United States Department of Agriculture

Riparian Ecosystems of the Salmon-Challis National Forest: An Assessment of Current Conditions in Relation to Natural Range of Variability

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Forest Service | Rocky Mountain Research Station | General Technical Report RMRS-GTR-394 | June 2019

Driscoll, Katelyn P.; Smith, D. Max; Warren, Steven D.; Finch, Deborah M. 2019. **Riparian ecosystems of the Salmon-Challis National Forest: An assessment of current conditions in relation to the natural range of variability.** Gen. Tech. Rep. RMRS-GTR-394. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 190 p.

Abstract

This assessment was conducted to provide information on the current conditions of riparian, wetland, and groundwater-dependent ecosystems in reference to their natural range of variation on the Salmon-Challis National Forest during forest plan revision. We used peer-reviewed literature, data from the Forest and other partners, and site visits to evaluate the status of eight key ecosystem characteristics: (1) distribution and connectivity of riparian ecosystems, (2) distribution of groundwater-dependent ecosystems, (3) surface water and groundwater fluctuations, (4) water quality, (5) channel and floodplain dynamics, (6) condition of spring runout channel, (7) composition and condition of riparian ecosystems, and (8) composition and condition of groundwater-dependent ecosystems. We determined that riparian, wetland, and groundwater-dependent ecosystems of the National Forest have experienced stressors that have influenced their current conditions, including livestock and wild ungulate grazing, altered streamflow and fire regimes, road construction, timber harvest, invasive and encroaching species, vegetation mortality due to insects and disease, and altered temperature and precipitation regimes. Some units of the Forest, particularly the North Fork Ranger District and sections of the Salmon-Cobalt and Middle Fork Ranger Districts, appear to be more resistant and resilient to stressors. Our results have been incorporated in ecosystem assessments completed during the forest plan revision process and will be useful to resource managers and planners during efforts to restore and/or maintain riparian, wetland, and groundwater-dependent ecosystems on the Salmon-Challis National Forest.

Keywords: forest plan, key ecosystem characteristic, riparian vegetation, flow regime, channel morphology, floodplain

Cover photo

Black cottonwoods (*Populus trichocarpa*) along Morse creek, with the Pahsimeroi Valley and Lost River Range in the background (photo by D.M. Smith, USDA Forest Service).

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Acknowledgments

We thank the Intermountain Region of the USDA Forest Service for financial support to conduct this assessment. We are grateful to employees of the Intermountain Region's Regional Office for their insights and particularly Mark Bethke for his oversight and support of the project, and Jeff Bruggink, Gina Lampman, Mark Muir, and Cynthia Tait for assistance in identifying goals, process, reviews, and points of contact on the Salmon-Challis National Forest. We appreciate the Salmon-Challis staff, including Bart Gammet, Dave Deschaine, Jeremy Back, and Josh Milligan, for supplying data, assisting site visits, and reviewing early drafts of this report. David Hawksworth provided research and editorial assistance.

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Introduction

Background and Objectives

We conducted this assessment of riparian, wetland, and groundwater-dependent ecosystems (GDEs) as part of an agreement between the USDA Forest Service Intermountain Region (Region 4) and the Rocky Mountain Research Station. The objective was to assist with revision of National Forest management plans under the 2012 Planning Rule (36 CFR Part 219). We designed methods to meet requirements outlined in the rule to complete a rapid assessment of ecological integrity that identifies and considers existing information and data relevant to the plan area. Ecological integrity is "the quality or condition of an ecosystem when its dominant ecological characteristics occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence." The rule specifies that the assessments should address drivers and stressors, as well as structure, function, composition, and connectivity of terrestrial and aquatic ecosystems. Recognizing that ecological systems cross administrative boundaries, the rule uses an "all-lands approach" that requires consideration of how conditions outside the National Forest influence resources on the Forest and how actions on the Forest impact resources beyond the boundary. The assessment was used by the Forest to understand ecological conditions under the current plan and to identify needs-for-change to be addressed by the updated forest plan.

We completed this assessment for the Salmon-Challis National Forest (SCNF) by synthesizing information obtained through literature review, data compilation, and site visits. The first draft of this report was completed in September of 2017. We incorporated comments from the Intermountain Regional Office and SCNF staff into this final assessment of ecological integrity of riparian ecosystems, wetlands, and GDEs.

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 systems shape riparian areas across three dimensions, with one dimension extending from the headwaters of a stream to its mouth, the second 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). Drivers of riparian structure and function include volume and timing of stream flows, watershed geology, channel geomorphology, extent of area inundated by surface water, fluctuations in depth to groundwater, evapotranspiration, and fluvial influences such as cut and fill alluviation (Gregory et al. 1991; Naiman and Decamps 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 brief periods of intense precipitation or seasonal snowmelt runoff and little to no connection with the water table, do not typically support riparian vegetation (Barrett et al. 1993; Meinzer 1923).

Groundwater is defined as "all water below the ground surface, including water in the saturated and unsaturated zones" (USDA FS 2012a,b,c). With this in mind, GDEs are "communities of plants, animals, and other organisms whose extent and life processes are dependent on access to or discharge of groundwater" (USDA FS 2012a,b). These systems occur where water discharges from the aquifer and can strongly influence local and regional biodiversity (Murray et al. 2006). On the SCNF, GDEs include springs, fens, some streams and rivers, and riparian wetlands along gaining river reaches, all of which may provide habitat for rare flora and fauna. In the GDE sections of this report, we focus on spring and wetland GDEs, with riparian areas and stream segments covered in the other sections. Springs are entirely supported by groundwater, while groundwater-dependent wetlands may receive additional inputs from surface water. Fens are wetlands supported primarily by groundwater with a minimum depth (usually 40 cm) of accumulated peat (Bedford and Godwin 2003; Chadde et al. 1998).

Methodology

Scale of Assessment

This assessment was completed at two spatial scales: the SCNF plan area and land type associations (LTAs), which the Forest uses for ecosystem evaluation and planning. Each LTA is a collection of land type units distinguished by processes of geology, geomorphology, soils, climate, and vegetation. These processes influence the structure and composition of vegetation types, including riparian communities (Padgett et al. 1989). In this assessment we evaluated riparian systems, wetlands, and GDEs at the scale of the LTAs and summarized results for the plan area.

Study Area

We conducted this assessment on the 4.2 million-acre SCNF of east-central Idaho, which encompasses 32 LTAs with distinct geology, climate, hydrology, and management history (SCNF 2004). The LTAs of the Forest can be grouped into eight general land covers: mountain slopelands, cryic uplands, strongly glaciated lands, glacial troughlands, steep canyonlands, dissected foothills, valley bottom, and cryic basinlands (fig. 1). The most common land type is mountain slopelands, which comprise 32 percent of the SCNF. These areas were formed by streams cutting through bedrock and tend to be moderately steep (SCNF 2004). The valleys in this landform are v-shaped, narrow, and steep sided. The vegetative communities of the mountain slopelands are primarily Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*) forests with some xeric grasslands present, including bluebunch wheatgrass (*Pseudoroegneria spicata*) communities. Precipitation in these areas can range from 15 to over 30 inches per year and snowpack duration is extremely variable depending on the precipitation zone, elevation, and aspect. Most streams in the mountain slopelands are intermittent or ephemeral. They are typically dominated by riffles and tend to have boulder and rubble substrates unless modified by beaver (SCNF 2004).

Cryic, or perennially frozen, uplands make up 28 percent of the Forest. These landscapes contain broad high-elevation, gently inclined ridges and mountain slopes formed by freeze/thaw cycles (SCNF 2004). The vegetation of the uplands includes subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), and whitebark pine (*Pinus albicaulis*), with small patches of Engelmann spruce (*Picea engelmannii*) and Douglas-fir at lower elevations. Some valleys are characterized by abundant riparian vegetation. These lands typically receive large amounts of precipitation, with the majority falling as snow. Snowpack duration in the uplands ranges from average to very long depending on aspect and elevation, making these landscapes important sources of sustained water yield for perennial streams and groundwater recharge. With high rates of percolation, surface water streams are not common. The few streams that form tend to be small with fine sediment substrates (SCNF 2004).

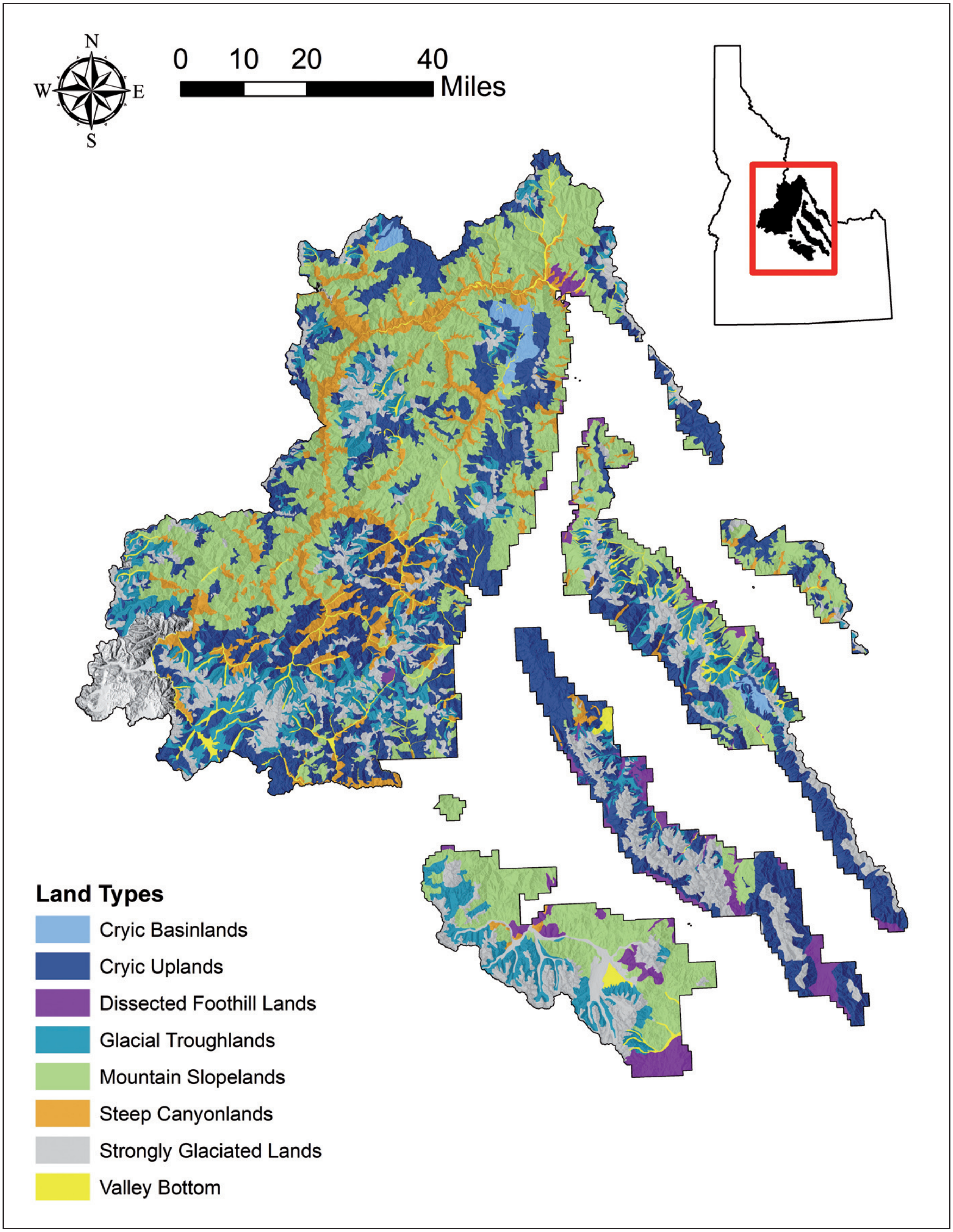

Figure 1—The eight major land types of the Salmon-Challis National Forest.

The third most common land cover is strongly glaciated lands that occupy 15 percent of the Forest. These areas are located at high elevations and have been highly modified by glaciation (SCNF 2004). Common features include cirques, cirque basins, headwalls, high peaks, and ridges carved by glaciers. The typical vegetation communities in the cirque basins are dense subalpine fir, lodgepole pine, and Engelmann spruce forests, with abundant whitebark pine at higher elevations. These high-elevation lands receive substantial precipitation, with the average annual amount exceeding 30 inches and the majority occurring as snow. Snowpack remains until late summer in many locations, making these lands the highest water producing areas on the Forest. The cirque basins in particular have high water storage capacity and are an important source of sustained water yield to lower elevation perennial streams. Some of these basins contain small lakes and shallow headwater streams dominated by pools and boulder substrates (SCNF 2004).

Steep canyonlands that include deep canyons with steep-sided slopes and their valley bottoms make up 8 percent of the SCNF. These areas were formed by streams cutting through bedrock, with some narrow valleys where active cutting continues, and some wide valley bottoms with meandering streams and depositional material (SCNF 2004). Distribution of vegetation in the canyonlands is limited by aspect and geology. Forested systems occur on north-facing slopes and typically include Engelmann spruce, Douglas-fir, and ponderosa pine. The hotter, dryer, southern aspects are characterized by bunch grass, sagebrush, mountain mahogany, greenbrush, and other low brush communities. This land type is generally adjacent to major streams and receives little precipitation. Streams originating in the canyonlands tend to be small, high gradient, and ephemeral or intermittent (SCNF 2004).

Dissected foothills comprise 3 percent of the Forest. These land types consist of low relief hills dissected by fluvial action (SCNF 2004). Timber cover is limited, with the most common vegetation communities composed of sagebrush and grass species. Average annual precipitation in the dissected foothills rarely exceeds 20 inches and streams originating in these lands are typically ephemeral or intermittent. Valleys are usually u-shaped with rubble and gravel substrates and moderate gradients (SCNF 2004).

A single association, Valley Bottom, occupies 2 percent of the Forest. This land type expands across the diverse geologic settings of the SCNF. It includes the channels and floodplains of some of the major streams on the Forest, including Yankee Fork, Panther Creek, and the Middle Fork, North Fork, and main stem of the Salmon River. The SCNF (2004) report lacks a comprehensive description of this land type.

The least common land type on the SCNF is the cryic basinlands, which occupy <1 percent of the Forest. These lands consist of subdued and rounded ridgetops with dendritic drainage patterns (SCNF 2004). The surfaces were formed by frost action and drainage from glaciers at higher elevations. The most common vegetation is subalpine fir, with some Douglas-fir and ponderosa pine found on warmer aspects and sedges (*Carex* spp.) and willow (*Salix* spp.) located in the valley bottoms. The hottest, southernmost aspects are often barren or support occasional grasses. Average annual precipitation in these lands ranges from 20 to 25 inches, with approximately half falling as snow. Wet meadows that provide high quality beaver habitat and good water storage capacity are significant features in the cryic basinlands. In these areas the water table is generally near the land surface and these land types serve as significant sources of year-round water. The streams that form in the cryic basinlands tend to be small, low gradient, and have meandering morphologies. The substrate is typically composed of gravel and fine sediment due to the depositional nature of the streams. This characteristic also makes these streams vulnerable to disturbance that results in headcutting and bank erosion (SCNF 2004).

Anthropogenic Changes to Riparian Ecosystems

The first well-documented human population in the area of the SCNF was the Lemhi band of the Shoshone Indian tribe. The Shoshone tribe constituted the early residents of the Upper Salmon River, above the Middle Fork, having occupied the area for 8 millennia or more (fig. 2). The area of the Mountain Shoshone was bounded by the Payette River on the west, Salmon River on the north, and Bear River Valley and Bruneau River on the south. Much of the Great Basin dried during a climatic change between 11,000 and 7,000 years ago, and much of the higher elevations became dominated by open forests and steppe. This changed the way of life of the peoples in the Great Basin. The ancestors of the Shoshone tribe, known as the Bitterroot Culture, withdrew into the high mountain country of the Salmon River, and retained their big game hunting way of life. Their subsistence life consisted primarily on seed gathering and hunting of small mammals (Smith 1969). There is little known about the impacts that the Bitterroot Culture and Shoshone tribe had on riparian and wetland ecosystems. However, it is likely, as with many indigenous cultures, that they altered their environment, responded to climatic changes, and adjusted to times of feast and famine. They did not live in romanticized harmony with nature. While the Native Americans clearly possessed vast knowledge of their environment, it did not prevent occasional overhunting or depletion of resources to the extent that their rudimentary tools and small populations allowed (Krech 2000). Specific, well-documented descriptions of the effects of the Shoshone Indians and their predecessors on riparian and wetland ecosystems of the Salmon-Challis Forest, positive or negative, are lacking.

Europeans apparently first entered the area of the SCNF with the arrival of the Lewis and Clark Expedition in 1805 (Smith 1969). President Thomas Jefferson commissioned the expedition, called the Corps of Discovery, and led by Captains Meriwether Lewis and William Clark, shortly after the Louisiana Purchase in 1803 to explore and map the newly acquired territory, to find a practical route across the western half of the continent, and to establish an American presence in the territory before Britain and other European powers tried to claim it (Ambrose 1996). The campaign's secondary objectives were scientific and economic, i.e., to study the

Figure 2—Pictographs along the Salmon River are indicative of the long history of human influence on riparian ecosystems (photo by D.M. Smith, USFS).

area's plants, animal life, and geography, and to establish trade with local Native American tribes. On 12 August 1805, Meriwether Lewis and three companions reached the summit of the Continental Divide at Lemhi Pass and stepped into what is now the State of Idaho and the SCNF. They were the first white men known to enter Idaho. The ridge on which they stood forms the Continental Divide between waters of the Atlantic and Pacific oceans.

In the decades following the Lewis and Clark expedition, parties of Euro-Americans entered the Intermountain West in increasing numbers to establish a fur trade. The removal of beaver from mountain streams is likely the earliest influence of Euro-Americans on riparian and wetland ecosystems in the SCNF. Beavers and other furbearers had been harvested by Native Americans for food and clothing for millennia, 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). Uncontrolled trapping would continue until the mid to late 1800s, when the fur trade became uneconomical and beavers received legal protection (Clements 1991).

The discovery of gold in California in 1849 brought large numbers of settlers to the western part of what would become the United States, and, with them, a demand for red meat, which was largely met by sheep (Beck 1989). Cattle numbers remained limited in much of the western United States until the end of the Civil War in 1865, which triggered rapid expansion of people and the associated livestock industry. The arrival of the railroad into Kansas in 1866 created a means to supply a growing demand for livestock shipped to the eastern United States. This period was made famous by the large cattle drives, primarily from Texas to railheads in Kansas. The cattle industry expanded into the central and northern Great Plains by the early 1870s. Much of the land used for grazing was public land, and few laws existed to regulate its use. Free-range grazing was the norm.

The years 1880–1885 saw a great boom in the numbers of range cattle in the West (Stewart 1936). Extensive unregulated grazing caused significant widespread degradation of the vegetation composition and density, and, with it, the stability of the soil surface. In 1898, the Department of Interior began granting grazing permits to try to limit the number of livestock on Federal land. In 1905, the U.S. Forest Service was established, and a system of grazing allotments was initiated for rangeland under its jurisdiction. Between 1910 and 1920, a series of laws were established on Forest Service lands to further regulate grazing. As the laws were established and enforced, the condition of grazed rangelands gradually improved.

Prior to 1862, most land west of the Mississippi river was held as “public domain” by the U.S. Government. In an effort to facilitate the movement of citizens to the West, Congress passed the Homestead Act of 1862 in which 160 acres were granted to anyone who lived on the land and cultivated it for 5 years. Almost all prime agricultural land was claimed over the next two decades. Most ranchers were unable to take advantage of the legislation because they typically needed more than 160 acres to raise enough livestock to support a family. Land not claimed under the Homestead Act of 1862 was considered part of the public domain and was available for use by almost anyone for almost any legal activity. Ranchers were content to use the public domain because it was free and not susceptible to taxes. Because nobody owned the land, nobody was responsible to maintain it, and public domain lands were severely abused and overgrazed. The consequence of the public domain policy is often referred to as the “Tragedy of the Commons” (Hardin 1968).

To encourage continued settlement of marginal lands, Congress passed the Enlarged Homestead Act of 1909 granting 320 acres to homesteaders for farming. In 1916, Congress passed the Stockraising Homestead Act granting 640 acres to ranchers if they raised at least 50 cows, although the General Accounting Office reported that on much of the remaining public domain land, due to climatic conditions or degraded condition of the land, it would require 160 acres to support a single cow for one month. In 1934, Congress passed the Taylor Grazing Act (named for Colorado Congressman Edward Taylor) that withdrew all remaining land from the public domain and placed it under the jurisdiction of what would become the Bureau of Land Management (Hurlburt 1935). Most of the withdrawn land was in a deteriorated state, as noted in the 1936 government publication *The Western Range* (Wallace and Silcox 1946). One of the expressed purposes of the Taylor Grazing Act was to "…stop injury to the public lands by preventing overgrazing and soil deterioration." Under the Taylor Grazing Act, ranchers could obtain long-term leases on public land for the purposes of livestock grazing. Stocking rates were established locally by the Bureau of Land Management. While some lands continue to be severely overgrazed, there has been a slow but generalized trend of improving condition since 1934, particularly on lands managed by the Bureau of Land Management and the Forest Service.

Because of recognition and regulation, the condition of most lands used for grazing has improved since the 1930s. However, some private landowners and users of public lands have still not adopted conservative grazing strategies to preserve the condition of the land on which they depend. Some rangeland continues to be grazed at unsustainable levels that continue to damage the resource. Damage can be particularly egregious in riparian and wetland ecosystems (Armour et al. 1991; Kauffman and Krueger 1984).

Where populations of wild or domestic ungulates are excessively high due to the lack of regulation and control, they may cause unintended and undesirable changes in the plant populations, especially if the overgrazing occurs over extended periods of time. Managers must bear in mind, however, that disturbance is not a new phenomenon. It has always existed in the form of natural fire, atypical weather, insect infestations, earthquakes, landslides, overgrazing by native ungulates during temporary population expansions, and so on. Such disturbances, and their consequences to the ecosystem, are natural and not regulatable. Nature has built-in mechanisms that allow for natural recovery following disturbance. Even grazing by domestic livestock is not necessarily negative, especially where it mimics natural disturbances for which natural recovery mechanisms already exist. The effects of overgrazing by domestic livestock, which may exceed the normal capacity of an ecosystem to recover, has the potential to set the recovery process temporarily back to levels unacceptable in terms of aesthetics, near-term productivity, and hydrology (Belsky et al. 1999). Hydrological impacts may manifest themselves in the form of flooding, gully erosion, and water pollution by sediments, livestock fecal material, and urine. These effects, however unaesthetic or displeasing, are generally reparable when stocking rates are reduced to an acceptable rate.

Another cost of overgrazing is facilitation of nonnative invasive plants. Nonnative plants may establish and overrun native riparian plant communities. Because the nonnative species have no natural control measures, there may be no mechanisms to control them in the future. Management that prevents the introduction of exotic species is a first-line defense that provides a sure solution; early detection and early response is a second-line defense (Hulme et al. 2017; Van Dyke 2008). Once established, invasive plants may cause a myriad of problems, such as alteration of hydrologic dynamics and increased risk of wildfire. Unlike overgrazing, there may be no apparent remedy, and the ecosystems are permanently impaired. Rush skeletonweed (*Chondrilla juncea*) and spotted knapweed (*Centaurea maculosa*) are already well-established in the Middle Fork of the Salmon River Corridor, and may be beyond control. The establishment of such species may displace desirable native species, significantly alter native plant community dynamics, interfere with normal hydrology, increase the frequency and intensity of wildfires, and alter nutrient cycling. As there are no native disease or insect vectors with the evolutionary capability to control them, other controls may not be possible.

Though fire is a natural disturbance, the frequency, severity, and extent of fires has been influenced by humans prior to and after Euro-American settlement (Nowacki et al. 2012). The direct and immediate effects of wildfire on riparian and wetland areas are minimal, primarily due to the fact such systems are of limited risk or burning due to the elevated moisture content of the vegetation. However, postfire conditions following wildfires of high severity and size can have deleterious effects on watershed hydrology, particularly in upslope areas. The conditions most affected by fire are those that are controlled by vegetation and the soils of the watershed. They include interception, infiltration, evapotranspiration, soil moisture storage, and overland flow of water. Fire can substantially reduce rainfall interception by destroying both the vegetation canopy and the organic litter on the soil surface, thereby exposing the soil to the erosive forces of raindrop impact and subsequent runoff. Fire can reduce infiltration into the soil by forming a water-repellent soil layer or by plugging soil pores with fine ash. Percolation through the soil may also be reduced. Reduced infiltration and percolation, in turn, can increase surface runoff and sedimentation. Increases in streamflow also may occur following fire due to the reduced transpiration losses by plants. The most effective way to reduce overall watershed damage by high severity wildfires is to reduce the accumulation of fuels (DeBano 2009).

The largest and most destructive fire season in the area of the SCNF, and possibly the largest in U.S. history, occurred in August of 1910. Rather than a single blaze, many smaller fires combined to burn some 3 million acres from the Canadian border south to the Salmon River, and east from the area of Spokane, Washington, past Missoula, Montana. The conflagration has been called the Great Fire of 1910. Records indicate that lightning ignited several of the blazes, but many were of anthropogenic origin resulting from careless campers, sparks from train engines, loggers clearing private lands, and fires of settlers and miners (Smith 1969). The flames were driven by fierce winds, causing many disparate fires to grow and merge. Occurring early after the origin of the U.S. Forest Service, for better or worse, it played a large role in defining modern methods and strategies of fighting forest fires of the fledgling organization. Fire suppression continued until the end of the 20th century, followed by a period of increasingly large and severe wildfires (Dennison et al. 2014). Large wildfires in ponderosa pine forests have been attributed to past suppression and fuel buildup, whereas wildfire patterns in higher elevation forests are largely driven by changes in temperature and precipitation (Schoennagel et al. 2004).

Key Ecosystem Characteristics

To determine whether riparian ecosystems, wetlands, and GDEs were within their natural range of variation (NRV), we selected characteristics of ecosystem integrity and sustainability: (1) distribution and connectivity of riparian ecosystems; (2) distribution of GDEs; (3) surface and groundwater fluctuations; (4) water quality; (5) channel and floodplain dynamics; (6) condition of spring runout channel; (7) composition and condition of riparian ecosystems; and (8) composition and condition of GDEs. These key ecosystem characteristics (KECs) were selected in accordance with current planning rules (USFS 2015) and included measures of composition, structure, function, and connectivity. We reviewed scientific literature and agency reports to develop a list of drivers and stressors that influence each KEC. We also selected indicators of current condition in relation to the NRV that could be evaluated with available data (table 1). We used Pearson's Correlation, which ranges from -1 to +1, to examine the association between stressors and indicators. Associations were considered strongly negative if Pearson's r was less than -0.7 and strongly positive if the value was greater than +0.7. Weak associations were identified by an r value between +0.3 and +0.7 or -0.3 and -0.7. A Pearson's r value between -0.3 and +0.3 indicated no association.

Table 1—Drivers, stressors, and indicators measured for assessment of riparian ecosystems, wetlands, and GDEs.

Key ecosystem characteristic	Drivers	Stressors	Indicators
Distribution and connectivity of riparian ecosystems	Surface flows, groundwater availability, groundwater discharge, beaver activity	Conifer encroachment, upland vegetation encroachment, fire suppression, diversions, dams, agriculture, development, beaver removal	Departure of existing vegetation from estimate of pre-European settlement vegetation coverage, conversion from riparian to anthropogenic cover; reservoir area
Distribution of GDEs	Geologic setting, extent of glaciation and glacial history, temperature, precipitation	Roads, diversions, dams, mining, climate change	Relative density of GDEs, current condition and characteristics of GDEs
Surface and groundwater fluctuations	Temperature, precipitation, geologic setting, beaver activity	Roads, diversions, dams, mining, timber harvest, high severity fire, insects and disease, grazing, climate change	Conifer and upland encroachment, deviation in winter temperatures, deviation in winter precipitation
Water quality	Geologic setting, chemistry of precipitation, hydrologic regime, dissolution of organic and mineral substances	Wildfire, agriculture, diversions, mining, grazing, roads, recreation, loss of wetlands and riparian cover	Community tolerance quotient for macroinvertebrates, stream temperature, median substrate size, impaired freshwater systems
Channel and floodplain dynamics	Geologic setting, terrain, hydrologic regime, large woody debris, beaver activity, stabilizing vegetation	Grazing, dams, diversions, timber harvest, invasive species, climate change	Floodplain acres per stream mile, sinuosity, bank stability, bank angle, frequency of large wood, volume of large wood, wildfire disturbance, wetland rating
Spring runout channel dynamics	Hydrologic regime, precipitation regime, geologic setting	Grazing, roads, diversions, spring development, recreation	Condition of bank morphology, condition of channel morphology
Composition and condition of riparian ecosystems	Surface water dynamics, groundwater availability, geologic setting, beaver activity	Wildfire, wildfire suppression, insects and disease, invasive species, livestock use, wild ungulate use, recreation	Conifer and upland encroachment, replacement by introduced vegetation, native cover, alien cover, condition of riparian and wetland vegetation, greenline cover, effective ground cover, wetland rating
Composition and condition of GDEs	Water availability, geomorphic setting, sediment dynamics, thermal activity	Spring development, livestock use, wild ungulate use, recreational use, ditching, channelization, droughts, earthquakes	Disturbance to riparian and wetland vegetation, soil exposure

Results

Current Conditions

Distribution and Connectivity of Riparian Ecosystems

For the purposes of this assessment, we defined riparian ecosystems as areas near streams that are influenced by surface water and groundwater and, under natural conditions, support plant species and communities that differ from upland areas (fig. 3). Distribution of these unique communities is a key characteristic because of the physical, hydrological, and biotic services they provide to forest landscapes. Essential physical functions include soil stabilization, which maintains conditions required for persistence of resident and anadromous fishes (Horan et al. 2000; Hubert 2004; Kershner et al. 2004). Riparian vegetation is also a key component of terrestrial wildlife habitat, providing food, cover, and nesting sites for numerous taxa of high conservation priority (Atamian et al. 2010; Collins 1977; Graham et al. 1999). At larger scales, riparian corridors are critical in connecting habitats and wildlife populations (Hauer et al. 2016).

Drivers

Physical and biotic processes influence the distribution and connectivity of riparian ecosystems in western landscapes. The lotic riparian ecosystems assessed in this report occur along perennial and intermittent streams that remain connected to groundwater when surface flows subside (Barrett et

Figure 3—The riparian vegetation along Morse Creek contrasts sharply with the surrounding uplands (photo by D.M. Smith, USFS).

al. 1993). Riparian vegetation can occur across unconfined valley bottoms if connectivity of floodplains and stream channels are maintained (Brierley and Fryirs 2013). At some streams, beaver dams and instream wood slow the movement of water and trap sediment to maintain late-season surface flows, floodplain connectivity, and substrate for riparian vegetation (Pollock et al. 2014; Roni et al. 2002).

