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Black Hills National Forest

Draft Forest Assessment:

Aquatic, Riparian, and Groundwater-Dependent Ecosystems

Hikers exploring Little Spearfish Trail, Black Hills National Forest (photo courtesy of the USDA Forest Service).

Contents

List of Tables

Chapter 1. Introduction

The Black Hills National Forest (Black Hills NF) is managed by the U.S. Forest Service (USFS), an agency of the U.S. Department of Agriculture (USDA). The mission of the USFS is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The National Forest Management Act requires all National Forests to develop a land and resource management plan (forest plan) to guide management actions and decisions. The National Forest Management Act requires that forest plans be periodically updated. The current Black Hills NF forest plan was approved in 1997. Substantial plan amendments were last approved in March 2006 resulting in the Black Hills National Forest Land and Resource Management Plan. Relatively minor amendments have occurred through 2018 and the latest version can be found on the Black Hills NF website (USDA Forest Service 2006).

In order to revise the current forest plan, the Black Hills NF has identified and evaluated existing information about relevant ecological, economic, and social conditions, trends, and sustainability and how those conditions relate to management direction in the forest plan. This draft assessment report documents findings for aquatic, riparian, and groundwater-dependent ecosystems.

Aquatic, Riparian, and Groundwater-Dependent Ecosystems on the Black Hills National Forest

Aquatic, riparian, and groundwater-dependent (GD) ecosystems are some of the most productive and biologically diverse lands on the Black Hills NF and provide living conditions for a greater variety of aquatic and terrestrial wildlife than any other habitat type (Montgomery 1996). The quality and extent of these riparian/wetland habitats are important factors because they have a direct influence on the associated aquatic ecosystem that is home to fish and amphibian species and supports the upland terrestrial ecosystem in the broader watershed.

This document is an assessment of the current known aquatic, riparian, and groundwater-dependent ecosystems in the Black Hills NF, which comprises the "plan area." These are the ecosystems that are dependent on accumulations of surface water or access to groundwater, whether via a shallow water table, via plant roots that can access shallow groundwater, or via springs that discharge groundwater at the ground surface. In general, these areas tend to support diverse and productive biotic communities that are distinct from the surrounding terrestrial areas that depend solely on precipitation and surface water runoff. For the purpose of this assessment, these ecosystem types are defined as follows:

- Aquatic ecosystems include the biotic communities that inhabit lakes, ponds, rivers, and perennial streams. Due to the size and accessibility of these geographic features, they offer a dependable source of water for biotic communities.
- Riparian ecosystems include the unique mix of biota that flourish at the interface between aquatic and terrestrial ecosystems.
- GD ecosystems include a wide range of biotic communities that are supported by access to groundwater. The hydrogeographic features that support these ecosystems include springs and seeps, caves and karst systems. In many cases, rivers, wetlands, and lakes are also considered groundwater-dependent ecosystems. Where groundwater meets the surface, unique communities of plants and animals may be present, including rare, threatened, and endangered species.

In this document, groundwater-dependent ecosystems are further categorized by depth of the water source and include (a) subsurface systems that reside within groundwater, which consist of caves, karsts, and aquifers that can occur well below the surface and are not reached by surface vegetation; (b) shallow water table phreatophytic ecosystems within the rooting depth of vegetation that depend on a constant subsurface source of water; and (c) discharge ecosystems including springs, fens, marshes, and wet meadows, as well as groundwater-dominant lentic and lotic systems. In discharge systems groundwater reaches to within one foot of the ground surface during part or all of the year.

The Black Hills NF Land and Resource Management Plan (forest plan) provides conservation and protection measures for streams and wetlands encompassed in the plan area (USDA Forest Service 2006). It states that the Black Hills NF will be managed so that the rivers, streams, wetlands, lakes, riparian areas, and caves of the plan area reflect healthy functioning ecosystems.

While rivers, streams, and wetlands are essential components of watersheds, consideration of the landscape at the watershed scale is not included as part of this document. Please see the *Draft Forest Plan Assessments: Soils and Watersheds* for the watershed assessment. Similarly, while the biotic communities of ecosystems featured in this assessment are comprised of myriad plant and animal species, detailed information for specific species can be found in the *Draft Forest Plan Assessment: At-Risk Species Status*.

Chapter 2. Conditions and Trends

This chapter presents a discussion of the constituent elements of aquatic, riparian, and groundwater-dependent ecosystems of the Black Hills NF and an assessment of the current conditions and trends based on available data.

Best Available Scientific Information

This assessment was prepared based on scientific data, reports and prior analyses provided by the Black Hills NF. Additional resources were identified using internet searches of publicly available information. To the extent possible, reasonable efforts were made to verify that the information used in this assessment represents the best publicly available, science-based evidence. When science-based data were not available to address the key questions, data gaps were identified.

Data Gaps Identified

Data gaps were identified during the process of drafting this assessment – data and information that would add to the understanding or reduce uncertainty about conditions and trends related to aquatic, riparian, and groundwater-dependent ecosystems. High-profile data gaps include wildfire hazard, groundwater source areas, and burn severity predictive models to understand relative threats to riparian and aquatic systems. Analysis using LANDFIRE, Forest Resource Coordinating Committee (FRCC), USGS Black Hills Hydrology Study, Water Resources Atlas and Groundwater Atlas of the Black Hills, and BAER assessments may be used to provide further planning guidance. The overall status of rare aquatic, riparian, and groundwater ecosystems is poorly understood, which is primarily due to the lack of multi-year watershed scale monitoring. Discrete trends can be inferred from plant species monitoring reports; however, these efforts do not consider the Forestwide processes and the relative condition of these systems. A group of watershed studies of regionally significant systems would help to understand the state and trends of aquatic and riparian systems, as well as the influence of watershed-scale processes on receiving bodies of water. Specifically, the following data gaps/needs are suggested:

- Continuance and consolidation of Forest inventory and mapping of springs, streams, and wetlands to be updated into the national datasets (USGS National Hydrography Dataset (NHD) and USFW National Wetlands Inventory (NWI))
- Inventory, classification, and assessment of riparian systems according to Rosgen stream classification methods
- Predictive modeling of riparian and wetlands using the Riparian Solutions national mapping model for Riparian Buffer Delineation (RBDM Model developed by USDA and partners
- Inventory and assessment of peatland ecosystems and assessment of conditions and stressors similar to the USFS GTR publication done for GDEs on the Fishlake and Dixie National Forests
- Completion of the Forest’s Water rights and uses inventory and database updates to assist in determine effects to riparian, aquatic, and wetland ecosystems from water developments and uses.
- Continuance of GDE inventories (full level 1 and Level 2)
- Floristic inventory of wetland and riparian plant species
- Climate change modeling to determine changes to hydrologic regime

There is a need for mapping of the vegetation and ecosystems discussed in this assessment. Although differentiated from data gaps, the acquisition of vegetation mapping in targeted watersheds would improve the understanding of riparian ecosystems. Similarly, mapping of groundwater ecosystems would aid management of the ecosystems considered in this report. There is also a need for habitat modeling to assess the ecosystem function of riparian areas. There is known data gap in NHD and more accurate numbers from the local BHNF dataset can provide an estimate of the number of resources present.

Overview of Aquatic, Riparian, and Groundwater-Dependent Ecosystems

Aquatic Ecosystems

Prior assessments and forest plans have distinguished two main types of aquatic ecosystems in the Black Hills NF: lake ecosystems and stream ecosystems.

Lakes

There are 38 named lakes and ponds among the 808 surface waterbody features within the Black Hills NF (U.S. Geological Survey [USGS] 2021); however, it is important to note that virtually all of the lakes are in fact reservoirs anthropogenically created by impounding water behind dams and other structures that allow for control of the water levels and outflow. The Black Hills NF maintains a database of known waterbodies, which includes water features not listed in the USGS NHD database. Total surface area of reservoirs within the Black Hills NF is approximately 2,000 acres, and the major waterbodies (i.e., greater than 100 acres) include Angostura Reservoir, Pactola Reservoir, Sheridan Lake, Deerfield Lake, and Stockade Lake. Due to their size and depth, these larger reservoirs are typically more resilient to fluctuations in temperature, dissolved oxygen, pollution inputs and sedimentation rates than smaller lakes. The recreational fisheries in these waterbodies are managed by the respective states and a description of these practices is included below:

- The Forest Service has management responsibility of the water levels and releases from Sheridan Reservoir, which is in part driven by the goal of maintaining “cold water permanent fisheries.”
- The U.S. Bureau of Reclamation (USBR) is responsible for Pactola and Deerfield reservoirs, and manages releases to provide for irrigation needs, domestic water supply, as well as cold water permanent fisheries (USDA Forest Service 2005a).
- Angostura Reservoir is also managed by USBR and operated by the Angostura Irrigation District.
- Stockade Lake is managed as “cold water marginal” habitat by South Dakota Game, Fish, and Parks.

