photo by S. Goodrich, USFS). (B) Stream and ungrazed meadow in the Ashley Creek watershed. This photo was taken during the drought year of 2012 (photo by G. Brown and A. Huber, USFS).

measured at five greenline transects, the oldest in 1987 and the most recent in 2001, and at three MIM areas in 2011 and 2012. Greenline transects were dominated by communities with water sedge and other herbaceous species, resulting in stability ratings ranging from 7.2–8.7. At the MIM area along Big Brush Creek, over 40 percent of greenline plots were dominated by late-seral sedges, 0.6 percent of the plots were altered by ungulate hooves, and 17 percent of the plots showed signs of fracture, sloughing, or slumping. The MIM area at Cart Creek had over 40 percent of plots dominated by mesic graminoids, no plots showing signs of alteration by ungulates, and 56 percent of the plots showed signs of fracture, sloughing, or slumping. The MIM area at Trout Creek had over 70 percent of plots dominated by mesic graminoids, 2 percent of plots showing signs of alteration by ungulates, and 71 percednt of the plots showed signs of fracture, sloughing, or slumping. We determined the status of vegetation and soil condition to be **trending toward** the NRV (table 7).

#### *Resistance to Invasive and Encroaching Species*

Encroachment of lodgepole pine and Engelmann spruce is ongoing in riparian zones. Conifer encroachment may be facilitated by old roads leading through meadows, but this encroachment has likely occurred during the fire return interval. R-CAT analysis indicated that encroachment by conifers and other upland plants has occurred along 13 percent of perennial stream miles (table 9). We determined the status of resistance to invasive and encroaching species in this LTA to be **trending toward** the NRV (table 7).

## Uinta Bollie LTA

### Riparian and Wetland Ecosystems

The Uinta Bollie LTA has a relatively large amount of wetland ecosystems, primarily freshwater emergent (table 2). Wetlands, ponds, lakes, and a small number of perennial streams support a moderate amount of riparian vegetation (table 3). There are eight riparian and wetland vegetation types mapped within the LTA (table 20). Willow-dominated and herbaceous-dominated types are located in the Carter Creek and Sheep Creek watersheds on the north slope of the Uinta Mountains and in the Ashley Creek, Dry Fork,

**Table 20**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Uinta Bollie land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Mixed dry and wet meadow complex | Herbaceous-dominated | 60.8 |
| Water sedge | Herbaceous-dominated | 1.4 |
| Brookgrass | Herbaceous-dominated | 0.3 |
| Low willow | Willow-dominated | 142.9 |
| Plane-leaf willow | Willow-dominated | 17.9 |
| Plane-leaf willow/water sedge | Willow-dominated | 63.6 |
| Plane-leaf willow/bluejoint | Willow-dominated | 10.3 |
| Low willow/wet and dry meadow complex | Willow-dominated | 23.0 |

Lake Fork River, Uinta River, Whiterocks River, and Yellowstone River watersheds on the south slope (fig. 2).

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

Streams are rare in this LTA, which is dominated by mountain peaks, bollies, and cirque headwalls. Most water movement is subsurface during snowmelt and overland during summer thunderstorms. Surface water and groundwater is released throughout the year. Hiking and livestock trails have altered the direction of flows from seeps and springs. There is a single dam in this LTA (table 5). There are several diversions in the Uinta Bollie LTA, but the density is low (table 6). One transbasin diversion transfers water from the Leidy Peak area to Ashley Creek. We determined the status of groundwater and surface water fluctuations to be **within** the NRV (table 7).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than length of perennial streams in this LTA, but both stream types are limited in their extent. R-CAT analysis classified nearly all floodplains associated with perennial streams as confined and unimpacted (table 8). Stream settings vary from stable bedrock-controlled channels to dynamic talus slope channels. The Uinta Bollies are important sources of sediment that enter streams and lakes in the lower LTAs. Sediment is created through freeze and thaw cycles, rock glaciers, rockfall, and debris flows. These events influence streams and lakes in the Uinta Bollie and lower LTAs. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 7).

### *Vegetation and Soil Condition*

Willows grow vigorously where a high water table is maintained by seepage from boulder fields. Plane-leaf willows are absent from some wet meadows, probably a result of elk browsing. R-CAT analysis indicated that conversion to barren land has occurred along 1 percent of perennial stream miles (table 9).

Damage to soil is localized in this LTA but is slow to recover. Gullies have formed as a result of primitive roads and ATV use. Other forms of disturbance include hiking trails, elk wallows, and pocket gophers. Streambank stability was measured at a greenline transect at Divide Creek in 1997 and at Clover Creek in 2004. The Clover Creek transect was dominated by water sedge, with a stability rating of 9.1. The Divide Creek transect was dominated by water sedge, plane-leaf willow, and other communities with a stability rating of 7.3. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 7).

### *Resistance to Invasive and Encroaching Species*

Increases in density of small conifers have been noted in willow fields and meadows, but not along streams in this LTA (fig. 22). R-CAT analysis indicated that encroachment of upland vegetation has occurred along 3 perceent of perennial stream miles (table 9). We determined the status of

**Figure 22**—Low willows and encroaching conifers in the Uinta Bollie LTA. An elk wallow is located in the upper right hand corner of the photo (photo by A. Huber, and M. Anderson, USFS).

resistance to invasive and encroaching species in this LTA to be **within** the NRV (table 7).

### Information and Research Needs/Data Gaps

1. *Damage by wild ungulates*. Information about forage use by elk and other herbivores, including introduced mountain goats, is needed to manage populations of willows and other riparian plants in this LTA.

## Wolf Plateau LTA

### Riparian and Wetland Ecosystems

The area of wetland and riparian ecosystems in the Wolf Plateau is small relative to other LTAs in the Uinta Mountains (fig. 2). Freshwater emergent systems make up a limited land cover in this LTA (table 2). Additionally, no riparian vegetation has been mapped (table 3). Riparian and wetland ecosystems are limited in this LTA because surface water rapidly infiltrates into soil and karst resulting in no lakes or ponds and low density of perennial streams (table 9). We did, however, find information about riparian vegetation in the Range Study Database. Notes from study 34-15 describe riparian vegetation along Iron Mine Creek consisting of herbaceous species including water sedge and wiregrass, with wolf willow present as well (fig. 23). Aspen, narrowleaf cottonwood, and other deciduous trees appear to line Mill Fork in Rhodes Canyon, based on photos from study 48-5B.

**Figure 23**—Herbaceous riparian and wetland vegetation along Iron Mine Creek in the Duchesne River watershed (photo by A. Huber and A. Zobell, USFS).

## Information and Research Needs/Data Gaps

We did not evaluate KECs for the Wolf Plateau because there are few perennial or intermittent streams and there are no riparian vegetation types mapped in the LTA. Additional surveys along Iron Mine Creek are needed to document the structure, composition, and extent of riparian and wetland vegetation that is present in this LTA.

## Antelope Flat LTA

### Riparian and Wetland Ecosystems

The Antelope Flat LTA includes a moderate amount of wetland ecosystem cover (fig. 24), primarily in the form of freshwater emergent systems and lakes (table 21). Unclassified and irrigated riparian vegetation types are mapped within the Antelope Flat LTA at the south end of Flaming Gorge Reservoir (table 22). Unclassified riparian vegetation flanks Spring Creek from the national forest boundary to its inlet on the east side of the reservoir (table 23). Riparian vegetation along the stream is largely herbaceous and includes wiregrass, Nebraska sedge, and several native and introduced grasses (fig. 25; studies 6-23H, 6-23I, 6-23J). Tamarisk appears to be the only woody riparian species that is abundant along the stream (study 6-23A). Several expanses of irrigated riparian vegetation are located near the inlet of Henry's Fork on the west side of the reservoir (fig. 26). These irrigated areas include a mixture of native and introduced graminoids, cattails, and other wetland species, along with stringers of cottonwoods and willows (studies 4-33D, 4-34C2, 71-2C, 71-4A1).

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Surface water and groundwater dynamics have been altered by Flaming Gorge Reservoir and irrigation developments. Where riparian vegetation is present, it is maintained by groundwater. Spring Creek is the only perennial stream in the LTA. Several irrigation canals cross the LTA and several stock ponds and wetlands have also been constructed. Excess irrigation water floods meadows and pastures near the Henry's Fork inlet. Spring creek was impounded by a debris dam created by a slump in 2011. There are four small dams in this LTA (table 24) and a moderate diversion density (table 25). We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 26).

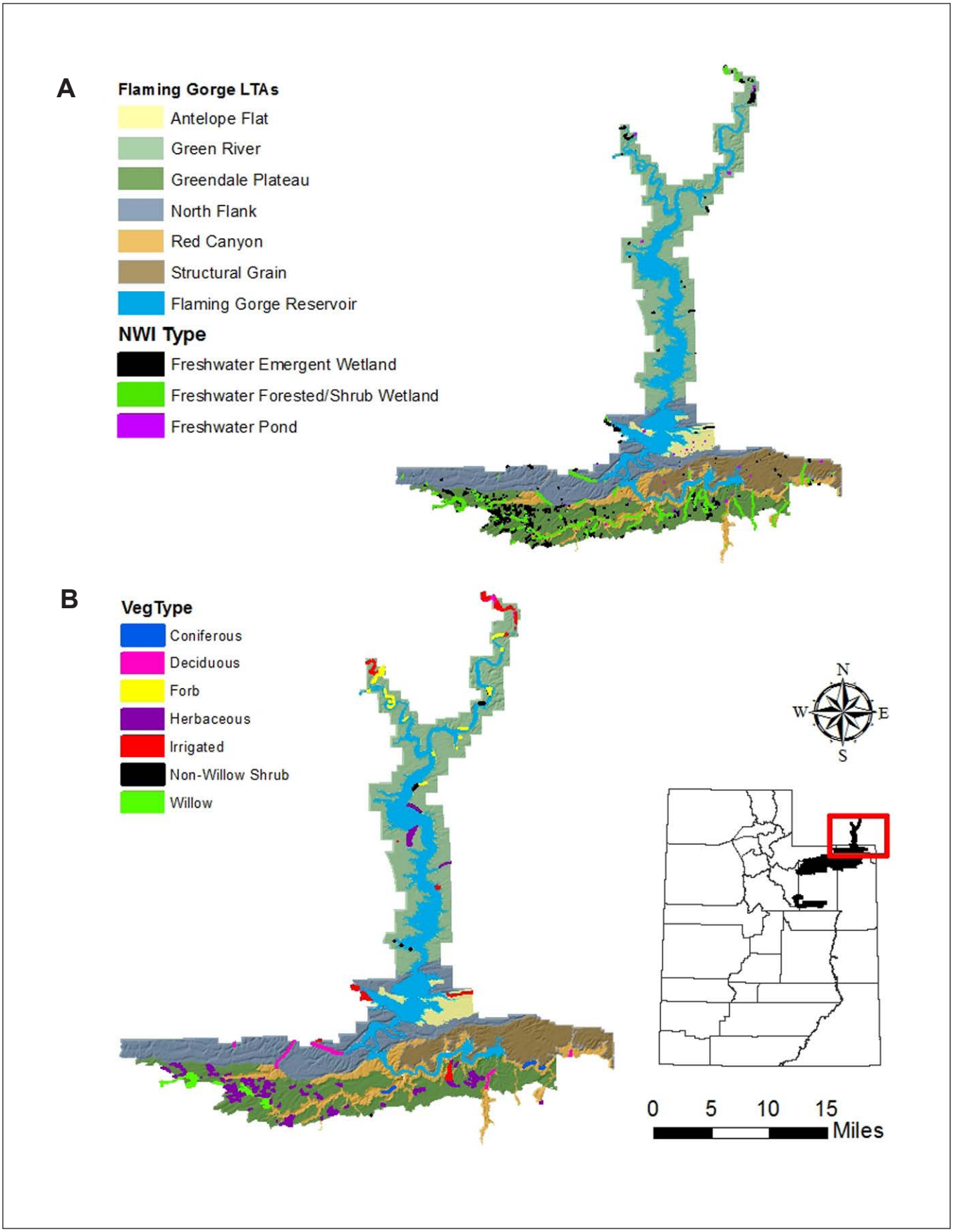


**Figure 24**—Wetland ecosystems (A) and riparian vegetation types (B) in the Flaming Gorge National Recreation Area.

**Table 21**—Area of wetland ecosystems in land type associations within the Flaming Gorge National Recreation Area. Data were obtained from the National Wetland Inventory (USFWS 2016).

| LTA | Freshwater emergent | Freshwater forested/shrub | Freshwater pond | Lake | Total |
|---|---|---|---|---|---|
| | | *Hectares* | | | |
| Antelope Flat | 57.4 | 1.0 | 5.7 | 92.6 | 156.7 |
| Green River | 66.0 | 21.7 | 4.9 | 596.5 | 689.1 |
| Greendale Plateau | 696.1 | 223.2 | 49.7 | 393.0 | 1,362.0 |
| North Flank | 5.7 | 6.9 | 0.9 | 92.3 | 105.8 |
| Red Canyon | 12.2 | 187.6 | 1.2 | 101.6 | 302.6 |
| Structural Grain | 4.6 | 0.1 | 6.0 | 5.6 | 16.3 |
| Total | 842.0 | 440.5 | 68.4 | 1,281.6 | 2,632.5 |

**Table 22**—Area of riparian and wetland vegetation type groupings in land type associations within the Flaming Gorge National Recreation Area. Data were obtained from the Ashley National Forest vegetation layer (ANF 2016).

| LTA | Unclassified/ other/irrigated | Deciduous tree-dominated | Coniferous tree-dominated | Non-willow shrub-dominated | Herbaceous-dominated | Willow-dominated | Total |
|---|---|---|---|---|---|---|---|
| | | | *Hectares* | | | | |
| Antelope Flat | 150.6 | 0 | 0 | 0 | 0 | 0 | 150.6 |
| Green River | 168.8 | 76.9 | 0 | 28.4 | 318.5 | 0 | 592.6 |
| Greendale Plateau | 108.7 | 0 | 0 | 0.8 | 1,058.1 | 377.5 | 1,545.1 |
| North Flank | 27.3 | 13.6 | 0 | 0 | 5.6 | 0 | 46.5 |
| Red Canyon | 70.4 | 141.4 | 26.6 | 0 | 35.1 | 7.5 | 281.0 |
| Structural Grain | 0 | 0 | 0 | 0 | 6.1 | 0 | 6.1 |
| Total | 525.8 | 231.9 | 26.6 | 29.2 | 1,423.4 | 385 | 2,621.9 |

**Table 23**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Antelope Flat land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type code/name | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 49.3 |
| Irrigated lands | Unclassified, other, or irrigated | 101.3 |

**Figure 25**—Spring Creek, obscured by wiregrass and Nebraska sedge (photo by S. Goodrich, USFS).

**Figure 26**—Irrigated wetland near Henry's Fork with cattails, willows, and Fremont cottonwood (photo by S. Goodrich, USFS).

**Table 24**—Number of dams in each code and density of dams in land type associations of the Flaming Gorge National Recreation Area. Data were obtained from the Utah Division of Water Rights.

| LTA | Code[a] | | | | | | | | Total dams/km² |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 7 | 200 | 300 | 307 | 500 | 800 | 900 | |
| Antelope Flat | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0.13 |
| Green River[b] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greendale Plateau | 0 | 8 | 2 | 0 | 0 | 0 | 1 | 0 | 0.05 |
| North Flank | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.01 |
| Red Canyon | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0.03 |
| Structural Grain | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 |
| Total | 0 | 16 | 3 | 0 | 0 | 0 | 1 | 1 | |

[a] Dam codes are: 0 = Small regulating, or insignificant dams that impounds more than 20 acre-feet of water; 7 = Small regulating, or insignificant dam that impounds 20 acre-feet of water or less; 200 = Inspected dams that are neither flood control or industrial and impound more than 20 acre-feet of water; 300 = Inactive dams that are neither flood control or industrial and impound more than 20 acre-feet of water; 307 = Inactive dams that are neither flood control or industrial and impound 20 acre-feet of water or less; 500 = Never-been-inspected (needs investigation); 800 = Inspected by other agency/inspection report must be submitted to Dam Safety Office; 900 = Federally inspected dams.