Stressors

Significant changes to surface flows and vegetation communities have occurred throughout the western United States, altering the distribution and connectivity of riparian ecosystems (Webb et al. 2007). Dams and diversions alter the volume and timing of surface flows, thereby reducing the extent of riparian vegetation (Dewine and Cooper 2007). Reservoirs inundate valley bottoms, disconnecting riparian corridors. Dams are relatively rare in the SCNF, but portions of some streams are diverted for irrigation. Stressors of greater importance include development of valley bottoms for municipal areas, agriculture, and industry (Jones et al. 2010; MacFarlane et al. 2017). Other forms of development, including roads and mines, have the potential to decrease extent and connectivity as well. In many areas, removal of beaver has resulted in loss of surface flows and stream incision, fragmenting riparian corridors in the process (Pollock et al. 2014).

Indicators

We determined the NRV status of riparian ecosystem distribution in each LTA by examining the area available for riparian vegetation, existing riparian vegetation cover, riparian vegetation departure, conversion to anthropogenic cover, and reservoir area. We used National Hydrography Dataset (NHD) flowlines to represent perennial and intermittent stream channels. To compare potential space for floodplain communities, we used the USFS Valley Confinement Algorithm (VCA) shapefile (Nagel et al. 2014). We used a map of the 50-year flood zone (Abood et al. 2012) that represents areas near perennial streams, intermittent streams, and valley bottoms that are inundated frequently enough to be considered riparian. It is therefore a useful indicator of riparian ecosystem extent. To measure coverage of riparian vegetation, we created an existing vegetation type (EVT) raster, using data generated by the LANDFIRE program (LANDFIRE 2017). We extracted cells classified as riparian and calculated total cover of these cells in each LTA.

We applied the Riparian Condition Assessment Tool (R-CAT), developed by MacFarlane et al. (2017), to the LANDFIRE, NHD flowline, and VCA data. In addition to the LANDFIRE EVT raster, we obtained a biophysical setting (BPS) raster, which displays vegetation types expected to exist in the landscape prior to Euro-American alteration. We created polygons of riparian ecosystems by adding 30 m buffers to perennial and intermittent flowlines and merging these shapefiles with the VCA shapefile. We compared proportion of these polygons covered by riparian vegetation in the BPS and EVT rasters to calculate an index of riparian vegetation departure (RVD) for perennial and intermittent stream segments. We used these results to compare potential changes in distribution of riparian vegetation among LTAs. A departure index of less than 0 indicated increase in vegetation, 0 to 0.1 represented negligible departure, an index of 0.1 to 0.33 represented minor departure, 0.33 to 0.66 represented significant departure, and an index greater than 0.66 represented large departure. See Appendix A for additional methodology and descriptions of riparian ecosystem distribution within each LTA.

Riparian Ecosystem Distribution on the SCNF

Distribution and connectivity was very high in much of the SCNF. We determined that 75 percent of the Forest was within the NRV, 25 percent was moderately altered, and less than 1 percent was outside the NRV (fig. 4). Dissected foothills in quartzite, located entirely in managed areas, was the only LTA considered outside the NRV.

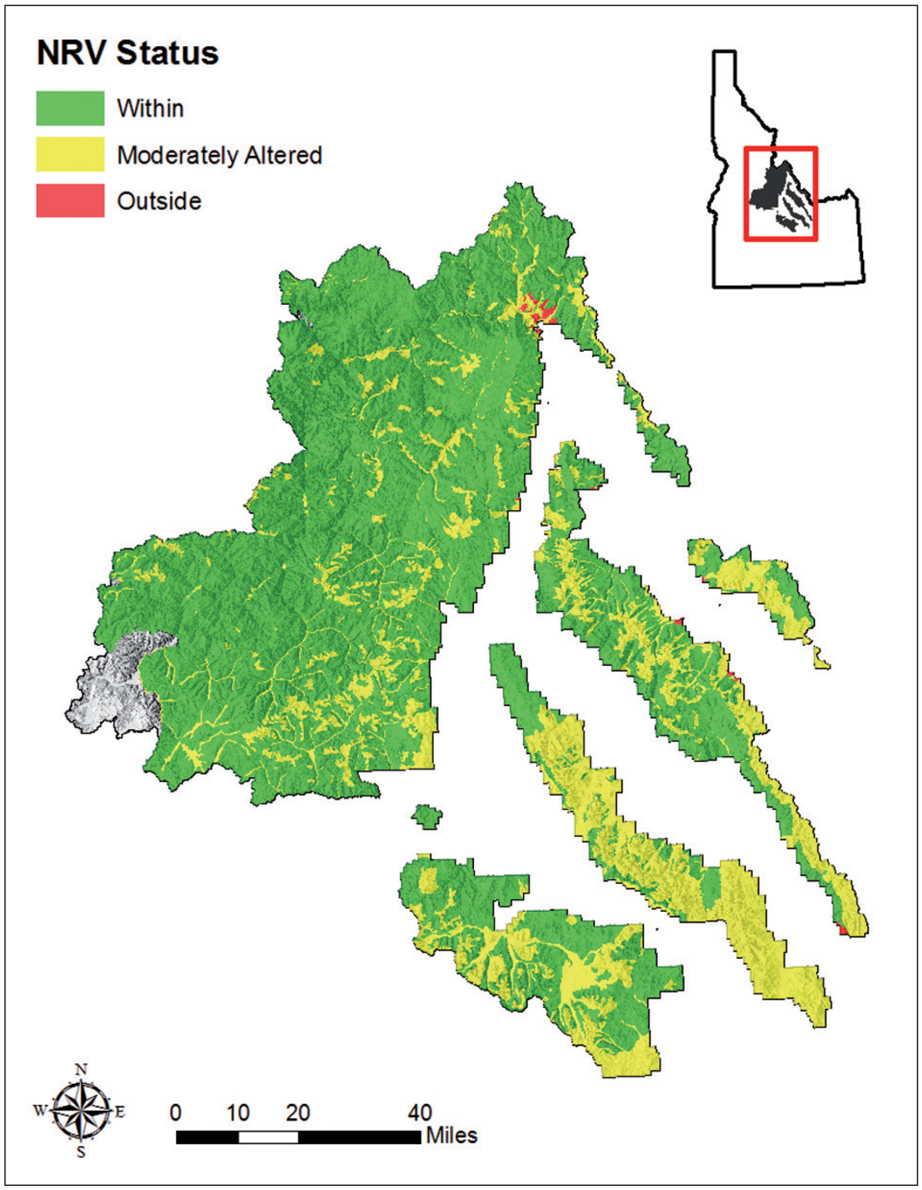

Figure 4—NRV status of riparian distribution and connectivity on the Salmon-Challis National Forest.

The LTAs of the SCNF contained a total of 6,367 miles of perennial streams and 7,813 miles of intermittent streams. Miles of perennial streams ranged from 2 to 876 in the LTAs, with a mean of 199 (table 2). Miles of intermittent streams ranged from 0.4 to 1,149 with a mean of 244. Total area

Table 2—Riparian distribution and connectivity indicators summarized for LTAs. Descriptions of LTA characteristics are located in the appendices. Positive RVD index scores indicate decrease in riparian vegetation, negative scores indicate an increase. Anthropogenic conversion types include roads, mines, and towns.

	Stream miles		RVD index			
LTA	**Per.**	**Int.**	**Per.**	**Int.**	**Anthropogenic Conversion (%)**	**Reservoir acres/ Per. stream miles**
10G	366.3	309.0	0.69	0.73	<1	0
10M	2.3	2.0	0.49	0.68	0	0
10Q	130.5	124.9	0.63	0.72	1.6	0
10S	15.0	25.7	0.86	0.93	1	0
10V	157.2	208.3	0.58	0.57	0	0
20G	560.7	634.4	0.57	0.61	<1	0
20M	3.6	2.8	0.69	0.65	0	0
20Q	530.9	842.3	0.64	0.67	<1	0
20S	38.9	126.8	0.88	0.85	1	0
20V	790.2	1148.6	0.67	0.72	<1	0.03
30G	444.5	284.5	0.29	0.30	<1	0
30M	2.1	2.9	0.34	0.47	0	0
30Q	297.4	522.3	0.52	0.68	0	0.005
30S	23.0	453.4	0.87	0.89	<1	0
30V	429.9	1017.6	0.47	0.60	<1	0
40G	60.5	41.2	-0.27	-0.17	0	0
40Q	10.7	10.6	0.61	0.70	0	0
40V	10.5	6.1	-0.36	-0.46	0	0
50G	441.4	267.4	0.12	0.44	0	0.0005
50M	3.2	0.4	-0.15	0.76	0	0
50Q	122.5	112.7	0.60	0.80	0	0
50S	26.1	85.6	0.79	0.89	0	0
50V	177.0	222.0	0.28	0.47	0	0
60G	298.9	113.2	0.01	0.24	0	0
60M	3.4	10.1	0.80	0.77	0	0
60Q	268.6	219.0	0.70	0.76	<1	0.1
60S	32.1	150.4	0.77	0.87	0	0
60V	136.8	355.8	0.38	0.61	0	0.3
70Q	4.9	38.4	0.87	0.86	11.6	0
70S	27.6	111.4	0.83	0.82	0	0.1
70V	74.2	158.9	0.78	0.90	<1	0.1
VB	876.1	203.9	0.38	0.62	1.4	0.0002

of valley bottoms was 30,077 acres in the Forest, ranging from 0 to 13,120 in the LTAs, with a mean of 940. Four LTAs, all categorized as mixed geology, had no unconfined valley bottoms. All LTAs contained land within the 50-year flood zone, which covered 4 percent of the Forest. Among LTAs, flood zone coverage ranged from 1 percent to 24 percent, with a mean of 5 percent. There were 45,732 total acres (1 percent of the Forest) of riparian vegetation types as mapped by LANDFIRE EVT. Percent cover of riparian types varied from 0.1 to 8 percent with a mean of 1 percent. As expected, the Valley Bottom LTA had the greatest percent area of riparian cover. Several LTAs with mixed and volcanic geology had relatively high cover as well (>2 percent).

R-CAT analysis indicated that 22 percent of perennial stream miles had increases in riparian vegetation or negligible departure and 72 percent had significant or large departure. At intermittent streams, 13 percent of miles had increases or negligible departure and 83 percent of miles had significant to large departure. Potential natural forms of departure were conifer encroachment, upland encroachment, and replacement by barren land. Anthropogenic forms of departure involved conversions to crops and hay, developed land, and introduced vegetation. All but four LTAs had fewer than 0.1 acres of reservoir per stream mile (table 2). Disruptions in connectivity were present along highway corridors and in developed areas, which included the town of Salmon and the Yankee Fork drainage.

Distribution of GDEs

Distribution of spring and wetland GDEs is a somewhat unusual KEC, but knowledge of the location, extent, and arrangement across the landscape is necessary for conservation and management of these systems. The 2012 Planning Rule (36 CFR Part 219) recognizes that groundwater, GDEs, and their associated resources are vital to forest health and sustainability, as well as local and regional biodiversity. Still, most National Forests have limited knowledge of the landscape-scale distribution of GDEs, as well as their species compositions and ecosystem processes. This is true for the SCNF. This KEC is included to emphasize the need for improved information on the location and characteristics of GDEs across the Forest. With better understanding, these systems can be more readily acknowledged in forest planning activities.

Drivers

Drivers of the distribution of spring and wetland GDEs include underlying geology, terrain, and historic land forming processes. The geologic units of the Salmon River basin are igneous, sedimentary, and metamorphic, but granitic rocks of the Idaho batholith are the most dominant (Young and Lewis 1982). Porous geologies allow recharge of groundwater and are important drivers of GDE distribution at lower elevations and in drier areas. On the SCNF, springs form at the contacts, joints, and faults of differing geologies. Groundwater reaches the surface by moving through low-permeability rock and unmodified fissures or through large cavities. In many cases, springs emerge at a fault line scarp (Whiting and Stamm 1995). Due to their location at faults, spring distribution in this region can be influenced by geologic activity. For example, changes in flow patterns, including desiccation of GDEs due to altered groundwater flow paths, was observed following the Borah Peak Earthquake in 1983 (Wood et al. 1985). Fens tend to occur in glacially influenced landforms such as cirques and outwash channels (Chadde et al. 1998) and two major types have been identified in Idaho: valley peatlands and subalpine peatlands (Bursik 1990). Valley fens are rare and form around lakes and ponds at relatively low elevations in major river valleys. Subalpine peatlands are more common in Idaho and tend to occur along low gradient subalpine streams (Chadde et al. 1998).

GDE distribution also is driven by regional climate and local weather patterns, particularly annual variation in snowpack and snow water equivalent. Their continued existence relies on discharge from groundwater sources and recharge to these systems depends on the amount and timing of precipitation, evapotranspirative losses, snow cover thickness, snow melt characteristics, and land use/land cover (Klove et al. 2013). Areas with high precipitation, particularly areas that accumulate snow that melts slowly, are important sources of recharge and are influential to water table depth. Typical climate patterns that include low humidity and prolonged dry periods on the SCNF significantly limit the development of fens and the location of springs (Chadde et al. 1998).

Stressors

GDE distribution is stressed by natural and anthropogenic activities and forces that alter hydrologic connectivity, deplete groundwater sources, or increase nutrient loads (Chadde et al. 1998). On the SCNF, the most common stressors impacting GDE distribution were roads, diversions, and mining. The construction of roads alters hillslope contours and adds impervious surfaces to landscapes, decreasing potential infiltration and increasing surface runoff (Forman and Alexander 1998; Reid and Dunn 1984). Roads are also unnatural sources of fine sediment that can obstruct natural flow paths between surface and groundwater systems (Forman and Alexander 1998; Reid and Dunn 1984). Diversions alter the amount and distribution of water received by aquatic systems (Winter et al. 1998). Certain mining practices can change the distribution of water within aquatic ecosystems and the disappearance or movement of springs is an extreme but possible result (Waddell et al. 1981). Peatlands in particular are sensitive to pollutants from mining or increased nutrient loads from other activities like grazing or agriculture (Chadde et al. 1998).

Lastly, changing climate may be the greatest stressor influencing the distribution of springs and GDE wetlands by altering the amount and form of precipitation received on the SCNF. According to the USFS Terrestrial

Condition Assessment of National Forest lands, climate exposure on the SCNF is considered in moderate to poor condition (Cleland et al. 2017). Seasonal temperatures across the Forest have increased in all four seasons, causing temperature exposure to be classified as very poor. Precipitation has decreased during winter and spring and increased during summer and fall, with only the northern half of the Forest considered in good or very good condition in terms of precipitation exposure (Cleland et al. 2017).

Spring Distribution on the SCNF

The Spring Stewardship Institute documented 669 springs and seeps from the NHD on the Forest (fig. 5). The NHD layer typically underestimates the true number of springs and does not provide information on their condition. Forest staff completed several proper functioning condition (PFC) assessments at springs that were not included in the Spring Stewardship database, suggesting there were likely more undocumented springs on the Forest.

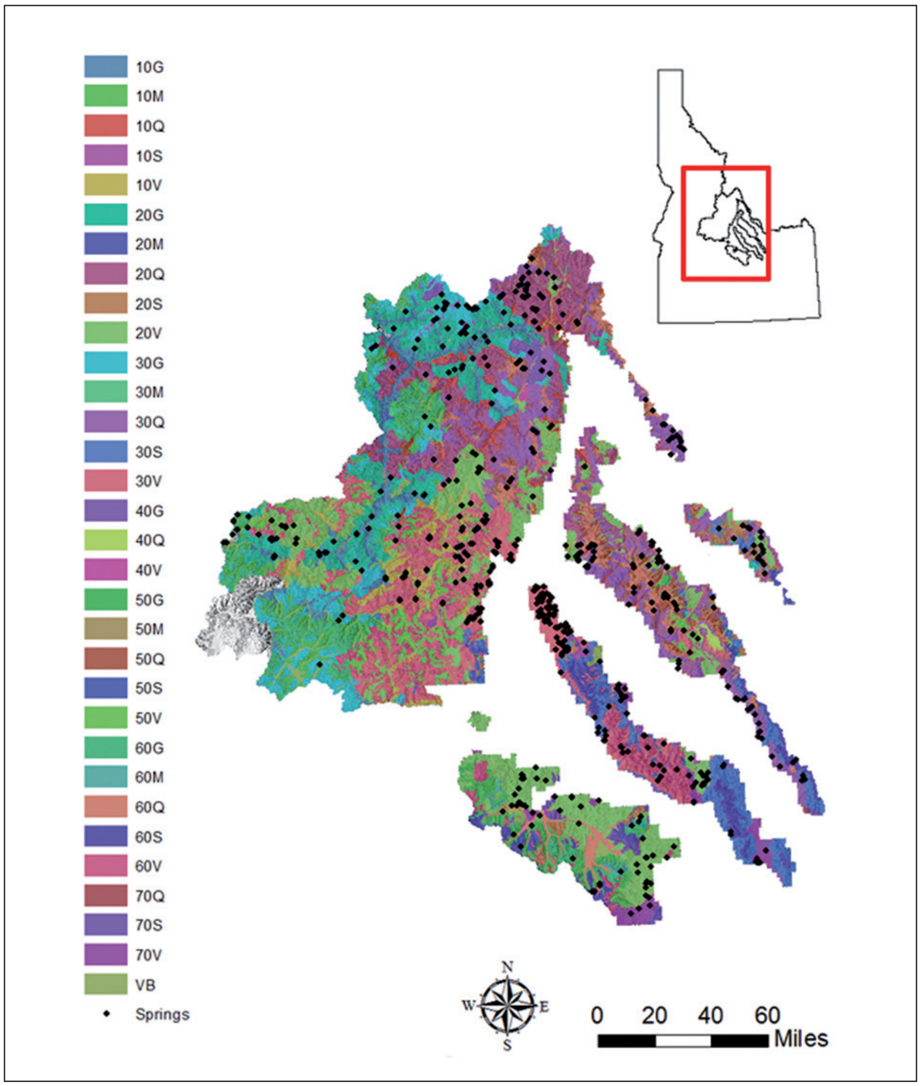

Figure 5—Distribution of documented springs occurring on the Salmon-Challis National Forest. The data were derived from the Spring Stewardship Institute database (http://springstewardshipinstitute.org/) and include all springs from the NHD.

The strongest driver of spring distribution appeared to be geologic setting, which also interacted with land types in some places. The largest spring densities were located in cryic uplands and dissected foothills set in quartzite and volcanic geologies (table 3). Approximately 41 percent of springs on the Forest were located in the four LTAs associated with these geologic settings (30V, 70V, 30Q, 70Q). There were also numerous springs in the Valley Bottom LTA. Steep canyonlands had very few springs, regardless of underlying geology. Similarly, mountain slopelands had moderate spring

Table 3—Number of springs and spring density on the SCNF. The data were derived from the Spring Stewardship Institute database (http://springstewardshipinstitute.org/) and include all springs in the NHD.

LTA	LTA Acres	# Springs	Spring Density (springs/acre)
10G	160844	8	0.00005
10M	791	0	0
10Q	65313	3	0.00005
10S	15055	0	0
10V	104674	9	0.00009
20G	309806	28	0.00009
20M	2172	0	0
20Q	405990	40	0.00010
20S	51784	10	0.00019
20V	599466	96	0.00016
30G	240927	33	0.00014
30M	2276	0	0
30Q	337764	67	0.00020
30S	170838	25	0.00015
30V	433239	167	0.00039
40G	28686	2	0.00007
40Q	7417	0	0
40V	4198	0	0
50G	231089	9	0.00004
50M	1118	0	0
50Q	90513	3	0.00003
50S	36421	3	0.00008
50V	98559	12	0.00012
60G	148007	6	0.00004
60M	13247	1	0.00008
60Q	167729	30	0.00018
60S	103742	8	0.00008
60V	217761	38	0.00017
70Q	9764	2	0.00020
70S	43036	7	0.00016
70V	75725	37	0.00049
VB	101331	25	0.00025

densities for all geologies. Spring distribution in cryic uplands depended on the geologic setting, with high spring densities observed in volcanic and quartzite settings, moderate spring densities observed in sedimentary and granitic geologies, and no springs documented in mixed geologic areas. There were very few springs located in cryic basinlands or glacial troughlands of any geology. Strongly glaciated lands tended to have moderate spring densities in all geologic settings and dissected foothill lands were associated with high spring densities.

Natural forces were generally the strongest drivers of spring distribution and 97 percent of the SCNF was considered within the NRV (fig. 6). For the majority of the Forest, distributions of springs within reference areas was comparable to managed portions of the Forest. A single LTA, the Valley Bottom, was identified as outside the NRV for spring distribution. This LTA makes up 2.4 percent of the Forest and was impacted by the cumulative

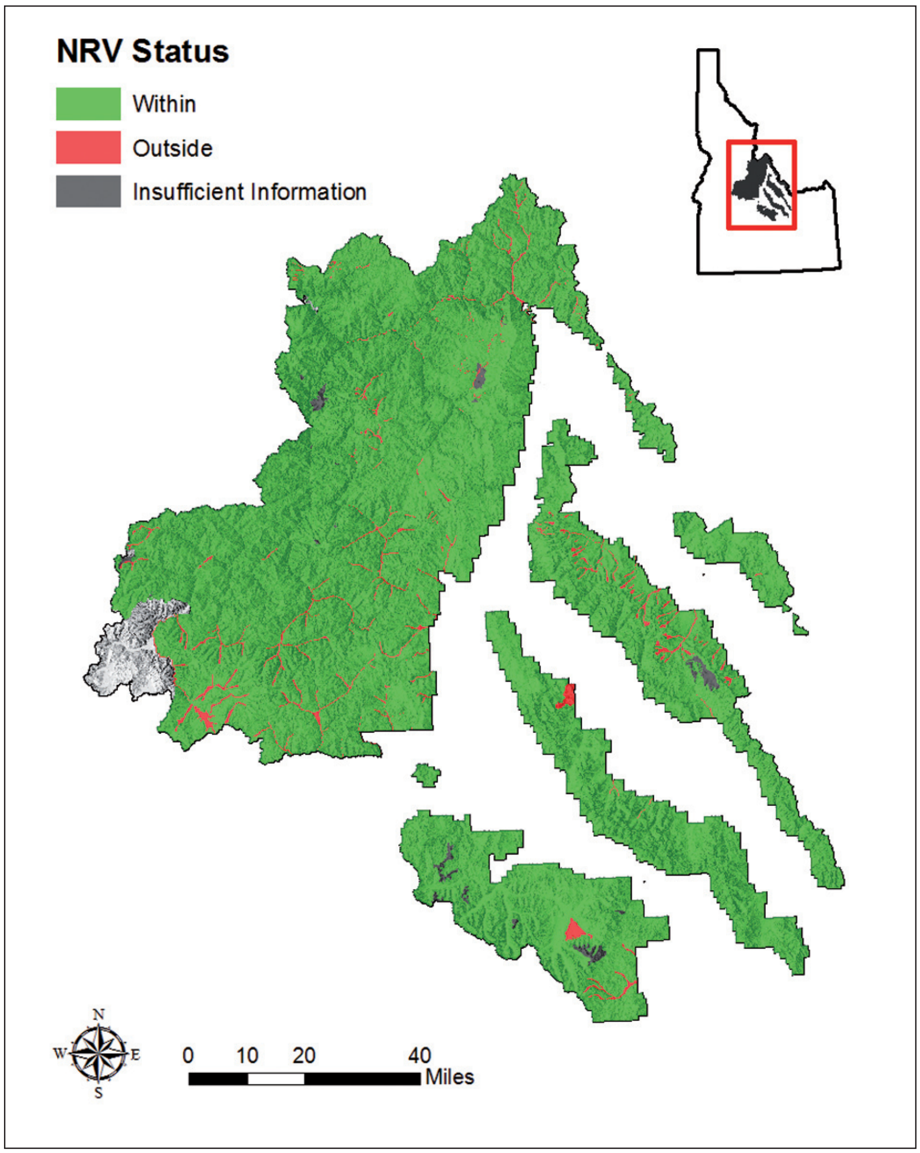

Figure 6—NRV status of spring distribution on the Salmon-Challis National Forest.

effects of mining, roads, and diversions, resulting in substantially fewer springs per acre in managed areas than in reference conditions. Lastly, there was insufficient information to evaluate the NRV status for <1 percent of the Forest. Most of these LTAs were in mixed geologies and lacked any LTA description.

It was likely that the resistance and resilience of spring distribution to disturbances differs across the Forest. Some LTAs, particularly those in the southern half of the Forest, had experienced large deviations in winter temperature and precipitation during recent years when compared to the previous century (Cleland et al. 2017). It appeared that springs on the Forest may be especially vulnerable to altered precipitation, as PFC reports noted drying and disappearance of springs during prolonged drought. LTAs that experienced large climate deviations were likely more vulnerable to cumulative effects of additional stressors including roads, mining, and diversions. See Appendix B for additional methodology and descriptions of spring distribution within each LTA.

Fen Distribution on the SCNF

We used three data sources to examine the distribution of fens on the SCNF. The first source was the National Wetlands Inventory (NWI) database. NWI typically underestimates the number and acreage of wetlands and we believe this to be true on the SCNF. Secondly, we used PFC reports for several GDE wetlands, none of which were recorded in NWI. Lastly, fen mapping for the SCNF was completed by the Colorado Natural Heritage Program (Smith et al. 2017). This report identified potential fens using digital aerial photography and topographic maps and assigned each estimated fen a confidence value: low confidence, possible fen, or likely fen.

NWI documented 2,754 palustrine emergent wetlands (PEMBs; potential fens) on the Forest with a total acreage of 2,105 (fig. 7). Nearly all the GDE wetlands captured by NWI were located in the southern half of the SCNF. The PEMB wetlands were generally located in cryic uplands, glacial troughlands, and other glaciated terrains in volcanic and granitic geologic settings. Smith et al. (2017) identified 3,401 potential fens covering 5,749 acres, including 385 likely fens (fig. 8). The primary drivers of potential fen distribution appeared to be geology, topography, and glacial history, with the majority of likely fens located in the Strongly Glaciated Lands in Granite LTA. Elevation appeared to strongly influence fen formation, with 62 percent of potential fens and 57 percent of likely fens occurring in two elevation bands (6,000 to 7,000 feet and 8,000 to 9,000 feet; Smith et al. 2017).

The Colorado Natural Heritage Program report showed the highest densities of potential fens in the southwestern part of the SCNF, particularly in the Upper Elk Creek, Swamp Creek-Marsh Creek, and Cape Horn Creek watersheds. A large spring and fen complex was identified in the Crane Meadow area, as well as the second largest potential fen on the Forest. The largest fen on the Forest, Blind Summit Fen, is located in the Swamp Creek-Marsh Creek watershed and measures 140 acres within the SCNF boundary

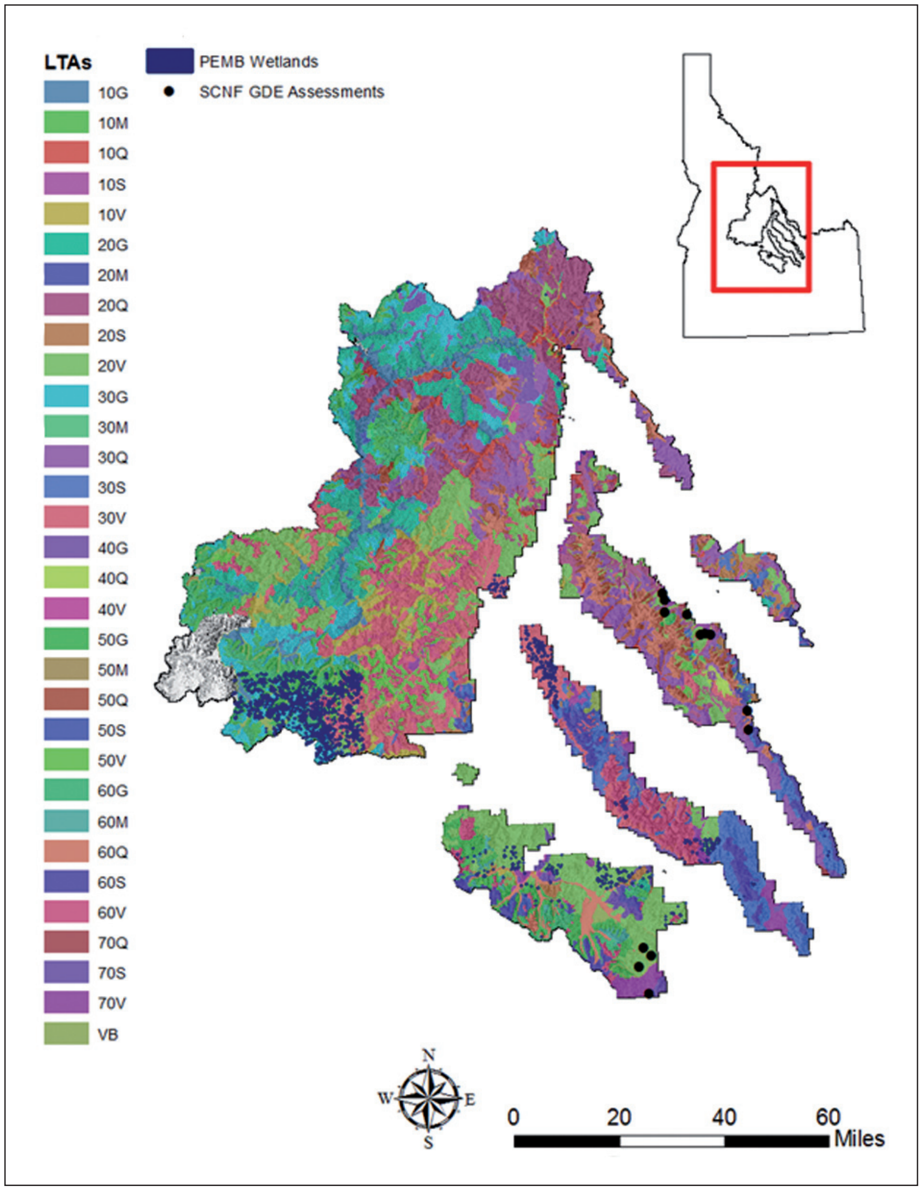

Figure 7—Distribution of palustrine emergent wetlands (PEMBs, potential fens; Cowardin et al. 1979) on the Salmon-Challis National Forest. PEMBs were derived from the National Wetlands Inventory (NWI) database.

(Smith et al. 2017). This site is nearly 2 miles long and one-third mile wide and is composed of quaking mats that are subirrigated by numerous springs (fig. 9; Chadde et al. 1998). Smith et al. (2017) also identified three possible iron fens in the Iron Bog Creek watershed. These sites are poor valley bottom fens located within a dry sagebrush-steppe ecosystem. The Iron Bog system formed on poorly drained alluvial material deposited by glaciers and is unusual due to its location (Chadde et al. 1998).