In addition, 47 smaller lakes and ponds in the South Dakota portion of the Black Hills NF are stocked and managed for trout (South Dakota Game, Fish, and Parks [SDGFP] 2020).

Streams

There are nearly 3,500 miles of drainages within the plan area, with an estimated 950 miles of perennial streams within the boundaries of the Black Hills NF. Major river and stream systems include Spring Creek, Beaver Creek, Stockade-Beaver Creek, Spearfish, Creek, Bear Butte Creek, Rapid Creek, Battle Creek, Elk Creek, and French Creek, with most surface drainage features draining from west to east. Sediment, bed and bank stability, and temperature are among the primary components of concern (USDA Forest Service 2010a).

One feature of particular significance to watershed management is the diminution or complete disappearance of flow where streams cross sedimentary formations (Brown 1944, Orr 1975). These channel segments are recharge zones to aquifers, which can be an important ground-water sources. At the same time, the diminution or disappearance of flow means that surface water yields can be significantly increased only in areas upstream from the loss zones—except in the case of floods or other high flows that exceed the intake capacities of channels.

Most streams, when at their base flow level, go completely dry downstream of where they cross the Minnelusa and Madison outcrops (Carter et al. 2002, Carter et al. 2003, USDA Forest Service 2005a). Only Rapid Creek, Whitewood Creek, and Spearfish Creek consistently maintain perennial flows through the loss zone on the South Dakota portion of the Forest (Carter et al. 2002a). Many miles of Forest streams disappear during drought cycles. The major flow loss zones include: Box Elder Creek (50 cubic feet per second (cfs)), Spring Creek (28 cfs), Spearfish Creek (23 cfs), Grace Coolidge Creek (21 cfs), Elk Creek (19 cfs), False Bottom Creek (15 cfs), Highland Creek (10 cfs), Rapid Creek (10 cfs). Stream sections below these loss zones are often dry because the amount of loss exceeds stream inputs (SDGFP 2020).

As reported in the *Draft Assessment: Soils and Watershed* (Table 4), of the 95 assessed sub-watersheds that lie either completely or partially in the Black Hills NF, 43 are considered functioning properly with the remaining sub-watersheds Functioning at Risk (Class 2). There are no Class 3 (Impaired Function) sub-watersheds in the Black Hills NF. As seen in Table 5 of that assessment, aquatic habitat condition and aquatic biota condition is considered good in more than half of the sub-watersheds. Riparian and wetland vegetation is in good condition in only 4 percent of the sub-watersheds. The Watershed Condition Framework ratings were established in 2010 and may not accurately reflect the current state of these systems.

Biotic Communities within Aquatic Ecosystems

Fish communities in the lakes and streams of the Black Hills NF can be grouped into the following broad categories: native/indigenous species, cold-water trout species, warm-water game species, and invasive species. Native fish species include suckers, chubs, and dace (Bailey and Allum 1962). Trout have been stocked since the late 1800s and are now abundant in many of the lakes and streams that provide consistent flow and appropriate habitat (Barnes 2007). Trout species include brown, brook, rainbow, cutthroat, lake, tiger, and splake (hybrid of brook trout and lake trout). Warm-water game species have also been introduced, propagated, and managed to provide fishing opportunities. Warm-water species include smallmouth bass, largemouth bass, walleye, black crappie, bluegill, yellow perch, and northern pike. A comprehensive list and more detail on each fish species is provided in the *Draft Assessment: At-Risk Species Status*.

The South Dakota Department of Game, Fish and Parks South Dakota Natural Heritage Program identifies species of greatest conservation concern (SGCN; South Dakota Department of Game, Fish and Parks 2014). The South Dakota Natural Heritage Program categorizes SGCN native fish species that have been recognized include, mountain sucker (*Catostomus platyrhynchus*), longnose sucker (*Catostomus catostomus;* also listed as threatened by the state of South Dakota), lake chub (*Couesius plumbeus*), and finescale dace (*Chrosomus neogaeus;* also listed as endangered by the state of South Dakota).

Invasive species are also prevalent throughout the aquatic ecosystems of the Black Hills NF. Two of the most significant nuisance species include Didymo (*Didymosphenia geminata*) and Curlyleaf pondweed (*Potamogeton crispus*). These and other invasive species are further discussed in the stressors section below and in further detail in the *Draft Assessment: Insects, Diseases, and Invasive Species*.

Riparian Ecosystems

Riparian ecosystems can be defined in numerous ways; but, for the purpose of this assessment they are defined as those areas situated adjacent to rivers, lakes, and streams. These systems are characterized by periodic flooding that reorganizes alluvial soils and provides a seed bed for various riparian plant species. Riparian ecosystems support a variety of interactions between terrestrial and aquatic ecosystem constituents and are generally comprised of a variety of tall and low deciduous trees, shrub species and herbaceous plants. Additional phreatophytic plant communities are addressed in the groundwater-dependent ecosystems section.

Riparian mapping used in Phase II and stream inventories have been ongoing since 2006, therefore the area classified as riparian may be slightly more with improved mapping, particularly if the Riparian Buffer Delineation Model is used to develop initial riparian habitat mapping. Riparian areas on the forest vary considerably in terms of structure and diversity, ranging from sedge/grass/forb communities to shrub/deciduous/tree communities. The biotic community varies across the continuity of stream systems in the plan area with high gradient first and second order streams supporting lower stature floodplain forest consisting of an assemblage of various willow species (*Salix* Spp.), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), boxelder (*Acer negundo*), American hophornbeam (*Ostrya virginiana*), hackberries (*Celtis* spp.), with scattered occurrences of bur oak (*Quercus macrocarpa*). Some sites may experience the intrusion of coniferous species including ponderosa pine (*Pinus ponderosa*) and white spruce (*Picea glauca*). Stands of eastern cottonwood (*Populus deltoides*) were formerly common along lower gradient stream systems, however these habitat types have undergone significant declines (Hoffman and Alexander 1987). Stands of Scouler's willow (*Salix scoulerlana*) may occur between transition zones from riparian to upland areas. Riparian stands often form mosaics of shrubs, trees, and open meadow. Back channels, also referred to as oxbows and cut-off meanders, and other wetlands support emergent wetland-obligate species. Common species in wetter sites that overlap with aquatic areas include arrowheads (*Sagittaria* spp.) bulrush (*Schoenoplectus* spp.), bur-reed (*Sparganium* spp.), sedge (*Carex* spp.), and cattails (*Typha* spp.).

Most riparian systems in the Black Hills have been severely degraded, with noted decreases in *Populus* and *Salix* cover (Hoffman and Alexander 1987). These declines are generally attributed to historic gold and hydro mining operations as well as historic and current water diversions to support mining efforts, and grazing pressures from both native ungulates and domestic livestock. Declines in the distribution and overall density of *Salix* have also been linked to disease or insects (Froiland 1962). Fire can also influence this system, however changes to the disturbance regime (e.g., flooding, dams, heavy grazing and trampling by both domestic animals and wildlife) are also factors.

Outside of floodplains, forests of quaking aspen and birch are located where groundwater produces adequate soil moisture to support deciduous trees. Riparian hardwood species include paper birch (*Betula papyrifera*), which are associated with higher elevation mesic northern aspects. Paper birch are often found in association with quaking aspen over burn scars, which may colonize smaller stream and drainage areas. High elevation riparian areas contain willows and water birch. The general elevation threshold between 4,000 and 6,240 feet may contain mixed stands of oak, ash, box elder, elm, and hawthorn. Lower elevation riparian shrublands contain western snowberry, gooseberry, currant, and rose with silver sagebrush occurring on floodplains (Hoffman and Alexander 1987).

Riparian areas support many wildlife species including native grazing ungulates such as Rocky Mountain elk (*Cervus elaphus nelsoni*), white-tailed deer (*Odocoileus virginianus dakotensis*) and mule deer (*Odocoileus hemionus*). Merriam’s Turkey (*Meleagris gallopavo merriami*) are associated with aspen and paper birch habitats.

Aspen and paper birch habitats support MacGillivray’s warbler (*Oporornis tolmiei*), Ovenbirds (*Seiurus aurocapillus*), western tanager (*Piranga ludoviciana*), Chipping sparrows (*Spizella passerina*), Swainson’s thrush (*Catharus ustulatus*), dusky flycatcher (*Empidonax oberholseri*), warbling vireo (*Vireo gilvus*), American robins (*Turdus migratorius*), mountain bluebird (*Sialia currucoides*), black-capped chickadee (*Parus atricapillus*), Northern flickers (*Colaptes auratus*), downy woodpecker (*Picoides pubescens*), Hairy woodpeckers (*Picoides villosus*), and Red-naped Sapsucker (Sphyrapicus nuchalis) (Shepperd 2002).