[b] Data from the State of Wyoming was not available for this LTA.

**Table 25**—Number of diversion types and density of diversions in land type associations of the Flaming Gorge National Recreation Area. Data were obtained from the Utah Division of Water Rights.

| LTA | Diversion type | | | | | | | Total diversions/km² | Canal miles |
|---|---|---|---|---|---|---|---|---|---|
| | Abandoned well | Point to point | Rediversion | Return | Spring | Surface | Under-ground | | |
| Antelope Flat | 0 | 6 | 3 | 3 | 0 | 7 | 2 | 0.70 | 0 |
| Green River[a] | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Greendale Plateau | 0 | 102 | 186 | 1 | 3 | 201 | 21 | 2.39 | 22.9 |
| North Flank | 0 | 63 | 1 | 4 | 2 | 15 | 14 | 0.48 | 2.9 |
| Red Canyon | 0 | 71 | 0 | 1 | 1 | 26 | 7 | 0.92 | 0 |
| Structural Grain | 0 | 45 | 0 | 1 | 1 | 5 | 8 | 0.61 | 0 |
| Total | 0 | 287 | 190 | 10 | 7 | 254 | 52 | | |

[a] Data from the State of Wyoming was not available for this LTA.

**Table 26**—NRV status of KECs in LTAs in the Flaming Gorge NRA management area.

| KEC | AF[a] | GR | GP | NF | RC |
|---|---|---|---|---|---|
| 1. Groundwater and surface water fluctuations | Out | Out | Out | Out | Out |
| 2. Channel, floodplain, and sediment dynamics | TT | TT | In | TT | TT |
| 3. Vegetation and soil condition | In | TT | In | TT | TT |
| 4. Invasive and encroaching species | Out | Out | TT | Out | Out |

[a] Abbreviations refer to LTAs: Antelope Flat, Green River, Greendale Plateau, North Flank, and Red Canyon.

### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is greater than the length of perennial streams in this LTA (fig. 27). Overall, there are very few perennial or intermittent/ephemeral streams in Antelope Flat LTA (table 27). Beds and banks of stream channels are largely unstable due to erosive parent materials. Stream channels have been altered by livestock and wild ungulates, whose numbers have recently increased. Though some geomorphic dynamics have been altered by Flaming Gorge Reservoir and livestock, natural processes, such as floodplain development, are occurring. The majority of perennial stream segments are surrounded by intact floodplains, according to the R-CAT analysis (table 27). Much of Spring Creek is confined to a wide gully, but the gully bottom is filling with

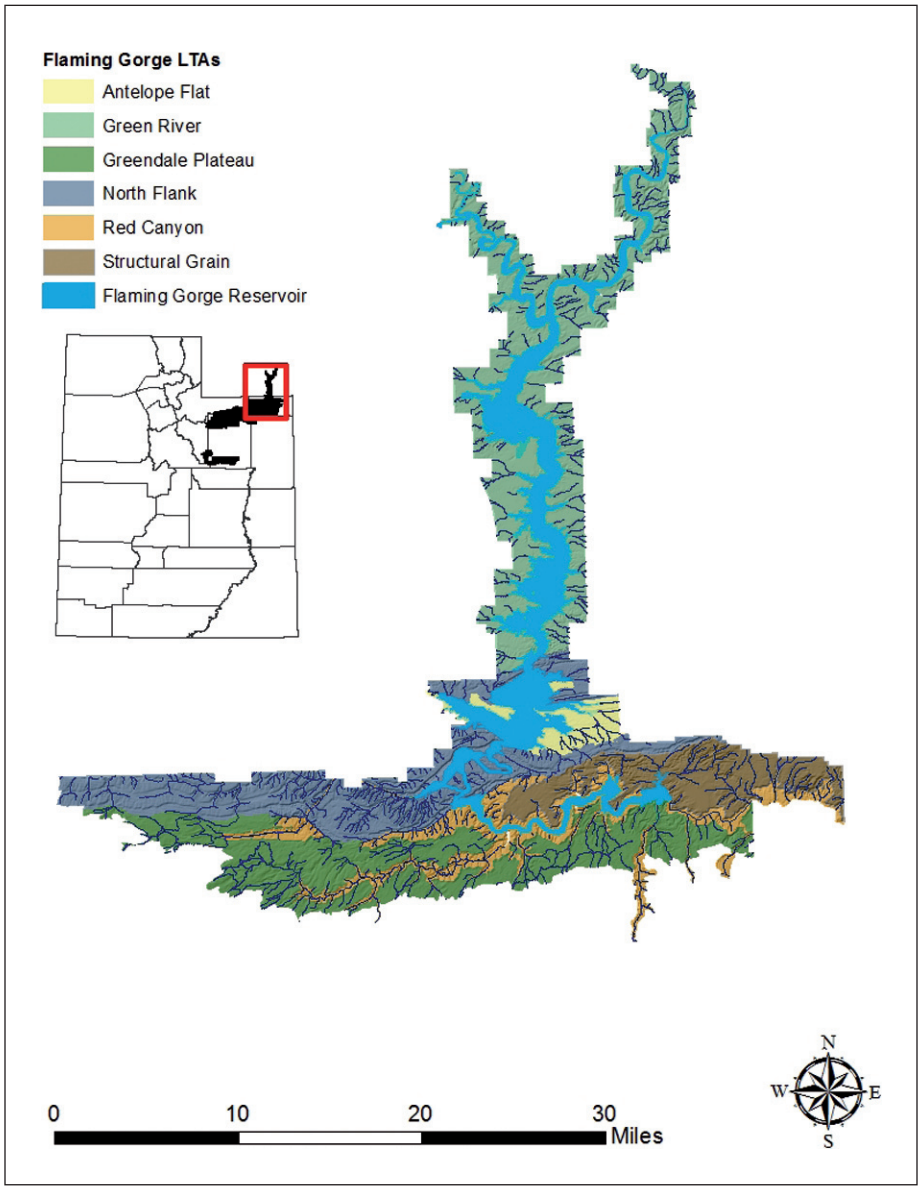


**Figure 27**—Location of perennial, intermittent, and ephemeral stream channels in the Flaming Gorge National Recreation Area.

**Table 27**—Length of stream types and riparian condition assessment classifications of perennial streams in the FGNRA area.

| LTA | Streams | | Perennial stream riparian conditions | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Intermittent/ ephemeral | Perennial | Percent confined-impacted | Percent confined-unimpacted | Percent floodplain intact | Percent floodplain in good condition | Percent floodplain in moderate condition | Percent floodplain in poor condition |
| | *km* | | | | | | | |
| Antelope Flat | 27.0 | 2.6 | 10 | 24 | 59 | 0 | 7 | 0 |
| Green River[a] | 268.9 | 0.3 | -- | -- | -- | -- | -- | -- |
| Greendale Plateau | 101.1 | 94.8 | 14 | 62 | 6 | 12 | 5 | 1 |
| North Flank | 226.9 | 14.8 | 32 | 60 | 1 | 6 | 0 | 2 |
| Red Canyon | 102.0 | 118.3 | 10 | 79 | 3 | 3 | 4 | 1 |
| Structural Grain | 82.7 | 6.8 | 75 | 25 | 0 | 0 | 0 | 0 |

[a] Data from the State of Wyoming were not available for this LTA.

sediment and developing a floodplain. Wiregrass, Nebraska sedge, and other stabilizing plants trap sediment to form floodplains and maintain a narrow channel of Spring Creek in flood-prone gully bottoms (fig. 25). Softstem bulrush increases floodplain stability near Spring Creek's inlet to Flaming Gorge Reservoir. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 26).

### *Vegetation and Soil Condition*

Riparian and wetland vegetation exists in a variety of growth forms and size classes in several locations. Mature cottonwoods and their snags are present along some portions of Birch Spring Draw. Cottonwoods, snags, and logs are also present near the Henry's Fork inlet. The herbaceous riparian vegetation in this LTA was lightly to moderately grazed by livestock in recent years. Wetland vegetation near the Henry's Fork inlet is maintained by beaver activity and excess irrigation water. These wetlands contain cattails and other plants that are vulnerable to cattle grazing. Disturbances to floodplain and meadow soils include trailing and trampling by livestock. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 26).

### *Resistance to Invasive and Encroaching Species*

Herbaceous and woody invasive species are widespread in this LTA. Russian olive and tamarisk were present in the floodplains of Birch Spring Draw, Henry's Fork, and Spring Creek. Herbaceous invasives in Birch Spring Draw include knapweed, musk thistle, and pepperweed. Whitetop, pepperweed, and common reed were present near the Henry's Fork inlet. Herbaceous invasives along Spring Creek include cheatgrass and pepperweed. Invasive chenopodiaceous species replace wiregrass in the Spring Creek floodplain where inundation from Flaming Gorge Reservoir occurs. Curly-leaf pondweed has been found near the Antelope Flat boat ramp. We determined the status of resistance to invasive and encroaching species to be **outside** the NRV (table 26).

### Information and Research Needs/Data Gaps

1. *Invasive species*. Monitoring is needed to determine if the presence of invasive plants prevents reproduction of native species including cottonwoods and willows. Monitoring is also needed to determine whether livestock are facilitating spread of invasive plants by grazing on native species.

## Green River LTA

### Riparian and Wetland Ecosystems

The Green River LTA has relatively large areas of wetland ecosystems, primarily in the form of lakes (table 21). These systems support a relatively large riparian ecosystem in Green River LTA, which is primarily associated with Flaming Gorge Reservoir (table 22). Mapped areas of riparian and wetland vegetation are located at or near the inlets of numerous streams along the northern portion of the Reservoir (fig. 24).

There are 11 riparian vegetation types mapped within this LTA (table 28). The largest area of riparian vegetation is made up of herbaceous-dominated types, followed by unclassified/other/irrigated, deciduous tree-dominated, and non-willow shrub. One patch classified as other is located around an ephemeral pond near the west side of the reservoir. Larger areas of irrigated riparian and wetland vegetation are located near the Black's Fork and Green River inlets. An additional irrigated area is located on the east side of the reservoir. The patches along the Black's Fork inlet contain mixtures of graminoids including wiregrass and alkali wildrye, as well as scattered stands of tamarisk (81-3B). The patches along the Green River inlet contains scattered cottonwoods, willows, Russian olives, and native and invasive herbaceous plants (83-183-12B1).

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Along intermittent streams, riparian vegetation is maintained by groundwater. There are no dams in this LTA (table 24) and diversion data

**Table 28**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Green River land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 168.3 |
| Deciduous tree, unclassified | Deciduous tree-dominated | 5.5 |
| Aspen | Deciduous tree-dominated | 51.0 |
| Fremont cottonwood | Deciduous tree-dominated | 20.4 |
| Tamarisk | Non-willow shrub-dominated | 28.4 |
| Wiregrass | Herbaceous-dominated | 7.8 |
| Foxtail barley | Herbaceous-dominated | 128.7 |
| Western wheatgrass | Herbaceous-dominated | 9.0 |
| Forb, unclassified | Herbaceous-dominated | 19.0 |
| Broadleaf pepperweed | Herbaceous-dominated | 154.0 |
| Other | Unclassified, other, or irrigated | 0.48 |

from the State of Wyoming were unavailable (table 25). However, the flow regimes of the Green River and its tributaries have been altered by the operation of Flaming Gorge Reservoir. Portions of tributaries within the drawdown zone experience fluctuations in surface water and groundwater that are far from historical levels. We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 26).

### *Channel, Floodplain, and Sediment Dynamics*

The vast majority of stream miles are ephemeral/intermittent in this LTA, which has the most ephemeral/intermittent streams of LTAs in the FGNRA (table 27). Additionally, this LTA has the least perennial streams of this management zone. Beds and banks of stream channels are largely unstable due to erosive parent materials. Instability and sedimentation is exacerbated by heavy grazing along streams. Grazing has also widened and shallowed stream channels. Wiregrass traps sediment and stabilizes banks, making this a critical species to maintain stream condition in the erosive Green River formation. Active beaver dams were observed in Upper Marsh Creek in 1994 but were absent in 2005. Beavers likely abandoned the dams after they had depleted the streamside willows. Recent assessments indicate stable, well-vegetated conditions in Upper Marsh Creek. Sediment is deposited in lower floodplains of tributaries during inundation of the drawdown zone. The high density of roads in the LTA increases sedimentation and adds salinity to streams and the reservoir. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 26).

### *Vegetation and Soil Condition*

Herbaceous riparian and wetland vegetation types in gully bottoms are recovering from long-term grazing faster than upland greasewood communities (fig. 28). Outside of exclosures, moderate winter use of

**Figure 28**—Wiregrass has trapped sediment, forming a floodplain along Upper Marsh Creek (photo by S. Goodrich and A. Huber, USFS).

wiregrass and creeping foxtail does not affect groundcover or stream stability. Many of the grazed floodplain grasses are seeded species. Cottonwood trees, snags, and logs were present in Scott-Whalen Bottom in 2012. Soil disturbances include roads that cut through riparian and wetland areas, livestock trailing, hoof trampling, headcuts, prairie dog activity, and ground left bare following invasive weed control. We determined the status of vegetation and soil condition to be **trending toward** the NRV (table 26).

#### *Resistance to Invasive and Encroaching Species*

Invasive plants are widespread and varied in this LTA and many are adapted to the flood-drought cycles occurring along the shores of Flaming Gorge Reservoir (fig. 24). Invasive herbaceous species include cheatgrass, pepperweed, halogeton, Russian thistle, and common reed. Halogeton displaced Gardiner saltbush at one site and is displacing seeded grasses below the reservoir's high water line. Russian olive and saltcedar are widespread in the LTA as well. We determined the status of resistance to invasive and encroaching species in this LTA to be **outside** the NRV (table 26).

## Greendale Plateau LTA

### Riparian and Wetland Ecosystems

The Greendale Plateau has the largest area of wetland ecosystems in the FGNRA, including freshwater emergent, freshwater forested/shrub, freshwater pond, and lake systems (table 21). These wetland ecosystems and a relatively large number of perennial streams support the largest amount of riparian vegetation in the FGNRA (table 22). There are nine riparian and wetland vegetation types mapped within this LTA (table 29). These types are located in the watersheds of Carter Creek, Sheep Creek, and several other streams on the north slope of the Uinta Mountains (fig. 24). Herbaceous-dominated types formed the largest area of riparian vegetation, followed by willow-dominated and unclassified/other/irrigated types. At least one of the irrigated patches appears to be a grazed pasture bordered by stringers of aspen, willows, and other deciduous shrubs and trees (studies 5-66J, 6-59A).

**Table 29**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Greendale Plateau land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Low shrub non-willow | Non-willow shrub-dominated | 0.8 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 1,008.0 |
| Wet meadow with conifer displacement | Herbaceous-dominated | 21.3 |
| Wet meadow undifferentiated | Herbaceous-dominated | 28.8 |
| Willow/meadow complex | Willow-dominated | 215.3 |
| Tall willow | Willow-dominated | 6.5 |
| Geyer willow | Willow-dominated | 65.2 |
| Geyer willow/water sedge | Willow-dominated | 90.5 |
| Irrigated lands | Unclassified, other, or irrigated | 108.7 |

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

Fluctuations in perennial streams are typically driven by runoff and groundwater sources outside of the LTA. Most streams originating within the LTA are ephemeral. Several dams are located in the Greendale Plateau LTA (table 24). Additionally, density of diversions, irrigation canals, and spring developments also is relatively high in this LTA (table 25). Timber harvest has likely increased water yield and peak flows during snowmelt runoff (Burton 1997). We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 26).