We observed large inconsistencies between the three data sources and Smith et al. (2017) acknowledged no strong relationship between their results and the potential fens mapped by NWI. Both maps provided by the Colorado

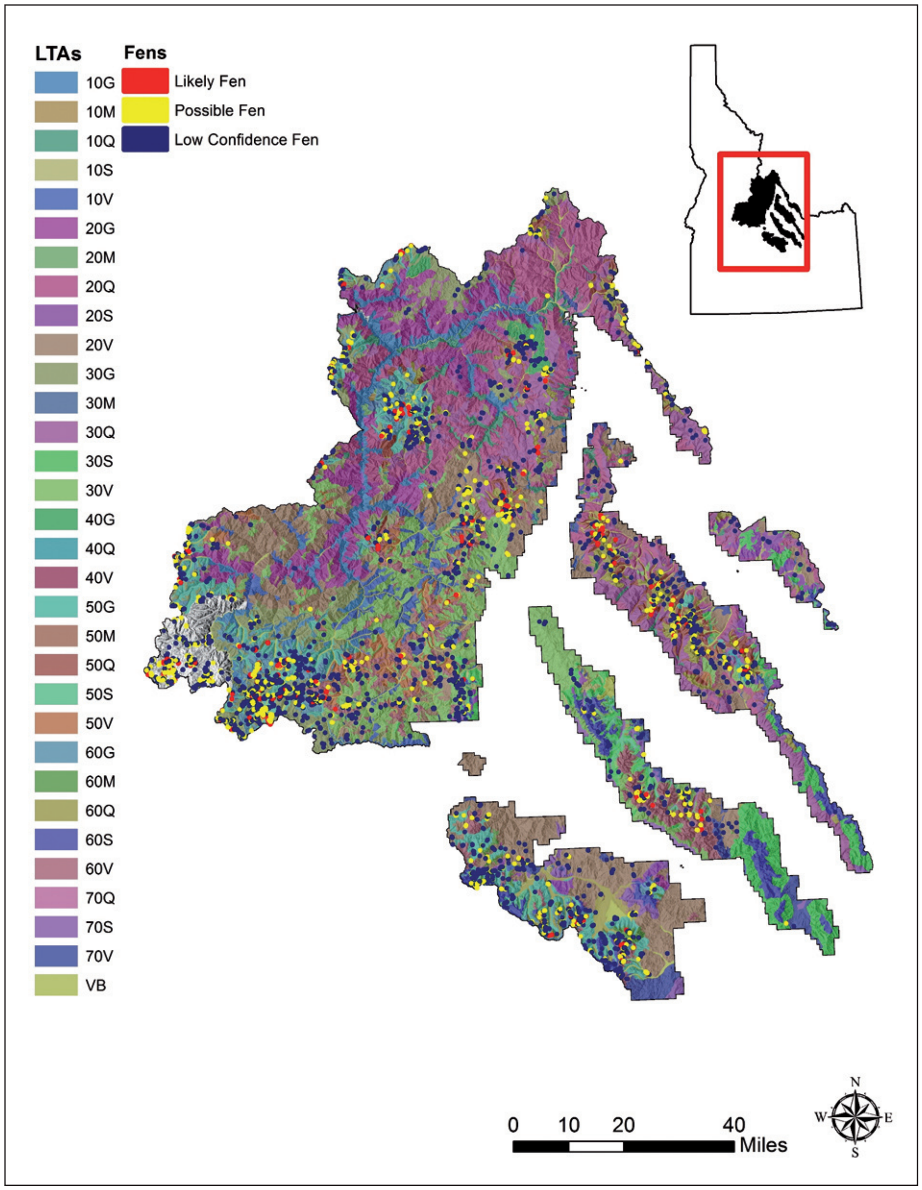

Figure 8—Distribution of potential fens on the Salmon-Challis National Forest. Potential fens were derived from the Colorado Natural Heritage Program database (Smith et al. 2017).

Natural Heritage Program and NWI are good starting points for field-based verification and biological assessment of potential GDE wetlands (Smith et al. 2017), but due to the discrepancies in datasets and lack of ground-truthed observations, there was **insufficient information** to evaluate GDE wetland distribution in any LTA. See Appendix B for additional methodology and descriptions of GDE wetland distribution within each LTA.

Figure 9—Blind Summit Fen near Marsh Creek is part of a large wetland complex subirrigated by numerous springs (photo by Salmon-Challis National Forest staff).

Surface Water and Groundwater Fluctuations

Fluctuations in surface and groundwater levels is a KEC that influences the structure, function, and composition of all riparian and freshwater systems. 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 natural disturbances (Resh et al. 1988) 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). During low flows, succession occurs as riparian plants establish and grow on recently scoured or deposited alluvium (Stromberg et al. 1991; Whited et al. 2007). These base flows are supported by discharge from groundwater resources that are maintained by infiltration from rainfall and snowmelt (Poff et al. 1997). Depth to groundwater and fluctuations in the level of water tables drives distribution, growth, survival, and composition of plant communities (Horton et al. 2001; Shafroth et al. 2000; Smith et al. 1998). Furthermore, the life histories of many plant and animal species evolved with natural water cycles and are dependent on reliable and predictable fluctuations (Lytle 2004; Poff et al. 1997; Stanford et al. 2005).

Flow regimes of GDEs are distinct from surface water systems dominated by runoff. The range of discharge from spring and wetland GDEs is narrower than the extremes observed in hydrographs that include snowmelt (Whiting and Stamm 1995). Examples from eastern Idaho suggest that baseflow in GDEs can be 65 percent of bankfull, which is much greater than the 10 percent observed in surface water systems. Groundwater-fed systems flow at bankfull approximately 20 percent of the time compared to runoff systems that reach bankfull 2 to 4 percent of the time. The timing of flows is also different, with peak discharge at GDEs occurring in late summer and fall (Whiting and Stamm 1995). Overall, the hydrographs of GDE flows are muted compared to surface water streams (Whiting and Moog 2001; Whiting and Stamm 1995). The timing, reliability, and reduced extremism of GDE discharge is important for species that are associated with GDEs and has implications for the base flows observed in surface water systems during late summer.

Drivers

Natural flow regimes of groundwater and surface water systems on the SCNF are primarily driven by climate, geology, and beaver activity. Fluctuations in ground and surface water levels are also influenced by the degree of connectivity between a channel and its floodplain (Junk et al. 1989), as well as vegetation that slows runoff and consumes water throughout the drainage. There are three distinct precipitation zones on the Forest and the hydrographs of streams reflect the precipitation zones in which they originate (Tennant and Crosby 2009). The dominant form of precipitation below 5,000 feet is rain, and streams with headwaters in this zone tend to be flashier and more dynamic. Snow dominates above 8,200 feet and hydrographs of streams that begin in this zone exhibit strong snowmelt patterns. Middle elevations, which compose the majority of the Salmon River basin, receive mixed precipitation and streams from this zone show a snowmelt pulse as well as flashy responses to summer thunderstorms (Tennant and Crosby 2009). About 50 percent of the precipitation received by the Forest falls as snow between October and March and this snowpack is the primary source of streamflow throughout the basin (Sridhar et al. 2013). For most systems on the SCNF, flooding driven by snowmelt in early spring through mid-summer is part of the natural flow regime (IDEQ 2001).

The hydrologic response of drainages depends on their geology, with some settings allowing infiltration to groundwater systems while others yield water through shallow subsurface or overland flow (SCNF 2004). The SCNF has complex and diverse geologic assemblages that drive these patterns across the Forest (Otto et al. 2005). Steep canyonlands tend to support ephemeral and intermittent streams with rapid hydrologic responses (SCNF 2004). In moderately steep mountain slopelands, most streams are intermittent and the hydrologic response can range from slow to very rapid depending on slope dissection. The cryic uplands are important sources of sustained water yield throughout the year as they allow high rates of infiltration and accumulate large amounts of snow (SCNF 2004). The hydrologic response of these areas is slow to average and overland flow is rare. The high-elevation, historically glaciated lands are the largest sources of perennial discharge on the Forest. Additionally, the basins and troughlands act as sponges that absorb significant water during snowmelt and release it throughout the year. The hydrologic response of these areas is slow and overland flow is rare due to the large storage capacity of the basins (SCNF 2004).

Lastly, dam building by beavers is a driver of natural flow regimes on the SCNF. These structures modulate peaks and troughs of the yearly hydrograph, particularly when a series of dams exist within a single drainage (Rosell et al. 2005). Beaver dams increase the storage capacity of catchments by absorbing and retaining water during high flows. Discharge is then slowly released and leads to higher base flows during late summer. Beaver ponds and their dams enhance the depth, extent, and duration of inundation during flooding and elevate the water table during both high and low flows (Westbrook et al. 2006). Significant beaver populations within a drainage can result in a transition from intermittent to perennial flow and make aquatic and riparian ecosystems more resistant and resilient to the effects of drought and climate change (Pollock et al. 2014; Rosell et al. 2005). Beavers were historically present and remain active on the SCNF, but their extent is naturally limited in some locations by high gradient channels (MacFarlane et al. 2015; SCNF 2004).

Stressors

Stressors to water fluctuations include activities and forces that alter the timing, frequency, magnitude, duration, or rate of change of natural flows or that impact the hydrologic connectivity between ground and surface water systems. These forces can be natural or anthropogenic. On the SCNF they include wildfire, vegetation mortality due to insects and disease, drought, dams and diversions, roads and trails, timber harvest, mining, livestock grazing, and altered temperature and precipitation regimes (table 4).

Table 4—Stressors to groundwater and surface water fluctuations summarized for LTAs.

LTA	Road miles/LTA acre	Road miles/ floodplain acre	Trail miles/ LTA acre	Trail miles/ floodplain acre	Diversion/ LTA acre	LTA grazed (%)	LTA vegetation mortality (%)	Floodplain vegetation mortality (%)	Floodplain recreation sites (%)	LTA high severity burn (%)	Mines/ acre	LTA timber harvest (%)
10G	0.0004	0.003	0.0010	0.005	0.00011	13	0	2	0.04	7	0.0008	1
10M	0	0	0	0	0	0	0	0	0	0	0	0
10Q	0.0013	0.007	0.0006	0.004	0.00021	56	0	8	0.12	4	0.0007	3
10S	0.0008	0.005	0.0002	0.002	0	100	5	5	0.11	0	0.0007	0
10V	0.0004	0.002	0.0009	0.005	0.00006	35	2	3	0.03	10	0.0005	1
20G	0.0008	0.001	0.0008	0.002	0.00005	21	14	14	0.00	23	0.0003	7
20M	0	0	0.0003	0.004	0	0	0	0	0	7	0.0009	0
20Q	0.0019	0.002	0.0005	0.001	0.00006	57	37	34	0.01	10	0.0004	12
20S	0.0012	0.005	0.0006	0.002	0.00006	93	10	7	0.03	0	0.0006	0
20V	0.0012	0.003	0.0007	0.002	0.00008	75	11	10	0.04	3	0.0002	5
30G	0.0010	0.001	0.0007	0.001	0	32	21	27	0.08	22	0.0004	3
30M	0	0	0.0001	0	0	2	0	0	0	2	0	0
30Q	0.0013	0.002	0.0007	0.002	0.00003	71	50	38	0.01	8	0.0004	4
30S	0.0010	0.008	0.0004	0.003	0.00001	98	7	6	0.00	0	0.0004	1
30V	0.0007	0.001	0.0006	0.002	0.00003	62	13	12	0.00	8	0.0003	1
40G	0.0012	0.002	0.0008	0.001	0.00003	75	74	73	0	8	0.0007	4
40Q	0.0006	0.001	0.0011	0.004	0	100	62	49	0	26	0.0001	6
40V	0.0019	0.001	0.0004	0.002	0	98	88	88	0	0	0.0007	17
50G	0.0004	0.001	0.0008	0.002	0	47	9	14	0.07	12	0.0004	1
50M	0	0	0.0003	0.003	0	0	0	0	0	2	0	0
50Q	0.0003	0.002	0.0006	0.002	0.00001	59	41	42	0	2	0.0003	1
50S	0.0013	0.004	0.0006	0.002	0	97	14	15	0	0	0.0004	2
50V	0.0004	0.001	0.0009	0.002	0	45	19	25	0.06	6	0.0002	1
60G	0.0002	0.000	0.0010	0.001	0.00001	27	5	11	0.00	8	0.0004	0
60M	0	0	0.0000	0	0	86	4	11	0	0	0.0002	0
60Q	0.0010	0.003	0.0009	0.002	0.00004	63	32	21	0.05	2	0.0002	0
60S	0.0003	0.002	0.0002	0.002	0	99	7	13	0	0	0.0003	0
60V	0.0002	0.000	0.0006	0.002	0.00000	61	10	18	0.01	5	0.0002	0
70Q	0.0014	0.003	0.0003	0.000	0.00041	84	3	1	0	0	0.0011	0
70S	0.0018	0.006	0.0002	0.001	0.00005	93	1	1	0	0	0.0003	0
70V	0.0014	0.006	0.0005	0.002	0.00001	95	5	4	0.25	0	0.0001	0
VB	0.0036	0.004	0.0033	0.004	0.00038	60	22	16	0.15	4	0.0008	2

Wildfire, vegetation mortality due to insects and disease, and drought are natural disturbances to water fluctuations. Depending on severity, fire can have major hydrologic implications that include flash flooding or severe sedimentation that disrupts connections between ground and surface water systems (Doerr et al. 2006; Ice et al. 2004). Widespread vegetation mortality due to insects and disease alters water fluctuations by increasing the amount of late summer infiltration to groundwater systems (Bearup et al. 2014). Prolonged dry and wet periods are linked to predictable changes in water table levels throughout the assessment area (Serbina and Miller 2016). Data from USGS stream monitoring, for example, shows diminished streamflows during drought conditions from 2000 to 2005. While these stressors are natural, they can be amplified by anthropogenic activities. A century of fire suppression has contributed to an increase in fuel loads that can lead to larger, more severe fires (Dennison et al. 2014). Altered temperature and precipitation regimes that include warmer temperatures in all four seasons and reduced winter precipitation (Cleland et al. 2017) could prolong drought on some parts of the Forest.

Anthropogenic stressors to water fluctuations include diversions, roads and trails, timber harvest, mining, and livestock grazing. Diversions disrupt natural hydrologic connections and alter the timing, frequency, duration, and magnitude of peak and base flows (Winter et al. 1998). Roads and trails alter hillslope contours and add impervious surfaces to landscapes, decreasing potential infiltration and increasing surface runoff. These features can also be unnatural sources of fine sediment that fill lakes, wetlands, and stream channels, and that obstruct natural flow paths between surface and groundwater systems (Forman and Alexander 1998; Pickering et al. 2009; Reid and Dunn 1984). The effects of timber harvest on surface and groundwater systems depend on how the harvest is managed (Bosch and Hewlett 1982). Clear cutting can increase surface runoff and provide a source of sediment that disrupts natural surface and groundwater networks (Bosch and Hewlett 1982). Mining activity can alter the direction and structure of natural flow paths and lead to channel entrenchment, potentially resulting in reduced groundwater discharge, different distribution of water within a stream, or the disappearance or movement of springs (Bjerklie and LaPerriere 1985). Lastly, livestock grazing can reduce vegetative cover in the uplands and riparian areas, decreasing stability, increasing runoff, and allowing down-cutting and entrenchment of streams. Ultimately, this process leads to lower water tables and the drying of perennial water sources (Krueper 1993).

Changes in temperature and precipitation influence natural flow regimes in numerous ways. Warmer temperatures and altered precipitation regimes result in reduced snowpack, earlier snowmelt, and more precipitation in the form of rain—all forces that alter the natural timing and magnitude of flows (Cayan 1996; Hamlet et al. 2005). Furthermore, warmer temperatures result in increased evapotranspiration and altered distribution of plants that draw on groundwater sources (Chen et al. 2011; Rind et al. 1990; Weiss et al. 2009). The average temperatures between 1985 and 2015 of all four seasons have increased compared to the previous century (Cleland et al. 2017). Precipitation has generally decreased during winter and spring and increased during summer and fall (Cleland et al. 2017). Natural groundwater and surface water fluctuations are strained by these changes in temperature and precipitation regimes, and therefore any additional stressors act cumulatively (IAP 2016).

The major stressors of concern on the SCNF included mining, grazing, vegetation mortality, diversions, and roads. Mining began in Napias Creek in 1866 and has since expanded across the Forest, with few creeks not affected (Smith 1969). Most of the mines were located within six LTAs. While mine density was helpful in predicting impacts to flow regimes, no surface mines GIS layer was available to capture effects to floodplains including entrenched channels that lower water tables. Like mining, there has been a long history of grazing on the Forest. In the earliest years, overgrazing occurred due to trespass stock and resulted in serious damage to some drainages (Smith 1969). By 1947, rapid runoff caused by overgrazing was apparent in limited areas and most watersheds were in satisfactory condition (Smith 1969). Vegetation mortality had primarily impacted the northern half of the Forest, with eight LTAs having relatively large amounts of affected lands. With only 205 diversions scattered across the SCNF, most LTAs had relatively low diversion density. The majority of diversions were located in lower elevation LTAs including the Valley Bottom, Dissected Foothills, and Steep Canyonlands. According to the recent USFS Terrestrial Condition Assessment (Cleland et al. 2017), there were slightly more than 4,200 miles of roads on the Forest and about 66 percent of these were classified as unimproved.

Fires also have a long history of impacts to water fluctuations on the SCNF, including the Great Burn in 1910 (Smith 1969). Reports completed in response to the Mustang Complex fire highlight the alterations to flow regimes that can follow large fires in this region (SCNF 2012). These fires burned nearly 250,000 acres in 2012 and generated approximately 45,000 acres of water-repellent soil. The Burned Area Emergency Assessment predicted a reduction in infiltration of 23-37 percent and an increase in streamflow by 218-451 percent in the affected watersheds (SCNF 2012). Effects of post-fire flooding, such as major channel shifts or reduced bank stability have been captured in the watershed monitoring completed by the Forest (SCNF 2017).

Indicators

We used conifer and upland encroachment, as well as deviations in winter temperature and precipitation, as indicators of the condition of water fluctuations in surface water systems (table 5). Altered flow regimes are linked to transitions from riparian cover to upland species, including conifers (MacFarlane et al. 2017). Encroachment initiates a positive feedback loop in which increased upland cover locks landforms in place, alters the flow regime by modifying water yield and timing of fluctuations, and allows further upland encroachment (Huxman et al. 2005; MacFarlane et

Table 5—Indicators of the condition of groundwater and surface water fluctuations.

LTA	Winter temperature deviation (°F)	Winter precipitation deviation (%)	Intermittent streams conifer encroachment (%)	Intermittent streams upland encroachment (%)	Perennial streams conifer encroachment (%)	Perennial streams upland encroachment (%)
10G	2.9	-5	51	41	48	30
10M	2.7	4	71	0	58	13
10Q	2.8	0	58	31	64	24
10S	2.8	-9	80	14	57	36
10V	2.9	-8	64	30	65	25
20G	2.9	-5	49	37	59	28
20M	2.9	-3	41	40	69	0
20Q	2.9	0	74	17	74	13
20S	2.9	-9	56	38	42	50
20V	2.9	-9	54	40	54	41
30G	2.9	-5	54	19	46	21
30M	2.9	-5	96	4	64	19
30Q	2.9	-1	75	10	69	9
30S	2.9	-10	74	19	70	21
30V	2.9	-9	59	25	71	21
40G	3.0	1	42	5	54	19
40Q	3.1	-4	65	21	77	13
40V	3.1	0	36	13	33	10
50G	3.0	-9	60	28	54	19
50M	2.9	-13	98	0	27	22
50Q	2.9	-2	73	17	66	9
50S	3.0	-12	75	13	80	16
50V	2.9	-9	73	12	81	8
60G	2.9	-9	31	20	24	13
60M	3.2	-19	77	18	42	53
60Q	3.0	-6	60	26	40	44
60S	3.0	-15	66	22	26	59
60V	3.0	-13	58	15	51	13
70Q	2.9	-2	17	60	30	47
70S	3.1	-17	31	41	21	64
70V	3.0	-11	29	64	32	62
VB	2.9	-7	58	27	57	20

al. 2017). We used R-CAT (MacFarlane et al. 2017) analysis to determine the percentage of intermittent and perennial streams altered by conifer and upland encroachment for each LTA and considered these values as indicators of water fluctuations. Changes in snowpack due to anthropogenic warming have contributed to altered flow regimes throughout the western United States (Safeeq et al. 2015). As the primary control on snow accumulation is winter temperature (Safeeq et al. 2015), we used deviation in winter temperature and precipitation from the USFS Terrestrial Condition Assessment (Cleland et al. 2017) as indicators of the current condition of water fluctuations in each LTA.

To evaluate water fluctuations at GDEs, we used PFC reports completed by SCNF staff. These assessments included information on whether the GDE experienced relatively frequent inundation, whether water fluctuations were extreme, and if water supply was sufficient to maintain hydric soils. We summarized these reports and used best professional judgment to determine the NRV status of water fluctuations at GDEs.

Surface and Groundwater Fluctuations on the SCNF

Water fluctuations in surface water systems on the SCNF had been impacted by multiple interacting stressors. Based on encroachment indicators and deviations in winter precipitation and temperature, 10 percent of the Forest was within the NRV, 79 percent was moderately altered, and 11 percent was outside the NRV (fig. 10). Volcanic and granitic geologies with cryic or historically glaciated lands tended to be the most resistant and resilient to stressors. Surface water systems in sedimentary geologies with mountain slopelands and dissected foothills were most vulnerable to stressors to the natural flow regime. Like surface water systems, water fluctuations at GDEs also appeared to be impacted by stressors on the Forest. There was insufficient information to evaluate the NRV status of GDE water fluctuations for 84 percent of the Forest (fig. 11). We were able to assess two LTAs and both were outside the NRV. It appears that water fluctuations of GDEs located in volcanic dissected foothills or mountain slopelands were especially vulnerable to stressors.

Overall, it appeared that roads in the floodplain, diversions, mining, recreation sites in the floodplain, grazing, and altered temperature and precipitation regimes may have influenced surface and groundwater fluctuations on the SCNF. There were weak correlations between upland encroachment along intermittent streams and floodplain road density, diversion density, mine density, and percent of floodplain impacted by recreation sites. We also observed weak associations between upland encroachment along perennial streams and floodplain road density, winter temperature deviation, winter precipitation deviation, and percent of floodplain impacted by recreation sites. It appeared that timber harvest and vegetation mortality did not have major impacts to water fluctuations on the Forest. Nevertheless, they may have interacted with other stressors such as roads and grazing.

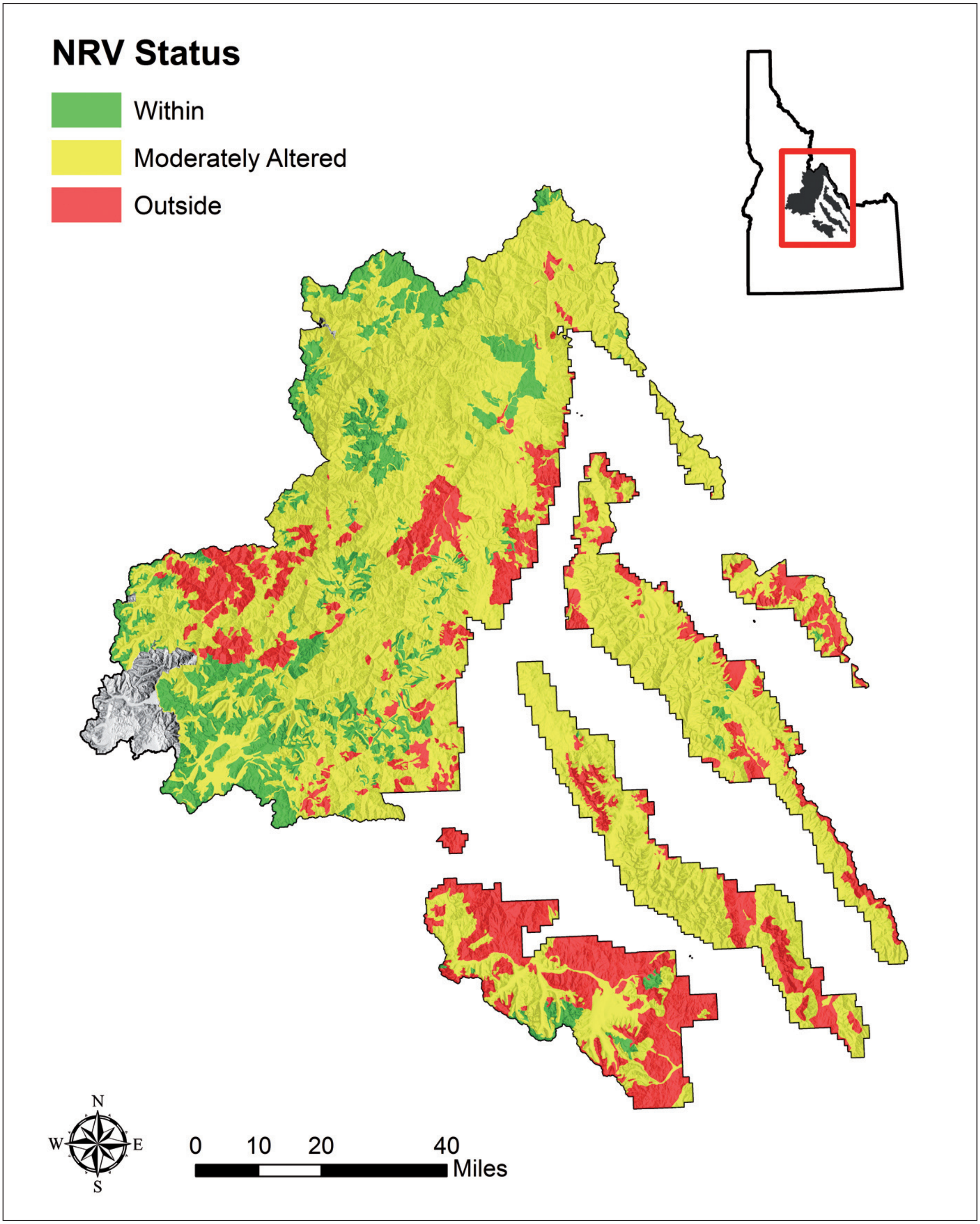

Figure 10—NRV status of water fluctuations in surface water systems on the Salmon-Challis National Forest.

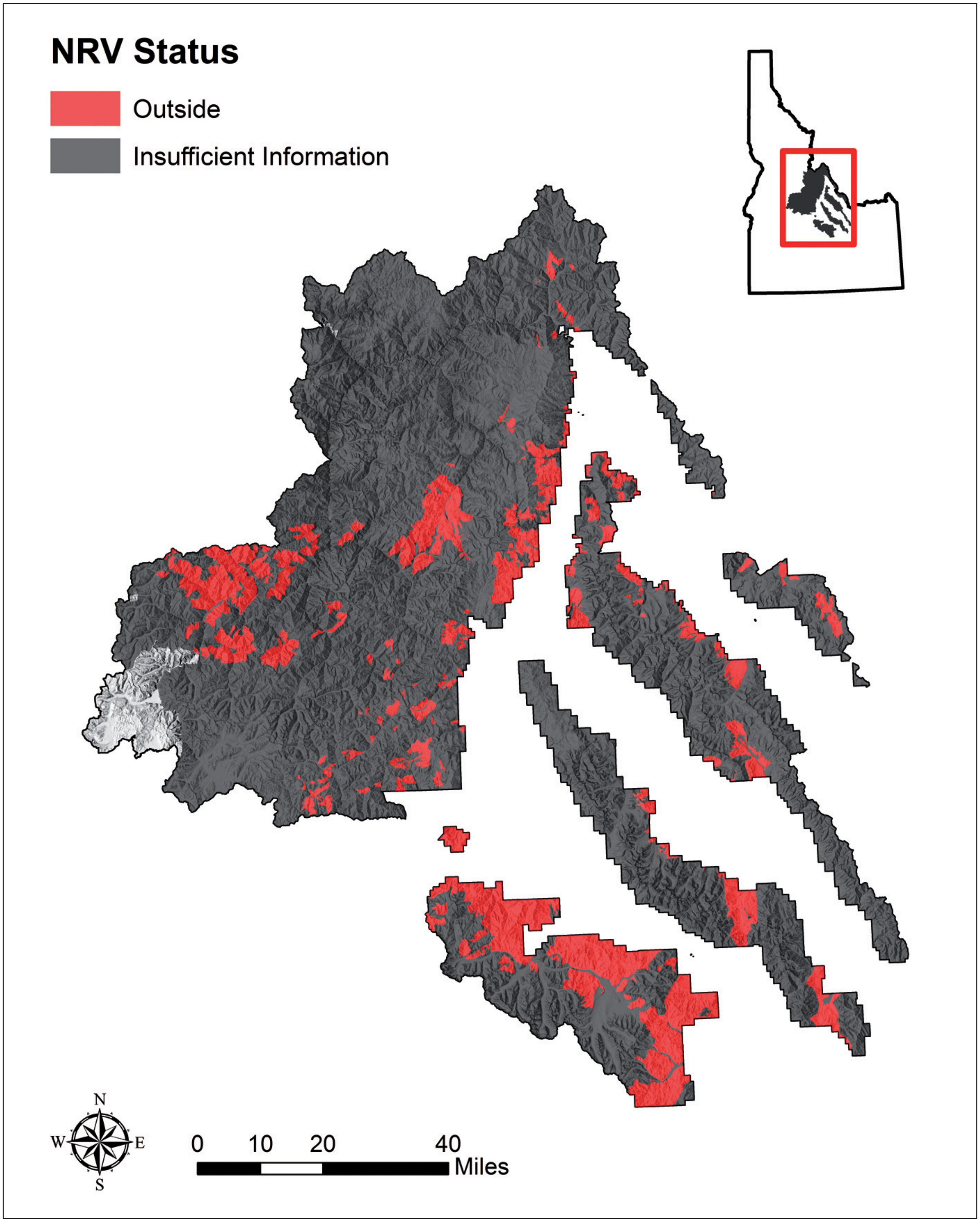

Figure 11—NRV status of water fluctuations at GDEs on the Salmon-Challis National Forest.

Stressors can have cumulative effects on natural flow regimes. For example, livestock grazing was a stressor in all LTAs considered outside their NRV. In addition to grazing, winter precipitation had decreased by at least 9 percent and winter temperatures had increased by at least 2.9 °F in all LTAs considered outside the NRV. Grazing was identified as a stressor in two LTAs considered within the NRV (40G and 40V), but these associations had experienced no reduction in winter precipitation. These results implied that cumulative stressors should be considered during planning and that management actions, such as using a rest period to limit grazing impacts, may be more successful in certain LTAs.

Our results aligned with many studies that have concluded that there has been a marked decline in annual streamflows in the region and throughout the western United States (Luce and Holden 2009; Safeeq et al. 2015). This trend is likely to continue as modeling for the Salmon River basin predicts the gradual advancement in the timing of peak flow associated with snowmelt by about 10 days. Furthermore, the VIC model indicates that the expected diminished snow water equivalent, reduced soil moisture, and increased evapotranspiration imply the potential to trigger drought in the basin (Sridhar et al. 2013). The transitional precipitation zones at mid-elevations will likely be extremely vulnerable to climate change as areas where snow accumulates near 0 °C are most sensitive to warming (Safeeq et al. 2015). See Appendix C for additional methodology and descriptions of groundwater and surface water fluctuations within each LTA.