Groundwater-Dependent Ecosystems

In addition to the aquatic and riparian ecosystems described above, the Black Hills NF also supports a variety of inland freshwater groundwater-dependent ecosystems (table 1). These include ecosystems that are formed entirely underground or that require the surface expression of groundwater producing features such as springs and wetlands. They include the ecosystems that develop as a result of groundwater presence, including those that are entirely dependent on groundwater (obligate) to those that can survive fluctuating water availability (proportional dependency; Eamus et al. 2016).

Table 1. Groundwater-dependent ecosystem categories in the Black Hills National Forest plan area

Groundwater-Dependent Ecosystem Categories	Location and Water Dependence	Examples in the Plan Area
Subsurface	Karst and Aquifers are obligate ecosystems occurring below the surface and may convey waters to the surface at specific locations.	Deadwood, Madison, Minnelusa, Minnekahta, and Inyan Kara Aquifers
Phreatophytic	Phreatophytic Ecosystems depending on shallow subsurface groundwater occurring close enough to the surface for vegetation with deep tap roots to reach but does not reach the upper foot of the ground surface.	Vegetation communities whose root systems obtain water from the groundwater or the soil above groundwater. Includes some riparian systems.
Discharge	Surface water ecosystems that depend on groundwater that reaches or comes within one foot of the ground surface.	Springs, peatland, wetlands, lakes, streams, and riparian habitats

Source: Eamus et al. 2016, USDA Forest Service 2012.

Subsurface

Karst Ecosystems

An extensive network of caves has formed beneath the Black Hills NF, a result of the presence of water-soluble rocks in the geologic layers below. As water falls on the surface, it enters the subsurface through cracks, fractures, and holes. There, it further dissolves soluble rock and can carve out enlarged flow paths, creating karst systems that includes caves (Palmer et al. 2016). The most well-known caves of the Black Hills region are Jewel and Wind Caves located in the soluble rocks of limestone and dolomite that comprise the Madison Formation (Palmer 2016). Jewel Cave contains 180 miles, and Wind Cave contains 143 miles of mapped passages. They are the third and sixth longest known caves in the world. While these two features are not managed by the Forest Service, impacts on them are considered during planning because of the underground linkages between karst resources under the Forest Service's purview and the National Park Service management of Jewel and Wind Caves.

Karst ecosystems are delicate and finite. It is assumed that the formation of new caves has substantially slowed in the recent age and protection of caves like Jewel and Wind Cave is essential to their longevity. Threats related to karst ecosystems include groundwater contamination (Whallon and Crawford 1985).

Aquifers

The major bedrock aquifers beneath the Black Hills are the Deadwood, Madison, Minnelusa, Minnekahta, and Inyan Kara aquifers. Aquifers primarily receive recharge from infiltration of precipitation, and the

Madison and Minnelusa aquifers also receive substantial recharge from streamflow losses (Carter et al. 2003). A Precambrian aquifer is also present at the deepest layers of geologic formation. Major aquifers are associated with the Limestone Plateau and outcrops along the Hogback encircling the Black Hills region; and that the Precambrian aquifers are associated with the granite and metamorphic central core of the Black Hills.

In South Dakota, approximately 52 percent of the public drinking water systems rely solely on ground water and approximately 74 percent of South Dakota's citizens use ground water as their source of drinking water (Iles 2008). The South Dakota Department of Agriculture and Natural Resources (SDDANR) Drinking Water Program's mission is to protect public health and the environment. According to SDDANR Drinking Water Program, there are approximately 150 public drinking water systems in the Black Hills NF. The majority of these public water systems are privately owned and operated. They are used for campgrounds, summer camps, horse and other recreational camps, ranches, and stores. There are several small municipal water systems as well (South Dakota Department of Agriculture and Natural Resources, 2021). Because shallow water aquifers are used extensively for drinking water supplies, a primary concern is groundwater quality. A study of groundwater flow, quality, and mixing in relation to Wind Cave National Park was conducted during 2007–2010 to evaluate water-quality issues and to determine possible sources of groundwater contamination that may affect drinking water quality (Long et al. 2012). The study indicated that there were no contaminant concerns derived from sampled springs, sinks, or cave drips for the constituents analyzed (arsenic, nitrate plus nitrite, trace metals, tritium, and chlorofluorocarbons). Higher arsenic levels found in springs are likely the result of natural conditions from existing shale layers. Additional information is available in assessments from the USGS publications by Carter et al (2002 and 2003) in the Water Resources of the Black Hills Atlas and Groundwater atlas, which summarize conditions and concerns for both quantity and quality of groundwater resources in the region.

Lowering of the water table is also a concern, as availability of groundwater is dependent on being able to reach it with wells. Aquifer observation wells in South Dakota show that water levels have fluctuated during the period of record (previous 30-50 years), but that the average water table elevation has not substantially changed in the aquifers monitored, and in many cases, was higher in 2020 than in previous years (South Dakota Department of Natural Resources 2021). The USGS also maintains a system of groundwater monitoring wells that may be referenced in further detail.

Although the Black Hills have ample ground water, it is not always available. Water-producing units may be deep and difficult or expensive to access, may have undesirable water quality, or may not produce the amount of water needed or in the area needed.

Phreatophytic Ecosystems

Phreatophytic ecosystems are unique due to the type of vegetation species they support and they include riparian as well as other phreatophytic ecosystems in the Forest. This broad category of ecosystem types is comprised of plant species that rely on a groundwater table that can be reached by deep tap roots. This ecosystem type is often situated near aquatic ecosystems. Phreatophytic vegetation is always dependent on ground water and is therefore well correlated with the distribution of groundwater. The root systems of phreatophyte species are capable of penetrating to depths ranging from just over one foot to more than one hundred feet below the surface.

Discharge Ecosystems

Discharge ecosystems occur where groundwater emerges or reaches the upper twelve inches of the ground surface. These include springs, wetlands, lakes, streams, and some riparian habitats where ground water is closer to the surface. Consequently, there is no clear division with the riparian systems described above.

Hydrological changes are the primary influence on plant communities in this group. They typically support vegetation with low to dense cover dominated by sedges, with cattails and bulrush more prevalent in larger and deeper open water areas such as ponds and lakes. Wet meadows and prairies are comparatively drier, particularly in late summer. These sites support narrow small-reed (*Calamagrostis stricta*), sedges, and prairie cordgrass (*Spartina pectinate*). Depressional wetlands are found in the low parts of floodplains where water collects. These sites may also occur with strongly saline soils and halophytic plant species such as saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), and foxtail barley (*Hordeum jubatum*). Floodplain forests may have an open to closed canopy dominated by deciduous trees including plains cottonwood, green ash, and various willow species (*Salix* spp.) in the lower and midstory vegetation strata.

Springs

Thousands of springs are present in the Black Hills NF. Hundreds of these springs are artesian, or free-flowing, and originate from confined aquifers around the periphery of the Black Hills, which are the formative springs for flowing surface water features. Collectively, these springs are a large source of groundwater discharge, contributing to the flow of streams, creation of wetlands, and volume of lakes in the region.

Artesian springs generally emerge from or near outcrop areas of the Spearfish Formation, which is a low permeability hydrogeologic unit (Long et al. 2012). This formation has a high shale content, is interspersed with flowing groundwater in fractures, and has numerous cavities created by dissolved gypsum. Artesian springs in the southern Black Hills may flow upward through breccia pipes that allow groundwater from deep bedrock aquifers to emerge from overlying formations (Hayes 1999). Springs can be differentiated from waters originating in aquifers via temperature and hydrochemical conditions. A detailed account of spring types and geologic descriptions can be found in USGS publications by Carter et al (2002 and 2003).

Warm, or geothermal, springs are a unique feature of the plan area and a popular destination for tourism. Many of the warm springs in the area, such as those at Hot Springs, SD, have been developed into resorts, where waters are funneled into retention ponds or into buildings, and are lined by paved pathways. Warm springs have been recognized as a unique biological feature, since these habitats support several rare plant species found only in South Dakota. Recreation areas draw thousands of visitors each year. The only warm spring currently managed by the Black Hills NF is the spring complex associated with the J.H. Keith picnic site at Cascade, SD (Cascade Springs).

Peatlands

Peatlands which include the subtypes features of fens and bogs, occur where minerotrophic groundwater emerges at the surface, such as at the lower slopes of a hill or cliff or in floodplains, and are characterized by saturated soil conditions due to an elevated water table and the accumulation of organic material. Accumulation of organic matter in peatlands can be extremely slow. Some fens in Colorado are over 10,000 years old with organic soil accumulation rates ranging from 4.3 to 16.2 inches per thousand years (US Fish and Wildlife Service 1999). Due to these slow accumulation rates, these resources should not be considered renewable resources. There are over 2,400 known peatlands on the Black Hills NF (USFS 2022). Two notable examples include the McIntosh Fen and a small area on Middle Boxelder Creek. Plants and animals associated with springs and fens, such as Autumn willow (*Salix serissima*), are discussed in the At-Risk Species assessment.