### *Channel, Floodplain, and Sediment Dynamics*

This LTA has a substantial number of both intermittent/ephemeral and perennial streams, though there are slightly more intermittent/ephemeral streams (table 27). Stream channels are either bedrock-controlled or stabilized by wet meadow vegetation. Most stream segments are classified as confined and unimpacted in the R-CAT analysis (table 27). Beaver dams and ponds have a large influence on stream channels in this LTA. Dams are continuously constructed, breached, and reconstructed, creating dynamic floodplains. Sediment is delivered to streams at road and trail crossings. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 26).

### *Vegetation and Soil Condition*

Narrowleaf cottonwoods established around a reservoir between 1997 and 2009. Geyer willow cover has increased in meadows, even those that are grazed. Willows and sedges are drowned out by beaver ponds but recover quickly when ponds are drained (fig. 29). The cycle of filling and draining of beaver ponds facilitates growth of willows away from stream channels.

**Figure 29**—A drained beaver pond on Lodgepole Creek has since been colonized by sedges and willows (photo by S. Goodrich and L. Kitchen, USFS).

Tall sedges colonize the green line below beaver dams and Nebraska sedge colonizes active dams. Beaver have permanently abandoned dams in locations where they have depleted willows and aspens. Browsing of planeleaf willow and Geyer willow by elk and moose was noted in some areas. Older Geyer willows show sign of past cattle grazing. Use of wet meadow vegetation by cattle is less excessive during drought years in this LTA than in wet meadows on the south slope. Cattle numbers and time in allotments was reduced in 2012 due to drought conditions. In this LTA, cattle will graze on mesic vegetation, move on to wet meadows and then on to willows if left on their allotment.

Soil disturbances include pocket gopher activity, trampling by horse, elk, and moose at watering sites, headcuts, gullies, wallows, bare areas at cattle shading sites, mineral licks, road maintenance at streams, and beaver trailing. Water sedge, beaked sedge, and willow maintain streambank stability, concurrent with cattle grazing. Streambank stability was measured at four transects, the oldest measurement in 2008 and the most recent in 2014. Transects were dominated by water sedge communities, resulting in stability ratings of 8.4 to 9.5. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 26).

### *Resistance to Invasive and Encroaching Species*

Spread of Canada thistle and cheatgrass is facilitated by activity of beavers and cattle. Didymo is present in Carter Creek and Browne Lake. Clasping-leaf pondweed is present in Browne Lake and Sheep Creek Lake. R-CAT analysis indicated that encroachment of conifers and other upland plants has occurred along 8 percent of perennial stream miles (table 30). Conifer encroachment is limited in riparian and wetland ecosystems, in part because of flooding by beaver ponds. We determined the status of resistance to invasive and encroaching species to be **trending toward** the NRV (table 26).

**Table 30**—Percentage of stream segments classified by conversion from riparian to other cover types for each LTA in the FGNRA area.

| LTA | Conifer encroach-ment | Conversion to ag | Conversion to barren | Conversion to developed | Conversion to invasive | Non-riparian to riparian | Upland encroach-ment | No change |
|---|---|---|---|---|---|---|---|---|
| Antelope Flat | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (100) |
| Green River[a] | -- | -- | -- | -- | -- | -- | -- | -- |
| Greendale Plateau | 3 | 0 | 0 | <1 | <1 | 0 | 5 | 91 |
| North Flank | 2 | 6 | 0 | 2 | 0 | 0 | 0 | 90 |
| Red Canyon | 7 | 1 | 1 | 1 | 1 | 0 | 1 | 88.0 |
| Structural Grain | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 96 |

[a] Data from the State of Wyoming were not available for this LTA.

## North Flank LTA

### Riparian and Wetland Ecosystems

There is a small amount of wetland ecosystem cover in the North Flank LTA, primarily in the form of lakes (table 21). These systems and a small number of perennial streams support a small amount of riparian vegetation (table 22). There are four riparian vegetation types mapped in the LTA (table 31). These vegetation types are located in the lower portions of the Sheep Creek and Henry's Fork drainages (fig. 24). Unclassified/irrigated/other riparian types formed the largest area of mapped riparian vegetation, followed by deciduous tree- and herbaceous-dominated. A large unclassified patch is located near the inlet of Henry's Fork into Flaming Gorge Reservoir (fig. 30). This patch contains numerous cottonwoods and Russian olives, based on studies 7-2A, 7-2D1, 7-2E2, and 7-2J (fig. 30).

**Table 31**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the North Flank land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 23.9 |
| Narrowleaf cottonwood/blue spruce/ponderosa pine/Douglas-fir | Deciduous tree-dominated | 13.6 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 5.6 |
| Irrigated | Unclassified, other, or irrigated | 3.4 |

**Figure 30**—Russian olives, willows, and cottonwoods near Henry's Fork (photo by S. Goodrich, USFS).

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

Perennial streams are maintained by groundwater discharged through karst systems. Precipitation from thunderstorms runs directly from bedrock and talus on slopes into gullies at the base of draws, causing floods, mudslides, and debris flows. Surface and groundwater dynamics have been altered by canals, wetland construction, development of springs, and Flaming Gorge Reservoir. There is a single dam in this LTA (table 24) and the North Flank has the lowest diversion density in the FGNRA management zone. We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 26).

### *Channel, Floodplain, and Sediment Dynamics*

Total length of ephemeral/intermittent streams is much greater than the length of perennial streams in this LTA (table 27). The majority of floodplains associated with perennial streams was classified by R-CAT as confined and unimpacted, but a relatively high percentage was identified as confined and impacted (table 27). Streams are bedrock-controlled with high stability. Stream channels are frequently rerouted and scoured by floods caused by summer and fall thunderstorms. Grazing has widened and shallowed streams and increased sedimentation in some areas. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 26).

### *Vegetation and Soil Condition*

Cover of narrowleaf cottonwood and Engelmann spruce has increased since severe flooding occurred along Sheep Creek in 1985 (fig. 31). Willows were planted as part of the post-flood restoration. Mature cottonwoods are

**Figure 31**—Deciduous and coniferous vegetation near Sheep Creek's inlet to Flaming Gorge Reservoir (photo by S. Goodrich, USFS).

scattered along lower Sheep Creek. Some willow dieback was recently visible along Sheep Creek. Grazing was discontinued along lower Sheep Creek in 1962. Mature cottonwoods and cottonwood saplings were growing along Henry's Fork in 2007. Tall grasses are present where there is no grazing near Henry's Fork. Riparian vegetation conversion analysis indicated that conversion to agricultural land and developed land has occurred along 8 percent of perennial stream miles (table 30). Soil disturbances include cutbanks, livestock trailing, and unauthorized ATV use. Stabilizing vegetation was planted as part of streambank restoration in response to flooding in 1985. We determined the status of vegetation and soil condition in this LTA to be **trending toward** the NRV (table 26).

#### *Resistance to Invasive and Encroaching Species*

Invasive herbaceous plants mapped in this LTA include knapweed, kochia, and whitetop. Russian olive trees are present near a wetland along Henry's Fork. R-CAT analysis indicated that encroachment of conifers has occurred along 2 percent of perennial stream miles (table 30). We determined the status of resistance to invasive and encroaching species to be **outside** the NRV (table 26).

## Red Canyon LTA

### Riparian and Wetland Ecosystems

The Red Canyon LTA contains a moderate area of wetland ecosystems that is mostly composed of freshwater forested/shrub and lake ecosystems (table 21). These ecosystems combined with a substantial number of perennial streams support a relatively small amount of riparian vegetation (table 22). There are eight riparian vegetation types mapped within the LTA. Patches are located in watersheds that drain into Flaming Gorge Reservoir and the Green River below Flaming Gorge Dam (fig. 24). Deciduous tree-dominated types comprise the largest area of mapped riparian vegetation, followed by unclassified/other/irrigated, herbaceous-dominated, coniferous tree-dominated, and willow-dominated types (table 32). Unclassified patches are mapped in the Skull Creek and Trail Creek watersheds. Vegetation along the Green River below the dam is unclassified, as is vegetation in a drainage east of Goslin Creek. Photos from studies 6-10F and 6-10P indicate that riparian vegetation below the dam includes large ponderosa pines and smaller deciduous shrubs, with little change since the dam was completed in 1964.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Baseflows in perennial streams are supported by discharge from karst systems. Perennial streams frequently flood during spring or early summer snowmelt runoff. Flash floods occur infrequently in side canyons of the Green River and along other ephemeral streams. There are few dams in this LTA (table 24), but the diversion density is relatively high (table 25). Flaming Gorge Dam has altered the hydrology of the portion of the Green River that flows through this LTA. Above the dam, the Green River was replaced by Flaming Gorge Reservoir. Below the dam, annual peak discharge magnitude is usually lower than in pre-dam years (fig. 32). Timing of peak flows were altered by the dam as well until 1992, when modifications of releases were

**Table 32**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Red Canyon land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 63.6 |
| Coniferous tree, unclassified | Coniferous tree-dominated | 26.6 |
| Deciduous tree, unclassified | Deciduous tree-dominated | 6.8 |
| Narrowleaf cottonwood/blue spruce/ ponderosa pine/Douglas-fir | Deciduous tree-dominated | 133.2 |
| Boxelder | Deciduous tree-dominated | 1.4 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 35.1 |
| Tall willow | Willow-dominated | 7.5 |
| Irrigated | Unclassified, other, or irrigated | 6.8 |

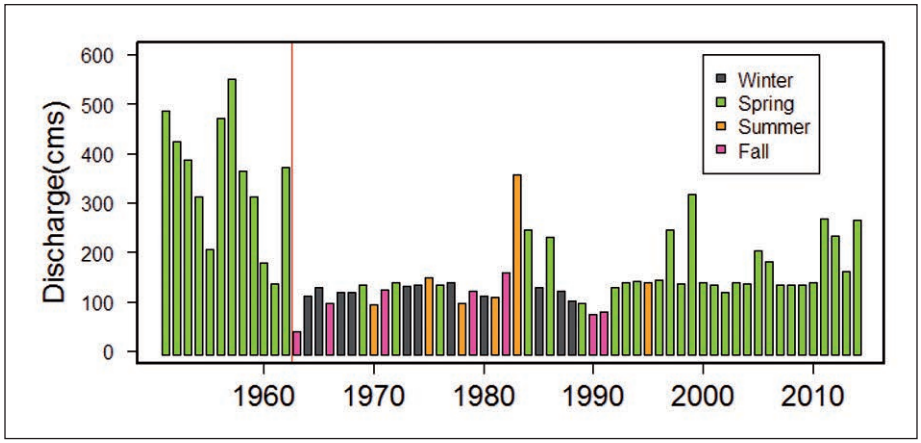


**Figure 32**—Magnitude of peak daily discharge at the Green River below Flaming Gorge Dam and season of peak discharge is indicated by bar color. The red line indicates the closing of the dam.

developed for the recovery of native fish (BOR 2005). We determined the status of groundwater and surface water fluctuations in this LTA to be **outside** the NRV (table 26).

### *Channel, Floodplain, and Sediment Dynamics*

There are more perennial stream miles in this LTA than intermittent/ephemeral, but there are large amounts of both habitats relative to other LTAs in the FGNRA (table 27). This LTA contains steep, bedrock-controlled ephemeral streams and low to moderate gradient perennial bottomland streams that migrate laterally within a narrow bedrock channel. Banks of several flood-prone streams have been armored to protect roads, bridges, and campgrounds from erosion. Shrubs and graminoids were matted by floods in Sheep Creek, highlighting the role of vegetation in stabilizing channels and decreasing flood velocity. Following the 2002 Mustang fire, Canada goldenrod stabilized the banks of Goslin Creek. Willows and narrowleaf cottonwood stabilize banks and prevent widening of channels. Most

perennial stream segments are classified as confined and unimpacted in the R-CAT analysis (table 27). Sedimentation has increased where roads and livestock grazing occur near streams, but effects are much more localized than in other LTAs due to the inaccessible terrain of Red Canyon. Large amounts of sediment were deposited from runoff of thunderstorms following the 2002 Mustang Wildfire. Though sediment is trapped behind Flaming Gorge Dam, natural sedimentation processes continue to occur below the dam (Grams and Schmidt 2005). We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 26).

### *Vegetation and Soil Condition*

Riparian vegetation along Goslin Creek was burned by the 2002 Mustang Wildfire. Cottonwoods resprouted along the stream and in narrow bedrock canyons. Other deciduous species that sprouted include boxelder, coyote willow, and red-osier dogwood. Post-fire narrowleaf cottonwood sprouts were 10–12 feet tall and boxelder was nearly mature by 2011. Mature cottonwoods and young cottonwoods were observed along Sheep Creek in 2011. Stable portions of the lower Sheep Creek and Carter Creek floodplains contain large cottonwood snags, fallen logs, and instream wood. Cottonwood, river birch, and willows established after the 1965 Sheep Creek flood. Large ponderosa pine trees and other woody plants that once grew along the Green River were lost with the filling of Flaming Gorge Reservoir in 1962. Riparian vegetation is now absent above the dam (fig. 33). Riparian vegetation conversion analysis indicated that conversion to agricultural land, barren land, and developed land has occurred along 3 percent of perennial stream miles (table 30). Soil disturbances include ATV use on red pine shale and heavy bank erosion during floods. We determined the status of vegetation and soil condition in this LTA to be **trending toward** the NRV (table 26).

### *Resistance to Invasive and Encroaching Species*

Invasive herbaceous species near streams include musk thistle, musk mustard, pepperweed, and whitetop. Didymo is present in Carter Creek.

**Figure 33**—Green River in the Red Canyon LTA before and after construction of Flaming Gorge Dam (photos by W.D. Hurst, S. Goodrich, and A. Zobell, USFS).

Curly-leaved pondweed is in the Green River below Flaming Gorge Dam. R-CAT analysis indicated that encroachment of conifers and other upland plants has occurred along 8 percent of perennial stream miles (table 30). Conifers are abundant among cottonwoods in the lower section of Sheep Creek. Blue spruce cover has increased since the 1970s. Large conifers are uprooted by channel migration, so bank stabilization may facilitate their encroachment. Tamarisk is present in the Sheep Creek floodplain growing among cottonwoods and willows. We determined the status of resistance to invasive and encroaching species in this LTA to be **outside** the NRV (table 26).

## Structural Grain LTA

### Riparian and Wetland Ecosystems

The Structural Grain LTA has the least number of wetland ecosystems in the FGNRA, with a small amount of freshwater emergent, pond, and lake systems (table 21). These wetlands, combined with a very small number of perennial streams, support little riparian vegetation (table 22). Herbaceous-dominated riparian and wetland vegetation have been mapped within the LTA (table 33). This vegetation is located north of the Green River and west of Goslin Creek in the Flaming Gorge National Recreation Area (fig. 24).

### Information and Research Needs/Data Gaps

We did not evaluate KECs for this LTA because it contained a small area (<10 ha) of mapped riparian vegetation with only two studies conducted in the area. The area contains a wet meadow that is fed by water from Dripping Springs. Additional information and research is needed to identify the structure, composition, and condition of riparian and wetland vegetation in this meadow. In addition, monitoring is necessary to document the long-term recovery of native vegetation and invasion of nonnative species following the 2002 Mustang Fire and the 2013 Dripping Springs Fire (fig. 34).