Water Quality

Water quality describes the complex biogeochemical interactions that occur within aquatic and riparian ecosystems. The ecology of freshwater systems depends on inputs of sediment, nutrients, temperature, dissolved oxygen, and pH (Bilotta and Brazier 2008; Dauer et al. 2000; Johnston 1991; Sanchez et al. 2007). These characteristics impact the structure and function of streams, lakes, and GDEs in various ways. Furthermore, aquatic systems, particularly aquifers and hyporheic zones, provide the fundamental ecosystem service of nutrient transformation and biological filtration that results in drinking water for numerous communities (Boulton 2005). As surface waters become more polluted, sources of good water quality, especially groundwater resources, will be important refugia for considerable biodiversity and water sources for human consumption.

Drivers

The biogeochemistry of aquatic systems is driven by geology, chemistry of precipitation, the length of time water is in contact with certain soil and rock types, mixing of cold and thermal water sources, and the dissolution of organic and mineral substances from vegetation, soil, and rocks (Yee and Souza 1987). These factors influence the concentrations of dissolved substances and the temperature of ground and surface water systems. The underlying geology of some watersheds naturally contributes certain constituents to both surface water systems and GDEs (Domenico and Schwartz 1998). As water moves through flow pathways, it comes in contact with soil particles and bedrock that provide sources of constituents such as calcium, sodium, carbonates, and other elements. The length of time in contact with geologic formations influences the concentrations and types of constituents dissolved in water. Additionally, geology influences total dissolved solids through the types of rock present and how it weathers (Domenico and Schwartz 1998). The chemistry of precipitation impacts the types of minerals and the rates they dissolve in solution (Douglas 1968; Reid et al. 1981). Water quality is further influenced by natural leaching of organic matter and nutrients from soil (Qualls and Haines 1992), as well as biological processes within the riparian zone and aquatic environment that alter the chemical composition of water (Hill 1996; Osborne and Kovacic 1993).

Stressors

Stressors to water quality include forces that alter temperature, suspended sediments, and the concentrations of nutrients, minerals, or pollutants (table 6; Bilotta and Brazier 2008; Dauer et al. 2000; Johnston 1991; Sanchez et al. 2007). Concentrations can be altered by increasing their input or changing the amount of water in the system (Yee and Souza 1987). Large nutrient loads can cause algal blooms that ultimately lead to eutrophication (Anderson et al. 2002; Smith et al. 1999). Large inputs of sediments can reduce the depth of channels, lakes, and ponds (Einstein 1950) and fine sediment can obstruct interstitial spaces that link surface and groundwater systems (Richards and Bacon 1994; Wood and Armitage 1997). Shallow streams and lakes and systems with diminished groundwater inputs tend to have higher water temperature (Poole and Berman 2001). Stream temperature can be further increased by the loss of riparian vegetation that shades aquatic systems (Poole and Berman 2001). Large inputs of sediment can affect water quality by transporting pollutants that threaten municipal water supplies and aquatic species. Fine sediments suspended in the water column also limit light penetration, leading to reduced primary production and impacts to trophic relations (Wood and Armitage 1997).

Stressors to water quality can be generated by natural and anthropogenic forces. Wildfires are a natural stressor that can temporarily increase nutrient and sediment inputs and remove shade-providing riparian vegetation (Shakesby and Doerr 2003; Spencer et al. 2003). Many freshwater ecosystems have evolved with regular and frequent fire occurring in their watersheds. Historically, aquatic systems with high degrees of connectivity and robust species populations were resilient to the temporary effects of fire on water quality (Dunham et al. 2007). With fragmentation and extensive anthropogenic stressors, refugia for species and functional aquatic systems are diminished (Neville et al. 2009).

Anthropogenic factors that influence water quality include burning of fossil fuels, agriculture, diversions, mining, roads, recreation, and loss of riparian zones. Fossil fuel combustion and high intensity agriculture have increased nitrogen deposited from the atmosphere (Carpenter et al. 1998). Additionally, runoff from fertilized fields or grazed areas can increase nutrient inputs to aquatic systems (Carpenter et al. 1998; Yee and Souza

Table 6—Stressors to and indicators of the condition of water quality in surface water systems on the Salmon-Challis National Forest.

	Stressors					Indicators				
LTA	Mines per acre	Floodplain rec sites (%)	Trail mile per floodplain acre	Road mile per floodplain acre	LTA grazed (%)	CTQ	D50	Median stream temp. (°C)	Streams impaired (%)	Waterbodies impaired (%)
10G	0.0008	0.04	0.005	0.003	13	59	0.09	13.4	1.5	0
10M	0	0	0	0	0	-	-	-	0	0
10Q	0.0007	0.12	0.004	0.007	56	61	0.06	11.4	7.7	0
10S	0.0007	0.11	0.002	0.005	100	60	0.03	10.1	31.1	0
10V	0.0005	0.03	0.005	0.002	35	54	0.05	10.6	1.3	0
20G	0.0003	0	0.002	0.001	21	61	0.08	11.4	0.3	0
20M	0.0009	0	0.004	0	0	-	-	-	0	0
20Q	0.0004	0.01	0.001	0.002	57	56	0.05	10	2.9	34.6
20S	0.0006	0.03	0.002	0.005	93	63	0.02	12	21.6	21
20V	0.0002	0.04	0.002	0.003	75	61	0.03	10.9	7.1	37.6
30G	0.0004	0.08	0.001	0.001	32	-	0.01	-	0.1	7.1
30M	0	0	0	0	2	-	-	-	0	0
30Q	0.0004	0.01	0.002	0.002	71	57	0.03	8.1	5.3	15.9
30S	0.0004	0	0.003	0.008	98	-	-	-	13.4	92.8
30V	0.0003	0	0.002	0.001	62	71	0.01	9.8	6.7	22.6
40G	0.0007	0	0.001	0.002	75	66	0.05	14.8	0	0
40Q	0.0001	0	0.004	0.001	100	-	-	-	11.3	3.1
40V	0.0007	0	0.002	0.001	98	-	-	-	0	0
50G	0.0004	0.07	0.002	0.001	47	47	0.04	9.4	0.9	6.2
50M	0	0	0.003	0	0	-	-	-	0	0
50Q	0.0003	0	0.002	0.002	59	42	0.05	9.3	5.1	38.1
50S	0.0004	0	0.002	0.004	97	-	-	-	4.8	0
50V	0.0002	0.06	0.002	0.001	45	50	0.05	9.6	2.6	27.7
60G	0.0004	0	0.001	0	27	-	-	-	0	26.8
60M	0.0002	0	0	0	86	-	-	-	0	0
60Q	0.0002	0.05	0.002	0.003	63	55	0.04	10.8	4.1	23.3
60S	0.0003	0	0.002	0.002	99	-	-	-	5.7	7.5
60V	0.0002	0.01	0.002	0	61	-	-	-	6.7	34.6
70Q	0.0011	0	0	0.003	84	-	-	-	5.2	0
70S	0.0003	0	0.001	0.006	93	-	0.04	-	18.7	0
70V	0.0001	0.25	0.002	0.006	95	82	0.01	-	7.6	0
VB	0.0008	0.15	0.004	0.004	60	54	0.05	10.5	2.8	11.1

1987). Diversions and pumping remove water from the system and can increase the concentration of dissolved minerals and solutes (Liu et al. 2003). Mining can introduce trace metals as well as increase phosphorus loading (Yee and Souza 1987). Roads, particularly those located within floodplains, are unnatural sources of sediment and are linked to altered levels of heavy metals, salinity, turbidity, and dissolved oxygen (Forman and Alexander 1998). Recreation areas, including trails and campsites, can increase sediment inputs and affect water quality through refuse disposal. Lastly, wetlands and riparian zones are very effective at trapping sediments and nutrients. In fact, Gilliam (1994) identified these areas as the most important factor influencing nonpoint-source pollutants and essential for surface water quality protection. Globally, riparian areas are shrinking, with potential deleterious effects to water quality (Verhoeven et al. 2006).

Indicators

We used five indicators to determine the NRV status of surface water quality of each LTA (table 6): the Community Tolerance Quotient (CTQ) for macroinvertebrates, average hourly temperature from July 15–August 31, median substrate size (D50s), and the percentages of streams and waterbodies classified as impaired by the Idaho Department of Environmental Quality (IDEQ). The CTQ is an index developed by Winget and Mangum (1979) that has been used frequently by the USFS and the Bureau of Land Management. Macroinvertebrate taxa are assigned a tolerance quotient ranging from 2 to 108, with lower quotients associated with high quality, unpolluted waters and higher quotients found in severely polluted waters. The CTQ data have been collected by the Pacfish-Infish Biological Opinion Effectiveness Monitoring Program (PIBO) since 2003. The PIBO program has also collected the average hourly temperature data and the median substrate size (D50) data used in our assessment of water quality. Temperature data were available from 2005 through 2016 and substrate size data were available from 2001 to 2016. We used IDEQ spatial data to determine the percentage of stream miles and waterbodies classified as impaired within each LTA.

To evaluate the water quality status of GDEs, we used PFC reports completed by SCNF staff. These assessments include information on the stressors present at each GDE including hydrologic and soil alteration or recreation and animal effects. Each report noted if changes in water quality were affecting the GDE. We summarized these reports for each LTA and used best professional judgment to determine the NRV status of GDE water quality.

Water Quality on the Salmon-Challis National Forest

Stressors had impacted water quality on a limited portion of the Forest. Based on indicators for surface water systems, 41 percent of the SCNF was within the NRV, 40 percent was moderately altered, and 1 percent was outside the NRV (fig. 12). There was insufficient information to evaluate surface water quality on 18 percent of the Forest. GDEs showed less impact to water quality with 14 percent of the Forest within the NRV and 2 percent considered to be moderately altered (fig. 13). However, there was insufficient

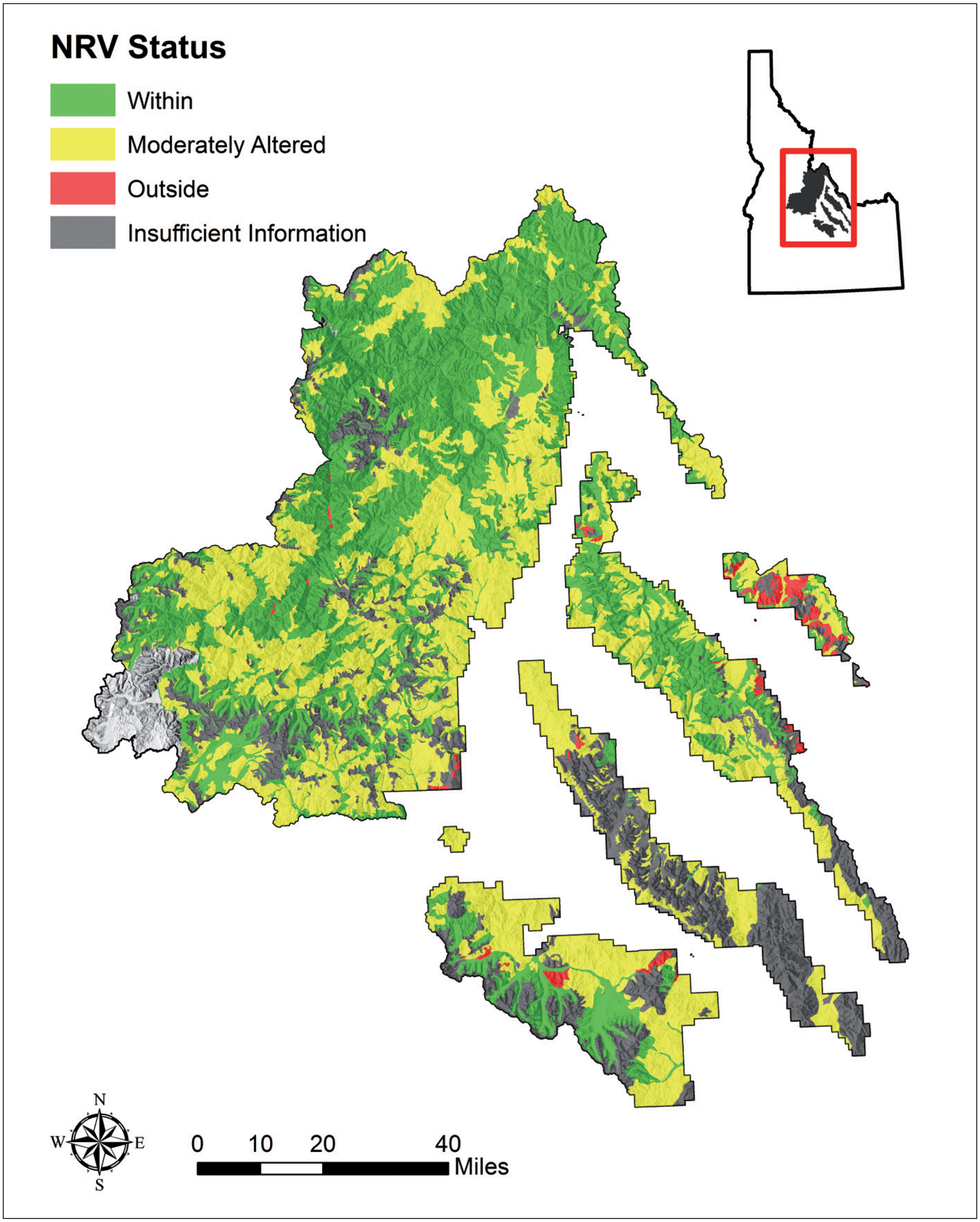

Figure 12—NRV status of water quality in surface water systems on the Salmon-Challis National Forest.

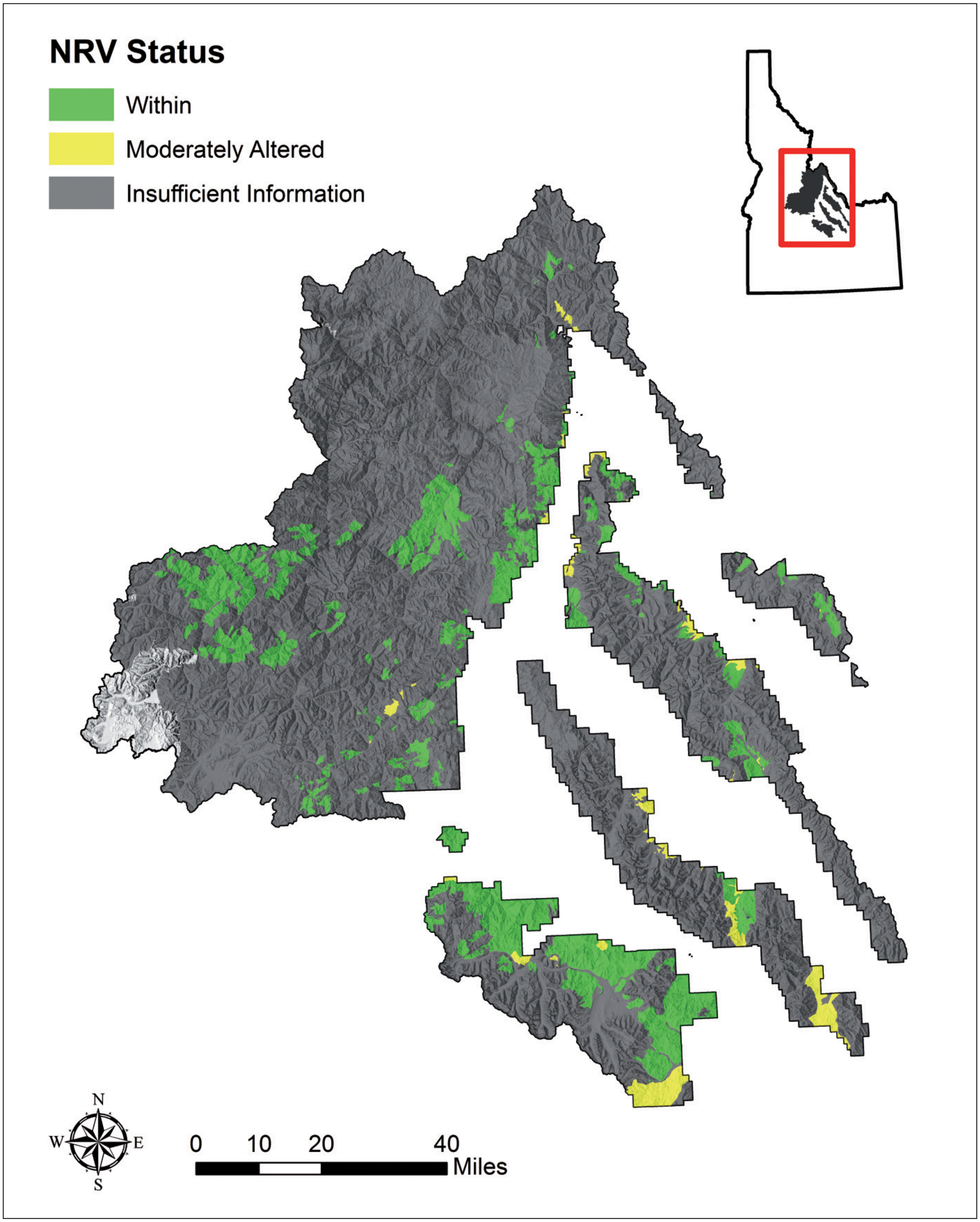

Figure 13—NRV status of water quality at GDEs on the Salmon-Challis National Forest.

information to evaluate GDE water quality on 84 percent of the SCNF. Geologic settings and landforms had some influence on water quality and the resistance or resilience of streams to stressors. Sedimentary land types are expected to be more productive than granitic, quartzite, or volcanic (SCNF 2004). Our results showed they also were potentially more vulnerable to changes in water quality, but there was insufficient information to evaluate the majority of sedimentary LTAs. Quartzite and granitic settings appeared fairly resistant and resilient to water quality stressors and volcanics were more sensitive.

The primary stressors to water quality on the SCNF were grazing and roads, with some observed effects from recreation sites within floodplains, diversions, and mines. There were weak positive associations between grazing pressure, measured as percentage of LTA located within an active allotment, and higher CTQ values, smaller median substrate size, and increased percentages of impaired stream miles. While roads throughout watersheds did not appear to have strong effects, roads within floodplains were associated with reduced water quality. LTAs with larger floodplain road density tended to have higher CTQ values and a larger percentage of impaired stream miles. There was a weak positive association between mine density and median stream temperature, diversion density and median substrate size, and floodplain recreation sites and greater CTQ values.

Our results were consistent with several IDEQ assessments completed for subbasins on the Forest including the Salmon River (Middle)-Panther Creek Subbasin (IDEQ 2001), the Salmon River (Upper and Lower Middle Forks) Subbasin (IDEQ 2008), the Lemhi River Subbasin (IDEQ 2012), the Pahsimeroi River Subbasin (IDEQ 2013), the Little Lost River Subbasin (IDEQ 2015), and the Salmon River (Upper) Subbasin (IDEQ 2016). These reports consistently document reduced water quality due to thermal loading and sediment deposition. Additionally, reports for the Upper Salmon, Lemhi, and Pahsimeroi Rivers include *E. coli* and fecal coliform bacteria as concerns. The assessments indicate alteration of streambanks and loss of riparian vegetative cover due to grazing as major contributors to high stream temperatures and large sediment loads. The reports conclude that these systems are responsive to restoration and management practices, with improvements observed in the Salmon River (Middle)-Panther Creek, Upper Salmon River, and Upper and Lower Middle Fork of the Salmon River subbasins. These conclusions support our analysis that shows many LTAs moderately altered from the NRV. See Appendix D for additional methodology and descriptions of surface and GDE water quality within each LTA.

Channel and Floodplain Dynamics

Riparian areas include aquatic and terrestrial habitats dispersed across a geomorphological template that is formed by the movement of sediment and water within the channel and between the channel and the floodplain (Junk et al. 1989; Stanford et al. 2005). The distribution of habitats across this template is driven by various patterns and processes operating across spatial and temporal scales including flooding, channel avulsion, cut and fill alluviation, recruitment of large wood, and regeneration of vegetation (Stanford et al. 2005). Streamflow in particular is a master variable that strongly influences channel and floodplain structure. High flows connect the stream to its floodplain, enabling the exchange of organic matter and energy (Junk et al. 1989; Poff et al. 1997). They also play an important role in the life cycle of many riparian vegetation species by dispersing seeds and scouring the channel, resulting in bare substrate needed by seedlings. Low flows allow for the establishment and growth of vegetation and successional rebuilding (Salo et al. 1986; Stanford et al. 2005; Thomaz et al. 2007). Complex floodplains with diverse and highly dynamic aquatic and terrestrial habitats are more productive (Junk et al. 1989; Thoms 2003), have higher biodiversity (Hauer et al. 2016; Ward et al. 1999), and are more resistant and resilient to disturbance (McCluney et al. 2014).

Drivers

A major driver of channel and floodplain dynamics is the underlying geology and surrounding terrain. In the Columbia River basin, catchment geology explains a significant amount of variation in channel substrates and bank attributes (Al-Chokhachy et al. 2010). Channels draining igneous catchments tend to support more undercut and steeper banks and larger amounts of fine sediment than those in sedimentary settings (Al-Chokhachy et al. 2010). Floodplain structure is further influenced by topography. Very steep gradients (fig. 14a) and narrow canyons (fig. 14b) limit floodplain development in many parts of the SCNF. Due to the steep slopes in these areas, debris slides and avalanches are common natural disturbances to channels and floodplains (SCNF 2004). These events alter channel structure by depositing large amounts of wood or sediment within channels (Benda et al. 2005; Fetherston et al. 1995). In topographies with shallower gradients or large meadows, wide valley bottoms with streams meandering through depositional material are common (fig. 15; SCNF 2004). Lastly, the vegetative communities of the surrounding terrain influence the frequency

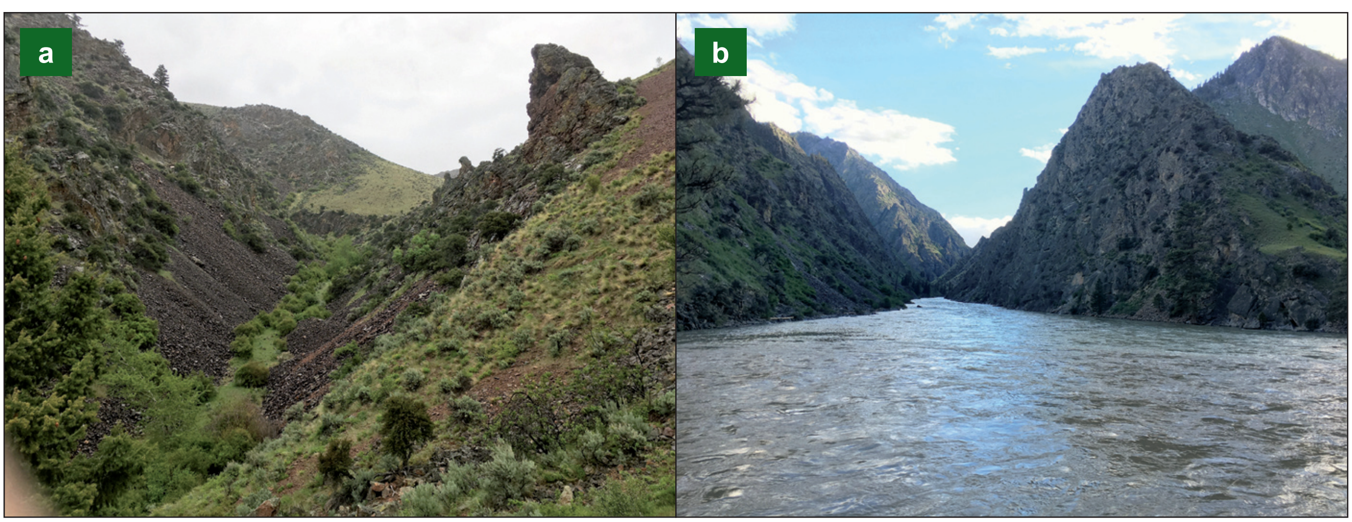

Figure 14—(a) The steep gradient limits development of a floodplain at Perreau Creek. (b) Similarly, the narrow canyon of the Middle Fork of the Salmon River also limits the development of a floodplain (photos by D.M. Smith, USFS).

Figure 15—Streams with shallower gradients and wider valley bottoms, such as Bear Valley Creek, meander through depositional material (photo by D.M. Smith, USFS).

and volume of wood within the channel. Debris create complex floodplains by altering water velocity, generating locations of scour and deposition, stabilizing streambanks, and creating pool habitats (Gurnell et al. 2002). Drainages on the SCNF range from forested to grassland and shrubland, naturally creating differing amounts of large wood expected within channels. The size and condition of forests near the channel, as well as gradient, account for variability in the frequency and volume of large woody debris, stream substrate, and channel shape (Al-Chokhachy et al. 2010).

In addition to geology and terrain, flooding is a driver of channel and floodplain dynamics on the SCNF. The timing, frequency, duration, and magnitude of flood pulses influence the extent and condition of riparian zones associated with aquatic habitats (Poff et al. 1997). Most of the hydrographs of streams on the Forest are dominated by a strong snowmelt signature in early summer, with the exception of some low-elevation streams that are highly influenced by summer thunderstorms (Tennant and Crosby 2009). Approximately 55 percent of streams on the SCNF are intermittent or ephemeral, limiting the development of their associated floodplains.

A final driver of channel and floodplain dynamics is beaver activity. Beavers modify stream morphology by cutting wood and building dams that effectively trap sediment, create and maintain wetlands, alter the structure and dynamics of the riparian zone, and lead to the formation of wide, low gradient, alluvial plains as the associated ponds fill with sediment (Gurnell et al. 1998; Naiman et al. 1988). These meadows contribute to a step pattern along the stream's longitudinal profile. Additionally, beaver dams slow water velocity and create variable substrates throughout the channel. Structures built by beavers increase the heterogeneity of channel widths and depths and the diversity of morphological features. Overall, beaver dams encourage stable channels with more complex floodplains (Gurnell et al. 1998; Pringle et al. 1988). Because of the stabilizing effects of beaver activity, it is common to deliberately introduce beaver during restoration efforts (Gurnell et al. 1988). In the Columbia River basin in particular, beavers have successfully been used to aggrade entrenched channels, raise water tables, and expand riparian habitat (Pollock et al. 2007).

Stressors

Compared to other salmon-bearing basins in the northern Pacific, the complexity of floodplains and the quality of stream habitats of the Columbia River basin are degraded (Luck et al. 2010). Alterations in the structure and function of aquatic and riparian systems within this large basin that includes the SCNF have frequently been attributed to stressors from certain land management practices, including livestock grazing, road construction, agriculture, timber harvest, and mining (Al-Chokhachy et al. 2010; Kershner et al. 2004; Kershner and Roper 2010). In addition to these stressors, channel and floodplain dynamics on the SCNF are also likely impacted by diversions, recreation, invasive species, and altered temperature and precipitation regimes.

Livestock grazing is one of the primary stressors to channel and floodplain dynamics on the Forest. There are numerous impacts to floodplains including trampling banks, over-widening streams, a decrease in stabilizing vegetation, and unnatural sediment from trailing (George et al. 2002; Thibault et al. 1999). With European settlement of the West came overgrazing and the removal of vegetation from landscapes (Rapport and Whitford 1999). As protective vegetation was destroyed, runoff became more sporadic and large amounts of sediment were introduced to channels (Armour et al. 1991; Packer 1953). Systems became out of balance between the supplies of water and sediment and streams were not able to clear depositional material (Armour et al. 1991). Larger peak flows that resulted from the loss of vegetation caused channels to become incised and the water table to be lowered. Riparian plants were left in drier soils and ultimately replaced by upland species, leading to an overall reduction in the size of the floodplain (Belsky et al. 1999). Overgrazing did occur on the SCNF, primarily due to trespass stock during the very early days of the Forest (Smith 1969). In 2017, approximately 60 percent of the Forest had active grazing allotments, and the steep terrain of many LTAs tends to concentrate livestock and wildlife to valley bottoms (SCNF 2004).

Stressors such as road construction, recreation, mining, and wildfire can impact channel and floodplain dynamics by altering sediment inputs or disrupting the connection between the channel and its floodplain (Bellmore et al. 2012; Benda et al. 2003; Forman and Alexander 1998; Jones et al. 2000; Trombulak and Frissell 2000). In addition to providing an unnatural source of fine sediment, roads disrupt floodplain development by confining or crossing the stream (fig. 16). Roads that parallel streams often limit

Figure 16—A road paralleling Colson Creek erodes into the channel, disrupting natural channel migration and contributing sediment to the channel (photo by D.M. Smith, USFS).

movement of the channel and road crossings cause streams to become wider and shallower with flattened banks (Forman and Alexander 1998; Jones et al. 2000; Trombulak and Frissell 2000). Trails and campgrounds can have similar effects by increasing sediment inputs and causing trampling of stream banks. Artificial banks built to protect roads and recreation structures disconnect the stream from its floodplain and simplify the structure of the system (Forman and Alexander 1998; Jones et al. 2000; Trombulak and Frissell 2000). Similarly, mining, especially instream placer mining, can have negative impacts on channel and floodplain dynamics. This type of disturbance is common across the Forest with an extreme example in the Yankee Fork drainage. Dredging and other mining activities often reduce streams to a single channel and limit channel migration and cut and fill alluviation (Bellmore et al. 2012). High severity wildfires increase sediment inputs to streams and remove riparian vegetation, further altering channel and floodplain dynamics (Benda et al. 2003).

Activities that alter the natural flow regimes and therefore the distribution of floodplain habitats include timber harvest, diversions, invasive species, and altered temperature and precipitation regimes. Depending on how timber harvest is managed, it may affect floodplain structure (Bosch and Hewlett 1982). Clear cuts can increase sedimentation and the timing and magnitude of surface runoff. The frequency of landslides usually increases following harvest, in turn leading to more debris flows that can alter channel morphology and the amount of instream wood (Benda et al. 2005). Dams and diversions decrease the magnitude of floods that reshape the geomorphological template, connect a stream to its floodplain, and transport sediment downstream (Winter et al. 1998). Dams can starve systems of sediment, resulting in channel incision and coarser substrate (Kondolf 1997). Furthermore, regulated reaches have 79 percent less active floodplain areas and 3.6 times more inactive floodplain area than comparable unregulated reaches (Graf 2006). Regulation reduces floodplain complexity by 37 percent and interior western rivers are most susceptible to these changes (Graf 2006). Certain types of invasive species withdraw more groundwater than native riparian vegetation, causing the water table to lower and conditions to become drier (Di Tomaso 1998; Ehrenfeld 2003). These invasions can initiate a positive feedback loop in which drier conditions facilitate more invasive species and an even lower water table, eventually leading to an incised channel with no connection to its floodplain and a loss in riparian cover (MacFarlane et al. 2017). Lastly, warmer and drier conditions can alter flow regimes and reduce inundation that drives floodplain dynamics (Dukes and Mooney 2004; Stromberg et al. 2007).

Indicators

We used eight indicators of channel and floodplain dynamics to determine the NRV status for each LTA: a ratio of floodplain acres per stream mile, sinuosity, bank stability, bank angle, frequency of large wood within the channel, volume of large wood within the channel, area within floodplains of perennial streams that has been burned with moderate to high severity between 1984 and 2014, and a cross section wetland rating. Floodplain acres per stream mile was calculated using a map of the 50-year floodplain and the NHD flowline GIS layer. The PIBO Effectiveness Monitoring Program provided the data for sinuosity, bank stability, bank angle, frequency and volume of large wood, and the cross section wetland rating. The area within floodplains burned with moderate to high severity was calculated using data from the USFS Terrestrial Condition Assessment (Cleland et al. 2017).