Wetlands

Wetlands are areas where water is present at the subsurface or at the surface for some period of the year. These saturated conditions generally produce hydric soils and support wetland-specific plant communities (hydrophytes). Wetlands typically occur within floodplains adjacent to river or stream systems, or along the margins of lakes and ponds. In mountainous settings, depressional wetlands, wet meadows, slope wetlands, fens, and bogs are other wetland types that may be present. In general, wetlands provide a buffer to control runoff and improve water quality. Wetlands also contribute to groundwater recharge and support special habitat types. A summary of wetland types, counts, and total area within the Forest is presented in table 2.

Table 2. Summary of NWI features in the Black Hills National Forest

Wetland Type	Definition	Average Size (acres)	Count	Acres
Palustrine	Marshes, swamps, bogs, fens, and ponds	1.40	3,054	4,254
Lacustrine	Permanently flooded lakes and reservoirs	3.18	2,162	6,862
Riverine	Rivers and creeks (flowing water)	3.13	4,662	14,581
Total			9,878	25,697

The Forestwide standards and guidelines for riparian areas, water influence zones and wetlands apply wherever those ecosystems occur (USDA Forest Service 2006). USFS National Best Management Practices (BMPs; USFS 2012) also directs at a minimum a 100-foot buffer around water features known as the Aquatic Management Zone. These areas are defined in the current forest plan as follows:

- Riparian ecosystems are “the moist transition zone between the aquatic ecosystem and the relatively drier, more upland, terrestrial ecosystem(s). This transition zone can extend both laterally and longitudinally away from aquatic ecosystems, sometimes into headwater swales that have no defined stream channel. The riparian ecosystem is the area whose soil is relatively moister than the adjacent upland and whose vegetation growth reflects the greater accumulation of available water.”
- Water Influence Zones include “the land next to streams and lakes where vegetation plays a major role in sustaining the long-term integrity of aquatic ecosystems. This includes the geomorphic floodplain, riparian ecosystem, and inner gorge, and has a minimum horizontal width (from top of each bank) of 100 feet or the mean height of mature dominant late-seral vegetation, whichever is greater.”
- Wetlands include “those areas that are inundated by surface water or groundwater with a frequency sufficient to support and under normal circumstances do or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, fens, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.”

A list of specific lakes, streams, and open-water wetlands to which riparian direction would (or would not) apply are not identified in the forest plan, because the Forest Plan riparian direction applies unilaterally to all water features. Instead, a description of conditions is used to identify areas on the ground where plan direction applies.

The groundwater-dependent ecosystems and associated wetland and riparian ecosystems supported by ground water are critical components of Rocky Mountain and Great Plains landscapes. These ecologically diverse ecosystems occur at all elevations and latitudes and provide a number of economic and ecological functions. They are critical as wildlife habitat and as centers of biodiversity, and these ecosystems support many unique biogeochemical, physical, and ecological processes (Gage and Cooper 2013).

Black Hills Ecoregions

The Black Hills primarily lie within the Middle Rockies (6.2) Level III Ecoregion, which is a dry-domain, temperate-steppe ecoregion, and is unique enough to require its own province type: M334 Black Hills Coniferous Forest Province. The Black Hills are surrounded by, and a small portion of the Black Hills NF is within, the Northwestern Great Plains (9.3) Level III ecoregion (Omernik 1987). The essential feature of a dry climate is that annual evaporative water loss is greater than what is received from precipitation (Bailey 1995). As a result, the availability and dependence on groundwater is a driving force of ecosystem development and sustainability throughout the plan area. Direct losses of trees affect the hydrologic cycle within the forest, and roadways result in aquatic habitat fragmentation and degradation. Numerous streams and subsurface waterways originate within the forest and then flow radially away from the forest into the surrounding landscape.

Aquatic, riparian, and groundwater-dependent ecosystems comprise a small proportion of the overall landscape of the Black Hills NF and could all be considered rare. Region 2 Forest Service Handbook (FSH) 2509.25 has direction that springs and fens/peatlands are rare, irreplaceable water features. In general, riparian and associated aquatic ecosystems support a higher level of biodiversity as compared to adjacent upland areas (Goebel et al. 2003) and sites dominated by white spruce, American hophornbeam, paper birch, and ponderosa pine (Gabel and Gabel 2007). Several rare plant and animal species have been identified in association with these ecosystems and are addressed in the species accounts. Monitoring of USFS Region 2 sensitive species and species of local concern (SOLC) has been performed on the Black Hills NF. A review of these monitoring reports indicates the ecosystems supporting these species are generally stable with local grazing and off-highway vehicle (OHV) use causing degradation at some sites (USDA Forest Service 2010b).

Riparian and Wetland-Supported Vegetation Communities

Vegetation communities within the Black Hills NF are regionally distinct by definition; they occur in a region that is otherwise primarily composed of grasslands. The portion of the Black Hills NF in Wyoming covers less than 5% of the state but contains nearly 38% of the vascular plant species in the state (Fertig and Oblad 2000). Moreover, the aquatic, riparian, and groundwater-dependent ecosystems within the Black Hills NF are more likely to support sensitive plant species. An aerial view of the Black Hills NF illustrates its "island" characterization, as the hills emerge from the surrounding grasslands. The presence of small order streams with upper elevation headwaters that gather water volume and join larger water bodies downstream are unique to the region.

Riparian areas have higher biodiversity than surrounding habitats and support rare and endangered plants, fish, and wildlife. These types of phreatophytic ecosystems comprise a small amount of surface area and are generally degraded within the planning area (Hoffman and Alexander 1987). Of the 27 rare plants considered in a 2000 floristic inventory of the Black Hills of Wyoming, 15 species were wetland species, which contributed to 18% of species richness (Fertig and Oblad 2000). Rare plants and their association with riparian and groundwater dependent ecosystems, are described in the at-risk species assessment.

Dominant Characteristics of Aquatic, Riparian, and Groundwater-Dependent Ecosystems

The dominant characteristics of aquatic and associated riparian ecosystems include the presence of perennially, intermittent, or ephemeral surface water associated with lakes, ponds, and various channel type features. The presence of surface and shallow groundwater supports a variety of specific plant communities of numerous structural vegetation types, which in turn support a diverse assemblage of fauna. The characteristics of these ecosystems vary widely across a spectrum of ecotypes from mature deciduous riparian forests to permanently or seasonally saturated wetlands dominated by herbaceous plant species. The composition, function, and structure of these ecosystems is addressed above where they are described.

Aquatic, riparian, and groundwater-dependent ecosystems play a significant ecological role, typically support high levels of plant and wildlife biodiversity, and contribute to desired function of associated aquatic systems. Specific ecological functions of riparian systems include the presence of root systems that provide bank stability and reduce erosion, and riparian buffers that provide biological filtering and improved water quality (Anbumozhi 2005).

Please refer to the *Draft Assessment: Soils and Watersheds* for detailed discussion of the various watershed condition attributes. This assessment system uses 12 watershed indicators related to watershed processes. Under this framework, watersheds that are classified as "functioning properly" provide a high degree of biotic integrity, are resilient, exhibit a high degree of connectivity longitudinally along a stream as well as across the floodplain, provide ecosystem services, and maintain long-term soil productivity. A watershed classified as "functioning at risk" is in fair condition with moderate water quality problems, various dams and diversion facilities, and moderate habitat fragmentation (USDA Forest Service 2011).

This section assesses the general level of ecological function of each aquatic, riparian, and groundwater-dependent ecosystem and determines if the disturbance processes are operating within the desired range of variation. Anthropogenic influences on ecosystem drivers and changes induced from anthropogenic modification are also addressed. Water requirements vary across GD ecosystems. Ecosystems entirely dependent on groundwater are obligate GD ecosystems. These communities can be affected by changes in groundwater availability or quality.

The principal driver of riparian and aquatic ecosystems is the presence of water in greater quantities as compared to upland areas. The relative abundance of water in these ecosystems initiates a variety of biotic and abiotic processes that result in highly diverse habitats. Abiotic drivers of riparian ecosystems include floods and drought, which interact with plant regenerative dynamics. Flooding mobilizes sediment, scours substrates, removes bank and floodplain vegetation, and creates the seedbed for plant colonization.

Beavers may have been the most important biological influence on the Black Hills riparian ecosystems, particularly in low-gradient drainages that supported abundant deciduous woody species. Historically, beaver dam complexes and wetland conditions were abundant on low-gradient streams (Parrish et al. 996). Livestock grazing, reduced water yields, farming, road construction, and placer mining have all contributed to the conversion of historical wetlands to drier sites.

Karst formation in the planning area occurs when soluble rock is dissolved forming intertwined groundwater features. The rate of karst formation is strongly influenced by climate, including periods of increased precipitation and drought (USDA Forest Service 2018). Karst formation is particularly sensitive to climate and changes in precipitation (Theilen-Willige 2018).