**Table 33**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Structural Grain land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Mixed dry and wet meadow complex | Herbaceous-dominated | 6.1 |

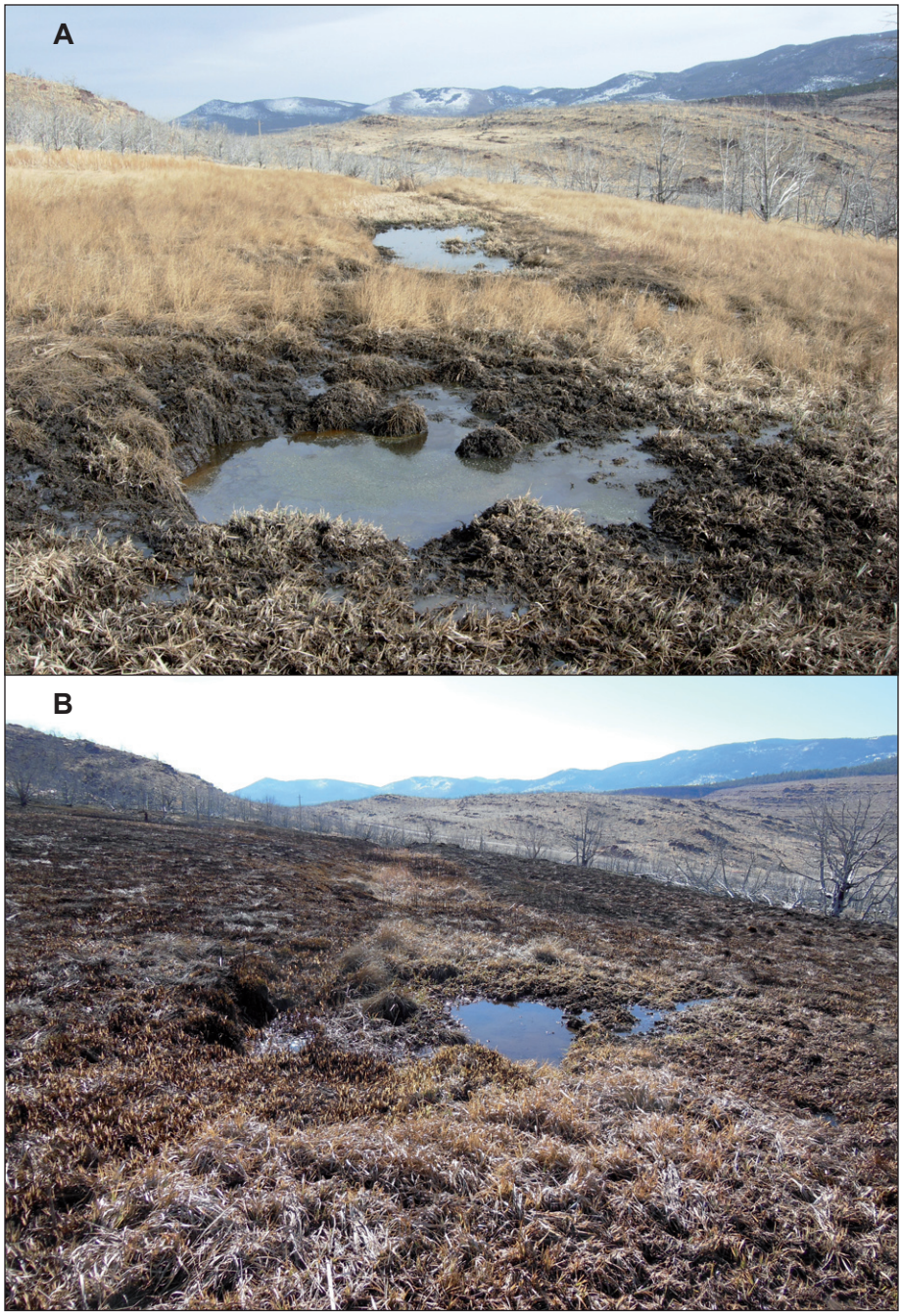


**Figure 34**—Wet meadow vegetation surround Dripping Springs photographed (A) after the 2007 Mustang fire and (B) the 2013 Dripping Springs fire (photos by S. Goodrich and A. Zobell, USFS).

## Anthro Plateau LTA

### Riparian and Wetland Ecosystems

The Anthro Plateau LTA contains the largest number of wetland ecosystems (fig. 35) in the Tavaputs Plateau and is primarily composed of freshwater emergent systems (table 34). Some perennial streams and these wetland areas support a moderate amount of riparian vegetation (table 35).

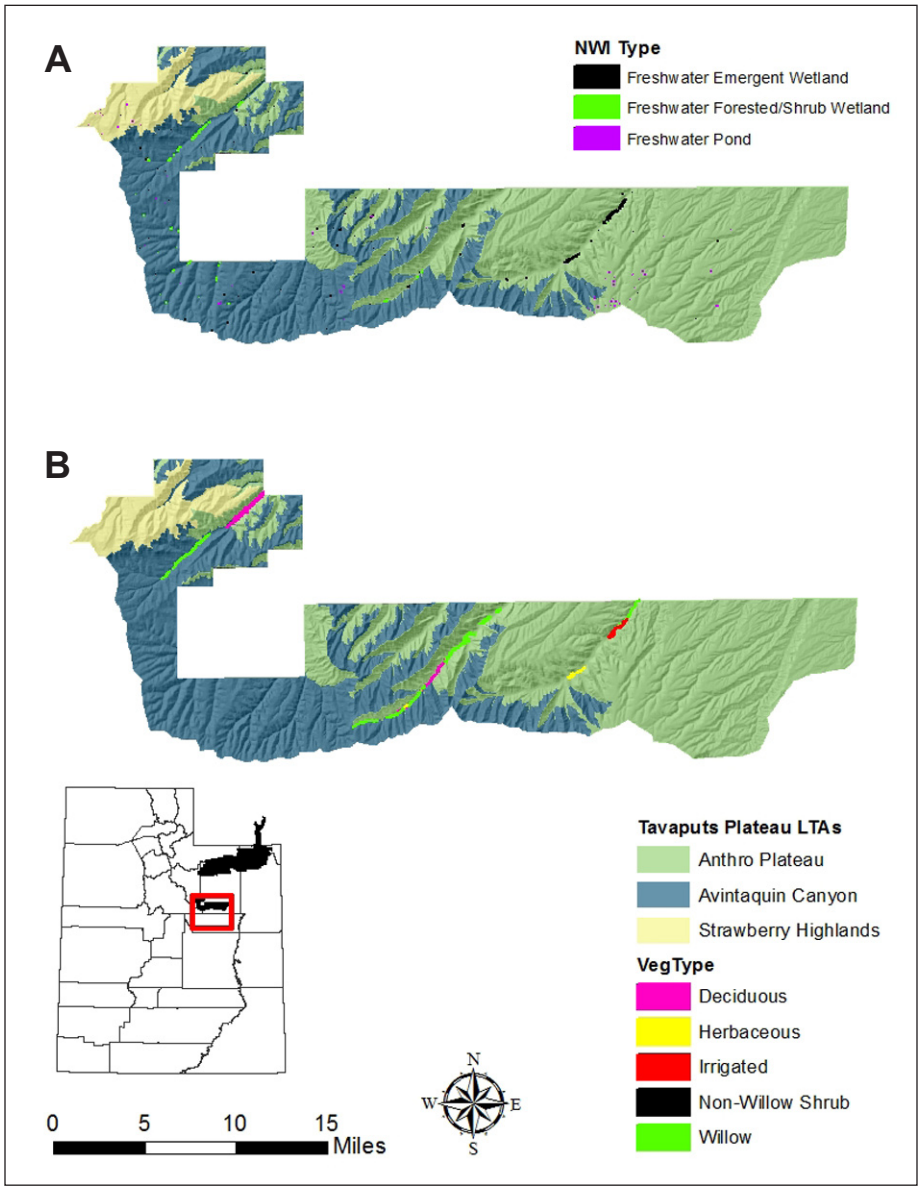


**Figure 35**—Wetland ecosystems (A) and riparian vegetation types (B) in the Tavaputs Plateau management area.

**Table 34**—Area of wetland ecosystems in land type associations within the Tavaputs Plateau management area. Data were obtained from the National Wetland Inventory (USFWS 2016).

| LTA | Freshwater emergent | Freshwater forested/shrub | Freshwater pond | Lake | Total |
|---|---|---|---|---|---|
| | | *Hectares* | | | |
| Anthro Plateau | 41.9 | 8.0 | 1.3 | 0 | 51.2 |
| Avintaquin Canyon | 1.7 | 19.8 | 0.7 | 0 | 22.2 |
| Strawberry Highlands | <1 | 0 | 0.7 | 0 | 0.7 |
| Total | 43.6 | 27.8 | 2.7 | 0 | 74.1 |

**Table 35**—Area of riparian and wetland vegetation type groupings in land type associations within the Tavaputs Plateau area. Data were obtained from the Ashley National Forest vegetation layer (ANF 2016).

| LTA | Unclassified/ other/irrigated | Deciduous tree-dominated | Coniferous tree-dominated | Non-willow shrub-dominated | Herbaceous-dominated | Willow-dominated | Total |
|---|---|---|---|---|---|---|---|
| | | | *Hectares* | | | | |
| Anthro Plateau | 33.4 | 25.5 | 0 | 0 | 16.5 | 21.5 | 96.9 |
| Avintaquin Canyon | 86.7 | 0 | 0 | 0 | 0 | 40.1 | 126.8 |
| Strawberry Highlands | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 120.1 | 25.5 | 0 | 0 | 16.5 | 61.6 | 223.7 |

There are six riparian and wetland vegetation types mapped in the Anthro Plateau LTA. These vegetation types are found over much of the length of Left Fork Indian Canyon and in the lower half of Sower's Canyon (fig. 35). Willow-dominated vegetation types comprise the largest area of mapped riparian vegetation, followed by unclassified/other/irrigated, deciduous tree-dominated, and herbaceous-dominated types (table 36). Unclassified patches are located along the middle section of Sowers Creek. These patches, adjacent to the creek, appear to contain mesic graminoids, scattered willows, and other shrubs based on photos from studies 68-52A, 68-52D, and 68-24E. Deciduous trees are present in Indian Creek Canyon but absent in Sowers Canyon, where riparian vegetation is dominated by tall willows in the lower sections. Riparian vegetation is absent in upper Sowers Canyon due to lack of perennial surface flows. Herbaceous vegetation in the middle portion of Sowers Canyon is dominated by wiregrass.

## Current Condition of Key Ecosystem Characteristics

### *Groundwater and Surface Water Fluctuations*

There are more intermittent/ephemeral and perennial stream miles in this LTA than the rest of the Tavaputs Plateau (fig. 36). Perennial stretches occur where baseflows are sustained by groundwater discharge. High flows result from snowmelt runoff in the spring and early summer, but floods from summer and fall thunderstorms can occur with greater magnitude. Beaver dams raise water table height and maintain perennial flows in some areas. Diversions and spring developments are present, but their density is relatively low (table 37). We determined the status of groundwater and surface water fluctuations in this LTA to be **within** the NRV (table 38).

**Table 36**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Anthro Plateau land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Riparian, unclassified | Unclassified, other, or irrigated | 33.4 |
| Narrowleaf cottonwood | Deciduous tree-dominated | 21.1 |
| Fremont cottonwood | Deciduous tree-dominated | 4.4 |
| Mixed dry and wet meadow complex | Herbaceous-dominated | 2.2 |
| Wiregrass | Herbaceous-dominated | 14.3 |
| Booth's willow | Willow-dominated | 21.5 |

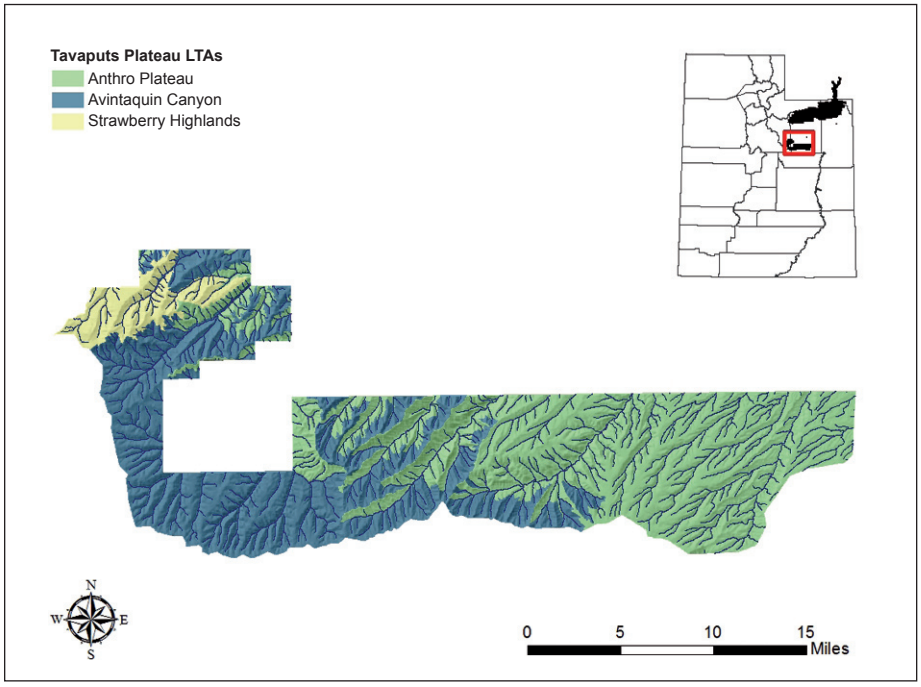


**Figure 36**—Location of perennial, intermittent, and ephemeral stream channels in the Flaming Gorge National Recreation Area.

**Table 37**—Number of diversion types and density of diversions in land type associations of the Tavaputs Plateau management area. Data were obtained from the Utah Division of Water Rights.

| LTA | Diversion type | | | | | | | Total diversions/ km² | Canal miles |
|---|---|---|---|---|---|---|---|---|---|
| | Abandoned well | Point to point | Rediversion | Return | Spring | Surface | Under-ground | | |
| Anthro Plateau | 0 | 79 | 0 | 0 | 6 | 18 | 1 | 0.24 | 0 |
| Avintaquin Canyon | 0 | 246 | 0 | 0 | 3 | 5 | 0 | 0.76 | 0 |
| Strawberry Highlands | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0.12 | 0 |
| Total | 0 | 365 | 0 | 0 | 9 | 23 | 1 | | |

**Table 38**—NRV status of KECs in LTAs in the Tavaputs Plateau management area.

| KEC | AP[a] | AC |
|---|---|---|
| 1. Groundwater and surface water fluctuations | In | In |
| 2. Channel, floodplain, and sediment dynamics | TT | In |
| 3. Vegetation and soil condition | In | In |
| 4. Invasive and encroaching species | TT | TT |

[a] Abbreviations refer to LTAs: Anthro Plateau and Avintaquin Canyon.

### *Channel, Floodplain, and Sediment Dynamics*

Most of the stream channels are ephemeral and bedrock-controlled, but alluvial segments have formed in some of the lower canyon bottoms. Alluvial channels are confined by roads and gullies in some sections and in others channel migration occurs across wide floodplains. Twenty-six percent of floodplains associated with perennial stream segments are confined and impacted and 24 percent are in moderate condition (table 39). Summer and fall thunderstorms produce debris flows from the highly erosive Uinta and Green River formations. These flows occur almost every year in this LTA and can reroute streams, widen stream channels, and prevent stabilization by riparian vegetation. Logs have been deposited into floodplains by debris flows. Fire-killed conifer snags also contribute wood into streams. Severe gullying has occurred on overgrazed slopes and canyon bottoms. High loads of sediment were deposited from summer thunderstorms in 2008, 2012, and 2013. Runoff from snowmelt typically deposits finer sediment than thunderstorm deposits. Runoff from roads also adds sediment to stream channels. Beaver dams and ponds slow the transport of sediment during moderate to high flows but are breached by heavy runoff and debris flows. Several gully plugs were installed in the 1970s and 1980s to slow the speed of high flows and protect streambanks from erosion. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **trending toward** the NRV (table 38).