Channel and Floodplain Dynamics on the SCNF

Stressors had moderately impacted channel and floodplain dynamics on a large portion of the Forest. Based on indicators of floodplain complexity, 33 percent of the SCNF was within the NRV and 49 percent was moderately altered (fig. 17). There was insufficient information to evaluate the NRV status for 18 percent of the Forest. It appears that some geologies and landforms were more resistant and resilient to stressors. Channels and floodplains in granitic geologies, steep canyonlands, and glacial troughlands were generally in the best condition on the Forest. Volcanic and sedimentary geologies, mountain slopelands, and cryic uplands appeared more vulnerable to stressors that alter channel and floodplain dynamics.

The primary stressors to channel and floodplain dynamics on the SCNF were grazing and roads. We observed weak negative correlations between the percentage of the LTA with active grazing and bank stability. When compared with the PIBO program’s index of physical habitat integrity, we found the index decreased with increased grazing pressure. Active grazing is common and extensive across the Forest, with a median of 98.5 percent of LTA

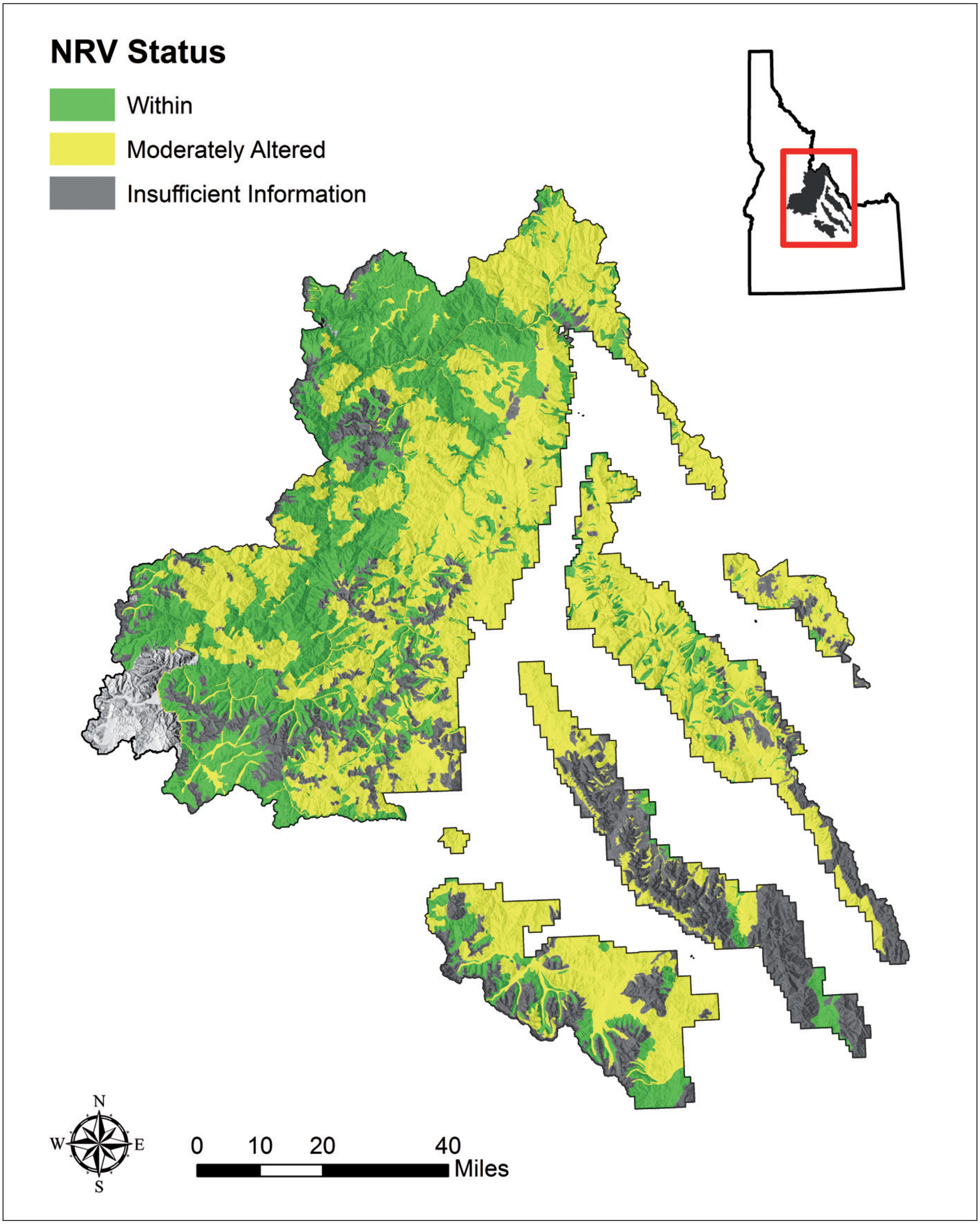

Figure 17—NRV status of channel and floodplain dynamics on the Salmon-Challis National Forest.

acreage located within active allotments (SCNF 2017). Roads, particularly those within floodplains, had also impacted channel and floodplain dynamics. Our results showed a correlation between large floodplain road densities and the loss of riparian cover, indicated by upland encroachment at perennial and intermittent streams. Furthermore, roads in floodplains were associated with reduced frequency of large wood and a more degraded PIBO physical habitat index. Finally, we observed reduced physical habitat integrity associated with more recreation sites within the floodplain.

The conditions of stream channels and their floodplains on the SCNF are monitored by the PIBO Effectiveness Monitoring Program (Archer and Ojala 2015). This program assigns an index of physical habitat integrity that is calculated using residual pool depth, percent pools, median substrate size, percent of pool tail fines less than 6 mm in diameter, large wood frequency, and average bank angle. Our results were consistent with analysis completed by this program that shows the overall physical habitat index for managed sites is slightly degraded compared to reference sites on the Forest, within the ecoregion, and throughout the Columbia River basin. The components of the index that are especially skewed from reference conditions on the SCNF are median substrate size, wood frequency, and bank angle. The PIBO program uses repeated measures to assess the trend of the physical habitat index and all its components. On the SCNF, there is a significant downward trend in the physical habitat integrity index since 2001 (Archer and Ojala 2015).

Archer and Ojala (2015) further identify patterns and trends for the following subbasins: Middle Salmon-Panther Creek, Lemhi, Little Lost, Big Lost, Upper Salmon, Lower Middle Fork Salmon, and the Upper Middle Fork Salmon. There were significant downward trends in the overall index of streams in the Middle Fork-Panther Creek, Little Lost, Big Lost, and Upper Middle Fork subbasins. The most common concerns throughout the basin are reduced frequency of large wood, smaller median substrate size, and larger percentage of fine sediment in pool tails. Wood frequency significantly differs from reference conditions in the Middle Fork-Panther Creek, Lemhi, Big Lost, and Upper Salmon subbasins. The median substrate size significantly differs from reference conditions in the Lemhi, Little Lost, and Upper Salmon subbasins. The percentage of pool tail fines less than 6 mm significantly differs from reference conditions in the Lemhi, Upper Salmon, and Upper Middle Fork subbasins. These conclusions are somewhat limited, however, by small sample sizes within the subbasins.

In addition to the PIBO program, streams and their floodplains on the SCNF also are monitored by the SCNF Watershed Program. Like PIBO's physical habitat index, the watershed monitoring program records an Aquatic Zone Analysis Rating (AZAR) that is based on qualitative ratings of vegetative stream cover, vegetative bank cover, dominant vegetative type, bank rock content, dominant bank rock size, bank cutting, instream sediment deposition, and ungulate bank damage. Our results were consistent with analysis completed by the watershed program, which has identified 50 monitoring sites of concern. The sites were identified if the percent fines was greater than 30 percent and/or bank stability was less than 80 percent and/or the AZAR rating was less than 70 percent based on the average of sampling done between 2012 and 2016. Of these, one site was located in the Middle Salmon-Chamberlain; 15 were in the Middle Salmon-Panther; 10 were in the Upper Salmon; two were in the Lower Middle Fork; one was in the Upper Middle Fork; six were in the Lemhi; nine were in the Big Lost; and six were in the Little Lost. Overall, the Watershed Monitoring Report (SCNF 2017) shows no relationship between the percentage of watershed grazed, percentage of watershed burned, or road density within the watershed and lower AZAR scores. These conclusions, however, are somewhat limited as the dataset lacks reference sites and the monitoring is completed only at streams with anadromous and/or resident fish and locations easily accessible by foot or vehicle. See Appendix E for additional methodology and descriptions of channel and floodplain dynamics within each LTA.

Condition of Spring Runout Channel

Runout channels are "groundwater-fed streams that emerge from springs or within groundwater-fed wetlands" (fig. 18; USDA FS 2012). Spring runout channels can be distinguished from those dominated by runoff by their flow regimes and sediment inputs (Griffiths et al. 2008). It is important to assess the condition of these unique downstream portions of springs or wetlands because they can support unusual aquatic and wetland biota and these features are especially vulnerable to spring development.

Figure 18—Example of a spring runout channel located in the Copper Basin on the Salmon-Challis National Forest (photo by D.M. Smith, USFS).

Drivers

The primary drivers of spring runout channel dynamics are flow regimes and sediment inputs (Griffiths et al. 2008; Whiting and Stamm 1995). The hydrographs of spring-dominated channels tend to be less variable than runoff channels (Whiting and Moog 2001). Sediments in spring channels tend to be variable in size with cobbles and boulders generally only present at the head of springs. Typically, springflow-dominated channels lack fine sediments or algae, indicating that sediments are regularly flushed from the system (Whiting and Moog 2001; Whiting and Stamm 1995). The muted hydrograph and the limited sediment inputs that are characteristic of springs lead to channels with steep banks and dense vegetative cover, armored beds, greater sinuosity, weakly developed bars, and lower width to depth ratios (Griffiths et al. 2008; Whiting and Moog 2001; Whiting and Stamm 1995).

Stressors

Stressors to the condition of spring runout channels include forces or activities that alter spring flow regimes, sediment inputs, or channel structure (USDA FS 2012). Diversions, regulation, and spring development can alter the amount of flow in the channel as well as the timing or magnitude of pulses (Kendy and Bredehoeft 2006; Sophocleous 2002). Road construction, recreation, and livestock grazing can increase the sediment load and overwhelm the system with sediment that cannot be cleared. These activities can also lead to trampling channel banks and shallower channels. Runout channels affected by trampling, erosion, entrenchment, ditching, or redirection of flow can lead to extreme degradation or the complete absence or elimination of a runout channel.

Indicators

To evaluate the dynamics of spring runout channels, we used PFC reports completed by SCNF staff. These assessments included information regarding the geomorphology and soils at each GDE, including if human-caused mass movement or other disturbances affected the site stability, if the runout channel was functioning naturally and not entrenched or otherwise altered, and whether soils were intact and functional without excessive erosion or deposition. We summarized these reports and used best professional judgment to determine the condition of spring runout channels.

Condition of Spring Runout Channel on the SCNF

Stressors have impacted the dynamics of spring runout channels on some parts of the Forest. Based on PFC reports, approximately 16 percent of the SCNF was outside the NRV for the condition of spring runout channels (fig. 19). There was insufficient information to evaluate 84 percent of the Forest. We were able to evaluate two LTAs for this KEC: 20V and 70V. Both are composed of volcanic geologies that appear to be vulnerable to forces that alter runout channels. Grazing was impacting spring channels with many reports describing trailing, trampling, and shearing and the subsequent erosion and entrenchment of the runout channels (fig. 20). More information across the Forest is needed to understand the extent of impacts to spring runout channels. See Appendix F for additional methodology and descriptions of the condition of spring runout channels within each LTA.

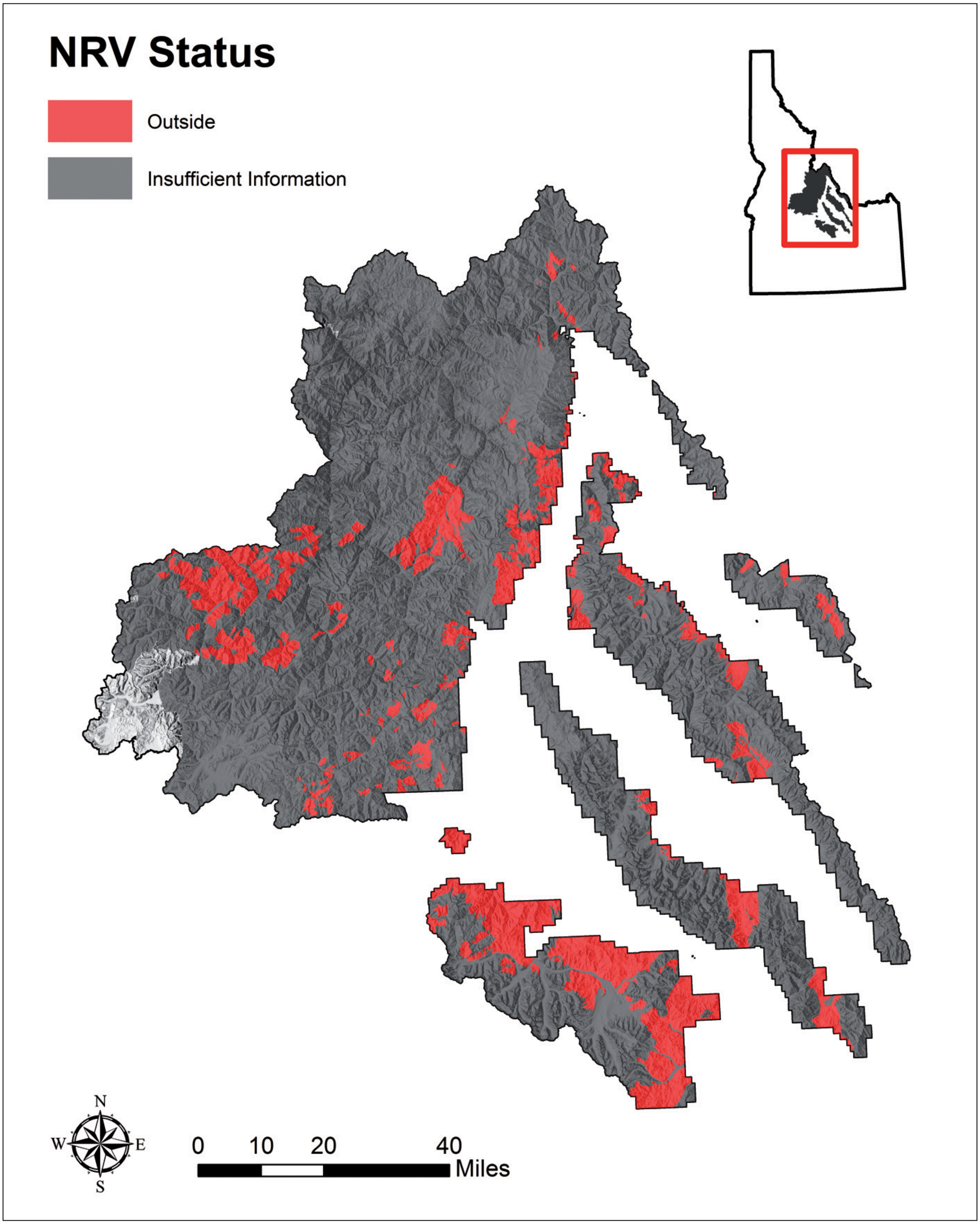

Figure 19—NRV status of spring runout channel condition on the Salmon-Challis National Forest.

Figure 20—Example of impacts, including trailing, trampling, and shearing imposed by cattle on a spring runout channel on the Salmon-Challis National Forest (photo by K.P. Driscoll, USFS).

Composition and Condition of Riparian Ecosystems

Composition and condition of riparian plant communities exert disproportionately large influences on forest resources, given the relatively small area of riparian ecosystems. Herbaceous and woody riparian plants enhance salmonid habitat by stabilizing soil, creating overhanging banks, and shading streams (Beschta 1997; Winward 2000). Cottonwoods and other riparian trees are favored roosts, nest sites, and foraging substrates for terrestrial wildlife (Smith and Finch 2013, 2016). Anthropogenic changes to composition and condition of riparian communities have been linked to reduction in quality of aquatic and terrestrial habitat and alteration of stream dynamics (Krueper et al. 2003; Pollock et al. 2014; Williams et al. 1999). An understanding of riparian communities and their condition is therefore key to evaluating ecosystem integrity in the SCNF.

Classification of Riparian Ecosystems in the SCNF

Classification of riparian ecosystems is essential to evaluating composition and condition because expected species, disturbance types, and response to disturbances vary among physical settings and biotic communities (Gregory et al. 1991). With its varied geology and topography, the SCNF has physical characteristics of several geographic provinces including the Rocky Mountains, Great Basin, and Columbia Plateau. As a result, numerous riparian vegetation communities are present in the Forest. Riparian ecosystems also are influenced by a variety of physical and biological processes that occur over relatively short time scales and can be impacted by anthropogenic activities. Given this complexity and dynamism, classification of riparian ecosystems remains a challenge.

Riparian classification has largely focused on existing plant species or communities. A field-based classification of riparian community types was developed by USFS Region 4 in the 1980s and was applied to portions of Idaho, Utah, and Wyoming (Padgett et al. 1989; Youngblood et al. 1985). Similar classification systems were developed for riparian and wetland types in Montana (Hansen et al. 1995) and eastern Oregon (Crowe and Clausnitzer 1997). Though a community type classification reference does not currently exist for the SCNF, we use the general framework as a basis for evaluation, as requested by the Forest staff. We lack the data to describe all of the riparian community types present in the Forest, so we instead describe physiognomic dominance groups, within which community types are nested.

Classification methods also consider the physical settings of riparian ecosystems. Geomorphic variables, such as valley confinement, have considerable influence over species composition and susceptibility to anthropogenic effects (Carlson 2009; Gregory et al. 1991). Below we describe general geomorphic settings of riparian ecosystems in the SCNF, along with dominance groups and associated species.

Conifer and low deciduous tree dominance groups are typically found in confined settings, which characterize the majority of the perennial stream miles in the Forest (fig. 21). Community types often resemble those of adjacent uplands (Gregory et al. 1991). Overstory species include subalpine

Figure 21—The riparian zone along this confined section of Colson Creek contains coniferous and low deciduous tree dominance groups. Stream and vegetation dynamics are influenced by instream wood and wildfire (photo by D.M. Smith, USFS).

fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*), gray alder (*Alnus incana*), quaking aspen (*Populus tremuloides*), and black cottonwood (*Populus trichocarpa*). Understory plants include water birch (*Betula occidentalis*), red osier dogwood (*Cornus stolonifera*), willows (*Salix* spp.), roses (*Rosa* spp.), sedges (*Carex* spp.), bluejoint reedgrass (*Calamagrostis canadensis*), other graminoids, and forbs. Ponderosa pine (*Pinus ponderosa*) and poison ivy (*Toxicodendron radicans*) are dominant species along the Salmon River and its larger tributaries (Horton 1972). Conifer-dominated riparian communities are habitat for wildlife species, such as the tailed frog (*Ascaphus montanus*), that occur at the interface of stream and terrestrial settings. (Dupuis and Steventon 1999).

Tall deciduous tree dominance groups are present in confined settings and unconfined valley bottoms (fig. 22). Quaking aspen and black cottonwood typically dominate the canopy. In large floodplains, understory species include coyote willow (*Salix exigua*), slender wheatgrass (*Elymus trachycaulus*), intermediate wheatgrass (*Thinopyrum intermedium*), Timothy-grass (*Phleum pratense*), bluegrasses (*Dactylis* spp.), and reed canary grass (*Phalaris arundinacea*). Invasive forbs include knapweed (*Centaurea* spp.) and thistles (*Cirsium* spp.) (Horton 1972). Migratory and resident wildlife rely on these community types throughout the year. Animals of conservation concern include Lewis's woodpecker (*Melanerpes lewis*) and several species of bats (Hollenbeck and Ripple 2008; Holloway and Barclay 2000; Saab and Vierling 2001).

Figure 22—This confined section of South Creek contains low deciduous tree and tall deciduous tree dominance groups (photo by Pacfish-Infish Biological Opinion, USFS).

Willow, non-willow shrub, and herbaceous dominance groups often co-occur in unconfined valley bottoms associated glacial cirques and mid-slope alluvial floodplains (figs. 23a,b). These settings are characterized by extensive stands of planeleaf willow (*Salix planifolia*), arctic willow (*Salix arctica*), Geyer's willow (*Salix geyerii*), coyote willow, Booth's willow (*Salix boothii*), and sedges. Also present are rushes (*Juncus* spp.), tufted hair grass (*Deschampsia cespitosa*), currants (*Ribes* spp.), shrubby cinquefoil (*Potentilla fruticose*), silver sagebrush (*Artemesia cana*), and roses. Valley

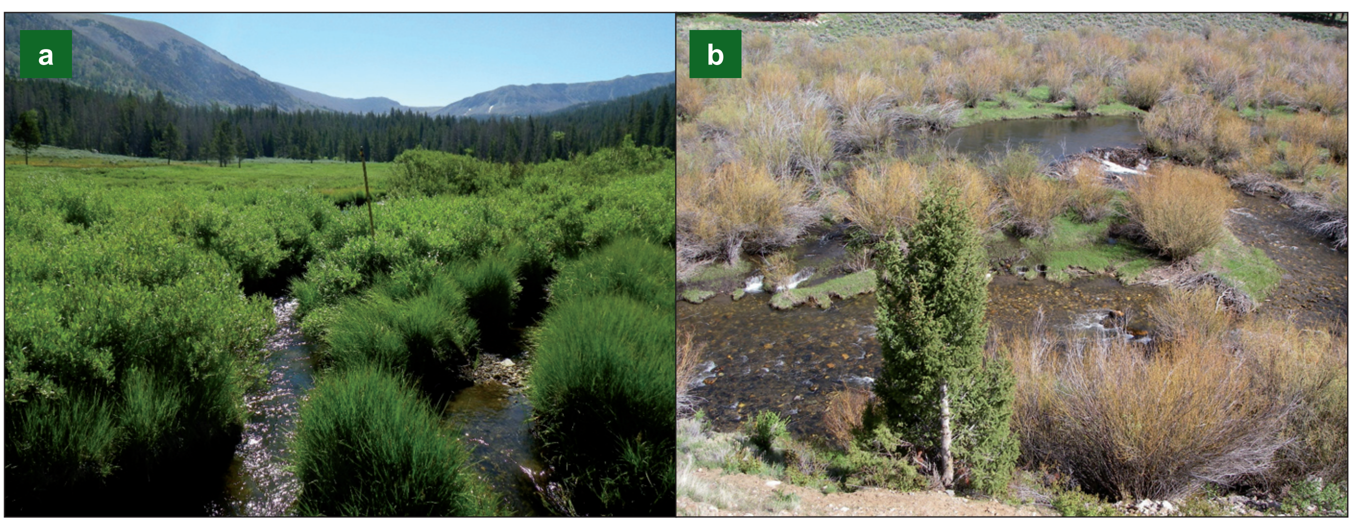

Figure 23—(a) This section of Lake Creek is located in a strongly glaciated, unconfined valley bottom. Surface flows and vegetation are influenced by several beaver dams. (b) This section of Big Timber Creek flows through a mid-slope unconfined valley bottom. Tall willow and herbaceous dominance groups are maintained by beaver ponds (photos by Pacfish-Infish Biological Opinion, USFS).

bottoms provide important foraging opportunities for moose (*Alces alces*), elk (*Cervus elaphus*), and beaver (Collins 1977). Herbaceous dominance groups are habitat for small mammals, marshbirds, and their predators (Hoffmann and Pattie 1968; Medin and Clary 1990, 1991; Pattie and Verbeek 1967; Perry 1982). Stands of tall willows are noted as critical nesting habitats for a variety of birds, including neotropical migrants (Olechnowski and Debinski 2008; Singer et al. 1994). Willow and herbaceous groups also contain forage plants that are critical to greater sage-grouse (*Centrocercus urophasinaus*) broods during dry periods of the year (Atamian et al. 2010). Stands of willows and herbaceous vegetation are often maintained by beaver ponds, which are also habitat for fish, waterbirds, western toads (*Anaxyrus boreas*), Columbia spotted frogs (*Rana luteiventris*), and other amphibians (Arkle et al. 2015; Hossack et al. 2015; McKinstry et al. 2001).

Drivers

Composition of riparian ecosystems varies among settings in the SCNF, with physical processes acting at multiple scales to determine the riparian community types that are present. Elevation, climate, and other features of the landscape place constraints on which vegetation communities can establish along a given stream segment (Hough-Snee et al. 2015).

Riparian and wetland ecosystems are also shaped by surface water and groundwater dynamics. Growth and survival of phreatophytes, deep rooted plants such as cottonwoods and willows, are dependent on stable groundwater connections (Bilyeu et al. 2008). These connections are maintained by numerous factors including occasional flooding, springs, beaver dams, and instream wood (Montgomery et al. 2003; Pollock et al. 2014; Stromberg 2001). Where present, karst systems influence surface flows through storage and transport of groundwater (Godfrey 1985; Mills 1989). By raising water tables, beaver dams encourage the establishment of willow- and herbaceous-dominated community types (Gibson and Olden 2014; Marshall et al. 2013).

A variety of natural disturbances influence composition of riparian communities in confined and unconfined settings. Reproduction of cottonwoods, willows, and other pioneering species occurs in response to valley bottom scour and sediment deposition during years with heavy precipitation and spring runoff (Baker 1990; Dykaar and Wigington 2000). High severity wildfire results in above-ground mortality of trees and shrubs but can encourage establishment of deciduous species through sprouting or germination (Dwire and Kauffman 2003; Smith et al. 2009; Wolf et al. 2007). Clonal sprouting of willows and cottonwoods is also triggered by flooding, beaver activity, and other disturbances (Wilding et al. 2014).

Stressors

Due to their dynamic nature and high productivity relative to upland ecosystems, riparian areas are especially vulnerable to colonization by introduced plants (Richardson et al. 2007). Introduced species with potential to spread into SCNF riparian areas include cheatgrass (*Stipa comata*), thistles, and other invasive species, forage grasses, and landscaped woody species such as Russian olive (*Elaeagnus angustifolia*).

In coniferous-dominated landscapes, fire maintains natural riparian vegetation by preventing encroachment and dominance by conifers and other late-successional species (Kleindl et al. 2015). Widespread suppression of wildfire has therefore led to changes in riparian composition in landscapes adapted to frequent wildfires. In coniferous-dominated riparian community types, high severity fire, along with insect and disease outbreaks, can have long-term influence on canopy composition. In low-elevation floodplains, fire can result in mortality of native deciduous trees and facilitate replacement by invasive and upland species (Smith et al. 2009).

Livestock grazing and wild ungulate herbivory have large impacts on vegetation and soil in riparian ecosystems. There are numerous effects from cattle grazing including decreases in woody and herbaceous vegetation, reduction in bank stability, and soil exposure from trailing (George et al. 2002; Thibault et al. 1999). Growth is also affected by wild ungulate browsing, beaver herbivory, and flooding behind beaver dams. Removal of beaver from watersheds has resulted in stream incision and lowering of water tables (Pollock et al. 2014). These changes prompt the loss of willow and herbaceous communities and the encroachment of conifers and upland plants into valley bottoms (Marshall et al. 2013). Additional anthropogenic stressors in the SCNF include direct damage to vegetation and introduction of invasive species resulting from recreational use of riparian areas.

Indicators

We used nine indicators of composition and condition to determine the NRV status for each LTA. Spatial indicators were conifer encroachment, upland encroachment, replacement of nonnative vegetation (from R-CAT), and watershed-scale condition of riparian and wetland vegetation (from Watershed Condition Framework). The set of field-sampled indicators consisted of five variables: reach native cover, reach alien cover, greenline cover, effective ground cover, and wetland rating. We also considered qualitative information from the Watershed Monitoring Program and Best Management Practices monitoring programs (WMP) of the SCNF and our own site visits.

To obtain indicators of composition and condition from spatial data, we applied the Riparian Condition Assessment Tool (R-CAT) to LANDFIRE data at perennial streams in the SCNF (MacFarlane et al. 2017). With this approach, we compared existing vegetation with expected vegetation to estimate changes in riparian cover along streams and in valley bottoms. We also examined data from the Watershed Condition Framework (WCF), which combines qualitative and quantitative assessments of variables including riparian and wetland conditions (Potyondy and Geier 2011).

Several field measurement protocols, developed to measure riparian composition and condition, remain in use in the SCNF. In Winward Greenline and Multiple Indicator Monitoring (MIM) protocols, riparian community types are identified within floodplain riparian complexes and at stream margins, the latter for an indication of bank stability (Burton et al. 2008; Winward 2000). The PIBO Effectiveness Monitoring Program focuses on structure and function of riparian ecosystems and as such does not address riparian community types (Kershner et al. 2004). The SCNF Watershed Monitoring Program incorporates qualitative measures of riparian composition and condition into evaluations of stream sites in managed portions of the Forest (SCNF 2017). We included PIBO and WMP results in our assessment but were unable to obtain greenline and MIM data.

Composition and Condition of Riparian Ecosystems in the SCNF

Composition and condition of riparian ecosystems had been moderately altered in much of the SCNF. We determined that 35 percent of the Forest was within the NRV, 41 percent was moderately altered, and there was insufficient information to evaluate 24 percent of the Forest (fig. 24). The composition and condition index derived from spatial data was high (≥0.9) at 10 LTAs with granitic, volcanic, and mixed geologies. This index was low (≤0.60) at seven LTAs, most of which were in sedimentary or volcanic geologies. Overall, estimates of conifer encroachment and upland encroachment were greater in managed portions of the Forest (table 7) and varied among LTAs (table 8). We observed a weak positive association between the percentage of the LTA with active grazing and

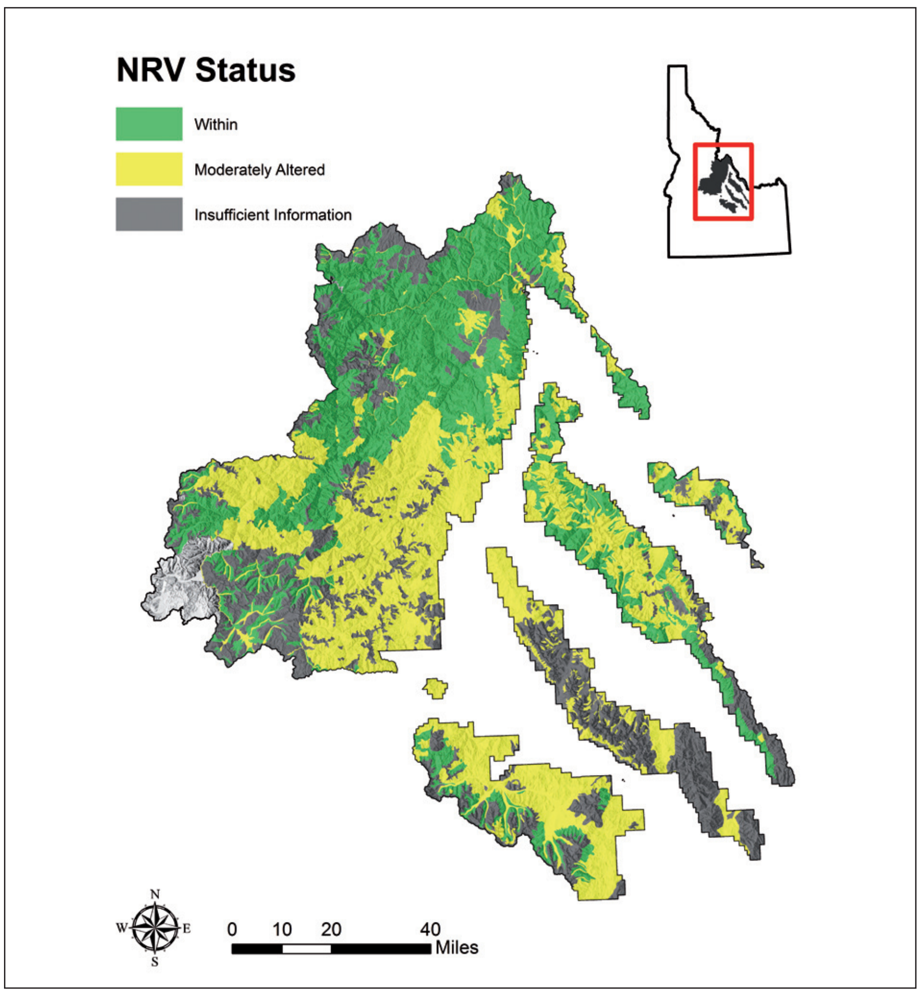

Figure 24—NRV status of riparian composition and condition in the Salmon-Challis National Forest.