Groundwater

In general, there is very little indication of long-term water-level declines from groundwater withdrawals in any of the bedrock aquifers in the Black Hills area (Carter et al. 2002b). This is supported by the long-term hydrograph for the Redwater Minnelusa well (Figure 26B; USGS 2003).

Wildland Fire Effects on Aquatic, Riparian, and Groundwater-Dependent Forest Ecosystems

Fire hazards in the vicinity of aquatic, riparian, wetland, and GD ecosystems may serve as a stressor to these systems when fire events in adjacent uplands spread into bottomlands.

The role of fire in the aquatic, riparian, and GD ecosystems described in this report is less clear and is generally understood to be influenced by fuel conditions in adjacent pine forests. Although the ecosystems considered in this section are generally wetter and less prone to catastrophic fire as compared to their general surroundings, the drying of these areas and conifer encroachment into riparian bottomlands may contribute to a higher fire recurrence interval. Fuel reductions in adjacent pine forest areas can contribute to a reduced probability of catastrophic fire impacting the areas considered in this section (USDA Forest Service 2005a).

Adaptations to Wildfire

Fire impacts to karst systems is largely dependent on the severity of the burn event; however, the effect of fire on karst processes is not well understood. High severity fire and resulting soil sterilization reduces the concentration of CO_2 in soil, which is an important component of the dissolution process. The removal of vegetation following a fire event may also change the surface hydrological inputs (Coleborn et al. 2015).

Although the aquatic, riparian, and GD ecosystems considered in this report are not typically prone to regular fire disturbance, post-fire flooding and other upland post-wildfire processes may contribute to significant alterations to stream integrity and function. Watershed conditions after high-severity fire events may transport undesirable amounts of sediment into aquatic systems, leading to decreased channel stability, more variable discharge, increased suspended sediment, removal of riparian vegetation, and negative impacts to fish populations (Driscoll et al. 2004). Hydrologic responses from post-fire precipitation events are largely dependent on the burn severity and resulting soil conditions. High-severity fire events are more likely to reduce canopy interception and increase the water repellency in soils, leading to increased runoff generation and potential impacts to stream systems (Hallema et al. 2017). Post-fire assessments of Black Hills NF fires consistently find a thin (2 mm or less) water repellent layer at the soil-ash interface in a mosaic pattern that is quickly broken with freeze-thaw cycling. Impacts to aquifers and other subsurface systems are not well understood (Rhoades et al. 2019) However, aerial observations of post-fire flooding have shown ash-laden waters flowing through stream systems until they abruptly ended surface flows into what was thought to be underground cave and karst features (USFS 2012).

Restoration Opportunities

In 2013, a total of 625 acres of riparian habitat had been restored or enhanced from 2003 to 2012. The report indicated that progress regarding the restoration of riparian shrub communities has been achieved throughout the Black Hills NF. Although the current state of riparian enhancement is unknown, the trend from 2003 to 2012 was attributed to increasing and persistent beaver activity, enclosures in riparian areas, and the planting of willows (USDA Forest Service 2014).

Large-scale, landscape restoration of riparian ecosystems involves modifications to the flood regime and floodplain as well as terrestrial and aquatic/riparian treatments. Specific watersheds are described in the Watershed Condition Framework, in which priority watersheds (6th level HUC12) are identified and projects are implemented across the watershed to improve conditions. Interactions between floodplain disturbance via periodic flooding of riparian zones and riparian regenerative processes are vital to restoring natural function to these corridors. Under the natural disturbance regime, fire is typically not a major disturbance factor. Several impacts to the structure and functioning of riparian areas through impacts related to human settlement, land use, and the modifications of natural flooding regimes by dams and other impoundments have been documented. Alterations to river hydrology have resulted in changes in geomorphic structure with considerable impacts to the physical and biological character of riparian areas. Additionally, there is a need for broad scale assessment and improvement of road-stream crossings for aquatic organism passage and flood flow passage. Potential priority watersheds have been identified previously and include several of the Rapid Creek and Spring Creek basins.

Insects, Disease, and Invasive Species within Aquatic, Riparian, and Groundwater-Dependent Ecosystems

Tree mortality caused by the mountain pine beetle (*Dendroctonus ponderosae;* MPB) has minimal direct effects on the watersheds, and therefore to the riparian and aquatic ecosystems in lower portions of the Black Hills NF that are not snow influenced. This can be attributed to increases in understory vegetation and tree regeneration in areas affected by the MPB, which filters run-off and minimizes changes to streamflow during normal or dry climactic conditions (Thom et al. 2020). However, beetle killed trees add fuels and change the fuel profile that can lead to larger and higher severity wildfires, which can impact water flow and sediment delivery. Watersheds experiencing post-fire effects can have potentially devastating effects to aquatic and riparian habitat either directly or due to erosion and sediment runoff.

In watersheds that are snow influenced, since insects and disease increase tree mortality, the resulting reductions of the forest canopy result in an earlier snow melt and some degree of increased runoff during periods when transpiration is low (Sheppard and Battaglia 2002).

The effects of MPB, and other insect species, on the forest is provided in more detail in the Insects, Disease, and Invasive Species Assessment.

Aquatic nuisance species (ANS) are defined as nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters. The Black Hills NF has developed an ANS Action Plan (USDA Forest Service 2014). An overview of ANS is provided in more detail in the Insects, Disease, and Invasive Species Assessment which also provides a list of potential ANS that may occur in Black Hills NF.

Infestations of didymo *(Didymosphenia geminata),* a diatom, in waterways of the Black Hills NF can have harmful effects on the native biota of these areas. Didymo is often referred to as rock snot and it can form thick, mat-like growths that can last for months. These mats often inhibit growth of native organisms that live on stream bottoms, which can have devastative impacts on aquatic food chains, including those of desirable game fish like trout (James 2015).

Another ANS, red-rimmed melania (*Melanoides tuberculata* a snail native to Africa and introduced to the U.S. by the aquarium industry), poses a risk to native aquatic ecosystems because it is a host to several pathogens that threaten native fish (Daniel et al. 2019). Chytrid fungus (*Batrachochytrium dendrobatidis*) is easily transferred from one waterbody to another and can cause disease in amphibian species.

The Black Hills NF uses the Watershed Condition Framework (WCF) to classify the functioning condition of watersheds on National Forest System lands (more information about the WCF is presented in the Soils and Watershed Assessment). The WCF is a 12-indicator model that considers both aquatic and terrestrial physical and biological indicators and rates each watershed as good (functioning properly), fair (functioning at risk), or poor (impaired function) according to a standardized rule set. The WCF includes an aquatic biological indicator, which includes a sub-indicator for exotic and/or invasive species. The sub-indicator ratings indicate that 53% of watersheds (50 of 95) are functioning properly, 27% of watersheds (26 of 95) are functioning at risk, and 20% of watersheds (19 of 95) are impaired. The WCF indicates that aquatic invasive species are potentially more of an impairment than terrestrial invasive species, given that 20% of sub-watersheds are impaired with respect to aquatic invasive species versus 2% for invasive species. An analysis of the South Dakota 'Least Wanted' ANS could provide further detail regarding high priority ANS species to consider in the Black Hills NF.

There is some indication that the didymo infestation in Rapid Creek is not impacting trout there. Since aquatic invertebrates are physical smaller in Rapid Creek than in comparable non-infested streams, trout are able to consume enough of them to maintain healthy growth and energy reserves (James 2015).

Landscape Level Conditions and Adaptations Within Aquatic, Riparian, and Groundwater-Dependent Ecosystems

Due to their position on the landscape, the health of aquatic, riparian, and groundwater-dependent ecosystems reflects, and is often an amplification of, the ecological conditions of the surrounding watersheds, whether or not those areas are within or outside of the Black Hills NF boundaries. The sustainability of the ecosystems within the plan area are heavily influenced by conditions of the broader landscape, especially considering the extensive in-holdings of private and non-Forest lands within the Black Hills.

The conditions of the broader landscape are determined by a combination of natural processes and human management actions. This section addresses the natural aspects of these conditions. The quantity, quality and timing of precipitation and surface water runoff are fundamental characteristics of lake, stream, and wetland ecosystems, and these are determined by conditions upslope and upstream. Similarly, groundwater availability is also a product of natural variation driven by conditions across the broader landscape, such as the characteristics of the underlying geological formations, rates of aquifer recharge, etc. The health of riparian and phreatophytic vegetation communities is closely related to landscape-scale conditions in the upland forests and terrestrial ecosystems, which are affected by the fire regime, intensity of drought and flooding, invasive species, insects and diseases, etc.