**Table 39**—Length of stream types and riparian condition assessment classifications of perennial streams in the Tavaputs Plateau area.

| | Streams | | Perennial stream riparian conditions | | | | | |
|---|---|---|---|---|---|---|---|---|
| LTA | Intermittent/ ephemeral | Perennial | Percent confined-impacted | Percent confined-unimpacted | Percent intact floodplain | Percent floodplain in good condition | Percent floodplain in moderate condition | Percent floodplain in poor condition |
| | *km* | | | | | | | |
| Anthro Plateau | 602.4 | 46.5 | 26 | 24 | 0 | 14 | 24 | 12 |
| Avintaquin Canyon | 365.6 | 39.8 | 29 | 53 | 0 | 3 | 15 | 1 |
| Strawberry Highlands | 56.3 | 0.5 | 61 | 39 | 0 | 0 | 0 | 0 |

### *Vegetation and Soil Condition*

Riparian vegetation is frequently scoured, flatted, and buried by floods and debris flows that result from summer and fall thunderstorms. In 2015, wiregrass and sedges were reestablishing after the 2012 and 2013 thunderstorms. Cover of willows increased in Left Fork Indian Canyon and Sowers Canyon in recent years. Mature narrowleaf cottonwoods, young cottonwoods, snags, and logs recently have been observed in gully bottoms of Indian Creek Canyon. Repeat photo comparisons indicate that cottonwood cover has increased in the canyon bottom in recent decades (fig. 37). Tall, dense stands of caudate willow have filled the gullies in lower Sowers Canyon. Willows are drowned out by beaver ponds in some locations but return within several years after ponds are drained. Grazing of floodplain vegetation has been light in this LTA in recent years, with cattle preferring seeded grasses over wiregrass and other riparian graminoids. Riparian vegetation conversion analysis indicated conversion to agricultural land and developed land has occurred along 1 percent of perennial stream miles (table 40).

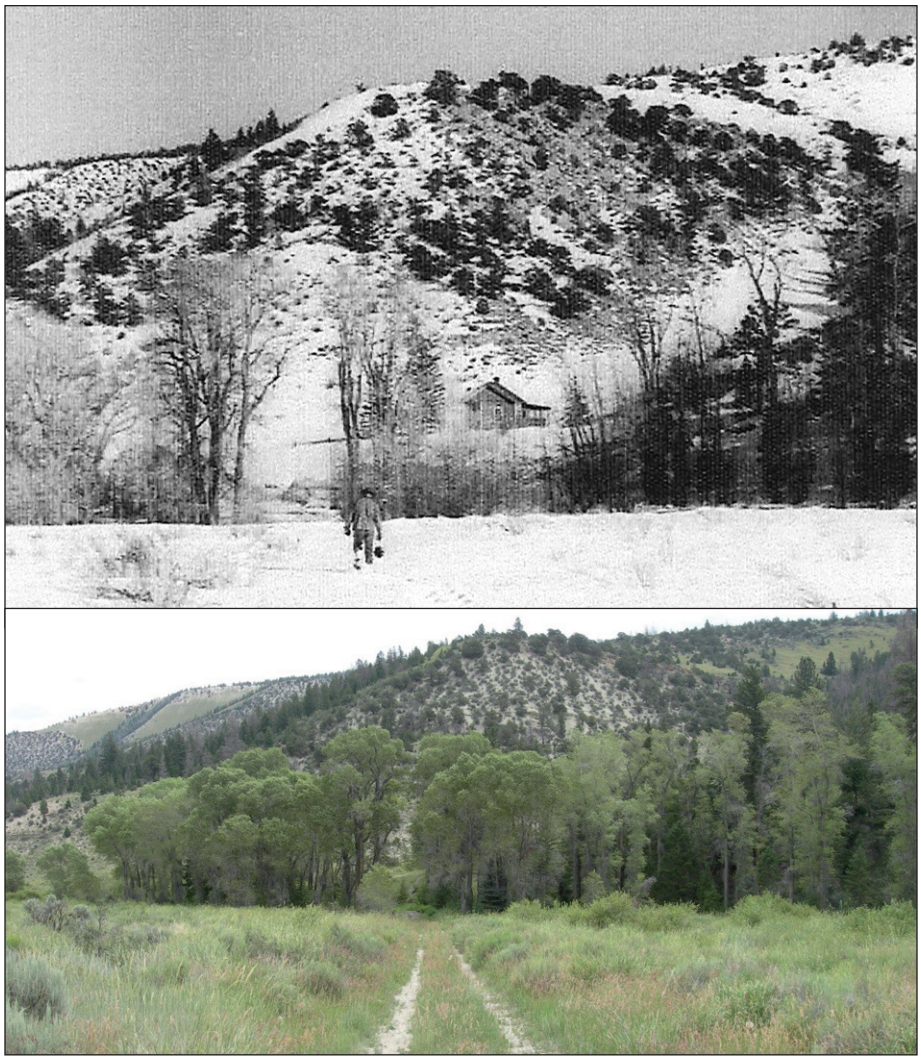

**Figure 37**—Repeat photo comparison showing increase in Narrowleaf cottonwood in the bottom of Left Fork Indian Canyon (photo by A. Helmus, USFS).

**Table 40**—Percentage of stream segments classified by conversion from riparian to other cover types for each LTA in the Tavaputs Plateau area.

| LTA | Conifer encroach-ment | Conversion to ag | Conversion to barren | Conversion to developed | Conversion to invasive | Non-riparian to riparian | Upland encroach-ment | No change |
|---|---|---|---|---|---|---|---|---|
| Anthro Plateau | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 96 |
| Avintaquin Canyon | 6 | 1 | 0 | 3 | 0 | 0 | 0 | 90 |
| Strawberry Highlands | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |

Debris flows cut into hillsides and banks and leave exposed soil in the floodplain. Gully incision is widespread but has recently stabilized. Willows, wiregrass, wildrye, and other plants were matted by floods and debris flows in 2012 and 2013, thereby holding channels and decreasing flood velocity (fig. 38). Wiregrass traps sediment and stabilizes banks, making this a critical species for maintaining stream condition in this erosive setting. After entering floodplains, debris flows are colonized by high-stability plants. Streambank stability was measured at eight greenline transects, with the oldest measurement in 1994 and the most recent in 2001. Transects were dominated by communities with Booth's willow, coyote willow, wiregrass, brookgrass, and other graminoids. This vegetation produced stability ratings that varied from 2.4 to 8.6, with a mean of 6.0. We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 38).

### *Resistance to Invasive and Encroaching Species*

Heavily used roads, livestock grazing, and recreation are potential means for spread of invasive herbaceous species into Left Fork Indian Canyon. A flowering tamarisk was present in a Left Fork Indian Canyon gully in 2013. Junipers are encroaching on floodplains in Left Fork Indian Canyon and Sowers Canyon. Beaver ponds control the spread of conifers in canyon bottoms and gullies. R-CAT analysis indicated that encroachment of conifers

**Figure 38**—Repeat photo comparison showing willows and herbaceous vegetation in Left Fork Indian Canyon before and after severe floods and debris flows were caused by thunderstorms in 2012 and 2013 (photos by A. Huber, USFS).

and other upland plants has occurred along 1 percent of perennial stream miles (table 40). We determined the status of resistance to invasive and encroaching species to be **trending toward** the NRV (table 38).

### Information and Research Needs/Data Gaps

1. *Gullies*. It is uncertain as to whether gully development can be attributed to natural condition of the parent materials or if they were caused by land use, such as heavy grazing in the 19th and 20th centuries.

2. *Spring and energy development*. Additional studies are needed to evaluate impacts of spring development and oil and gas extraction on groundwater, surface water, and riparian and wetland vegetation.

## Avintaquin Canyon LTA

### Riparian and Wetland Ecosystems

Riparian and wetland ecosystems of the Avintaquin Canyon LTA are generally associated with perennial and ephemeral stream segments. There is little wetland ecosystem cover in this LTA (table 33), but the Avintaquin Canyon does contain the largest amount of riparian vegetation in the Tavaputs Plateau (table 34). These segments occur in narrow canyons and in floodplains that have developed at lower elevations. There are four riparian vegetation types mapped within the LTA (table 41). Deciduous tree-dominated and willow-dominated types are located in Timber Canyon and the upper portion of Left Fork Indian Canyon (fig. 35). Additional, unmapped areas in Mill Hollow, Reserve Canyon, and South Fork Avintaquin Canyon are documented in the Range Study Database.

### Current Condition of Key Ecosystem Characteristics

#### *Groundwater and Surface Water Fluctuations*

Most streams in the LTA are ephemeral or intermittent (table 39). High flows result from snowmelt runoff in the spring and early summer, but floods from summer and fall thunderstorms can occur with greater magnitude. Beaver dams raise water table height and help to maintain perennial flows in Timber Canyon. High levels of species richness and structural diversity of riparian vegetation indicate stable groundwater fluctuations in the lower portion of Timber Canyon. There are no dams in this LTA, but density of diversions is greater than other LTAs on the Tavaputs Plateau (table 37). We determined groundwater and surface water fluctuations in this LTA to be **within** the NRV (table 38).

**Table 41**—Area of riparian and wetland vegetation types (Padgett et al. 1989) mapped within the Avintaquin Canyon land type association in the Ashley National Forest vegetation layer (ANF 2016).

| Vegetation type | Grouping | Hectares |
|---|---|---|
| Deciduous tree, unclassified | Deciduous tree-dominated | 85.5 |
| Narrowleaf cottonwood | Deciduous tree-dominated | 1.2 |
| Tall willow | Willow-dominated | 37.8 |
| Booth's willow | Willow-dominated | 2.3 |

### *Channel, Floodplain, and Sediment Dynamics*

Most of the stream channels are bedrock-controlled, but alluvial segments have formed in some of the lower canyon bottoms (fig. 39). Alluvial channels are confined by roads and gullies in some sections. In others, channel migration occurs across the floodplain. Summer and fall thunderstorms produce debris flows from the highly erosive Uinta and Green River formations. These flows can reroute streams and prevent stabilization by riparian vegetation. Severe gullying has occurred on historically overgrazed slopes and canyon bottoms. Wood is scoured from the channel and floodplain during floods and debris flows, but these flows also deposit new wood into the stream channels. Most of the perennial stream that occupies floodplains is in moderate condition, according to the R-CAT analysis (table 39). High loads of sediment are deposited during summer thunderstorms. Runoff from roads also adds sediment to stream channels. Beaver dams and ponds slow the transport of sediment during moderate to high flows but are breached by heavy runoff and debris flows. We determined the status of channel, floodplain, and sediment dynamics in this LTA to be **within** the NRV (table 38).

### *Vegetation and Soil Condition*

Newly established cottonwood and willow saplings were observed in Timber Canyon in 2000. Mature cottonwoods are present, and their cover has increased since 1985. Large, intact cottonwood snags are visible in recent photos of lower Timber Canyon. Drained beaver ponds and sediment deposits are quickly colonized by willow seedlings in Timber Canyon. Dieback of Booth's willow was visible in 2001, but recovery was evident in 2005. Extensive willow fields are present in upper portion of Timber Canyon. Patches of Booth's willow are located in the upper portion of Left Fork Indian Canyon adjacent to riparian vegetation in the Anthro Plateau LTA. Extent is not affected by cattle, which show little preference for willows in

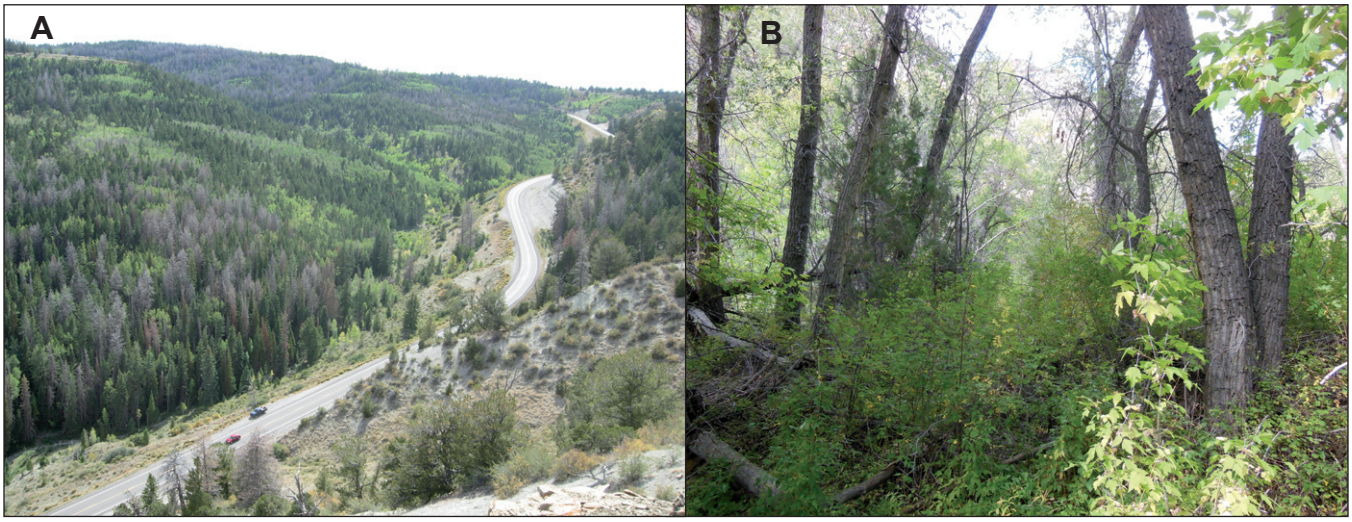


**Figure 39**—(A) Bedrock-controlled segment of upper Left Fork Indian Canyon in 2007 (photo by S. Goodrich and A. Huber, USFS). (B) Riparian forest in alluvial segment of lower Timber Canyon in 2012 with mature narrowleaf cottonwood, deciduous understory, and course woody debris (photo by S. Goodrich and J. Lott, USFS).

these settings. Mature willows shade streams, stabilize banks, and dampen the force of floods and debris flows. Riparian vegetation conversion analysis indicated that conversion to agricultural land has occurred along 1 percent of perennial stream miles (table 40).

Damage to streambanks is localized and includes trailing and hoof trampling at stream crossings by livestock. Breached beaver dams leave exposed soil along streams in Timber Canyon, resulting in incised channels and bare streambanks. Booth's willow and other stabilizing vegetation is well-established in a gully that is filling in with sediment in Left Fork Indian Canyon. Several gully plugs were installed in the 1970s and 1980s to slow the speed of high flows and protect streambanks from erosion. These structures, along with establishment of beaver colonies since the 1980s, have aggraded and halted the expansion of gullies in Timber Canyon (Plunkett 2016). We determined the status of vegetation and soil condition in this LTA to be **within** the NRV (table 38).

#### *Resistance to Invasive and Encroaching Species*

Heavily used roads, livestock grazing, and recreation are potential means for spread of invasive herbaceous species into Timber Canyon. Musk thistle was abundant in the bottom of Timber Canyon in 2012. Conifers are encroaching into some of the willow fields in Timber Canyon. R-CAT analysis indicated that encroachment of conifers has occurred along 6 percent of perennial stream miles (table 40). We determined the status of resistance to invasive and encroaching species in this LTA to be **trending toward** the NRV (table 38).

### Information and Research Needs/Data Gaps

1. *Herbaceous vegetation*. We found little information on effects of livestock grazing on herbaceous vegetation in riparian and wetland ecosystems of this LTA.