Table 7—Composition and condition indicators derived from spatial data on the Salmon-Challis National Forest.

	Percent confined	Mean conifer encroachment (%)	Mean upland encroachment (%)	Mean introduced vegetation (%)
Forestwide	9	16	9	1
Managed areas	11	18	10	1
Reference areas	5	13	7	1

Table 8—Composition and condition indicators derived from spatial data, summarized for LTAs.

LTA	Mean conifer encroachment	Mean upland encroachment	Mean introduced vegetation	Riparian/wetland condition		
				Poor (%)	Fair (%)	Good (%)
10G	0.15	0.11	0.03	0	21	79
10M	0.16	0.02	0	0	0	100
10Q	0.21	0.09	0.01	0	55	45
10S	0.21	0.21	<0.01	0	100	0
10V	0.20	0.12	0.02	0	54	46
20G	0.16	0.10	0.02	0	11	89
20M	0.17	0.03	0.03	0	0	100
20Q	0.26	0.06	0.01	0	51	49
20S	0.17	0.19	<0.01	0	93	7
20V	0.19	0.15	0.01	0	74	26
30G	0.10	0.05	<0.01	0	37	63
30M	0.13	0.02	0.01	2	0	98
30Q	0.25	0.04	<0.01	0	75	25
30S	0.25	0.12	0	0	60	40
30V	0.20	0.09	0.01	0	74	26
40G	0.10	0.02	<0.01	0	75	25
40Q	0.19	0.05	0	0	100	0
40V	0.10	0.03	<0.01	0	100	0
50G	0.10	0.04	<0.01	0	61	39
50M	0.04	0.02	0	0	0	100
50Q	0.26	0.04	<0.01	0	63	37
50S	0.25	0.06	0	0	70	30
50V	0.18	0.03	<0.01	0	76	24
60G	0.03	0.01	<0.01	0	50	50
60M	0.13	0.08	0	0	99	1
60Q	0.16	0.14	<0.01	0	80	20
60S	0.10	0.11	0	0	67	33
60V	0.10	0.03	0	0	64	36
70Q	0.23	0.21	<0.01	0	71	28
70S	0.10	0.26	0	0	76	24
70V	0.14	0.24	<0.01	0	53	47
VB	0.18	0.08	0.01	0	69	31

upland encroachment. There was also a weak positive association between upland encroachment and recreation sites in the floodplain. Estimates of replacement by introduced species were similar in reference and managed areas. LTAs with high percentages of replacement were near the mainstem Salmon River and Middle Fork of the Salmon River. We observed a weak negative correlation between grazing and replacement by introduced vegetation. Percentage of the LTA with high fire hazard had a weak positive association with introduced vegetation. Grazing had a positive association with percentage of LTA in good riparian and wetland condition, whereas fire hazard had a weak negative association.

Composition and condition indices derived from field data were high at five LTAs with granitic or quartzite geologies. Indices were low at seven LTAs with sedimentary, quartzite, or volcanic geologies. Of the PIBO variables, reach native cover and greenline cover were greater at reference sites than at managed sites (table 9). Reach alien cover was greater in managed sites. Effective ground cover and wetland index were similar between managed and reference sites. Means on field-sample indicators varied among LTAs and sampling occasions (table 10). Percentage of LTA grazed had a weak negative association with native cover, a weak positive association with alien cover, and a weak negative association with greenline cover during the first sampling occasion. Percentage of LTA with high fire hazard had a weak positive association with native cover during the first sampling occasion and a weak positive association with greenline cover during the first and most recent sampling occasions. Density of recreation sites had a weak negative association with effective ground cover during the most recent sampling occasion. Recreation had weak positive associations with wetland rating during the first and most recent sampling periods.

A variety of riparian vegetation dominance groups were present in most LTAs. Some communities in these groups had been moderately altered, with livestock grazing as a primary stressor. To determine which community types were most impacted, analysis of MIM and greenline data is needed, along with a reach-scale understanding of factors that include current and historical beaver presence, departure from historical fire regimes, and intensity of use by livestock and wildlife. See Appendix G for additional methodology and descriptions of the composition and condition of riparian ecosystems within each LTA.

Table 9—Field-sampled composition and condition indicators at the Salmon-Challis National Forest.

LTA	Reach native cover (%)		Reach alien cover (%)		GL cover (%)		EG Cover (%)		Mean wetland index	
	First	Last	First	Last	First	Last	First	Last	First	Last
Forest-wide	68	71	4	4	82	87	91	92	53	53
Managed areas	67	70	5	4	81	87	90	92	53	52
Reference areas	76	76	1	1	86	84	92	93	52	55

Table 10—Field-sampled composition and condition indicators summarized for LTAs.

LTA	Reach Native Cover (%)		Reach Alien Cover (%)		GL cover (%)		EG Cover (%)		Mean Wetland Index	
	First	Recent	First	Recent	First	Recent	First	Recent	First	Recent
10G	83	81	1	<1	92	90	99	91	46	44
10M	--	--	--	--	--	--	--	--	--	--
10Q	82	75	4	1	94	114	97	98	57	58
10S	54	79	9	6	70	89	85	93	34	36
10V	69	73	6	6	87	92	88	93	53	56
20G	162	86	3	1	177	96	88	93	47	51
20M	--	--	--	--	--	--	--	--	--	--
20Q	76	82	2	1	88	96	95	95	54	55
20S	73	86	4	4	87	96	86	97	49	41
20V	59	68	5	4	73	80	88	91	53	52
30G	111	64	2	4	145	83	67	83	54	62
30M	--	--	--	--	--	--	--	--	--	--
30Q	102	76	1	<1	111	95	99	95	54	50
30S	--	--	--	--	--	--	--	--	--	--
30V	54	42	4	3	67	59	90	92	32	27
40G	66	55	<1	2	77	62	73	91	61	51
40Q	--	--	--	--	--	--	--	--	--	--
40V	--	--	--	--	--	--	--	--	--	--
50G	80	79	4	<1	97	86	88	93	47	54
50M	--	--	--	--	--	--	--	--	--	--
50Q	51	54	1	2	67	68	93	91	71	65
50S	--	--	--	--	--	--	--	--	--	--
50V	71	72	5	3	79	77	90	94	58	62
60G	--	--	--	--	--	--	--	--	--	--
60M	--	--	--	--	--	--	--	--	--	--
60Q	58	60	4	4	77	90	88	90	50	45
60S	--	--	--	--	--	--	--	--	--	--
60V	--	--	--	--	--	--	--	--	--	--
70Q	--	--	--	--	--	--	--	--	--	--
70S	87	87	3	4	112	109	98	92	61	54
70V	53	99	5	4	57	92	86	90	76	76
VB	68	70	4	5	79	86	92	92	55	56

Composition and Condition of GDEs

The composition and condition of communities associated with GDEs reflect environmental conditions and management activities, with different types promoting regional biodiversity (Springer and Stevens 2009). The surface pools of springs and GDE wetlands provide lentic habitat for plants, vertebrates, and other biota (fig. 25). Spring runout channels provide unique lotic habitats due to relatively uniform water temperatures and low oxygen concentrations (Springer and Stevens 2009). These channels also increase connectivity across the landscape for organisms associated with surface water systems. Runout channels may connect with streams or may terminate to subsurface flow while still supporting aquatic and riparian species. Spring mounds, composed of calcareous minerals, peat, and other substrates, provide specialized habitat features as well. Karst systems, which facilitate movement and discharge of groundwater in many parts of the Forest, also host unique floras and faunas (Humphreys 2006).

GDE wetlands, particularly those with accumulated peat, create distinct plant communities with many species limited to these specialized environments (Bedford and Godwin 2003; Chadde et al. 1998; USDA FS 2007, 2012a). Whether GDEs are connected to streams and riparian areas or isolated and surrounded by upland vegetation, they provide critical habitat and ecosystem services (Cohen et al. 2016). The current composition of plants, animals, and other biota must be evaluated to inform management decisions (Kreamer et al. 2015) and the condition of vegetation and soils at GDEs influence the composition and function of these ecosystems.

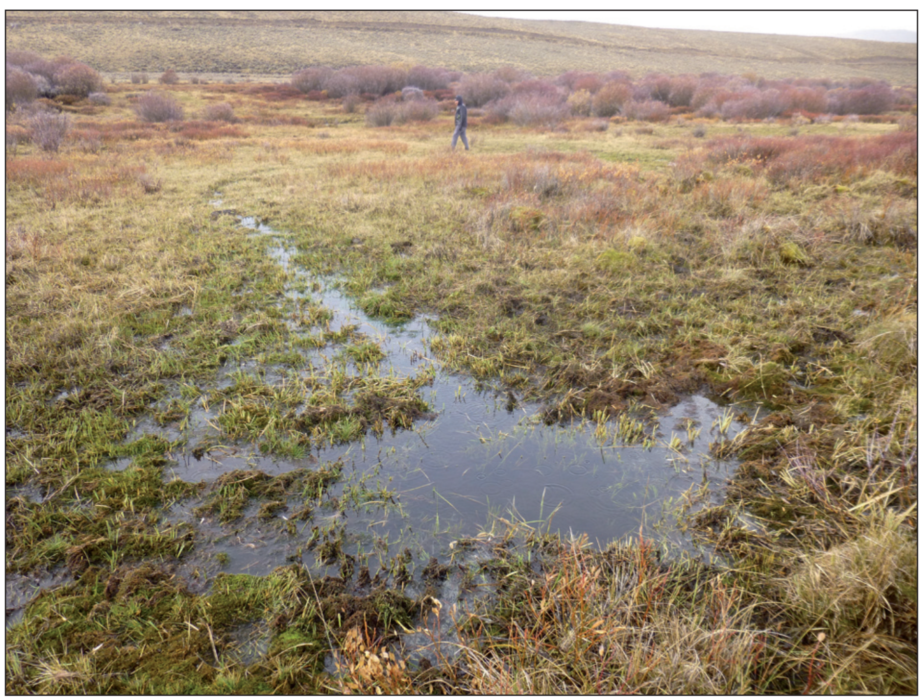

Figure 25—This spring pool and runout channel are part of an extensive GDE near the East Fork Big Lost River. Graminoids were grazed by cattle in the fall of 2016 (photo by D.M. Smith, USFS).

Drivers

Water availability and geomorphic setting are the primary bottom-up drivers of GDE composition (Cooper and Merritt 2012; Magee and Kentula 2005; Stevens and Meretsky 2008). Geology and hydrology interact to shape water chemistry, which is a determinant of plant community composition of fens (Chimner et al. 2010). Other drivers influencing composition of SCNF GDEs include sediment dynamics and thermal activity (Brock 1994).

Stressors

Springs are among the ecosystems most threatened by anthropogenic activities in the western United States (Stevens and Meretsky 2008). They have been developed for irrigation and livestock use through headbox installation, diversion of flows to troughs, and pond construction. These activities alter the composition and condition of GDEs, but in some situations, spring-dependent flora and fauna persist (Unmack and Minckley 2008).

Wildlife and livestock directly affect spring ecosystems through grazing and browsing of vegetation. Grazing and browsing can cause soil compaction, hummocking, and headcutting. Thermal springs are popular recreation sites in the SCNF and there are numerous human impacts to these unique ecosystems. These include vegetation trampling, soil compaction, and alteration of the natural runout channels for the creation of soaking pools. Natural stressors to spring ecosystems include wildfire, which directly impacts plant and animal communities, drought cycles, and geological events such as the 1983 Borah Peak Earthquake (Wood et al. 1985).

In fens and other wetlands, disturbance to soils by ditching, trailing, and stream incision can cause drying, resulting in oxidation and degradation of peat (Chimner and Cooper 2003). Wetland vegetation and soil are also vulnerable to grazing, browsing, and trampling.

Indicators

To evaluate the composition and condition of GDEs, we used PFC reports completed by SCNF staff. These assessments included information regarding the vegetation and soils at each GDE, including disturbances affecting site stability. We summarized these reports to describe the dominant groups and plant species that are present. We used the above data and best professional judgment to determine the composition and condition of GDEs in each LTA.

Composition and Condition of GDEs on the SCNF

Data are too limited to describe differences in composition among the many types of GDEs in the SCNF. Review of reports and photographs indicate, however, that many GDEs on the Forest contain willow dominated community types that include arctic willow (*Salix arctica*), Booth's willow (*Salix boothii*), and Geyer's willow (*Salix geyeriana*). Fens support additional shrubs species such as bog laurel (*Kalmia polifolia*), western Labrador tea (*Ledum glandulosum*), bog blueberry (*Vaccinium occidentale*), resin birch (*Betula glandulosa*), and gray alder (*Alnus incana*) (Chadde et al. 1998; Jankovsky-Jones et al. 1999). Herbaceous-dominated community types are frequent in GDEs as well. Dominant/indicator species include water sedge (*Carex aquatilis*), rushes (*Juncus* spp.), mosses (*Sphagnum* spp.), bluejoint reedgrass (*Calamagrostis canadensis*), tufted hairgrass (*Deschampsia cespitosa*), few-flowered spike-rush (*Eleocharis pauciflora*), and elk slip marsh marigold (*Caltha leptosepala*). Introduced vegetation is present at several of the GDEs that were surveyed. Nonnative species include Kentucky bluegrass (*Poa pratense*), Timothy-grass (*Phleum pratense*), and other forage grasses. Animal communities were largely undescribed in the PFC reports.

Damage to vegetation and soil from livestock and wild ungulates has been documented at spring pools, along channels, and in wetlands. This damage includes excessive grazing, browsing of trees and shrubs, and soil disturbance. Fences can protect vegetation and soil from livestock but must be maintained (fig. 26). Channelization, diversion, and ditching have resulted in replacement of wetlands by upland vegetation at several GDEs.

We were able to evaluate two LTAs for this KEC (fig. 27), both of which were in volcanic geologies. We determined that composition and condition were outside of the NRV at 20V because 15 of 25 GDEs were determined to be functions at risk due to livestock impacts, upland encroachment, and other stressors. Composition and condition were moderately altered at 70V, where 10 of 17 GDEs were in properly functioning condition. More information across the Forest is needed to understand the extent of impacts to GDE condition and composition. See Appendix H for additional methodology and descriptions of the composition and condition of GDEs within each LTA.

Figure 26—This hillslope spring in the Twelvemile Creek Drainage was previously diverted to the trough in the background. Vegetation and soil at the head of the spring have been disturbed by livestock following the collapse of an exclosure fence (photo by Salmon-Challis National Forest staff).

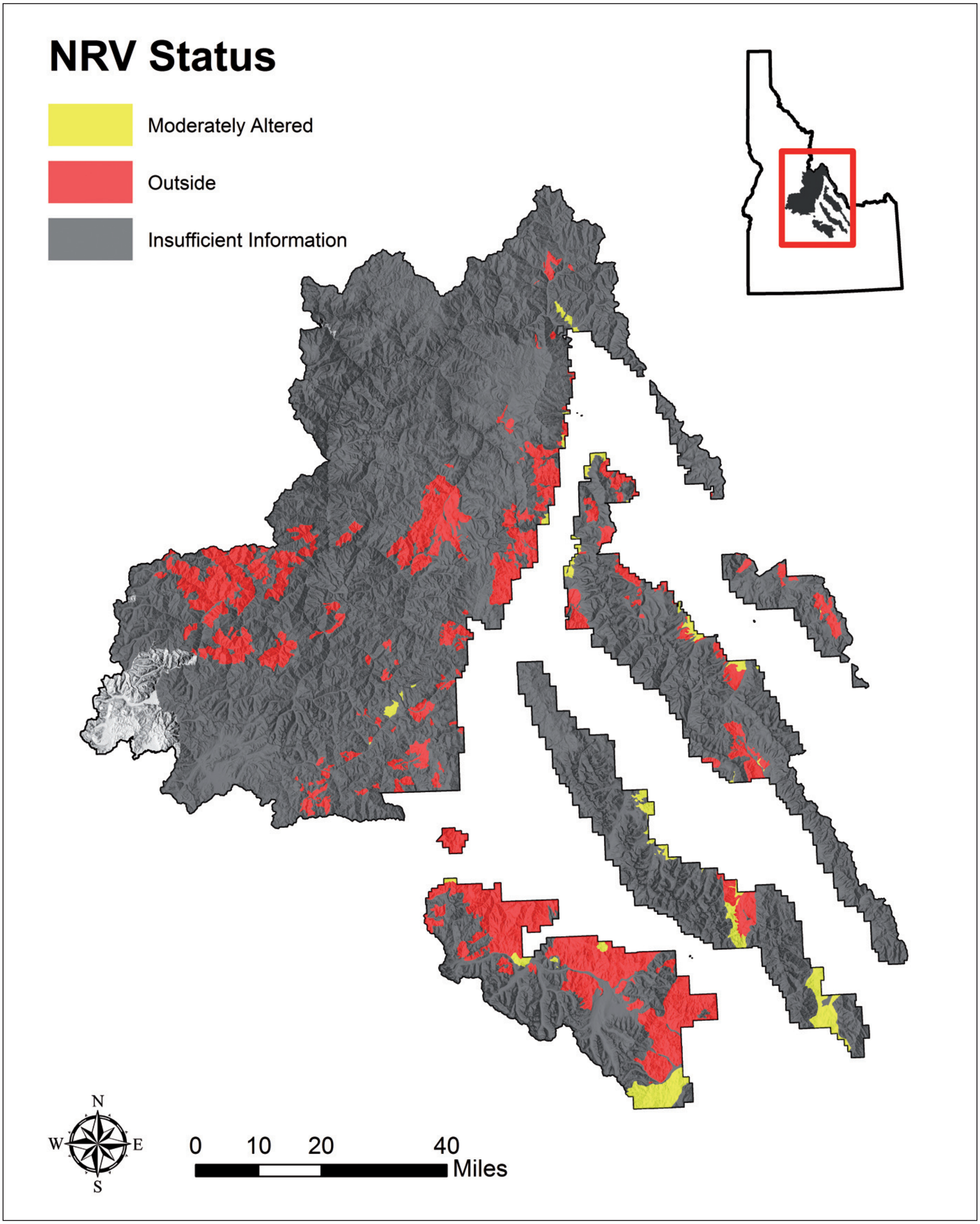

Figure 27—NRV status of composition and condition of GDEs in the Salmon-Challis National Forest.

Summary

Forest-Wide Patterns and Trends

Livestock grazing and roads appeared to be the primary stressors to riparian ecosystems, wetlands, and GDEs on the Forest. We observed negative impacts from these two stressors to many KECs including surface and groundwater fluctuations, water quality, channel and floodplain dynamics, spring runout channel dynamics, and composition and condition of riparian ecosystems and GDEs. We found little evidence that livestock grazing had shifted composition and condition outside of the NRV at perennial streams. Long-term impacts of grazing may be greater at intermittent streams and GDE wetlands.

The secondary stressors present on the SCNF with less substantial impacts included diversions, mining, and recreation. We observed negative impacts to groundwater and surface water fluctuations from diversions and mining, but not to other KECs. Recreation sites within floodplains are also associated with alterations to water fluctuations and channel and floodplain dynamics. Lastly, we assessed timber harvest, high-severity burns, and vegetation mortality as potential stressors to riparian ecosystems, wetlands, and GDEs.

In addition to stressors caused by management, patterns in temperature and precipitation from 2010 to 2014 have been altered from the patterns of the previous century (Cleland et al. 2017). These changes in climate can have major impacts on riparian systems and GDEs by shifting the flow regime. We found that changes in temperature and precipitation were slightly more substantial on the southern half of the Forest. All other stressors were acting in addition to altered temperature and precipitation (IAP 2016) and there was some correlation between stressors caused by management and changing temperature and precipitation regimes. LTAs that had experienced larger increases in winter temperature tended to have a larger percentage of land within active grazing allotments and LTAs with large reductions in winter precipitation were also impacted by vegetation mortality, high fire hazard, mining, and timber harvest.

Stressors to riparian ecosystems, wetlands, and GDEs tended to act cumulatively (IAP 2016). This is of concern for the SCNF as many LTAs had multiple stressors. We have identified livestock grazing, roads, and recreation sites within the floodplain, mining, and diversions as the major activities linked to degraded riparian areas and GDEs. Many of these stressors were correlated, meaning an LTA with impacts from one stressor was more likely to be affected by multiple stressors. For example, LTAs with a high percentage within active grazing allotments also had greater LTA and floodplain road density, more unimproved roads, and larger percentage of the LTA impacted by vegetation mortality. LTAs with high road densities also tended to have more trail miles per acre, higher diversion density, more recreation sites within floodplains, more mines, and a larger percentage having experienced timber harvest. Lastly, LTAs with high mine density also tended to have more diversions. See Appendix I for maps displaying the level of stressors and indicators in all LTAs.

Data Gaps

GDEs

Existing information on the distribution, composition, and condition of GDEs was uneven and often lacking across the Forest. We used the NWI and NHD databases to locate springs and groundwater-dependent wetlands, but both underestimate the true number on the Forest. Fen and bog mapping completed by the Colorado Natural Heritage Program (Smith et al. 2017) identified potential fen locations and acreages, but there were large discrepancies between their report and the NWI database. We found 56 GDE assessments completed by SCNF staff, with the majority located in two LTAs. There is a need for GDE inventories and more thorough biological assessments of spring and GDE wetland resources. Monitoring is needed to determine if livestock effects on surface pools, runout channels, fens, and other GDE features are carried over from one grazing season to the next. Additional Level II spring surveys, incorporating inventories of flora and fauna, should be conducted in managed and reference portions of the Forest to develop a better understanding of anthropogenic effects on GDEs. The NHD spring layer and the Colorado Natural Heritage Program fen database serve as frameworks to conduct on-the-ground surveys and assessments.

We used the SSI (http://springstewardshipinstitute.org/) database to evaluate distribution of springs on the SCNF. It includes all springs from the NHD (USGS 2014), as well as documented GDE locations and information from the scientific literature and unpublished reports by governmental agencies and non-governmental organizations. The only data for the Forest in the SSI database is from the NHD layer. We recommend incorporating data collected by the SCNF into the SSI database to preserve valuable field data and make information available to wider audiences.

Beaver Activity

Beaver activity is a driver of many of the KECs assessed in this report including water quality, water fluctuations, and channel and floodplain dynamics. Current levels of beaver activity were poorly documented in most of the perennial channels within the Forest. Robust beaver populations would increase the resistance and resilience of freshwater systems to the effects of climate change and predicted drought. More information is needed to determine if the current population is comparable in size and distribution to historic levels and locations.

Aquatic Invasives

Aquatic invasive species can have major impacts on channel dynamics and trophic relations within freshwater ecosystems. According to the USFS national dataset, there are no instances of aquatic invasives on the SCNF. However, there are several documented cases in the surrounding National

Forests and throughout Idaho. It is likely that there are aquatic invasive species on the Forest and either monitoring has not occurred or the data have not been added to the national database. Information on the distribution and extent of these species would improve our assessment of channel dynamics and are important for planning efforts.

Surface Mines

We found no spatial data capturing the location and extent of surface mines on the Forest. There is a long history of mining on the SCNF and there are examples of extreme impacts, such as those observed in the Yankee Fork drainage. While the locations and impacts of large operations are likely known, a GIS layer would improve our assessment of channel dynamics and water fluctuations and help identify smaller areas that may need restoration.

MIM Data

There was a substantial number of Multiple Indicator Monitoring (MIM) sites located on the Forest. These data offer information on annual grazing use and long-term trends that would be valuable for ecosystem assessments and planning efforts. The data, however, were not in an accessible format and we were unable to use them for this report. A more thorough accounting of riparian community types may be assembled from these data.

Monitoring Sites

We used PIBO and SCNF Watershed Program monitoring sites to evaluate many of the KECs in this report. We also evaluated the location of MIM sites, despite the lack of data. There were several LTAs on the Forest with no or very few monitoring sites. Adding sites or evaluating ecosystems using PFC, MIM, and Level II GDE protocols would improve assessments of riparian, wetland, and GDE conditions in these LTAs.

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Appendix A—Distribution of Riparian Ecosystems

Methods

We scored nine indicators for riparian ecosystem distribution based on whether they showed evidence of no, moderate, or substantial alteration from reference conditions in the Frank Church-River of No Return and Jim McClure-Jerry Peak Wildernesses. If the indicator had little or no alteration it was given a score of 5; moderate alteration was given a score of 3; substantial alteration was given a score of 1 (table A1). We scored land type associations (LTAs) based on mean RVD index among stream segments. Next, we determined the mean proportion of perennial stream segments with riparian vegetation replaced by anthropogenic cover (development including mines, roads, and towns), according to Riparian Condition Assessment Tool (R-CAT) results. Finally, we calculated total reservoir density for each LTA. We used the means of the above variables calculated for reference areas Frank Church-River of No Return Wilderness and Jim McClure-Jerry Peak Wilderness to inform assignment of LTA means to alteration levels. The cumulative score for each LTA was divided by the potential total (20 points) to determine a final riparian distribution and connectivity score. We considered this score and other information in our determination of natural range of variation (NRV) status.

Table A1—Criteria for assigning riparian distribution and connectivity scores, which were used to calculate an index value for each LTA.

Indicator	Data source	Little or no alteration (5 points)	Moderate alteration (3 points)	High alteration (1 point)
Percent conifer encroachment	R-CAT	<15	15–20	>20
Percent upland encroachment	R-CAT	<10	10–15	>15
Percent replacement by introduced vegetation	R-CAT	<1	1–2	>2
Riparian condition	WCF	Majority of LTA in good condition	Majority of LTA in fair condition	Majority of LTA in poor condition
Percent reach native cover	PIBO	>75	50–75	<50
Percent reach alien cover	PIBO	<1	1–2	>2
Percent greenline cover	PIBO	>80	70–80	<70
Percent effective ground cover	PIBO	>90	80–90	<80
Cross-section wetland index	PIBO	>50	40–50	<40

Land Type Association Summaries

10G—Steep Canyonlands in Granite

This LTA had over 360 miles of perennial streams, over 300 miles of intermittent streams, and 177 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation types covered 1 percent. Most (60 percent) of the LTA was in Wilderness. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

10M—Steep Canyonlands in Mixed Geology

This small LTA contained 4 miles of perennial and intermittent streams, had no unconfined valley bottom acres, and was entirely within Wilderness. The 50-year flood zone covered 6 percent of the LTA and riparian vegetation covered 3 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

10Q—Steep Canyonlands in Quartzite

The LTA had over 130 miles of perennial streams, 125 miles of intermittent streams, and 159 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered 1 percent. Most of the LTA was in managed areas (82 percent). R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial and intermittent segments. The distribution and connectivity index was low (52 percent) because of replacement by introduced vegetation and developed land. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was moderately altered from the NRV.

10S—Steep Canyonlands in Sedimentary Bedrock

This LTA had 15 miles of perennial streams, over 25 miles of intermittent streams, and 112 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 1 percent. The LTA was entirely in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was 1 percent at perennial segments and less than 1 percent at intermittent segments. The distribution and connectivity index was fair (60 percent), so we determined that this KEC was **moderately altered** from the NRV.

10V—Steep Canyonlands in Volcanics

This LTA had over 150 miles of perennial streams, over 200 miles of intermittent streams, and 237 unconfined valley bottoms acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 2 percent. Most (66 percent) of the LTA was in Wilderness. There were 27 acres of reservoirs, or 0.03 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial segments and 1 percent at intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

20G—Mountain Slopelands in Granite

This LTA had over 560 miles of perennial streams, over 630 miles of intermittent streams, and 168 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 2 percent. Most (56 percent) of the LTA was in Wilderness. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

20M—Mountain Slopelands in Mixed Geology

This wilderness LTA had over 3 miles of perennial streams, 3 miles of intermittent streams, and no unconfined valley bottom acres. The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered 1 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial segments and greater than 5 percent at intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

20Q—Mountain Slopelands in Quartzite

This LTA had 530 miles of perennial streams, over 840 miles of intermittent streams, and 303 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 1 percent. Most (83 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

20S—Mountain Slopelands in Sedimentary Bedrock

This LTA had over 30 miles of perennial streams, over 120 miles of intermittent streams, and 577 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered 1 percent. Most (98 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 2 percent at perennial and less than 1 percent at intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

20V—Mountain Slopelands in Volcanics

This largest of LTAs had 790 miles of perennial streams, over 1,140 miles of intermittent streams, and 1,658 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 1 percent. Most (68 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial segments and 1 percent intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

30G—Cryic Uplands in Granite

This LTA had over 440 miles of perennial streams, over 280 miles of intermittent streams, and 564 unconfined valley bottom acres (< 1 percent of the LTA). The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered 1 percent. Most (54 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (100 percent), so we determined that this KEC was **within** the NRV.

30M—Cryic Uplands in Mixed Geology

This LTA had 2 miles of perennial streams, 3 miles of intermittent streams, and no unconfined valley bottom acres. The 50-year flood zone covered 2 percent of the LTA and riparian vegetation covered 1 percent. Nearly all of the LTA (>99 percent) was in Wilderness. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was 1 percent at perennial segments and 0 percent at intermittent segments. The distribution and connectivity index was high (90 percent), so we determined that this KEC was **within** the NRV.