The aquatic, riparian, and GD ecosystems of the Black Hills NF are dynamic and experience a constant flux of drivers from the surrounding landscape. Lake levels are determined by a balance of inputs from surface and groundwater with outputs from evaporation, percolation and released reservoir flows. The morphology of streams is dictated by the amount and timing of flow, along with sediment, wood, and nutrient inputs. Phreatophytic vegetation communities are structured by the availability of water that can vary seasonally and year to year. All of these ecosystems have adapted over millennia to a range of variation in these dynamic landscape-scale drivers.

Natural riparian ecosystems, particularly in areas with broad floodplains, are typically composed of a patchwork of early- to mid-seral stage plant communities held in a dynamic equilibrium that is maintained by a relatively frequent hydrologic disturbance regime. The primary source of disturbance is flooding and seasonal flow fluctuation that can alter the planform of the river or stream, erode banks, deliver water to off-channel features and generally reset plant growing conditions on a regular basis. Riparian disturbance can also be caused by upland/terrestrial influences such as fire and insect infestation, along with a host of human caused disturbances such as grazing and development. These upland disturbances and land use practices can alter watershed hydrologic processes, create uncharacteristic fire events, which may lead to channel degradation and water quality impairments.

In the Black Hills, the generalized pathway of forest succession includes mid-seral stage aspen and other deciduous forests eventually becoming late-seral stage ponderosa pine and white spruce dominated forests, barring any disturbance. Two natural sources of disturbance historically maintained the presence of hardwood forests across the landscape and in riparian areas: fire and beavers.

The effect of beavers in maintaining mid-seral stage riparian plant communities through hydrologic alteration and frequent disturbance is believed to have been profound (Parrish et al. 1996). The cycle of riparian succession caused by beavers begins with colony establishment and dam building to impound water and raise the water table, which improves growing conditions for willows and other deciduous species. However, eventually overbrowsing causes the beavers to migrate, which results in unmaintained dams that fail and expose nutrient rich substrates to support reestablishment of riparian and transitional semi-mesic plant communities. The removal of beavers from the landscape has led to less frequent disturbance to riparian ecosystems and encroachment of coniferous tree species (Hoffman and Alexander 1987).

Terrestrial and Aquatic Resources within Aquatic, Riparian, and Groundwater-Dependent Forest Ecosystems

As described previously, riparian ecosystems represent the interface between terrestrial and aquatic ecosystems, and as such they are affected by changes to either one. The most significant changes to the terrestrial ecosystems (described in the Soils and Watersheds Assessment) that affect riparian ecosystems include livestock grazing, which can profoundly change the type of plant communities in riparian zones. In addition, timber harvesting and road building can lead to changes in sediment delivery and erosion within riparian areas. In addition to beaver trapping and dam removal (described above), reservoir construction and operation activities have resulted in withdrawals for irrigation and other uses and changes in the quantity, quality, and timing of water flows in downstream reaches.

Effects of Climate Change on Aquatic, Riparian, and Groundwater-Dependent Forest Ecosystems

Climate trends and projections of future climate are discussed in *Climate Change Vulnerability in the Black Hills National Forest* (Timberlake et al. 2022). Altered snowpack and hydrologic regimes may exert significant stress on riparian ecosystems in the Black Hills. In general, a warmer climate and reduced soil moisture may cause riparian areas to decrease in size over time. Additionally, riparian areas are expected to experience secondary effects from increasing fire events and the expansion of invasive plant species (Dwire et al. 2018).

Riparian systems are impacted by the environmental stress resulting from a warmer climate and an altered hydrologic regime. Land management techniques related to resiliency have been offered to ameliorate the effects of climate change. Land management proposals include fire-hazard reduction in upland conifer-dominated settings to prevent the spread of fire into riparian areas. These treatments include removal of small diameter fuels to reduce fuel loads and prescribed burning where low to moderate severity fire protects soil characteristics and allows for the rapid recovery of organic material and vegetative ground cover.

Human Influences on Aquatic, Riparian, and Groundwater-Dependent Forest Ecosystems

Human influences, including Forest Service management, can have extensive effects on the processes that sustain aquatic, riparian, and groundwater-dependent forest ecosystems. This section explores the effects on three specific components: water quality, fish migration barriers, and sediment transport.

Myriad human influences play a role in determining the current composition, structure, function, and connectivity of aquatic, riparian, and groundwater-dependent ecosystems in the Black Hills NF. These influences are manifested across different geographic and temporal scales. While a comprehensive list of these human influences is not possible due to their pervasiveness, the general categories include water use (stream diversions, reservoirs, ditches, groundwater extraction), mineral extraction, transportation (roads, trails, culverts), recreation, biological control (invasive species, beaver removal, pesticides), vegetation management (timber harvest, livestock grazing, wildland fire management), and urbanization (Gage and Cooper 2013).

Water temperature in aquatic systems can be altered by increases in air temperature caused by a changing climate, the impoundment of water in large reservoirs, the reduction of summer flows in streams due to diversion for agricultural, municipal, or industrial uses, the loss of riparian vegetation that reduces shade along the water's edge, and changes in stream and wetland characteristics that alter the dimension, pattern or profile of their features. The chemical composition of water is affected by potential acid mine drainage from legacy mining operations in the region, which can lead to elevated concentrations of heavy metals. Pesticide treatments to the surrounding landscape, other pollution inputs from urbanized areas, and elevated bacteria levels from high densities of livestock near water features also result in adverse effects.

Broad-scale water quality monitoring in the Black Hills NF is not conducted by the Forest Service; however, the Forest Service works cooperatively with the states to conduct project-level monitoring and employ best management practices in compliance with state mandates and the Clean Water Act (USDA Forest Service 2009, USDA Forest Service 2013). Beyond the project-level, the focus of water quality monitoring is on water bodies that may not be meeting established beneficial uses or that are listed as impaired on the State's 303(d) list.

Barriers in water courses occur across the stream networks of the Black Hills NF and can affect the distribution of fish species. In addition to natural barriers (e.g., waterfalls or seasonally dry reaches), anthropogenic barriers include dams, road culverts, and diversion structures. Barriers may result in adverse effects to native fish populations by preventing migration to productive habitat; however, they can also be useful for managers to prevent dispersal of non-native species that may otherwise compete with sensitive native fish. The presence of stream barriers may preserve the genetic integrity of certain fish species and therefore be beneficial to the system, whereas other fish barriers may restrict the spawning migrations of fish. The presence or absence of these features must be considered on an individual stream basis.

The rate of sediment delivery to aquatic and riparian ecosystems has been altered by human actions, in many cases leading to adverse effects on fish habitat. Direct removal of vegetation (timber harvest), grazing, roads and urbanization all tend to increase the rate of sediment entering streams. Long-term suppression of the natural wildland fire regime has resulted in high-intensity fires that also lead to loss of vegetation and alteration of soil properties, making them more susceptible to erosion post-fire.

Adaptations to Human Influence

The extensive nature of human influences on aquatic, riparian, and groundwater-dependent ecosystems in the Black Hills NF have resulted in permanent changes to the landscape. Climate change has influenced the landscape to the extent that objectives defined in the forest plan need to be analyzed to ensure they are being met. In areas where the ecosystems have been anthropogenically altered to the point that they are not meeting the objectives defined in the forest plan, restoration actions should be taken to reestablish historic conditions to the extent possible given climate change will continue to alter the landscape. The effectiveness of management actions within the Forest are monitored and evaluated (USDA Forest Service 2015), but the degree to which ecosystems on the forest are withstanding and recovering from human influence is difficult to determine based on available data. Comparative studies or monitoring programs are required to assess the condition and trend of these systems.

In general, the composition, structure, function, and connectivity of riparian ecosystems have varying abilities to withstand levels of disturbance, whether from natural or human sources. If chronic anthropogenic stressors can be removed or minimized through land and resource management actions at the appropriate scale, these ecosystems should be able to recover within the range of natural variation; however, even in the absence of direct human influence, climate change will continue to exacerbate landscape-level changes.

The *Final Environmental Assessment and Record of Decision for Black Hills National Forest Phase II Amendment to 1997 Land and Resource Management Plan* suggests that riparian conditions have improved across the Black Hills NF in response to ongoing efforts to implement best management practices, reduce sediment delivery from roads, exclude livestock, and re-plant woody shrubs (USDA Forest Service 2005a). It will take years of continued monitoring and data collection to determine if these treatments are ultimately successful and to reveal the long-term effects of human influences on the hydrology, fire regime, and other drivers/stressors of riparian ecosystems.

Considerations for Managing Multiple Use within Aquatic, Riparian, and Groundwater-Dependent Forest Ecosystems

Riparian areas support multiple uses such as recreation, livestock watering, and irrigation, while also providing important ecosystem services. These areas support wildlife habitat, improve water quality through pollutant filtering, and provide flood dampening and maintenance of water tables. To continue providing services for these multiple uses and to prevent degradation and preserve ecosystem services, riparian areas require special management attention. BMPs for riparian systems are designed to preserve or enhance ecosystem services in these settings. BMPs include maintaining water quality, managing wildlife habitat, and enhancing floodplain interaction with the channel. Additionally, activities such as restoration and maintenance of riparian features to maintain stable conditions will prevent degradation and continue to support multiple uses.