## Strawberry Highlands LTA

### Riparian and Wetland Ecosystems

There are very limited wetland ecosystems and riparian vegetation in the Strawberry Highlands LTA (fig. 35). The area of wetland ecosystems is less than 1 hectare of freshwater pond mapped (table 34). Additionally, no riparian vegetation has been mapped in the Strawberry Highlands (table 35). R-CAT results indicated there are many more intermittent and ephemeral streams than there are perennial, of which there is very little (table 39). Numerous diversions likely affect the limited aquatic and riparian habitats (table 37).

### Information and Research Needs/ Data Gaps

We did not evaluate KECs for the Strawberry Highlands because riparian and wetland vegetation were not mapped in the LTA. Nor did we find studies of riparian and wetland ecosystems from this LTA in the ANF study database. Work is needed to document the structure, composition, and extent of any riparian vegetation present in the steep, ephemeral channels that dissect this LTA.

# Summary

## Riparian and Wetland Communities of the Ashley National Forest

In conducting this assessment, we reviewed information about riparian and wetland ecosystems associated with streams, lakes, and ponds. We limited our assessment to areas within LTAs where riparian and wetland vegetation was mapped by the ANF and the NWI. For this reason, it was not possible to include every vegetation type on the forest that could be classified as riparian or wetland. At the highest elevations (the Alpine Moraine and Uinta Bollie LTAs), the riparian and wetland ecosystems we assessed were largely composed of herbaceous- and willow-dominated vegetation types. The primary disturbances affecting these types are livestock grazing and browsing by wild ungulates. In mid-to-low elevation LTAs, we assessed riparian and wetland ecosystems composed of deciduous and coniferous tree-dominated vegetation types, shrub-dominated types, and herbaceous-dominated types. Irrigated types are a large component of the riparian and wetland ecosystems we assessed at the lowest elevations (i.e., the Green River LTA). A greater number of natural and anthropogenic disturbances influence riparian and wetland ecosystems at mid and low elevations. These disturbances include: livestock grazing, beavers, wildfire, floods, landslides, debris flows, and browsing by wild ungulates.

We found that riparian and wetland vegetation was mapped in 20 of the Forest's 24 LTAs. Of the four LTAs without mapped riparian and wetland vegetation, we found studies of riparian and wetland ecosystems in Moenkopi Hills and Wolf Plateau. We could not find studies or evidence of riparian or wetland ecosystems in the Limestone Plateau or Strawberry Highland LTAs. Riparian and wetland ecosystems are therefore documented in at least 22 of the 24 LTAs that comprise the ANF.

By developing KECs of riparian and wetland ecosystems and evaluating their NRV, we identified several issues affecting their integrity and sustainability. Invasive and encroaching species are significant issues for riparian and wetland ecosystems in many of the LTAs in the Uinta Mountains and FGNRA management areas. Change in groundwater and surface water dynamics is an issue affecting riparian and wetland ecosystems at all LTAs in the FGRNA and several of the Uinta Mountain LTAs. Finally, damage to riparian and wetland vegetation by livestock and wild ungulates is an issue in the Uinta Mountains and to a lesser extent in the FGNRA. We identified floodplain dynamics and invasive and encroaching species as issues affecting riparian and wetland ecosystems in the two LTAs that we evaluated at the Tavaputs Plateau, but these issues were not as far outside of the NRV as they were in the Uinta Mountains and FGNRA. Below we discuss factors driving the above issues and the potential for management intervention.

## Invasive and Encroaching Species

Conifer encroachment is occurring across elevations on the south slope and north slope of the Uinta Mountains and in portions of the FGNRA and Tavaputs Plateau. High elevations of the Uinta Mountains appear to be the most resistant to invasive and encroaching species, with these LTAs generally classified within their NRV (fig. 40). At mid to low elevations, conifer encroachment in riparian and wetland ecosystems is concurrent with encroachment into upland grassland and shrubland ecosystems. This widespread encroachment has been attributed to fire suppression. At higher elevations, the causes may include changes in climate, fire regimes, and soil productivity, some of which may be attributable to natural cycles (ANF 2009a).

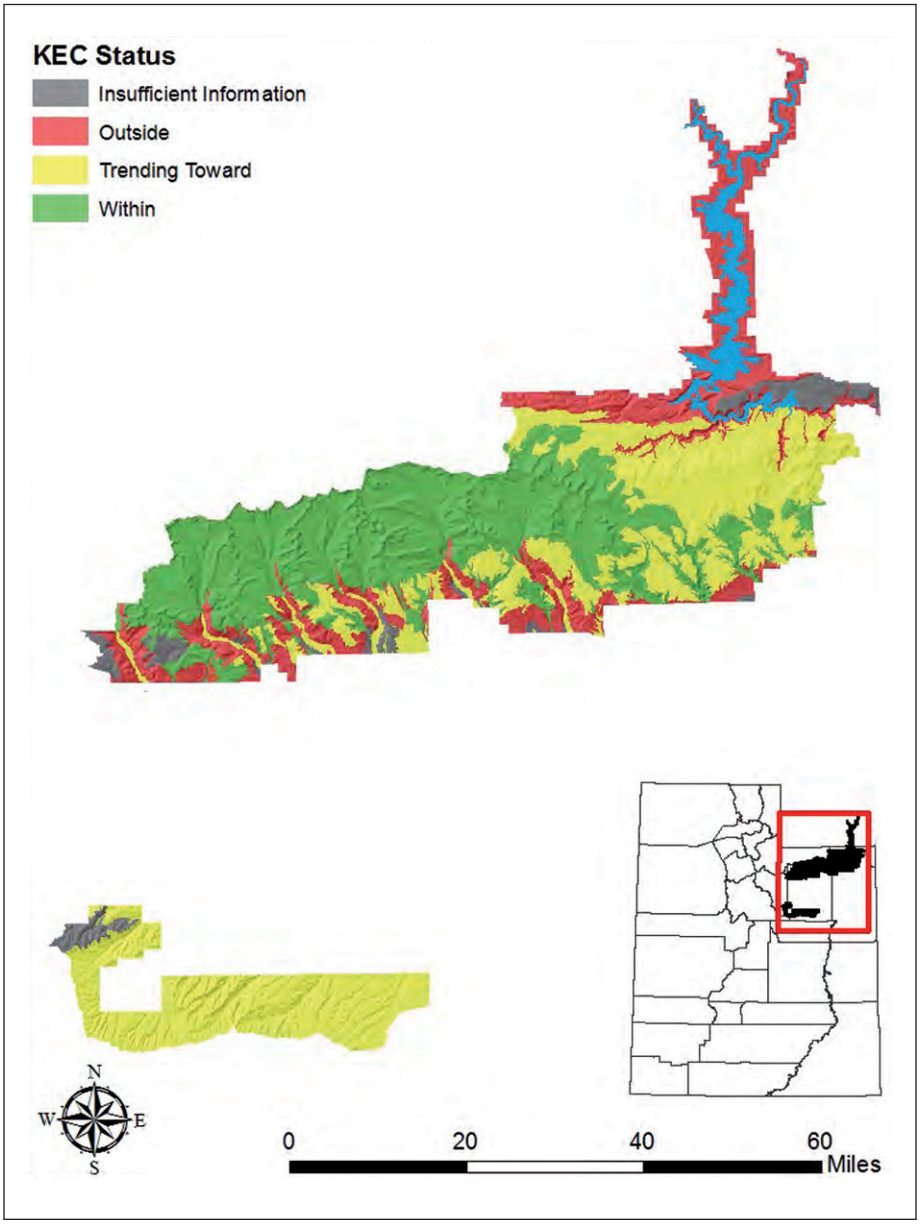


**Figure 40**—The status of invasive and encroaching species as a key ecosystem characteristic in terms of natural range of variation by LTA for the Ashley National Forest, Utah.

Managers can address conifer encroachment at mid to low elevations by allowing wildfires and prescribed fires to burn into riparian zones. We did not find evidence for negative effects of fire on riparian and wetland ecosystems in the Uinta Mountains. In fact, native woody riparian vegetation recovered vigorously from fire and herbaceous vegetation was protected by water in streams and beaver ponds. Russian olive, a nonnative tree, resprouted following fire on the south slope, but not as vigorously as native cottonwoods. Fire also created cottonwood snags, which are used by Lewis's Woodpeckers as nesting sites and perches. Postfire riparian zones were also used as brood rearing habitat by Greater Sage-Grouse. For these reasons, managers can use fire as a tool to restore or maintain riparian and wetland composition and create habitat features for wildlife species of concern. Other natural controls on conifer encroachment include beaver activity and channel migration. If use of fire is not a possibility, managers can slow or prevent conifer encroachment by maintaining a dynamic floodplain that is favorable to herbaceous and deciduous vegetation.

Conifers such as ponderosa pine are natural components of some streams in the FGNRA. Historical photographs show that large ponderosa pines were the dominant riparian tree along the Green River prior to the construction of Flaming Gorge Dam. Large pines are currently present in the floodplains of Red Canyon and other LTAs in the FGNRA, but their growth and survival are threatened by several stressors including beetle kills and high-intensity wildfire (Allen et al. 2002). Because large ponderosa pines provide numerous ecological services along low elevation streams, they should not be perceived as disruptive to ecosystems as conifers in the Uinta Mountains.

Invasion by nonnative herbaceous and woody plants is an issue affecting riparian ecosystems at mid to low elevations throughout the forest. This issue appears most urgent in the Antelope Flat, Green River, North Flank, and Red Canyon LTAs, where cycles of flood and drought, created by fluctuations in Flaming Gorge Reservoir, make conditions ideal for invasive plants. Invasive species are aggressively managed by several agencies in these LTAs and this management will be necessary if reservoir fluctuations continue.

Though reintroduction of fire may benefit riparian and wetland ecosystems in the Uinta Mountains, this disturbance could have negative consequences in areas such as the Green River LTA, which have higher rates of nonnative invasions. In such riparian ecosystems, Russian olive, saltcedar, and other nonnative woody plants recover more vigorously than native species, especially where hydrologic conditions have changed (Smith et al. 2009; Stromberg and Rychener 2010). Management interventions other than fire should therefore be used to control or prevent invasion and encroachment.

## Groundwater and Surface Water Fluctuations

Changes to groundwater and surface water have occurred on both slopes of the Uinta Mountains and throughout the FGNRA (fig. 41). Changes have occurred as a result of dams and diversions constructed at glacial lakes and in the main stems of Rock Creek and Lake Fork River in the Uinta Mountains. Canals both transfer flows out of watersheds and deliver flows to watersheds in the Uinta Mountains. Despite these changes in hydrology, we found woody riparian vegetation to be in good condition in terms of reproduction, growth, and survival at locations downstream from dams and diversions. These results indicate that flood disturbance is adequate to create germination sites for cottonwoods, willows, and other pioneer species. In addition, groundwater fluctuations appear adequate to maintain growth and survival

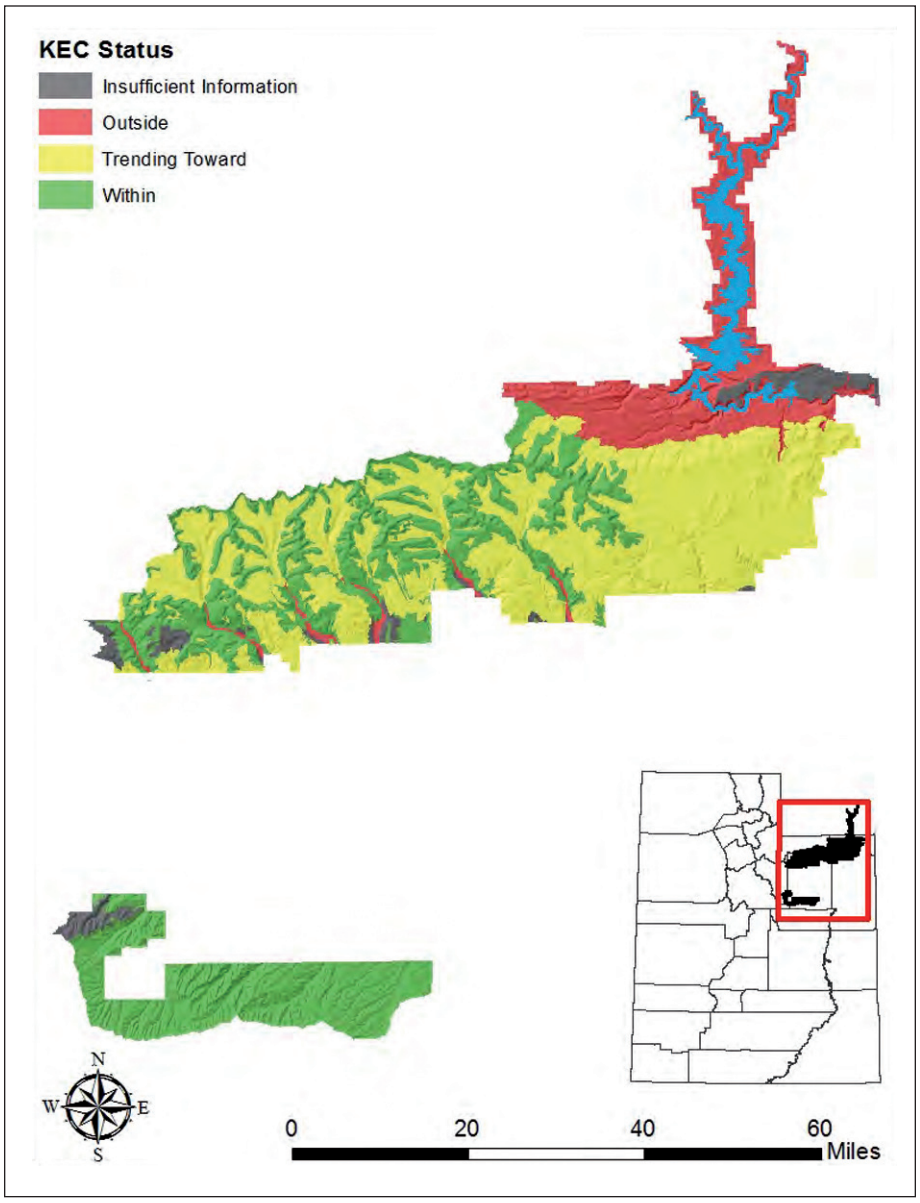


**Figure 41**—The status of groundwater and surface water fluctuations as a key ecosystem characteristic in terms of natural range of variation by LTA for the Ashley National Forest, Utah.

of phreatophytes. Groundwater data are needed, however, to determine if increases in water storage and diversion have the potential to influence riparian vegetation in the future.

## Grazing and Browsing

A larger issue affecting condition of riparian vegetation is impacts of livestock grazing on herbaceous vegetation along streams. We found studies reporting damage to riparian and wetland graminoids throughout the Uinta Mountains, but effects were most pronounced in the Limestone Hills, Parks Plateau, and Trout Slope LTAs (fig. 42). In these areas, damage was greatest during periods of drought such as the summer of 2012. Reductions in grazing pressure may be needed during such periods to prevent loss of water sedge, Nebraska sedge, and other stabilizing species in these LTAs.