30Q—Cryic Uplands in Quartzite

This LTA had nearly 300 miles of perennial streams, over 520 miles of intermittent streams, and 262 unconfined valley bottom acres (0.1 percent of the LTA). The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered less than 1 percent. Most (95 percent) of the LTA was in managed areas. There was 1 acre of reservoirs, or 0.005 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

30S—Cryic Uplands in Sedimentary Bedrock

This LTA was entirely in managed areas, with over 20 miles of perennial streams, over 450 miles of intermittent streams, and 181 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered less than 1 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

30V—Cryic Uplands in Volcanics

This LTA had 430 miles of perennial streams, over 1,010 miles of intermittent streams, and 326 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 1 percent. Most (69 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was 1 percent at perennial segments and less than 1 percent at intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

40G—Cryic Basinlands in Granite

This LTA had over 60 miles of perennial streams, over 40 miles of intermittent streams, and 151 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 4 percent of the LTA and riparian vegetation covered 1 percent. Most (76 percent) of the LTA was in managed areas. R-CAT analysis indicated that riparian vegetation had increased at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (100 percent), so we determined that this KEC was **within** the NRV.

40Q—Cryic Basinlands in Quartzite

This LTA was entirely in managed areas, with over 10 miles of perennial streams, over 10 miles of intermittent streams, and 11 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 6 percent of the LTA and riparian vegetation covered 1 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

40V—Cryic Basinlands in Volcanics

This LTA was entirely in managed areas, with over 10 miles of perennial streams, over 5 miles of intermittent streams, and 32 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 6 percent of the LTA and riparian vegetation covered 2 percent. R-CAT analysis indicated that riparian vegetation had increased at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (100 percent), so we determined that this KEC was **within** the NRV.

50G—Glacial Troughlands in Granite

This LTA had over 440 miles of perennial streams, over 260 miles of intermittent streams, and 2,521 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered 1 percent. Most (55 percent) of the LTA was in Wilderness. There was less than 1 acre of reservoirs, or 0.0005 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (100 percent), so we determined that this KEC was **within** the NRV.

50M—Glacial Troughlands in Mixed Geology

This Wilderness LTA had 3 miles of perennial streams, less than 1 mile of intermittent streams, and no unconfined valley bottom acres (0.1 percent of the LTA). The 50-year floodplain covered 3 percent of LTA and riparian vegetation covered 2 percent. R-CAT analysis indicated that riparian vegetation had increased perennial stream segments and decreased at intermittent segments. Mean percentage of floodplain converted to anthropogenic cover was 0 percent at perennial and intermittent segments. The distribution and connectivity index was high (90 percent), so we determined that this KEC was **within** its NRV.

50Q—Glacial Troughlands in Quartzite

This LTA had over 120 miles of perennial streams, over 110 miles of intermittent streams, and 150 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 3 percent of LTA and riparian vegetation covered less than 1 percent. Most (87 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fairly high (80 percent), so we determined that this KEC was **within** the NRV.

50S—Glacial Troughlands in Sedimentary Bedrock

This LTA had over 20 miles of perennial streams, over 80 miles of intermittent streams, and 454 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered less than 1 percent. Almost all of the LTA (99 percent) was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

50V—Glacial Troughlands in Volcanics

This LTA had over 170 miles of perennial streams, over 220 miles of intermittent streams, and 301 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered 2 percent. Most (59 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (90 percent), so we determined that this KEC was **within** the NRV.

60G—Strongly Glaciated Lands in Granite

This LTA had nearly 300 miles of perennial streams, over 110 miles of intermittent streams, and 475 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered less than 1 percent. Most (67 percent) of the LTA was in Wilderness. R-CAT analysis indicated that minor decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was high (100 percent), so we determined that this KEC was **within** the NRV.

60M—Strongly Glaciated Lands in Mixed Geology

This LTA had 3 miles of perennial streams, 10 miles of intermittent streams, and two unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered only 1 percent of the LTA and riparian vegetation covered less than 1 percent. Most (74 percent) of the LTA was in managed areas. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was 0 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

60Q—Strongly Glaciated Lands in Quartzite

This LTA has over 260 miles of perennial streams, over 210 miles of intermittent streams, and 5,606 unconfined valley bottom acres (3 percent of the LTA). The 50-year flood zone covered 7 percent of the LTA and riparian vegetation covered less than 1 percent. Most (96 percent) of the LTA was in managed areas. There were 28 acres of reservoirs, or 0.1 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

60S—Strongly Glaciated Lands in Sedimentary Bedrock

This LTA was entirely in managed areas, with over 30 miles of perennial streams, 150 miles of intermittent streams, and 129 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered less than 1 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

60V—Strongly Glaciated Lands in Volcanics

This LTA had over 130 miles of perennial streams, over 350 miles of intermittent streams, and 158 unconfined valley bottom acres (<1 percent of the LTA). The 50-year flood zone covered 3 percent of the LTA and riparian vegetation covered less than 1 percent. Most (73 percent) of the LTA was in managed areas. There were 37 acres of reservoirs, or 0.3 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (60 percent), so we determined that this KEC was **moderately altered** from the NRV.

70Q—Dissected Foothill Lands in Quartzite

This LTA was entirely within a managed area, with 5 miles of perennial streams, over 30 miles of intermittent streams, and 156 unconfined valley bottom acres (2 percent of the LTA). The 50-year flood zone covered 5 percent of the LTA and riparian vegetation covered 1 percent. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 10 percent at perennial stream segments, most of which was conversion to developed land. Anthropogenic conversion was greater than 1 percent at intermittent segments. The distribution and connectivity index was low (50 percent) because of conversion to developed land. For this reason, we determined that this KEC was **outside** the NRV.

70S—Dissected Foothill Lands in Sedimentary Bedrock

This LTA had over 20 miles of perennial streams, over 110 miles of intermittent streams, and 1,694 unconfined valley bottom acres (4 percent of the LTA). The 50-year flood zone covered 7 percent of the LTA and riparian vegetation covered less than 1 percent. Most (>99 percent) of the LTA was in managed areas. There were 3 acres of reservoirs, or 0.1 acres per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (60 percent), so we determined that this KEC was **moderately altered** from the NRV.

70V—Dissected Foothill Lands in Volcanics

This LTA had over 70 miles of perennial streams, over 150 miles of intermittent streams, and 390 unconfined valley bottom acres (1 percent of the LTA). The 50-year flood zone covered 6 percent of the LTA and riparian vegetation covered less than 1 percent. Most (99 percent) of the LTA was in managed areas. There were 10 acres of reservoirs, or 0.1 per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was less than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (60 percent), so we determined that this KEC was **moderately altered** from the NRV.

VB—Valley Bottom

This most riparian of LTAs had over 870 miles of perennial streams, over 200 miles of intermittent streams, and 13,120 unconfined valley bottom acres (13 percent of the LTA). The 50-year flood zone covered 24 percent of the LTA and riparian vegetation covered 8 percent. Most (87 percent) of the LTA was in Wilderness. There were 22 acres of reservoirs, or 0.0002 per perennial stream mile. R-CAT analysis indicated that decreases in riparian vegetation had occurred at perennial and intermittent stream segments. Mean percentage of floodplain converted to anthropogenic cover was greater than 1 percent at perennial and intermittent segments. The distribution and connectivity index was fair (70 percent), so we determined that this KEC was **moderately altered** from the NRV.

Appendix B—Distribution of Groundwater-Dependent Ecosystems (GDEs)

Methods

We assessed the current distribution of springs and groundwater-dependent ecosystems (GDE) wetlands for each land type associations (LTA) on the Salmon-Challis National Forest (SCNF). If information on drivers, stressors, or indicators was lacking, we noted that **insufficient information** was available to make a determination. We identified stressors if the value of the stressor for the LTA was greater than 50 percent of other LTAs on the Forest. We used relative GDE density, as well as a comparison between managed and reference areas as indicators of the current distribution of spring and GDE wetlands. GDE distribution was considered **within** the natural range of variation (NRV) if the GDE density of the managed portion of the LTA was comparable to the range of reference conditions for that geologic setting. GDE distribution was considered **moderately altered** from the NRV if the GDE density of the managed portion was less than the inner fence for outliers determined by the distribution of GDEs in reference areas. GDE distribution was considered **outside** the NRV if the density of the managed portion was less than the outer fence for outliers determined by the distribution of GDEs in reference areas.

Land Type Association Summaries

10G—Steep Canyonlands in Granite

Stressors to the distribution of springs in this LTA included diversions and mining. The impacts of diversions were somewhat extensive throughout the LTA, but large portions of the LTA did not have any diversions. Mines were extensive throughout the LTA.

Spring Distribution: The spring density in 10G was 0.00005 springs/acre. The number of springs was consistent with the climate and geology of this LTA and the spring density within reference areas did not differ from the spring density of managed areas, suggesting that spring distribution was **within** the NRV.

GDE Wetland Distribution: According to the NWI dataset, there were 25 palustrine emergent wetlands (PEMB) wetlands with 6.8 total acres in this LTA. Smith et al. (2017) documented 22 potential fens totaling 33 acres. Of these, three were considered likely fens. There was **insufficient information** on the distribution of wetland GDEs, particularly in the north zone of the Forest, to determine the NRV status of GDE distribution in 10G.

10M—Steep Canyonlands in Mixed Geology

This is a very small LTA with no documented springs or GDE wetlands. There was **insufficient information** on the geologic setting to determine the NRV status of this LTA.

10Q—Steep Canyonlands in Quartzite

Stressors in this LTA included roads, diversions, and mines. Roads were somewhat extensive throughout the LTA. The impacts of diversions were fairly localized within 10Q. Mines extended throughout the LTA.

Spring Distribution: The spring density in 10Q was 0.00005 springs/acre. Spring distribution in this LTA appeared to be primarily driven by geology and the spring density of managed areas was slightly greater than reference areas, indicating that spring distribution in this LTA was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there was a single PEMB wetland that was 0.2 acres in this LTA. Smith et al. (2017) documented one potential fen totaling 2 acres. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

10S—Steep Canyonlands in Sedimentary Bedrock

The only stressor we identified in this LTA was mining. The extent of mines throughout the LTA was localized.

Spring Distribution: This is a small LTA with no documented springs. The lack of springs in this LTA appeared to be driven by geology. Spring distribution was **within** the NRV in 10S.

GDE Wetland Distribution: According to the National Wetlands Inventory (NWI) database, there were no documented PEMB wetlands in this LTA. Smith et al. (2017) described a single potential fen that was less than 1 acre in size. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

10V—Steep Canyonlands in Volcanics

Stressors in 10V included high severity fire and diversions. Reference areas and managed areas had both experienced high severity fire, suggesting this was a natural stressor. Impacts from diversions were localized in this LTA, with large sections having no diversions.

Spring Distribution: There were 0.00009 springs/acre in 10V. Despite the stressors, spring density within reference areas was similar to spring density in managed areas. It appeared spring distribution was primarily driven by geology. Spring distribution was considered **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were three PEMB wetlands that totaled 0.4 acres in this LTA. Smith et al. (2017) documented two potential fens that totaled 1 acre in this LTA. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

20G—Mountain Slopelands in Granite

Stressors in this LTA included diversions and high severity burns. The impact of diversions was limited due to localized distribution. High severity fire had occurred in both managed and reference areas, suggesting it was a natural stressor.

Spring Distribution: The spring density in this LTA was 0.00009 springs/acre. The spring distribution appeared to be primarily driven by geology and the spring density of reference areas did not differ from the spring density of managed area, indicating that spring distribution was **within** the NRV in 20G.

GDE Wetland Distribution: According to the NWI database, there were three PEMB wetlands totaling 2.6 acres in this LTA. Smith et al. (2017) documented 15 potential fens totaling 14 acres in 20G. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

20M—Mountain Slopelands in Mixed Geology

This is a very small LTA with no documented springs or GDE wetlands. This LTA had a relatively high mine density (90th percentile), but this was a result of a single mine. There was **insufficient information** on the geologic setting to determine the NRV status for spring or fen distribution in this LTA.

20Q—Mountain Slopelands in Quartzite

This LTA was among those most impacted by roads, with a road density greater than 90 percent of other LTAs on the Forest. Additionally, roads were located throughout the LTA and their impacts were extensive. About 10 percent of this LTA had burned at high severity, a greater percentage than 80 percent of LTAs on the Forest. High severity fire was fairly localized and impacted the reference area more than the managed area. The diversion density in this LTA was moderately high. Like roads, diversions extended throughout the LTA and their impact was extensive.

Spring Distribution: The spring density in this LTA was 0.00010 springs/acre. Geology appeared to be the primary driver of spring distribution and there were more springs in managed areas than reference areas, suggesting spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were two PEMB wetlands totaling 0.3 acres in this LTA. Smith et al. (2017) documented 43 potential fens totaling 37 acres. Of these, one was a likely fen. The SCNF completed an assessment of the Cove Creek GDE. This GDE was not documented in the NWI database and suggested that GDE wetlands were likely prevalent on the northern sections of the Forest. The assessment only contained photos. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

20S—Mountain Slopelands in Sedimentary Bedrock

The stressors in this LTA included diversions, mining, and roads. The impact from diversions was localized. Mines were scattered throughout the LTA, extending their impacts. There were 0.0012 road miles/acre in this LTA, which was greater than 60 percent of other LTAs on the Forest. Roads were somewhat localized.

Spring Distribution: There were 0.00019 springs/acre in this LTA. Despite stressors, there was no difference in the spring densities of managed and reference areas. Climate and geology appeared to remain the primary drivers of spring distribution and this LTA was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there was a single PEMB wetland that totaled 0.4 acres in this LTA. Smith et al. (2017) documented 14 potential fens totaling 44 acres in 20S. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

20V—Mountain Slopelands in Volcanics

The stressors in this LTA included roads and diversions. Roads were somewhat localized throughout the managed portion and large parts of this LTA were located in Wilderness and were not impacted by roads. Diversions were fairly localized within the managed portion of this LTA.

Spring Distribution: The spring density in this LTA was 0.00016 springs/acre. The primary driver of spring distribution appeared to be geology and the spring density within reference conditions was comparable to managed portions. This LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 293 PEMB wetlands with a total acreage of 282 in this LTA. Smith et al. (2017) documented 302 potential fens totaling 285 acres in this LTA. Of these, eight were classified as likely fens. The SCNF had completed six assessments of GDEs in this LTA: Dry Canyon, Burnt Hollow, Bear Creek, Lower Grove, Swan Basin-Chandler Springs, and Deer Park Upper Adams. None of these was documented in the NWI database and indicated that there were likely numerous undocumented GDE wetlands on the north zone of the Forest. Fen characteristics, including peat accumulation, were observed at the Bear Creek and Burnt Hollow GDEs. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

30G—Cryic Uplands in Granite

Stressors in this LTA included high severity burns and mines. High severity fires had occurred both in the managed and reference areas of this LTA, suggesting it was a natural stressor. Mine locations were fairly extensive throughout the LTA.

Spring Distribution: The spring density in this LTA was 0.00014 springs/acre. The spring distribution appeared to be primarily driven by geology and the spring density in managed areas was greater than the spring density of reference areas, suggesting that spring distribution was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 417 PEMB wetlands totaling 269 acres in this LTA. Smith et al. (2017) documented 258 potential fens with a total acreage of 314. Of these, 30 were likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

30M—Cryic Uplands in Mixed Geology

This is an extremely small LTA with no documented springs or PEMB wetlands. There was **insufficient information** to determine the NRV status of spring or GDE wetland distribution of this LTA.

30Q—Cryic Uplands in Quartzite

Stressors in this LTA included roads and high severity fire. Roads were extensive throughout the managed portion of 30Q. The impacts of high severity fire were somewhat localized and impacted both the reference and managed areas.

Spring Distribution: The spring density in this LTA was 0.00020 springs/acre. Despite the stressors, the spring density of managed areas was comparable to reference conditions and the primary driver appeared to be geology. The LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were five PEMB wetlands totaling 0.9 acres in this LTA. Smith et al. (2017) documented 115 potential fens with a total acreage of 103. Of these, 13 were likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

30S—Cryic Uplands in Sedimentary

Levels of stressors in this LTA were low.

Spring Distribution: There were 0.00015 springs/acre in this LTA. The primary driver of spring distribution in 30S appeared to be geology. Spring distribution was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 12 PEMB wetlands totaling 15 acres in this LTA. Smith et al. (2017) documented 25 potential fens with a total acreage of 11. The SCNF completed a single GDE assessment in 30S: Lake Creek. This GDE was not documented in the NWI database and suggests that GDE wetlands were underestimated on the northern zone of the Forest. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

30V—Cryic Uplands in Volcanic

Stressors in this LTA included high severity fire and altered temperature and precipitation regimes. High severity burns were somewhat localized and occurred both within reference and managed areas. The average winter temperature from 1985 to 2015 was 2.9 °F warmer than the average of the last 100 years. In the same timeframe, winter precipitation had decreased by 9 percent.

Spring Distribution: This LTA had more springs than any other LTA on the Forest: 0.00039 springs/acre (167 documented springs). The land type provided important spring habitat and potentially was vulnerable to climate change. Despite stressors, the primary driver of spring distribution in 30V appeared to be geology and the spring density of managed areas was greater than that of reference areas. Spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were 426 PEMB wetlands totaling 207 acres in this LTA. All of these GDE wetlands were located in managed areas. Smith et al. (2017) documented 164 potential fens with a total acreage of 112 in this LTA. Of these, nine were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

40G—Cryic Basinlands in Granite

Stressors in this LTA included high severity fire, roads, and mines. The impacts of high severity fire were localized and occurred entirely in the reference area. The impacts of roads were very localized. Mines were fairly extensive throughout the LTA.

Spring Distribution: This is a very small LTA that only had two documented springs. The spring density in this LTA was 0.00007 springs/acre. This value was comparable to reference conditions and the primary driver appeared to be geology. This LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were no documented GDE wetlands in this LTA. Based on geology and climate, we expected that this LTA likely did contain GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) described 86 potential fens with a total acreage of 367. Of these, five were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

40Q—Cryic Basinlands in Quartzite

Stressors in this LTA included high severity fire and altered temperature and precipitation regimes. About 26 percent of this LTA had experienced high severity burns, more than any other LTA on the Forest. The average winter temperature between 1985 and 2015 was 3.1 °F warmer than that of the previous century. During the same timeframe, winter precipitation had decreased by about 4 percent.

Spring Distribution: This is a small LTA with no documented springs. There was no reference area for this LTA, but based on the geology and land type we expected there were undocumented springs in 40Q. There was **insufficient information** to evaluate the NRV status of spring distribution.

GDE Wetland Distribution: According to the NWI database, there were no documented PEMB wetlands in this LTA. Based on geology and climate, we expected that this LTA likely did contain GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) reported 41 potential fens totaling 50 acres in 40Q. Of these, eight were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of spring distribution.

40V—Cryic Basinlands in Volcanics

Stressors in this LTA included roads and mines. Both road and mining impacts were fairly localized.

Spring Distribution: This is a small LTA with no documented springs. There was no reference area in this LTA for comparison, but based on the geology and land type we expected there were undocumented springs in 40V. There was **insufficient information** to evaluate the NRV status of spring distribution.

GDE Wetland Distribution: According to the NWI database, there were no documented PEMB wetlands in this LTA. Based on geology and climate, we expected that this LTA likely did contain GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) reported eight potential fens totaling 10 acres in this LTA. Of these, two were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

50G—Glacial Troughlands in Granite

Stressors in this LTA included high severity fire and altered temperature and precipitation regimes. High severity fire occurred in reference and managed areas, suggesting it was a natural stressor. Between 1985 and 2015, winter temperatures were 3.0 °F warmer than the previous century and in the same timeframe winter precipitation had decreased by 9 percent.

Spring Distribution: The spring density of this LTA was 0.00004 springs/acre. Spring distribution of managed areas was comparable to spring distribution of reference areas and the primary driver of density in this LTA appeared to be geology and land type. This LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 424 PEMB wetlands totaling 348 acres in this LTA. Based on geology, climate, and past glaciation, we expected that this LTA likely contained a larger number of GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) recorded 332 potential fens totaling 568 acres. Of these, 33 were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

50M—Glacial Troughlands in Mixed Geology

This is a very small LTA with no documented springs or GDE wetlands. There was **insufficient information** to determine the NRV status of spring or GDE wetland distribution in this LTA.

50Q—Glacial Troughlands in Quartzite

Levels of stressors in this LTA were low.

Spring Distribution: The spring density in this LTA was 0.00004 springs/acre. There were nine documented springs and all were located in managed areas. It appeared climate and geology were the primary drivers of spring density in this LTA and spring distribution was **within** the NRV in 50Q.

GDE Wetland Distribution: According to NWI there were no PEMB wetlands in this LTA, but the SCNF had completed an assessment at the Lee Creek Eightmile Large GDE. Based on geology and climate, we expected that this LTA likely did contain additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) reported 48 potential fens totaling 39 acres in this LTA. Of these, five were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

50S—Glacial Troughlands in Sedimentary Bedrock

Stressors in this LTA included roads, mining, and altered temperature and precipitation regimes. Roads extended throughout the LTA, but the location of mines was somewhat localized. The average winter temperature from 1985 to 2015 was 3.0 °F warmer than the average of the previous century. In the same timeframe, winter precipitation had decreased by 12 percent.

Spring Distribution: There were 0.00008 springs/acre in this LTA. All of the springs were located in managed areas and geology appeared to be the primary driver of spring distribution. This LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there was a single PEMB wetland totaling 0.1 acre in this LTA. Based on geology and climate, we expected that this LTA likely did contain additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) reported 14 potential fens totaling 12 acres in this LTA. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

50V—Glacial Troughlands in Volcanics

The only stressor identified in this LTA was altered temperature and precipitation regimes. The average winter temperature from 1985 to 2015 was 2.9 °F warmer than the previous century. During the same timeframe, winter precipitation had decreased by about 9 percent.

Spring Distribution: The spring density in this LTA was 0.00012 springs/acre. Climate and geology appeared to be the primary drivers of spring distribution and the density of springs within managed areas was greater than the spring density of reference areas in this LTA. Spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were 84 PEMB wetlands totaling 46 acres. Based on geology and climate, we expected that this LTA likely did contain additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) reported 78 potential fens totaling 78 acres in this LTA. Of these, six were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

60G—Strongly Glaciated Lands in Granite

Stressors in this LTA included high severity fire, mining, and altered temperature and precipitation regimes. This LTA was among those with the largest percentage burned at high severity (80th percentile). The number of mines/acre was low, but they were highly concentrated within the managed portion of the LTA. The average winter temperature from 1985 to 2015 was 2.9 °F warmer than the previous century. During the same timeframe, winter precipitation decreased by 9 percent.

Spring Distribution: The spring density of this LTA was 0.00004 springs/acre. Geology appeared to be the primary driver of spring distribution and the spring density of managed areas was only slightly less than the spring density of reference areas. This LTA was considered **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 397 PEMB wetlands totaling 243 acres in this LTA. Based on geology and climate, we expected that this LTA likely does contain additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) documented 545 potential fens totaling 511 acres in this LTA. Of these, 107 were considered likely fens. This LTA contained the greatest number of fens mapped by the Colorado Natural Heritage Program (Smith et al. 2017). There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

60M—Strongly Glaciated Lands in Mixed Geology

The main stressor in this LTA was altered temperature and precipitation regimes. The average winter temperature between 1985 and 2015 was 3.2 °F warmer than the previous century. This was a larger increase in temperature than any other LTA on the Forest. During the same timeframe, winter precipitation had decreased by 19 percent. This is a larger deviation than any other LTA on the Forest.

Spring Distribution: This is a fairly small LTA with a single documented spring. All of this LTA was managed and there was no description of the geologic setting. There was **insufficient information** to determine the NRV status of spring distribution in this LTA.

GDE Wetland Distribution: According to the NWI database, there were five PEMB wetlands totaling 0.9 acres in this LTA. Smith et al. (2017) documented 13 potential fens with a total acreage of 8 in this LTA. Of these, one was considered a likely fen. There was **insufficient information** on the geology of this LTA and the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

60Q—Strongly Glaciated Lands in Quartzite

The primary stressor in this LTA was altered temperature and precipitation regimes. The average winter temperature from 1985 to 2015 was 3.0 °F warmer than the previous century. During the same timeframe, winter precipitation decreased by 6 percent.

Spring Distribution: The spring density in this LTA was 0.00018 springs/acre. Natural climate and geology appeared to be the primary drivers of spring distribution in 50V and the density of springs within managed areas was greater than the spring density of reference areas. Spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were 12 PEMB wetlands totaling 35 acres in this LTA. Based on geology and climate, we expected that this LTA likely contained additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) recorded 434 potential fens totaling 631 acres in 60Q. Of these, 74 were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

60S—Strongly Glaciated Lands in Sedimentary Bedrock

The primary stressor in this LTA was altered temperature and precipitation regimes. The average winter temperature between 1985 and 2015 was 3.0 °F warmer than that of the previous century. During the same timeframe winter precipitation had decreased by 15 percent.

Spring Distribution: The spring density in this LTA was 0.00018 springs/acre. Climate and geology appeared to be the primary drivers of spring distribution in 60S. The density of springs within managed areas was greater than the spring density of reference areas. Spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were four PEMB wetlands totaling 5 acres in this LTA. Based on geology and climate, we expected that this LTA likely contained additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) documented 87 potential fens totaling 78 acres in this LTA. Of these, three were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

60V—Strongly Glaciated Lands in Volcanics

The primary stressor in this LTA was altered temperature and precipitation regimes. The average winter temperature between 1985 and 2015 was 3.0 °F warmer than that of the previous century. During the same timeframe, winter precipitation had decreased by 13 percent.

Spring Distribution: The spring density in this LTA was 0.00017 springs/acre. Climate and geology appeared to be the primary drivers of spring distribution in 60V and the density of springs within managed areas was greater than the spring density of reference areas. Spring distribution was **within** the NRV in this LTA.

GDE Wetland Distribution: According to the NWI database, there were 284 PEMB wetlands totaling 205 acres in this LTA. Based on geology and climate, we expected that this LTA likely contained additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) documented 305 potential fens totaling 231 acres in this LTA. Of these, 30 were considered likely fens. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

70Q—Dissected Foothill Lands in Quartzite

The stressors in this LTA included roads, diversions, and mines. Impacts from roads and mines were somewhat localized, while diversions were very limited in their extent.

Spring Distribution: This was a small LTA with two documented springs, both of which were located in managed areas. The spring density was 0.00020 springs/acre. Geology and climate appeared to be the primary drivers of spring density in this LTA. Spring distribution was **within** the NRV in 70Q.

GDE Wetland Distribution: According to the NWI database, there were no documented PEMB wetlands in this LTA. Smith et al. (2017) documented one potential fen totaling less than 1 acre in 70Q. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

70S—Dissected Foothill Lands in Sedimentary Bedrock

Stressors in this LTA included roads and altered temperature and precipitation regimes. Roads extend throughout the LTA. The average winter temperature between 1985 and 2015 was 3.1 °F warmer than the previous century. During the same timeframe, winter precipitation had decreased by 17 percent.

Spring Distribution: The spring density in this LTA was 0.00016 springs/acre. Natural climate and geology appeared to be the primary drivers of spring density. All of 70S was managed, providing no comparison to a reference area. Spring distribution in this LTA was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 4 PEMB wetlands totaling 1.3 acres. Smith et al. (2017) documented nine potential fens totaling 7 acres in this LTA. Of these, one was considered a likely fen. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

70V—Dissected Foothill Lands in Volcanics

Stressors in this LTA included roads and altered temperature and precipitation regimes. The impacts of roads were extensive throughout the LTA. The average winter temperature between 1985 and 2015 was 3.0 °F warmer than the previous century. During the same timeframe, winter precipitation had decreased by 11 percent.

Spring Distribution: The spring density in this LTA was 0.00049 springs/acre, which was the largest spring density on the Forest. Natural climate and geology appeared to be the primary drivers of spring distribution in this LTA. All of the springs were located in managed areas. Spring distribution in this LTA was **within** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 24 PEMB wetlands totaling 18 acres in this LTA. The SCNF had documented three GDEs in 70V: Dry Fork, Lee Creek Lee Creek, and Lee Creek-Walters Unit, indicating that there were likely more GDE wetlands on the north zone of the Forest. Smith et al. (2017) documented 34 potential fens totaling 17 acres in this LTA. Of these, one was considered a likely fen. There was **insufficient information** on the distribution of GDE wetlands, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

VB—Valley Bottom

This LTA is composed of valley bottoms constructed by streams across the Forest. It likely has variable geologic settings but consistently has water tables at or near the surface throughout the majority. Stressors in this LTA included roads, diversions, and mines. The impacts of roads, mines, and diversions in this LTA were extensive.

Spring Distribution: The spring distribution in this LTA was 0.00025 springs/acre. There were 0.0005 more springs/acre in the reference areas of this LTA compared to the managed areas. Due to the extensive and cumulative impacts of roads, diversions, and mines, this LTA was **outside** the NRV.

GDE Wetland Distribution: According to the NWI database, there were 327 PEMB wetlands totaling 418 acres in this LTA. Based on geology and climate, we expected that this LTA likely did contain additional GDE wetland systems that had not been documented by the Forest or NWI. Smith et al. (2017) documented 293 potential fens totaling 1,206 acres in VB. Of these, 23 were considered likely fens. There was **insufficient information** on the distribution of wetland GDEs, particularly in the north zone of the Forest, to determine the NRV status of this LTA.

Reference

Smith, G.; Lemly, J.; Schroder, K. 2017. Fen mapping for the Salmon-Challis National Forest. Fort Collins, CO: Colorado State University, Colorado Natural Heritage Program. 31 p.

Appendix C—Surface Water and Groundwater Fluctuations

Methods

We scored six indicators for water fluctuations in surface water systems based on whether they showed evidence of no, moderate, or substantial alteration from reference conditions in the Frank Church-River of No Return and Jim McClure-Jerry Peak Wildernesses. If the indicator had little or no alteration it was given a score of 5; moderate alteration was given a score of 3; substantial alteration was given a score of 1 (table C1). The scores for each land type associations (LTA) were summed and divided by the potential total of 30 to give a percentage rating for each association. LTAs were considered within the natural range of variation (NRV) for groundwater and surface water fluctuations if the index was greater than 75 percent; moderately altered from the NRV if the index was between 60 percent and 75 percent; and outside the NRV if the index was less than 60 percent.

To evaluate water fluctuations at groundwater-dependent ecosystems (GDEs), we used proper functioning condition (PFC) reports completed by Salmon-Challis National Forest (SCNF) staff. These assessments included information on whether the GDE experienced relatively frequent inundation, whether water fluctuations were extreme, and if water supply was sufficient to maintain hydric soils. We summarized these reports and used best professional judgment to determine the status of water fluctuations at GDEs.

Table C1—Scoring of indicators of groundwater and surface water fluctuations within each LTA.

Indicator	Little or no alteration (5 points)	Moderate alteration (3 points)	Significant alteration (1 point)
Conifer encroachment of intermittent streams	<25%	25% < x < 50%	>50%
Upland encroachment of intermittent streams	<25%	25% < x < 50%	>50%
Conifer encroachment of perennial streams	<25%	25% < x < 50%	>50%
Upland encroachment of perennial streams	<25%	25% < x < 50%	>50%
Deviation in winter temperature	<3 °F	3 °F < x < 3.2 °F	>3.2 °F
Deviation in winter precipitation	<5%	5% < x < 10%	>10%

Land Type Association Summaries

10G—Steep Canyonlands in Granite

Surface water systems: This LTA is composed of steep canyonlands that receive less than 15 to 20 inches of precipitation annually (SCNF 2004). Streams in 10G are usually ephemeral or intermittent with flashy hydrographs that rapidly respond to precipitation events. This association does not have a perennial water supply (SCNF 2004). The stressors in this LTA that potentially were impacting water fluctuations were mining and trails located within floodplains. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 10G was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 10G.