Diffuse sources of nonpoint source pollution can lead to water quality problems. Sediment is the most common nonpoint source pollutant. Various management practices can address nonpoint sources to support multiple uses and ecosystem services, including riparian buffers, removal of stream crossings, and the closure of high value riparian areas to public use (Philips et al. 2000). The potential for dispersed recreation impacts is high in riparian areas, however, they have a low potential for developed recreational uses because *Populus* is damaged easily and does not survive high intensity use (Hoffman and Alexander 1987).

Impacts to riparian and wetland ecosystems result from direct disturbances such as the clearing of vegetation, over-utilization by livestock or wildlife, development of roads, or trails (e.g., stream crossings), placement of fill material (e.g., development in a floodplain), and wildfire. Additionally, indirect disturbances on riparian resources can result from upstream and downstream activities in the Black Hills NF. These disturbances may include channelization downstream that causes stream channel adjustments upstream; post fire flooding from burned hillslopes upstream; dewatering of a stream resulting from construction of impoundments upstream that capture spring-fed source; and loss of riparian habitat and channel bed features due to dewatering activities.

The compatibility of multiple uses and maintaining ecosystem integrity is uncertain. Recreational uses generally adversely impact riparian ecosystem integrity. Riparian corridors and associated surface water features support biodiversity and also attract human disturbance. Aquatic and groundwater-dependent habitats attract a unique assemblage of fish and wildlife, which in turn attracts human interest, including recreational uses such as hunting, fishing, birdwatching, photography, and enjoyment of nature.

It is challenging to assess the adaptive capabilities of aquatic, riparian, and GDE resources as few inventories and current assessments exist with which to do so. Additional data collection is needed to inform the effects of multiple uses on these resources and to implement management strategies.

Management

Forest Plan Direction

The Black Hills National Forest 1997 Land and Resource Management Plan contained management direction to manage for aquatic, riparian, and groundwater-dependent ecosystems. Original direction was revised in 2005 during the Plan II amendment process in order to better provide for species conservation and fire and insect hazard reduction. The current management direction for these ecosystems is listed below.

Forestwide Goals and Objectives

- Protect basic soil, air, water and cave resources (Forestwide Goal 1),
- Use a qualitative survey which emphasizes riparian condition, such as the Proper Functioning Condition methodology, to refine the preliminary watershed health assessments (FP-FEIS, Appendix J) within the next planning period. This survey would focus first on Class III watersheds, and could be supplemented with additional quantitative methods, as needed, for the design of watershed improvements. Class I watersheds do not need to be surveyed unless information becomes available which suggests there was an error in classification (Forestwide Objective 102),
- Maintain or improve long-term stream health. Achieve and maintain the integrity of aquatic ecosystems to provide stream-channel stability and aquatic habitats for water quality in accordance with state standards (Forestwide Objective 103),
- Maintain or enhance watershed conditions to foster favorable soil relationships and water quality.
    - Implement projects to improve watershed conditions on an average of at least 300 acres annually over the plan period.
    - Achieve and maintain stable stream beds and banks, diverse riparian vegetation, and effective ground cover that controls runoff and erosion (Forestwide Objective 104),
- Prohibit motorized vehicle use in wetlands, wet meadows and riparian areas, except at specified locations and times of the year (Forestwide Objective 105),
- Manage water-use facilities to prevent gully erosion of slopes and to prevent sediment and bank damage to streams (Forestwide Objective 106),
- Restore degraded wetlands except where exemptions are allowed by a Clean Water Act Section 404 permit (Forestwide Objective 107),
- Manage for sustained or improved water flows (Forestwide Objective 108),
- Maintain or enhance existing riparian area biodiversity, physical structure and size.
- Restore riparian shrub communities across the forest by 500 acres during the Plan period on sites capable of supporting this community (Forestwide Objective 214),
- Manage for at least five stream reaches in a rehabilitated condition during the Plan period. Select reaches where the water table has receded and plant species composition has changed as a result of human activities. Coordinate planning and implementation with state game and fish agencies and downstream private landowners. Use Objective 215 a through d in designing the projects.
    - a. Raise the water table to saturate historically inundated soils.

  - b. Convert drier-site vegetation to native wet-meadow species.
  - c. Reintroduce beaver into the drainage once suitable habitat is developed.
  - d. Design management to maintain wet-meadow conditions (Forestwide Objective 215),
- Maintain or improve instream fisheries habitat. Cooperate with state agencies in aquatic ecosystem improvements to meet mutually agreed-upon objectives (Forestwide Objective 219), and
- Manage and/or install structures to provide water for livestock and to protect the aquatic, shoreline and upland vegetation around ponds or water catchments containing leopard frogs (Forestwide Objective 240).

Forestwide Standards and Guidelines for Water

- Conduct actions so that stream pattern, geometry, and habitats are maintained or improved toward robust stream health (Forestwide Standard 1201),
- Move stream channels only if all other practical alternatives to protect critical resources or capital investments have been exhausted and other legal requirements have been met. If streams are put in channels:
  - a. Use methods that create stable beds and banks and beneficial aquatic habitat features; and
  - b. Use stream geometry relationships to reestablish meanders, width/depth ratios, etc. consistent with each major stream type (Forestwide Guideline 1202),
- Design and construct all stream crossings and other instream structures to provide for passage of flow and sediment, withstand expected flood flows, and allow free movement of resident aquatic life (Forestwide Standard 12003),
- Naturally occurring debris shall not be removed from stream channels unless it is a threat to life, property, important resource values, or otherwise covered by legal agreement (Forestwide Guideline 1204),
- When projects are implemented which can affect large, woody debris, retain natural and beneficial volumes of large, woody debris for fish habitat, stream energy dissipation, and as sources of organic matter for the stream ecosystem (Forestwide Guideline 1205),
- When stabilizing damaged stream banks, preferentially use methods that emphasize vegetative stabilization. Use native vegetation for streambank stabilization whenever possible (Forestwide Guideline 1206),
- Manage water-use facilities to prevent gully erosion of slopes and to prevent sediment and bank damage to streams (Forestwide Standard 1207),
- Design water developments to minimize damage to channel capacity, aquatic habitat and riparian vegetation (Forestwide Guideline 1208),
- Manage vegetation treatments so that stream flows are not changed to the extent that long-term stream health is degraded (Forestwide Standard 1209),
- Maintain enough water in perennial streams to sustain existing stream health. Return some water to dewatered perennial streams when needed. Comply with Section 505 of the FLPMA and 36 CFR 251.56 when issuing and re-issuing authorizations for water storage and diversion facilities (Forestwide Standard 1210),
- Place new sources of chemical and pathogenic pollutants where such pollutants will not reach surface or ground water (Forestwide Standard 1211),
- Apply runoff controls to disconnect new pollutant sources from surface and ground water (Forestwide Standard 1212),
- Apply chemicals using methods which minimize risk of entry to surface and ground water (Forestwide Standard 1213),

- Where natural background water pollutants cause degradation, it is not necessary to implement improvement actions. Short-term or temporary failure to meet some parameters of the applicable federal or state standard, such as increased sediment from road crossing construction or water resource development, may be permitted in special cases (Forestwide Guideline 1214),

Forestwide Standards and Guidelines for Riparian Zones, Water Influence Zones, and Wetlands

- In the water influence zone next to perennial and intermittent streams, lakes, and wetlands, allow only those actions that maintain or improve long-term stream health and riparian ecosystem condition (Forestwide Standard 1301),
- Maintain long-term ground cover, soil structure, water budgets, and flow patterns in wetlands to sustain their ecological function, per 404 regulations (Forestwide Standard 1302),
- Vegetative type conversion should only be done in riparian areas to reestablish riparian vegetation for the protection and/or enhancement of those ecosystems (Forestwide Guideline 1303),
- As opportunities arise, and need dictates, relocate or implement mitigation measures for roads, trails, watering tanks, ponds, water catchments, and similar facilities currently located within the Water Influence Zone (Forestwide Standard 1304),
- Locate camping sites for contractual purposes (e.g., mining, logging, etc.) such that channel and riparian areas are not impacted (Forestwide Standard 1305), and
- Prohibit log landing, decking areas and mechanical slash piling within riparian areas unless the integrity of the riparian area can be protected (e.g., frozen, snow-covered ground conditions) (Forestwide Standard 1306).