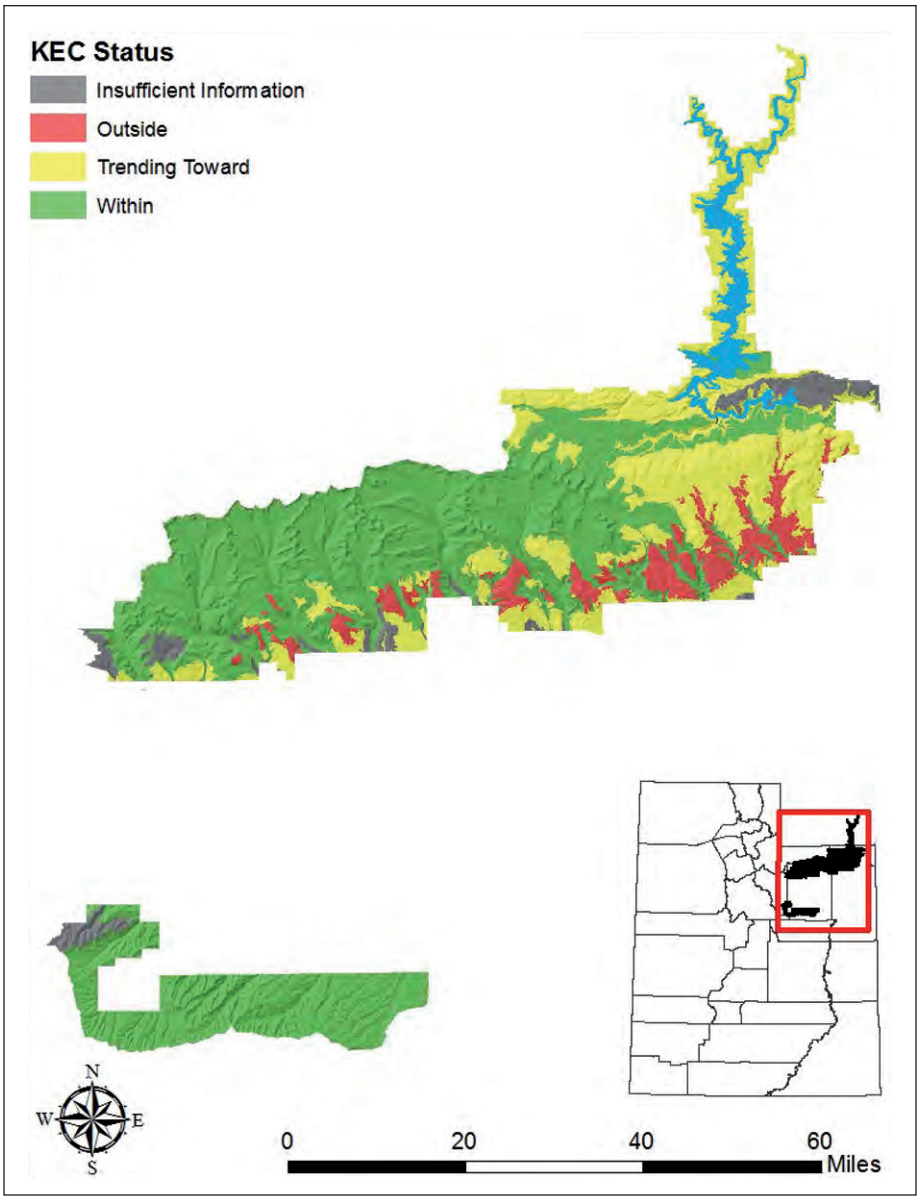


**Figure 42**—The status of vegetation and soil condition as a key ecosystem characteristic in terms of natural range of variation by LTA for the Ashley National Forest, Utah.

Herbivory by wild ungulates affects woody riparian species, most noticeably browsing by elk on willows at high elevations in the Uinta Mountains. If elk numbers are outside of the natural carrying capacity, intensive management may be necessary to protect ecosystems associated with plane-leaf willow and other woody species.

## Other Issues Affecting Riparian and Wetland Ecosystems

Channel, floodplain, and sediment dynamics were within or trending toward their NRV in all of the LTAs (fig. 43). We found effects on these characteristics to be localized in the forest. Anthropogenic drivers and stressors include roads, canals, livestock grazing, and recreation. In many cases, however, drivers and stressors were natural processes including activity by wild herbivores, geological settings, and deposition of instream wood. Management to maintain natural processes and address anthropogenic processes will keep channel and floodplain conditions within their NRV.

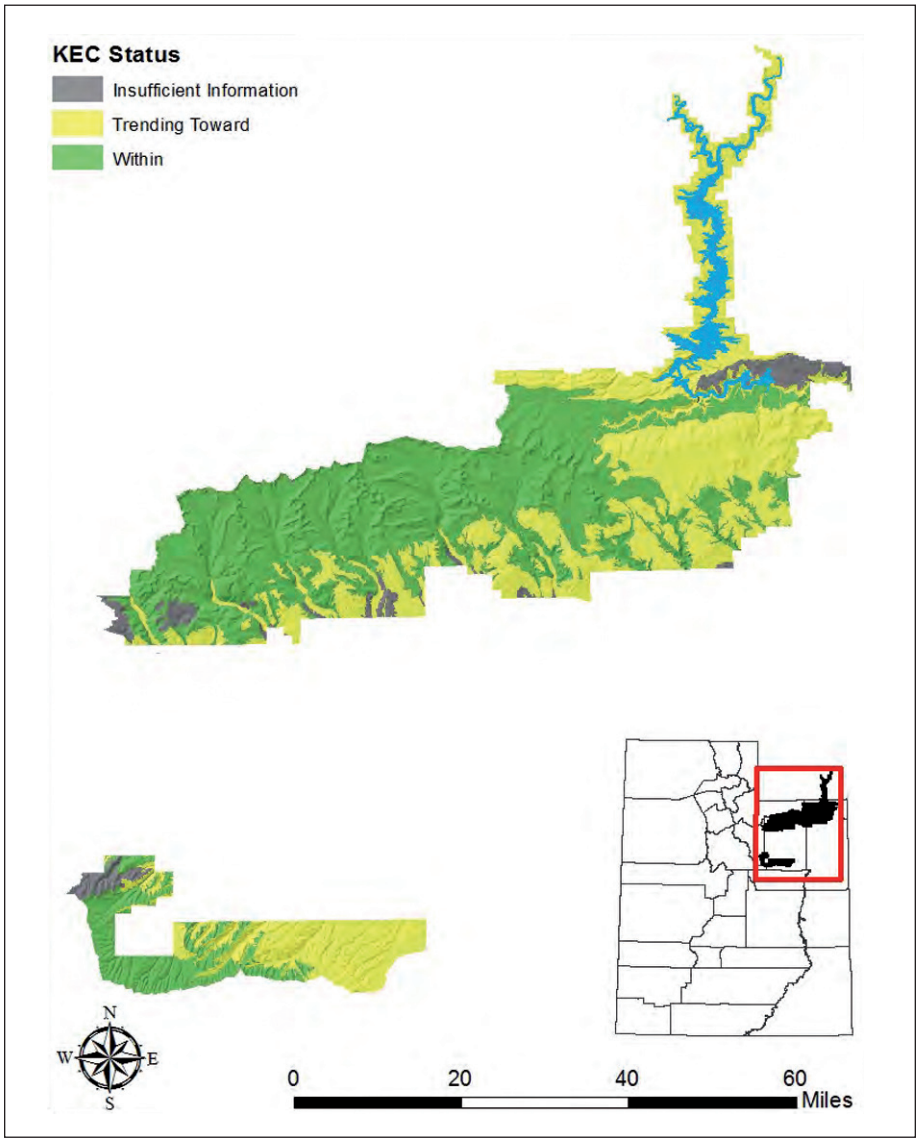


**Figure 43**—The status of channel, floodplain, and sediment dynamics as a key ecosystem characteristic in terms of natural range of variation by LTA for the Ashley National Forest, Utah.

## Next Steps

Several topics are important to the integrity and sustainability of riparian and wetland ecosystems, but they are inadequately addressed in this assessment due to lack of information. The following topics arose in several of the LTAs.

### Coniferous Tree-Dominated Riparian Vegetation Types

Many streams flow through coniferous forests, but little information is available on the extent, function, and composition of coniferous tree-dominated riparian and wetland vegetation, relative to types dominated by shrubs, deciduous trees, and herbaceous plants.

### Damage by Wild Ungulates

Heavy browsing of willows and localized soil disturbance by elk and moose were noted at many LTAs. Information about the NRV status of wild ungulate populations is needed to determine if this use is sustainable.

### Conifer Encroachment

The mechanisms causing encroachment of lodgepole pine and Engelmann spruce must be determined in order to slow or prevent the advance of conifers into riparian and wetland ecosystems.

### Beaver Activity

Current levels of beaver activity are poorly documented in most of the perennial channels within the forest. This information is needed to determine whether current stream conditions are influenced by presence or absence of active beaver dams.

### Invasive Species

Monitoring is needed to determine if invasive plants prevent reproduction of native species including cottonwoods and willows. Monitoring is also needed to determine whether livestock are facilitating spread of invasive plants by grazing or browsing native species.

### Stream Incision

In areas such as the Tavaputs Plateau and the Green River LTA, it is uncertain as to whether gully development can be attributed to natural condition of parent materials or if it is caused by land use, such as heavy grazing in the 19th and 20th centuries.

Our assessment results indicated that encroachment, invasion, hydrological changes, and livestock use were the greatest issues affecting riparian and wetland ecosystems in the Ashley National Forest. Our results also indicated that conditions at the Tavaputs Plateau area were within their NRV to a greater extent than conditions at the Uinta Mountains and FGNRA areas. The implications are that greater management changes are needed in the Uinta Mountains and FGNRA. Our conclusions, however, are based on the information we could obtain for this assessment. Additional sources of knowledge and data from the ANF should be examined to confirm our results.

# References


Allen, C.D.; Savage, M.; Falk, D.A.; [et al.]. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. Ecological Applications. 12: 1418–1433.

Allred, T.M.; Schmidt, J.C. 1999. Channel narrowing by vertical accretion along the Green River near Green River, Utah. Geological Society of America Bulletin. 111: 1757–1772.

Ashley National Forest (ANF). 2009a. Ashley National Forest ecosystem diversity evaluation report, draft #5. 3-30-2009. Vernal, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest. 240 p.

Ashley National Forest (ANF). 2009b. Ashley National Forest existing conditions and trends report. Vernal, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest. 117 p.

Ashley National Forest (ANF). 2016. Ashley National Forest vegetation geodatabase. Vernal, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest. https://www.fs.usda.gov/main/ashley/landmanagement/gis.

Atamian, M.T.; Sedinger, J.S.; Heaton, J.S.; [et al.]. 2010. Landscape-level assessment of brood rearing habitat for greater sage-grouse in Nevada. Journal of Wildlife Management. 74: 1533–1543.

Atwood, W.W. 1909: Glaciation of the Uinta and Wasatch Mountains. Professional Paper 61. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 96 p.

Auchincloss, L.C.; Richards, J.H.; Young, C.A.; [et al.]. 2013. Inundation depth, duration, and temperature influence Fremont cottonwood (*Populus fremontii*) seedling growth and survival. Western North American Naturalist. 72: 323–333.

Baker, W.L. 1990. Climatic and hydrologic effects on the regeneration of *Populus angustifolia* James along the Animas River, Colorado. Journal of Biogeography. 17: 59–73.

Belsky, A.J.; Matzke, A.; Uselman, S. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation. 54: 419–431.

Bilby, R.E. 1984. Removal of woody debris may affect stream channel stability. Journal of Forestry. 82: 609–613.

Brown, T.K. 2002. Creating and maintaining wildlife, insect, and fish habitat structures in dead wood. In: Laudenslayer, W.F., Jr.; Shea, P.J.; Valentine, B.E.; [et al.], tech. cords. Proceedings of the symposium on the ecology and management of dead wood in western forests; 1999 November 2–4; Reno, NV. Gen. Tech. Rep. PSW-GTR 181. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 883–892.

Bureau of Land Management (BLM). 1993. Riparian area management: Process for assessing proper functioning condition. Tech. Ref. 1737-9. Denver, CO: U. S. Department of the Interior, Bureau of Land Management Service Center. 58 p.

Burton, T.A. 1997. Effects of basin-scale timber harvest on water yield and peak streamflow. Journal of the American Water Resources Association. 33: 1187–1196.

Burton, T.A.; Smith, S.J.; Cowley, E.R. 2008. Monitoring stream channels and riparian vegetation—Multiple indicators. Interagency Tech. Bull. Version 50. Boise, ID: U.S. Department of the Interior, Bureau of Land Management; Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 151 p.

Carson, E.C. 2003. Report on GIS-based analysis of valley-type / stream-type associations in Ashley Creek, southeastern Uinta Mountains, Utah. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest, Vernal, UT. 32 p.

Carson, E.C. 2007. Temporal and seasonal trends in streamflow in the Uinta Mountains, northeastern Utah, and relation to climatic fluctuations. Arctic, Antarctic, and Alpine Research. 39: 521–528.

Chittenden, H.M. 1902. The American fur trade of the far west. New York: Sentry Press. 1,011 p.

Collins, W.B. 1977. Diet composition and activities of elk on different habitat segments in the lodgepole pine type, Uinta Mountains, Utah. Thesis. Logan, UT: Utah State University. 83 p.

Dillon, G.K.; Knight, D.H.; Meyer, C.B. 2005. Historic range of variability for upland vegetation in the Medicine Bow National Forest, Wyoming. Gen. Tech. Rep. RMRS-GTR-139. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 85 p.

Dwire, K.A.; Kauffman, J.B. 2003. Fire and riparian ecosystems in landscapes of the western USA. Forest Ecology and Management. 178: 61–74.

Federal Interagency Committee for Wetland Delineation (FICWD). 1989. Federal manual for identifying and delineating jurisdictional wetlands. Cooperative Tech Publ. Washington, DC: U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and USDA Soil Conservation Service. 76 p. plus appendices.

Gage, E.; Cooper, D.J. 2013. Historical range of variation assessment for wetland and riparian ecosystems, U.S. Forest Service Rocky Mountain Region. Gen. Tech. Rep. RMRS-GTR-286WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 239 p.

Godfrey, A.E. 1985. Karst hydrology of the south slope of the Uinta Mountains, Utah. In: Picard, M.D., ed. Geology and energy resources, Uinta Basin of Utah. Salt Lake City, UT: Utah Geological Association Guidebook. 12: 277–294.

Goodrich, S. 2004. Summary of studies, Sowers Canyon allotment, Duchesne District, Ashley National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest, Vernal, UT. 30 p.

Goodrich, S.; Huber, A. 2014. Uinta Flora. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region.

Graham, R.T.; Rodriguez, R.L; Paulin, K.M.; [et al.]. 1999. The northern goshawk in Utah: Habitat assessment and management recommendations. Gen. Tech. Rep. RMRS-GTR-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 48 p.

Grams, P.E.; Schmidt, J.C. 2005. Equilibrium or indeterminate? Where sediment budgets fail: Sediment mass balance and adjustment of channel form, Green River downstream from Flaming Gorge Dam, Utah and Colorado. Geomorphology. 71: 156–181.

Grayson, D.K. 1993. The desert's past: A natural prehistory of the Great Basin. Washington, DC: Smithsonian Institution Press.

Gregory, S.V.; Swanson, F.V.; McKee, W.A.; [et al.]. 1991. An ecosystem perspective of riparian zones. BioScience. 41: 510–551.

Hansen, W.R. 1969: The Geologic story of the Uinta Mountains. Geological Survey Bulletin 1291. U.S. Department of the Interior, U.S. Geological Survey. 144 p.

Hansen, W.R. 1986: Neogene tectonics and geomorphology of the eastern Uinta Mountains in Utah, Colorado, and Wyoming. Professional Paper 1356. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 78 p.

Hollenbeck, J.P.; Ripple, W.J. 2008. Aspen snag dynamics, cavity-nesting birds, and trophic cascades in Yellowstone's northern range. Forest Ecology and Management. 255: 1095–1103.

Horan, D.L.; Kershner, J.L; Hawkins, C.P.; [et al.]. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta Mountain streams. Transactions of the American Fisheries Society. 129: 1250–1263.

Horton, J.L.; Kolb, T.E.; Hart, S.C. 2001. Responses of riparian trees to interannual variation in ground water depth in a semi-arid river basin. Plant, Cell and Environment. 24: 293–304.