Forestwide Standards and Guidelines for Managing Rangeland Activities in Wetlands and Riparian Areas

- Residual levels (or remaining height of key plant species) will be prescribed for riparian areas in the allotment management plan (AMP) or the annual letter of operating instructions (AOI) to the livestock permittee. Residual levels will be based upon specific objectives for the location in question and will consider season of use and range conditions (Forestwide Standard)
- Allowable use and/or residual levels:
  - c. Utilization of willows, shrubs, woody vines or young deciduous trees (such as aspen, birch and oak) in any year by livestock or wildlife is limited to browsing 40 percent of the total individual leaders produced in that year (not to be confused with 40 percent use on each and every leader produced).
  - e. No authorized utilization will be allowed by domestic livestock on known occurrences of willow emphasis species (e.g., *Salix candida*, *Salix serissima*, *Salix lucida*).
  - f. Implement additional measures to assure avoidance of livestock use on *Carex alopecoidea*. Restrict livestock use of all or portions of 5 of the largest geographically spaced occurrences at site numbers: CAAL8-19, CAAL8-20, CAAL8-22, CAAL8- 30, CAAL8-31. STANDARD (Forestwide Standard).
- Allow use of forage by livestock and wildlife in fenced riparian pastures so long as it meets the objectives of maintaining, enhancing, or conserving the riparian ecosystem and emphasis species persistence (Forestwide Standard 2507).

Forestwide Standards and Guidelines for Endangered, Threatened or Sensitive Species – Protection and Management

- Do not develop springs or seeps as water facilities where sensitive species or species of local concern exist unless development mitigates an existing risk (Forestwide Standard 3104),
- Riparian areas or wetlands where populations of sensitive species are located are to be avoided during ground disturbing activities. Use one or more of the following (or other mitigation measures) tied to the site-specific conditions for disturbances adjacent to known occurrences:
  - a. Avoid removing riparian or wetland vegetation; filling or dredging the riparian area or wetland; diverting stream flow from the current channel.
  - b. Prevent storm runoff from washing silt into the stream or wetland.
  - c. Reseed and/or replant cut and fill slopes with native seed and/or native plants promptly to control erosion and for prevention of noxious-weed infestations. Use appropriate measures to control erosion on disturbed areas that are steep, are highly erosive, and/or adjacent to the riparian area.
  - d. Timing, placement, and installation of temporary stream diversions shall allow passage of aquatic life and protect sensitive and species of local concern (Forestwide Standard 3106).

Forestwide Standards and Guidelines for General Wildlife and Fish in Riparian Areas

- Provide riparian habitat by maintaining or establishing riparian shrub and tree species, and protect riparian habitat from animal damage if needed (Forestwide Guideline 3210),
- Provide riparian habitat diversity through vegetation treatments or in conjunction with other resource activities designed to maintain or improve wildlife or fisheries habitat and stream stability (Forestwide Guideline 3211),
- Manage for high quality riparian communities.
  - a. Provide stable stream banks.
  - b. Retain woody vegetation along streams and lakes to provide shading for aquatic life and habitat for terrestrial species.
  - c. Provide large woody material for aquatic life (Forestwide Guideline 3212), and
- Plan and implement lake- and stream-habitat improvement projects so that they harmonize with the visual setting and incorporate discussions with other federal and state agencies. Include dredging lakes and ponds among potential projects when appropriate and cost-effective to enhance or maintain resources. Plan projects using site-by-site analysis (Forestwide Guideline 3213).

Forestwide Standards and Guidelines for Transportation and Travel Management in Riparian Areas

- Prohibit land vehicles from entering perennial streams where resource damage would occur except to cross at specified points (Forestwide Guideline 9107),
- Vehicular traffic, except for snowmobiles, will be restricted to roads and trails in riparian areas (Forestwide Guideline 9108), and
- Walk-in fisheries are closed to motorized travel (Forestwide Guideline 9109).

Additional forest plan management direction applies to specific management areas, as detailed in the 1997 Black Hills National Forest Land and Resource Management Plan (USDA Forest Service 2006).

A more recent large project, the Black Hills Resilient Landscapes Project, is primarily designed to respond to recent mountain pine beetle infestations in the Black Hills NF. Individual site-specific projects implemented under this landscape project are primarily oriented towards the extensive pine landscapes in the Black Hills NF, however, the implementation of these treatments is expected to reduce the risk of impaired water quality that may result from wildfire (USDA 2018).

Other Forest Service Direction

Forest Service Manual and Handbook Directives contain legal authorities, objectives, policies, responsibilities, instructions, and guidance for resource management on National Forest System lands. Forest Service Manual Series 2000 contains several chapters that address aquatic, riparian, and groundwater-dependent ecosystems. Forest Service Handbook 2500, Watershed and Air Management and Forest Service Handbook 2600, Wildlife, Fish, and Sensitive Plant Habitat Management contain additional guidance.

Other Federal Laws, Policies, and Executive Orders

A number of other pieces of guidance exist, including the National Environmental Policy Act, the Clean Water Act, Executive Order 11988 Floodplain Management, and Executive Order 11990 Wetlands that direct Forest Service activities in aquatic, riparian, and groundwater-dependent ecosystems.

Potential Needs for Change

Where there are stressors and drivers for aquatic, riparian, and groundwater-dependent ecosystems as described in this document, there are potential needs for change. Below, those needs for change are briefly discussed.

1. Mining and Grazing

Declines in riparian system habitat have been attributed to historic gold and hydro mining operations as well as historic and current water diversions to support mining efforts. Grazing pressures from both native ungulates and domestic livestock are prevalent throughout the forest. These all contribute to the degraded conditions seen in many riparian, aquatic, and wetland ecosystems across the Forest.

2. Road Crossings, Water Diversions

There is a need for broad scale assessment and improvement of road-stream crossings for aquatic organism passage and flood flow passage. Potential priority watersheds have been identified previously and include several of the Rapid Creek and Spring Creek basins.

3. Post-Fire Direct and Indirect Effects

Upland disturbances and land use practices can alter watershed hydrologic processes. Uncharacteristic fire events are becoming more prevalent in forested areas. Evaluation of impacts to the watershed, especially post-fire short term and long term effects require detailed evaluation and analysis. Extreme fire events become a stressor that is unforeseen and hard to plan for. Evaluation of the current state of disturbance regimes and planning for future disturbance regimes can aid in planning for such events.

The following Potential Needs for Change are also noted in the Soils and Watersheds Assessment.

4. Climate change – Climate Change in the Black Hills is predicted to be warmer and drier than currently in the summers (CCVA). While winters are expected to receive more precipitation that may help to restore aquifer levels, the hotter summers with lower than average precipitation could increase wildfire risk and may also prolong the peak wildfire season.

More water is expected to be lost than average to evapotranspiration during warmer summers, further stressing ecosystems. Since most water resources in the Black Hills NF are groundwater fed, there may be opportunities for water managers to alter current water operations. If water is conserved more in the winter, when precipitation is expected to increase, it may be possible to balance the decreased runoff expected in the drier summer months and keep rivers and streams wetter for longer. Continued population increase, resulting in increased demand for water use may offset or further decline water tables.

5. Aquatic Habitat – Climate change could potentially reduce flows in the summer months and impair aquatic habitat. There are opportunities to remove instream barriers at road stream crossings to promote stream connectivity over a range of flows and environmental conditions. These actions can improve aquatic habitat by creating passage for fish and suitable habitat at a range of flow conditions. More information about climate change and its potential impacts is available in the Climate Change Vulnerability in the Black Hills National Forest assessment.

6. Wetland Restoration – Protect, restore, and/or reconnect degraded wetlands adjacent to or connected to stream systems for improved stability and to improve favorable water flows, habitat quality and water quality. Examples include fencing to exclude livestock; stream restoration to restore channelized flows to natural stream dimensions, pattern, and profile; enhance in-stream habitat for fisheries; and wetland restoration such as restoring water tables and wetland vegetation through arresting head cutting that is dewatering wetlands and peatlands, and vegetation plantings; and relocation or reclamation of roads and trails that cross or are immediately adjacent to springs, streams, and wetlands.

Actions of Others

The management of surface and groundwater resources may impact the functioning and integrity of the ecosystems discussed in this assessment. Surface water quality and groundwater regulation is provided by two state agencies: the South Dakota DENR and Natural Resources and Wyoming Department of Environmental Quality. Coordination with these regulatory bodies regarding the protection and enforcement of water quality standards and the protection of water resources is critical. The DENR conducts a biennial assessment of South Dakota's lakes that delineates areas of source water, lists an inventory of contaminants, and provides vulnerability ratings from aquifers throughout the state (DENR 2020).

Chapter 3. Public Participation in the Planning Process

This section may have some placeholders until after the public has had chance to review the assessment reports and the Black Hills NF has completed other public engagement activities.

Public Interest

The most likely to be interested in this topic are those currently who live or recreate in or near the Black Hills NF, those who rely on the resources for their livelihoods, and those whose water supply depends on the Black Hills NF. Pending additional outreach, this section will be revised to reflect current interest and comments.

Future Involvement

Pending additional outreach, this section will answer how do stakeholders want to be informed about this topic as the planning process proceeds.

Public Information Needs

Pending additional outreach, this section will answer what is confusing about this topic and what follow-up could improve understanding?

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