Hubert, W.A. 2004. Ecological processes of riverine wetland habitats. In: McKinstry, M.C.; Hubert, W.A.; Anderson, S.A., eds. Wetland and riparian areas of the Intermountain West: Ecology and management. Austin, TX: University of Texas Press: 52–73.

Hundey, E.J.; Moser, K.A.; Longstaffe, F.J.; [et al.]. 2014. Recent changes in production in oligotrophic Uinta Mountain lakes, Utah, identified using paleolimnology. Limnology and Oceanography. 59: 1987–2001.

Hundey, E.J.; Russell, S.D.; Longstaffe, F.J.; [et al.]. 2016. Agriculture causes nitrate fertilization of remote alpine lakes. Nature Communications. 7: Article 10571. doi: 10.1038/ncomms10571.

Junk, W.J.; Bayley, P.B.; Sparks, R.E. 1989. The flood pulse concept in river-floodplain systems. Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Science. 106: 110–127.

Kendrick, G.D., ed. 1989. Beyond the Wasatch: The history of irrigation in the Uinta Basin and Upper Provo River area of Utah. Denver, CO: U.S. Department of the Interior, National Park Service; Bureau of Reclamation. 125 p.

Knight, T.A. 2011. Dendrochronology on the Tavaputs Plateau, northeastern Utah: Insights on past climate, woodland demography, and Fremont archaeology. Dissertation. Tucson, AZ: University of Arizona. 182 p.

Larsen, I.J.; Pederson, J.L; Schmidt, J.C. 2006. Geologic versus wildfire controls on hillslope processes and debris flow initiation in the Green River canyons of Dinosaur National Monument. Geomorphology. 81: 114–127.

Lawrence, D.J.; Stewart-Koster, B.; Olden, J.D.; [et al.]. 2014. The interactive effects of climate change, riparian management, and a nonnative predator on stream-rearing salmon. Ecological Applications. 24: 895–912.

Lienkaemper, G.W.; Swanson, F.J. 1987. Dynamics of large woody debris in streams in old-growth Douglas-fir forests. Canadian Journal of Forest Research. 17: 150–156.

Macfarlane, W.W.; Gilbert, J.T.; Jensen, M.L.; [et al.]. 2017. Riparian vegetation as an indicator of riparian condition: Detecting departures from historic condition across the North American West. Journal of Environmental Management. 202(2): 447–460.

Marlow, C.B.; Tucker, R.; Sauer, B.; [et al.]. 2006. Broadening the scope of prescribed fires: Opportunities to rehabilitate degrades riparian zones. Forest Ecology and Management. 234: S169.

Matyjasik, M.; Hernandez, M.W.; Welsh, S.; [et al.]. 2015. Classification of wetlands in the Reader Creek Basin using remote sensing and water chemistry, Uinta Mountains, USA. Utah Geological Association Publication. 44: 119–138.

Meinzer, O.E. 1923. Outline of ground-water hydrology, with definitions. Geological Survey Water-Supply Paper 494. Washington, DC: U.S. Department of the Interior, Geological Survey. 77 p.

Meyer, C.B.; Knight, D.H.; Dillon, G.K. 2005. Historic range of variability for upland vegetation in the Bighorn National Forest, Wyoming. Gen. Tech. Rep. RMRS-GTR-140. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 94 p.

Muir, M. 2008. US Forest Service hydrology specialist report for Timber Canyon Rotenone Project. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest, Vernal, UT. 13 p.

Munroe, J.S. 2007. Exploring relationships between watershed properties and Holocene loss-on-ignition records in high-elevation lakes, southern Uinta Mountains, Utah, USA. Arctic, Antarctic, and Alpine Research. 39: 556–565.

Munroe, J.S., Klem, C.M.; Bigl, M.F. 2013. A lacustrine sedimentary record of Holocene periglacial activity from the Uinta Mountains, Utah, USA. Quaternary Research. 79: 101–109.

Naiman, R.J.; Décamps, H. 1997. The ecology of interfaces: Riparian zones. Annual Review of Ecology and Systematics. 28: 621–658.

Naiman, R.J.; Décamps, H.; McClain, M.E. 2005. Riparia: Ecology, conservation, and management of streamside communities. Burlington, MA: Elsevier Academic Press. 430 p.

Nowacki, G.J.; MacCleery, D.W.; Lake, F.K. 2012. Native Americans, ecosystem development, and historical range of variation. In: Wiens, J.A.; Hayward, G.D.; Safford, H.D.; [et al.], eds. Historical environmental variation in conservation and natural resource management. Hoboken, NJ: Wiley-Blackwell: 76–91.

Padgett, W.G.; Youngblood, A.P.; Winward, A.H. 1989. Riparian community type classification of Utah and southeastern Idaho. R4-Ecol-89-01. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. 191 p.

Parker, M.; Wood, F.J.; Smith, B.H.; [et al.]. 1985. Erosional downcutting in lower order riparian ecosystems: Have historical changes been caused by removal of beaver? In: Johnson, R.R.; Ziebell, C.D.; Patton, D.R.; [et al.], tech. cords. Riparian ecosystems and their management: Reconciling conflicting uses. First North American riparian conference; 1985 April 16–18; Tucson, AZ. Gen. Tech. Rep. RM-120. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 35–38.

Plunkett, C. 2016. Strawberry Peak livestock conversion: Hydrology specialist report. Report to the Ashley National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Intermountain Region, Ashley National Forest, Vernal, Utah. 17 p.

Poff, N.L.; Allan, J.D.; Bain, M.B.; [et al.]. 1997. The natural flow regime. Bioscience 47: 769–784.

Pollock, M.M.; Naiman, R.J.; Erickson, H.E.; [et al.]. 1995. Beaver as engineers: Influences on biotic and abiotic characteristics of drainage basins. In: Jones, C.G.; Lawton, J.H., eds. Linking species & ecosystems. New York: Springer: 117–126.

Redmond, Z. 2000. Moon Lake Project. Washington, DC: U.S. Department of the Interior, Bureau of Reclamation.

Reynolds, R.L.; Mordecai, J.S.; Rosenbaum, J.G.; [et al.]. 2010. Compositional changes in sediments of subalpine lakes, Uinta Mountains (Utah): Evidence for the effects of human activity on atmospheric dust inputs. Journal of Paleolimnology. 44: 161–175.

Richardson, D.M.; Holmes, P.M.; Esler, K.J.; [et al.]. 2007. Riparian vegetation: Degradation, alien plant invasions, and restoration prospects. Diversity and Distributions. 13: 126–139.

Saab, V.A.; Vierling, K.T. 2001. Reproductive success of Lewis's woodpecker in burned pine and cottonwood riparian forests. The Condor. 103: 491–501.

Schmidt, J.C.; Galbraith, D.; Hernandez, J. 2008. Channel change of unregulated and regulated streams near three U.S. Geological Survey gaging stations, Uinta Mountains, Utah. Final Report. Cooperative agreement 03-CS-1221625-205 between the USFS and Utah State University. 47 p.

Simms, S.R. 2016. Ancient peoples of the Great Basin and Colorado Plateau. Walnut Creek, CA: Left Coast Press.

Smith, D.M.; Finch, D.M. 2014. Use of native and nonnative nest plants by riparian-nesting birds along two streams in New Mexico. River Research and Applications. 30: 1134–1145.

Smith, D.M.; Finch, D.M.; Gunning, C.; [et al.]. 2009. Post-wildfire recovery of riparian vegetation during a period of water scarcity in the southwestern U.S. Fire Ecology. 5: 38–55.

Squire, O.J. 2012. Examining atmospheric dust deposition and its effects on alpine lakes in the Uinta Mountains, Utah. Thesis. London, Ontario, Canada: University of Western Ontario. 241 p.

Stanford, J.A.; Ward, J.V. 1988. The hyporheic habitat of river ecosystems. Nature. 335: 64–66.

Stanford, J.A.; Ward, J.V. 1993. An ecosystem perspective of alluvial rivers: Connectivity and the hyporheic corridor. Journal of the North American Benthological Society. 12: 48–60.

Stanford, J.A.; Lorang, M.S.; Hauer, F.R. 2005. The shifting habitat mosaic of river ecosystems. Verhandlungen Des International Verein Limnologie. 29: 123–136.

Stohlgren, T.; Jarnevich, C.; Kumar, S. 2007. Forest legacies, climate change, altered disturbance regimes, invasive species and water. Unasylva. 58: 44–49.

Stromberg, J.C.; Rychener, T.J. 2010. Effects of fire on riparian forests along a free-flowing dryland river. Wetlands. 30: 75–86.

Stromberg, J.C.; Fry, J.; Patten, D.T. 1997. Marsh development after large floods in an alluvial, arid-land river. Wetlands. 17: 292–300.

Stromberg, J.C.; Tluczek, M.G.F.; Hazelton, A.F.; [et al.]. 2010. A century of riparian forest expansion following extreme disturbance: Spatial-temporal change in *Populus*/*Salix*/*Tamarix* forests along the San Pedro River, Arizona, USA. Forest Ecology and Management. 259: 1181–1189.

U.S. Army Corps of Engineers (USACE). 1987. Corps of Engineers wetlands delineation manual. Vicksburg, MS: U.S. Army Corps of Engineers. 143 p.

U.S. Bureau of Reclamation (BOR). 2005. Record of decision: Operation of Flaming Gorge Dam: Final environmental impact statement. Washington, DC: U.S. Department of the Interior, Bureau of Reclamation. 11 p.

U.S. Fish and Wildlife Service. 2016. National wetlands inventory overview. [Last updated July 26 2016.] Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. https://www.fws.gov/wetlands/nwi/Overview.html.

USDA Forest Service (USFS). 2012. National best management practices for water quality management on National Forest system lands. Volume 1: National core BMP technical guide. FS-990a. Washington, DC: U.S. Department of Agriculture, Forest Service. 165 p.

USDA Forest Service (USFS). 2013. Distribution of aquatic invasive species in the intermountain region. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region. Spatial data available online: http://www.fs.usda.gov/detail/r4/landmanagement/resourcemanagement/?cid=fsbdev3_016101.

USDA Forest Service. 2015. Land Management Planning Handbook Chapter 10—Assessments. FSH 1909.12. Washington, DC: U.S. Department of Agriculture, Forest Service. 70 p.

Utah Division of Water Rights (WDWR) 2016. GIS data and related tables. Salt Lake City, UT: Utah Division of Water Rights. http://waterrights.utah.gov/gisinfo/wrcover.asp [Accessed July 29, 2016].

Utah Division of Wildlife Resources (UDWR). 2010. Utah beaver management plan 2010–2020. DWR Publication 0-29. Salt Lake City, UT: Utah Division of Wildlife Resources. 33 p.

Utah Division of Wildlife Resources (UDWR). 2015. Aquatic invasive species program, Utah Northeastern Region summary. Salt Lake City, UT: Utah Division of Wildlife Resources.

Utah Division of Wildlife Resources (UDWR). 2015. Utah statewide elk management plan. Salt Lake City, UT: Utah Division of Wildlife Resources. 28 p.

Vannote, R.L.; Minshall, G.W.; Cummins, K.W.; [et al.]. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences. 37: 130–137.

Vitousek, P.M., D'Antonio, C.M.; Loope, L.L.; [et al.]. 1996. Biological invasions as global environmental change. American Scientist. 84: 468–478.

Wheaton, J.M. 2009. Riparian Condition Assessment Tool (R-CAT). U.S. Department of the Interior, Bureau of Land Management; U.S. Department of Agriculture, Forest Service, Great Basin Native Plant Project. http://etal.joewheaton.org/rcat.

Wilding, T.K., Sanderson, J.S.; Merritt, D.M.; [et al.]. 2014. Riparian responses to reduced flood flows: Comparing and contrasting narrowleaf and broadleaf cottonwoods. Hydrological Sciences Journal. 59: 605–617.

Winter, T.C. 2007. The role of groundwater in generating streamflow in headwater areas and in maintaining base flow. Journal of the American Water Resources Association. 43: 15–25.

Winward, A.H. 2000. Monitoring the vegetation resources in riparian areas. Gen. Tech. Rep. RMRS-GTR-47. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.

# Appendix

## Common and Scientific Names of Plants Mentioned in This Assessment

Nomenclature follows Goodrich and Huber (2014).

| Common Name | Scientific Name |
|---|---|
| Acute-leaf evening-primrose | *Oenothera acutissima* |
| Alkali wildrye | *Elymus simplex* |
| Trembling aspen | *Populus tremuloides* |
| Beaked sedge | *Carex utriculata* |
| Bebb's willow | *Salix bebbiana* |
| Bigtooth maple | *Acer grandantatum* |
| Black alpine sedge | *Carex nigricans* |
| Bluejoint | *Calamagrostis canadensis* |
| Booth's willow | *Salix boothii* |
| Boxelder | *Acer negundo* |
| Broadleaf pepperweed | *Lepidium latifolium* |
| Brookgrass | *Catabrosa aquatic* |
| Canada goldenrod | *Solidago canadensis* |
| Canada thistle | *Cirsium arvense* |
| Cattail | *Typha* spp. |
| Caudate willow | *Salix lucida* |
| Cheatgrass | *Bromus tectorum* |
| Chokecherry | *Prunus virginiana* |
| Common reed | *Phragmites australis* |
| Cottongrass | *Eriophorum* spp. |
| Coyote willow | *Salix exigua* |
| Creeping foxtail | *Alopecurus arundinaceus* |
| Currant | *Ribes* spp. |
| Douglas-fir | *Pseudotsuga menziesii* |
| Drummond's Rush | *Juncus drummondii* |
| Drummond's willow | *Salix drummondii* |
| Englemann spruce | *Picea englemannii* |
| Foxtail barley | *Hordeum jubatum* |
| Fremont cottonwood | *Populus fremontii* |

(Continued on next page)

| Common Name | Scientific Name |
|---|---|
| Gardner saltbush | *Atriplex gardneri* |
| Geyer willow | *Salix geyeriana* |
| Graybark willow | *Salix eriocephala* |
| Grayleaf willow | *Salix glauca* |
| Halogeton | *Halogeton glomeratus* |
| Kentucky bluegrass | *Poa pratensis* |
| Knapweed | *Centaurea* spp. |
| Kochia | *Bassia* spp. |
| Lodgepole pine | *Pinus contorta* |
| Mountain alder | *Alnus incana* |
| Mountain silver sage | *Artemisia cana* |
| Mud Sedge | *Carex limosa* |
| Musk mustard | *Chorispora tenella* |
| Musk thistle | *Carduus nutans* |
| Narrowleaf cottonwood | *Populus angustifolia* |
| Nebraska sedge | *Carex nebrascensis* |
| Northern single-spike sedge | *Carex scirpoidea* |
| Plane-leaf willow | *Salix planifolia* |
| Ponderosa pine | *Pinus ponderosa* |
| Red-osier dogwood | *Cornus sericea* |
| River birch | *Betula glandulosa* |
| Russian olive | *Elaeagnus angustifolia* |
| Russian thistle | *Salsola* spp. |
| Rocky Mountain juniper | *Juniperus scopulorum* |
| Shrubby cinquefoil | *Potentilla fruticosa* |
| Softstem bulrush | *Scirpus supinus* |
| Tamarisk | *Tamarix* spp. |
| Timber oatgrass | *Danthonia intermedia* |
| Tufted hairgrass | *Deschampsia cespitosa* |
| Twinberry | *Lonicera involucrata* |
| Water sedge | *Carex aquatilis* |
| Western wheatgrass | *Elymus smithii* |
| Whitetop | *Cardaria* spp. |
| Wiregrass | *Juncus arcticus* |
| Woolfruit sedge | *Carex lasiocarpa* |

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