10M—Steep Canyonlands in Mixed Geology

Surface water systems: The level of stressors in this LTA was relatively low. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 10M was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 10M.

10Q—Steep Canyonlands in Quartzite

Surface water systems: This LTA is composed of steep canyonlands that receive less than 15 to 20 inches of precipitation annually (SCNF 2004). Streams in 10Q are usually ephemeral or intermittent with flashy hydrographs that rapidly respond to precipitation events. This association does provide a perennial water supply (SCNF 2004). The stressors in this LTA that may be impacting groundwater and surface water fluctuations were mining, roads, and recreation. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 10Q was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 10Q.

10S—Steep Canyonlands in Sedimentary Bedrock

Surface water systems: This LTA is composed of steep canyonlands that receive 10 to 20 inches of precipitation annually (SCNF 2004). Streams in 10S are usually ephemeral or intermittent with flashy hydrographs that rapidly respond to precipitation events. This association rarely provides a perennial water supply (SCNF 2004). The stressors in this LTA were recreation sites, roads located within floodplains, and grazing. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 10S was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 10S.

10V—Steep Canyonlands in Volcanics

Surface water systems: This LTA is composed of steep canyonlands that receive less than 15 to 20 inches of precipitation annually (SCNF 2004). Streams in 10V are usually ephemeral or intermittent with flashy hydrographs that rapidly respond to precipitation events. This association does not have a perennial water supply (SCNF 2004). The primary stressor in this LTA was trails within the floodplain. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 10V was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 10V.

20G—Mountain Slopelands in Granite

Surface water systems: The hydrology of this LTA is characterized by wide climatic variation (SCNF 2004). Flow regimes of streams are influenced by precipitation zone, elevation, and aspect. Water yield is greater and more sustained from drainages with large proportions of north-facing aspects and weak dissection. These areas can be a source of perennial streamflow, but the majority of streams remain intermittent. The hydrologic response ranges from slow to very rapid (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was high severity fire. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 20G was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 20G.

20M—Mountain Slopelands in Mixed Geology

Surface water systems: There is no description available of hydrology in this LTA. The stressors in this LTA that may have impacted water fluctuations were mining and trails located within floodplains. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 20M was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 20M.

20Q—Mountain Slopelands in Quartzite

Surface water systems: The hydrology of this LTA is characterized by wide climatic variation (SCNF 2004). Flow regimes of streams are influenced by precipitation zone, elevation, and aspect. Water yield is greater and more sustained from drainages with large proportions of north-facing aspects and weak dissection. These areas can be a source of perennial streamflow, but the majority of streams remain intermittent. The hydrologic response ranges from slow to very rapid (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were vegetation mortality throughout the LTA and within the floodplain and timber harvest. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 20Q was considered to be **moderately altered** from the NRV.

GDEs: A single GDE assessment (Cove Creek-Cove Creek) had been completed for a spring in this LTA. The report did not note any hydrologic disturbances and indicated that there was no evidence that the aquifer supplying groundwater was affected by withdrawal or loss of recharge. There was **insufficient information** to evaluate the NRV status of groundwater and surface water fluctuations at GDEs.

20S—Mountain Slopelands in Sedimentary Bedrock

Surface water systems: The hydrology of this LTA is characterized by wide climatic variation (SCNF 2004). Flow regimes of streams are influenced by precipitation zone, elevation, and aspect. Water yield is greater and more sustained from drainages with large proportions of north-facing aspects and weak dissection. These areas can be a source of perennial streamflow, but the majority of streams remain intermittent. The hydrologic response ranges from slow to very rapid. The LTA description notes that beaver are present in this LTA, but no current data on distribution or population size are available (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were roads within floodplains and livestock grazing. The index score for groundwater and surface water fluctuations in this LTA was 52 percent and 20S was considered to be **outside** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 20S.

20V—Mountain Slopelands in Volcanics

Surface water systems: The hydrology of this LTA is characterized by wide climatic variation (SCNF 2004). Flow regimes of streams are influenced by precipitation zone, elevation, and aspect. Water yield is greater and more sustained from drainages with large proportions of north-facing aspects and weak dissection. These areas can be a source of perennial streamflow, but the majority of streams remain intermittent. The hydrologic response ranges from slow to very rapid (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was livestock grazing. The index score for groundwater and surface water fluctuations in this LTA was 52 percent and 20V was considered to be **outside** the NRV.

GDEs: Eighteen GDE assessments had been completed for this LTA. Fourteen reported the systems were functional-at-risk. Many of the assessments indicated that drought reduced flows and limited spring discharge. Channelization of spring channels and soil compaction had caused surrounding areas to dry and the fluctuations of water in some GDEs had been altered by diversions and stock ponds. Overall, groundwater and surface water fluctuations in this LTA showed major impacts from drought and livestock grazing. The KEC was considered **outside** the NRV for GDEs.

30G—Cryic Uplands in Granite

Surface water systems: This LTA is an important source of sustained water yield and has high rates of percolation to groundwater systems (SCNF 2004). 30G receives large amounts of precipitation, the majority in the form of snow. Snowpack remains on the landscape for long durations throughout the LTA. The hydrologic response of streams is slow and overland flow is rare. Formation of streams in this LTA is limited due to the high rates of infiltration (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were high severity fire and recreation sites within the floodplains. The index score for groundwater and surface water fluctuations in this LTA was 76 percent and 30G was considered to be **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 30G.

30M—Cryic Uplands in Mixed Geology

Surface water systems: The level of stressors in this LTA was relatively low. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 30M was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 30M.

30Q—Cryic Uplands in Quartzite

Surface water systems: This LTA is an important source of sustained water yield and has high rates of percolation to groundwater systems (SCNF 2004). 30Q receives large amounts of precipitation, the majority in the form of snow. Snowpack remains on the landscape for long durations throughout the LTA. The hydrologic response of streams is slow and overland flow is rare. Formation of streams in this LTA is limited due to the high rates of infiltration (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations included vegetation mortality throughout the LTA and within the floodplain and livestock grazing. Because forage is limited in this LTA, livestock tend to become concentrated in moist meadows and valley bottoms (SCNF 2004). There is also pressure from elk, particularly during the rut, and there may often be competition in wet areas between elk and grazing (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 30Q was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 30Q.

30S—Cryic Uplands in Sedimentary Bedrock

Surface water systems: This LTA is an important source of sustained water yield and has high rates of percolation to groundwater systems (SCNF 2004). 30S receives moderate amounts of precipitation, the majority in the form of snow. Snowpack remains on the landscape for long durations throughout the LTA. The hydrologic response of streams is slow and overland flow is rare. Formation of streams in this LTA is limited due to the high rates of infiltration (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were roads located within floodplains and livestock grazing. Forage is limited to valley bottoms and moist headlands and there is high use by livestock and elk in these riparian areas (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 30S was considered to be **moderately altered** from the NRV.

GDEs: A single GDE assessment had been completed by SCNF staff in this LTA: Timber Creek-Trail Creek. The PFC noted that fen characteristics were present at this site and that there were some impacts from grazing by wild animals and a horse trail. There was no evidence that the aquifer that supplied groundwater to the site was affected by withdrawal or loss of recharge or that watershed conditions were negatively impacting the GDE. The site was considered to be in properly functioning condition. Without additional GDE assessments, there was **insufficient information** to evaluate the NRV status of water fluctuations at GDEs in this LTA.

30V—Cryic Uplands in Volcanics

Surface water systems: This LTA is an important source of sustained water yield and has high rates of percolation to groundwater systems (SCNF 2004). 30V receives large amounts of precipitation, the majority in the form of snow. Snowpack remains on the landscape for long durations throughout the LTA. The hydrologic response of streams is slow and overland flow is rare. Formation of streams in this LTA is limited due to the high rates of infiltration (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was livestock grazing. Because forage tends to be confined to isolated patches and valley bottoms in 30V, livestock use within this LTA tends to be more concentrated within riparian areas (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 30V was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments have been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 30V.

40G—Cryic Basinlands in Granite

Surface water systems: This LTA receives a moderate to high amount of precipitation, most of which falls in the form of snow (SCNF 2004). Snowpack duration is average on south-facing slopes and long on north-facing, well protected aspects. The hydrologic response is rapid and overland flow is common in areas with shallow soils and bedrock outcrops. There are some wet meadows that slow the hydrologic response and store water that is released throughout the year. 40G is a significant source of sustained water yield. The LTA description notes that beaver are often found in streams with low gradients and willow dominated riparian areas in this LTA, but there are no data available on their current distribution or population size (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were vegetation mortality throughout the LTA and within the floodplain and livestock grazing. Valley bottoms often provide the principal forage supply for cattle, elk, and deer (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 76 percent and 40G was considered to be **within** its NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 40G.

40Q—Cryic Basinlands in Quartzite

Surface water systems: This LTA receives moderate to high amounts of precipitation and about half falls as snow (SCNF 2004). The duration of snowpack is average on south-facing slopes and ridges and is long on north-facing aspects. The hydrologic response is slow on slopes and very slow in wet meadows where the water table is at or near the surface. Valley bottoms are the primary source of forage for cattle, elk, and deer. The LTA description notes that beaver are often found in low gradient, willow lined streams, but there are no data available on their current distribution or population size (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were high severity fire, trails within the floodplain, and vegetation mortality in the LTA and the floodplains. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 40Q was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 40Q.

40V—Cryic Basinlands in Volcanics

Surface water systems: This LTA receives moderate to high amounts of precipitation and about half falls as snow (SCNF 2004). The duration of snowpack is average on south-facing slopes and ridges and is long on north-facing aspects. The hydrologic response is slow on slopes and very slow in wet meadows where the water table is at or near the surface. Valley bottoms provide the principal source of forage for cattle, elk, and deer. The LTA description notes that beaver are often found in low gradient, willow lined streams, but there are no data available on their current distribution or population size (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were mining, timber harvest, grazing, and vegetation mortality throughout the LTA and the floodplain. The index score for groundwater and surface water fluctuations in this LTA was 76 percent and 40V was considered to be **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 40V.

50G—Glacial Troughlands in Granite

Surface water systems: This LTA receives a large amount of precipitation and the majority falls as snow (SCNF 2004). Snowpack in 50G tends to persist until early summer and this LTA produces a significant amount of water throughout the year. The hydrologic response ranges from very slow to average in the valley bottoms to rapid on the steep, glaciated sideslopes (SCNF 2004). The level of stressors in this LTA were relatively low. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 50G was considered to be **moderately altered** from the NRV.

GDEs: Three GDE assessments have been completed by Forest staff in this LTA. All three reports indicated that the systems experienced relatively frequent inundation and that fluctuations were excessive. Two assessments recorded that drought was limiting flows and that riparian vegetation was being impacted by reduced spring discharge. This is a large LTA and there was **insufficient information** to evaluate the NRV status of GDE water fluctuations.

50M—Glacial Troughlands in Mixed Geology

Surface water systems: The level of stressors in this LTA was relatively low. The index score for groundwater and surface water fluctuations in this LTA was 76 percent and 50M was considered to be **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 50M.

50Q—Glacial Troughlands in Quartzite

Surface water systems: This LTA receives a large amount of precipitation and the majority falls as snow (SCNF 2004). Snowpack in 50Q tends to persist until early summer and this LTA produces a significant amount of water throughout the year. The hydrologic response ranges from very slow to average in the valley bottoms to rapid on the steep, glaciated sideslopes (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were vegetation mortality throughout the LTA and within the floodplain. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 50Q was considered to be **moderately altered** from the NRV.

GDEs: Two GDE assessments had been completed in this LTA by SCNF staff: Lee Creek-Big Eightmile and Deer Park-North Fork. One GDE was a spring and the other displayed fen characteristics. Both PFC assessments report nonfunctional troughs and impacts from livestock grazing at the sites. Nevertheless, the assessments recorded that there was no evidence that the aquifer supplying water was affected by withdrawal or loss of recharge. It appeared that vegetation at the sites was transitioning to drier cover and both GDEs were classified as functional-at-risk. There was **insufficient information** to evaluate the NRV status of water fluctuations at GDEs in this LTA.

50S—Glacial Troughlands in Sedimentary Rocks

Surface water systems: This LTA receives a large amount of precipitation and the majority falls as snow (SCNF 2004). Snowpack in 50S tends to persist until early summer and this LTA produces a significant amount of water throughout the year. The hydrologic response ranges from very slow to average in the valley bottoms to rapid on the steep, glaciated sideslopes. Valley bottoms are the primary forage source for both cattle and elk (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was livestock grazing. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 50S was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 50S.

50V—Glacial Troughlands in Volcanics

Surface water systems: This LTA receives a moderate amount of precipitation and the majority falls as snow (SCNF 2004). Snowpack in 50V tends to persist until late spring at middle elevations and until early summer at higher elevations. This LTA produces a significant amount of water throughout the year. The hydrologic response ranges from very slow to average in the valley bottoms to rapid on the steep, glaciated sideslopes (SCNF 2004). The level of stressors in this LTA was relatively low. The index score for groundwater and surface water fluctuations in this LTA was 76 percent and 50V was considered to be **within** its NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 50V.

60G—Strongly Glaciated Lands in Granite

Surface water systems: This LTA is high elevation and receives a large amount of precipitation, the majority of which falls as snow (SCNF 2004). Snowpack can persist until late summer in some locations. This association is among the highest water producing LTAs. Cirque basins in 60G have a very slow hydrologic response and these areas release water throughout drier seasons (SCNF 2004). The level of stressors in this LTA was relatively low. The index score for groundwater and surface water fluctuations in this LTA was 92 percent, which is the highest index score of any LTA on the Forest. 60G was considered to be **within** its NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 60G.

60M—Strongly Glaciated Lands in Mixed Geology

Surface water systems: The stressor in this LTA that may have impacted water fluctuations is livestock grazing. Winter temperature increases and the amount of reduced winter precipitation were greater than any other LTA on the Forest. The index score for groundwater and surface water fluctuations in this LTA was 44 percent and 60M was considered to be **outside** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 60M.

60Q—Strongly Glaciated Lands in Quartzite

Surface water systems: This LTA is high elevation and receives a large amount of precipitation, the majority of which falls as snow (SCNF 2004). Snowpack can persist until late summer in some locations. This association is among the highest water producing LTAs. Cirque basins in 60Q have a very slow hydrologic response, high storage capacity, and these areas release water throughout drier seasons (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations is vegetation mortality throughout the LTA and livestock grazing. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 60Q was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 60Q.

60S—Strongly Glaciated Lands in Sedimentary Bedrock

Surface water systems: This LTA is high elevation and receives a large amount of precipitation, the majority of which falls as snow (SCNF 2004). Snowpack can persist until late summer in some locations. This association is among the highest water producing LTAs. Cirque basins in 60S have a very slow hydrologic response, high storage capacity, and these areas release water throughout drier seasons (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was livestock grazing. Impact from grazing is likely limited because steep slopes and difficult access makes this association more suitable to big game species (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 52 percent and 60S was considered to be **outside** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 60S.

60V—Strongly Glaciated Lands in Volcanics

Surface water systems: This LTA is high elevation and receives a large amount of precipitation, the majority of which falls as snow (SCNF 2004). Snowpack can persist until late summer in some locations. This association is among the highest water producing LTAs. Cirque basins in 60V have a very slow hydrologic response, high storage capacity, and these areas release water throughout drier seasons (SCNF 2004). The primary stressor in this LTA that may have impacted water fluctuations was livestock grazing. The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 60V was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 60V.

70Q—Dissected Foothill Lands in Quartzite

Surface water systems: This LTA is composed of foothills that receive little precipitation (SCNF 2004). Snowpack duration tends to be short, however it may persist longer on protected north-facing slopes. Streams emerging from this LTA are generally ephemeral or intermittent with somewhat flashy hydrographs. 70Q is not a perennial source of water (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were mining, diversions, and grazing. Pressure within riparian areas may be limited as 70Q is capable of supporting considerable amounts of grazing by game and domestic livestock (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 68 percent and 70Q was considered to be **moderately altered** from the NRV.

GDEs: No GDE assessments have been completed in this LTA. There was **insufficient information** to evaluate the status of water fluctuations at GDEs in 70Q.

70S—Dissected Foothill Lands in Sedimentary Bedrock

Surface water systems: This LTA is composed of foothills that receive little precipitation (SCNF 2004). Snowpack duration tends to be short, but it may persist longer on protected north-facing slopes. Streams emerging from this LTA are generally ephemeral or intermittent with somewhat flashy hydrographs. 70Q is not a perennial source of water (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were roads within the floodplain and livestock grazing. Despite the high percentage of the LTA with active grazing, pressure to riparian areas may be limited due to gentle slopes and moderate to high production of forage throughout the LTA (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 60 percent and 70S was considered to be **moderately altered** from the NRV.

GDEs: Two GDE assessments had been completed by SCNF staff in this LTA: Spring Hill Site 3 and Sawmill Canyon/Head of Left Fork. Both reports noted impacts from livestock and wild ungulate grazing and one recorded that a tank was diverting flow from the spring. One PFC assessment stated that there was no evidence that the aquifer supplying groundwater was affected by withdrawal or loss of recharge. The second report indicated that the system was inundated regularly frequently and that fluctuations in water levels was not excessive. However, the assessment also indicates that the seep complex is losing flow due to drought. There was **insufficient information** to evaluate the NRV status of water fluctuations at GDEs in this LTA.

70V—Dissected Foothill Lands in Volcanics

Surface water systems: This LTA is composed of foothills that receive little precipitation (SCNF 2004). Snowpack duration tends to be short but it may persist longer on protected north-facing slopes. Streams emerging from this LTA are generally ephemeral or intermittent with somewhat flashy hydrographs. 70Q is not a perennial source of water (SCNF 2004). The stressors in this LTA that may have impacted water fluctuations were recreation sites and roads within the floodplain and livestock grazing. Slopes tend to be too steep to supply forage for cattle and the primary use would be domestic sheep (SCNF 2004). The index score for groundwater and surface water fluctuations in this LTA was 52 percent and 70V was considered to be **outside** the NRV.

GDEs: Twenty-seven GDE assessments had been completed by SCNF staff in this LTA. Of these, 13 noted that the system experiences relatively frequent inundation and 15 indicated that water fluctuations are not excessive. Ten assessments recorded that the saturation of soils is sufficient to compose and maintain hydric soils. The majority of the reports indicated that drought was having some affect by either a total loss of flow, reduced flow, or transition from perennial to ephemeral flow. Three of the reports indicated that water fluctuations at the GDE may have been altered by the Borah Peak Earthquake in 1983. In addition to natural disturbances, the assessments also reported impacts from livestock and roads. GDEs in 70V appeared especially sensitive to drought conditions. Due to the cumulative stressors, impacts of altered temperature and precipitation in this LTA, and anthropogenic effects recorded at one-third of the sampled sites, water fluctuations at GDEs was considered **outside** the NRV in 70V.

VB—Valley Bottom

Surface water systems: The stressors in this LTA that may have impacted water fluctuations were mining, diversions, recreation sites within the floodplain, trails throughout the LTA and within the floodplain, and roads throughout the LTA. The index score for groundwater and surface water fluctuations in this LTA was 60 percent and VB was considered to be **moderately altered** from the NRV.

GDEs: A single GDE assessment has been completed by SCNF staff in this LTA. It recorded minor impacts from wild animal grazing. The report indicated that there was no evidence that the aquifer supplying groundwater was affected by groundwater withdrawal or loss of recharge and that flow regulation was not affecting the site. Without additional assessments, there was **insufficient information** to evaluate the NRV status of GDE water fluctuations in this LTA.

Reference

Salmon-Challis National Forest [SCNF]. 2004. Landtype association and landtypes of the Salmon-Challis National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Salmon-Challis National Forest, Salmon, ID.

Appendix D—Water Quality

Methods

We scored five indicators for water quality of surface water systems based on whether they showed evidence of no, moderate, or substantial alteration from the natural range of variation (NRV). We determined a range of reference conditions for macroinvertebrate communities, temperature, and median substrate size by evaluating Pacfish-Infish Biological Opinion (PIBO) sites within the Frank Church-River of No Return and Jim McClure-Jerry Peak Wilderness areas. We categorized these distributions by their median, 1st quartile, 3rd quartile, and upper and lower outlier fences. We then compared the median value of each indicator in each land type associations (LTA) to the reference condition range and assigned a score based on whether it was comparable to reference conditions, moderately altered, or substantially altered (table D1). We used guidance from the Watershed Condition Framework to determine thresholds for moderate and significant alteration for the percentage of streams and waterbodies classified as impaired. We only evaluated the NRV status if data were available for at least four indicators. When no data existed for more than one indicator, we determined there to be insufficient information to evaluate the NRV status.

Indicators determined to be comparable to reference conditions were given a score of 5, while moderately altered indicators were scored as a 3, and significantly altered indicators were given a score of 1. The scores for each LTA were summed and divided by the potential total to determine a final water quality score. Finally, LTAs were considered within the NRV if the water quality score was greater than 75 percent. They were identified as moderately altered from the NRV if the water quality score was between 60 percent and 75 percent. LTAs were classified as outside the NRV if the water quality score was less than 60 percent.

Table D1—Scoring of indicators of water quality within each LTA.

Indicator	Comparable to reference conditions	Moderately altered	Substantially altered
CTQd	<58	≥58	>76
Temperature	<11.9	≥11.9	>15.4
D50	>0.04	0.01 ≤ x ≤ 0.04	≤0.01
Impaired streams	<1%	1% ≤ x ≤ 10%	>10%
Impaired waterbodies	<1%	1% ≤ x ≤ 10%	>10%

To evaluate groundwater-dependent ecosystems (GDE) water quality, we used proper functioning condition (PFC) reports completed by SCNF staff. These assessments included information on whether water quality was sufficient to support riparian or wetland plants and if accumulation of chemicals affecting productivity or composition was apparent. We summarized these reports and used best professional judgment to determine the NRV status of water quality at GDEs.

Land Type Association Summaries

10G—Steep Canyonlands in Granite

Surface water systems: Stressors in this LTA included mining and recreation. The percentage of impaired waterbodies, the macroinvertebrate community, and fine sediment values were all comparable to reference conditions. The average temperature and the percentage of impaired streams were moderately altered from reference conditions. The overall water quality score was 84 percent and the LTA was considered **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 10G.

10M—Steep Canyonlands in Mixed Geology

Surface water systems: The level of stressors in this LTA was relatively low. There was no macroinvertebrate, temperature, or fine sediment data available. The percent of impaired streams and the percent of impaired waterbodies were comparable to reference sites. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 10M.

10Q—Steep Canyonlands in Quartzite

Surface water systems: The stressors in this LTA included mining, roads, and recreation. Despite these stressors, average temperature, fine sediment, and percent of impaired waterbodies were comparable to reference sites. The macroinvertebrate community and the percent of impaired streams were moderately altered from reference conditions. The water quality score was 84 percent and the LTA was considered **within** the NRV for water quality.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 10M.

10S—Steep Canyonlands in Sedimentary Bedrock

Surface water systems: The stressors in this LTA included grazing and roads. Despite these stressors the average temperature and percent of impaired waterbodies were comparable to reference conditions. The macroinvertebrate communities and fine sediments were moderately altered from reference conditions and the percent of impaired streams was much greater than reference conditions. The water quality score was 68 percent and the LTA was **moderately altered** from the NRV.

GDE: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 10S.

10V—Steep Canyonlands in Volcanics

Surface water systems: Stressors in this LTA included recreation, specifically trails located within floodplains. The macroinvertebrate community, average temperature, fine sediment, and percentage of impaired waterbodies were all comparable to reference sites. The percentage of impaired streams was moderately altered from reference sites. The water quality score was 92 percent and the LTA was considered **within** its NRV.

GDE: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 10V.

20G—Mountain Slopelands in Granite

Surface water systems: The level of all stressors in this LTA was relatively low. The macroinvertebrate community, average temperature, fine sediment, percentage of impaired streams, and the percentage of impaired waterbodies were all comparable to reference. The overall water quality score was 100 percent and the LTA was considered **within** the NRV.

GDE: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 20G.

20M—Mountain Slopelands in Mixed Geology

Surface water systems: The stressors in this LTA included mining and recreation, specifically trails located within the floodplain. There were no macroinvertebrate community, temperature, or fine sediment data available. The percent of impaired streams and the percent of impaired waterbodies were both comparable to reference sites. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 20M.

20Q—Mountain Slopelands in Quartzite

Surface water systems: The levels of all stressors in this LTA were relatively low. The macroinvertebrate community, average temperature, and fine sediment were all comparable to reference conditions. The percentage of impaired streams was slightly greater than reference conditions and the percent of impaired waterbodies was much greater than reference conditions. The overall water quality score was 76 percent and the LTA was considered **within** the NRV.

GDEs: A single GDE assessment (Cove Creek-Cove Creek) was completed at a spring in this LTA in 2015. The report noted impacts to soils from wild ungulate and livestock grazing and that herbivory was adversely affecting the site. However, changes in water quality were not affecting the GDE. The site was described as functioning at risk with a downward trend. This LTA is large with only one GDE assessment available. Therefore, there was **insufficient information** to evaluate GDE water quality in 20Q.

20S—Mountain Slopelands in Sedimentary Bedrock

Surface water systems: The stressors in this LTA included grazing and roads. The macroinvertebrate community, average temperature, and fine sediment were moderately altered from reference conditions. The percentage of impaired streams and the percentage of impaired waterbodies were much greater than reference conditions. Overall, the water quality score was 44 percent and the LTA was considered **outside** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 20S.

20V—Mountain Slopelands in Volcanics

Surface water systems: The primary stressor in this LTA was grazing. Average temperature was comparable to reference sites. The macroinvertebrate community, fine sediment, and percent of impaired streams were moderately altered from reference conditions. The percent of impaired waterbodies was much greater than that of reference conditions. Overall, the water quality score was 60 percent and the LTA was considered **moderately altered** from the NRV.

GDEs: Forest staff completed 17 GDE Assessments within this LTA: Smiley Meadow Spring, Antelope/Iron Bog/Big Canyon, Burnt Hollow, Mahogany Gulch, Mahogany Gulch Bear Creek Pond 3, Middle Fork Swan Basin, Antelope/Iron Bog/Spring, Dry Canyon GDE #1, Death Canyon Pond 5, Death Canyon Pond 6, Antelope/Bear Creek Unit, Antelope/Bear Creek Unit Pond/Spring #7, Antelope/Bear Creek Unit Pond #5, Antelope/Bear Creek Unit Pond #3, Swan Basin-Ted Whitaker, and Swan Basin-Chandler Springs. Of these, Burnt Hollow, Mahogany Gulch Bear Creek Pond 3, Middle Fork Swan Basin, Swan Basin-Ted Whitaker, Swan Basin Lower Grove, and Swan Basin-Chandler Springs displayed fen characteristics. Every PFC assessment in this LTA noted impacts to the GDE from grazing and photos of the sites show erosion, hummocking, and soil disturbance from livestock. However, all reports indicated that changes in water quality were not impacting the system and GDE water quality was considered **within** the NRV in 20V.

30G—Cryic Uplands in Granite

Surface water systems: The level of all stressors in this LTA was relatively low. There was no macroinvertebrate community or temperature data available. The percentage of impaired streams was comparable to reference conditions, although the percentage of impaired waterbodies was moderately greater than reference conditions. Fine sediment was substantially altered from reference conditions. The water quality score was 60 percent and the LTA was considered **moderately altered** from the NRV, but this determination was made with low confidence due to the lack of macroinvertebrate and temperature indicators.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 30G.

30M—Cryic Uplands in Mixed

Surface Water Quality: The level of all stressors in this LTA was relatively low. There were no macroinvertebrate, temperature, or fine sediment data available for 30M. The percent of impaired streams and the percent of impaired waterbodies were both comparable to reference sites. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 30M.

30Q—Cryic Uplands in Quartzite

Surface water systems: The primary stressor in this LTA was grazing. The macroinvertebrate community and average temperature were comparable to reference conditions. Fine sediment and the percent of impaired streams were moderately altered from reference conditions and the percent of impaired waterbodies was much greater than reference conditions. The water quality score was 68 percent and the LTA was considered **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 30Q.

30S—Cryic Uplands in Sedimentary Bedrock

Surface water systems: The stressors in this LTA included grazing and roads. There were no macroinvertebrate community, temperature, or fine sediment data available for 30S. The percent of impaired streams and the percent of impaired waterbodies were both much greater than reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: A single GDE assessment had been completed in 2015 in this LTA: Lake Creek Trail Creek Big Timber. This site did display fen characteristics. The PFC report indicated that changes in water quality were not affecting the system, but without additional assessments there was **insufficient information** to evaluate GDE water quality in 30S.

30V—Cryic Uplands in Volcanics

Surface water systems: The primary stressor in this LTA was grazing; with limited forage, impacts are typically confined to valley bottoms where moisture is available (SCNF 2004). The average stream temperature was comparable to reference conditions. The macroinvertebrate community, fine sediment, and percent of impaired streams were moderately altered from reference conditions. The percentage of impaired waterbodies was much greater than reference conditions. Overall, the water quality score was 60 percent and the LTA was considered **moderately altered** from the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 30V.

40G—Cryic Basinlands in Granite

Surface water systems: The primary stressor in this LTA was grazing. The percentage of impaired waterbodies, the percentage of impaired streams, and fine sediment values in this LTA were comparable to reference. The macroinvertebrate community and average temperature were moderately altered from reference conditions. Overall the water quality score was 84 percent and the LTA was considered **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 40G.

40Q—Cryic Basinlands in Quartzite

Surface water systems: The stressors in this LTA included grazing and recreation, specifically trails located within the floodplain. There were no macroinvertebrate community, temperature, or fine sediment data for this LTA. The percentage of impaired waterbodies was slightly greater than reference conditions and the percent of impaired streams was much greater than reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 40Q.

40V—Cryic Basinlands in Volcanics

Surface water systems: The stressors in this LTA included mining and grazing. There were no macroinvertebrate community, temperature, or fine sediment data for this LTA. There were no impaired waterbodies or streams in 40V. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 40V.

50G-Glacial Troughlands in Granite

Surface water systems: The level of stressors in this LTA was low. The macroinvertebrate community, average stream temperature, fine sediment, and percentage of impaired streams were comparable to reference conditions. The percentage of impaired waterbodies was slightly greater than reference conditions. The water quality score was 92 percent and the LTA was considered **within** the NRV.

GDEs: Three GDE assessments had been completed in this LTA: Antelope/Smiley Meadow, Smiley Mountain Spring 1, and Smiley Mountain Spring 2. Photos showed major impacts from grazing to these GDEs including erosion, hummocking, and drying. Nevertheless, the PFC reports indicated that water quality was sufficient to support riparian-wetland plants and that no accumulation of chemicals affecting plant productivity or composition was apparent. This is a large LTA and without additional assessments there was **insufficient information** to evaluate GDE water quality in 50G.

50M—Glacial Troughlands in Mixed Geology

Surface water systems: The level of all stressors in this LTA was relatively low. There were no macroinvertebrate community, temperature, or fine sediment data for this LTA. Without additional indicators, there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 50M.

50Q—Glacial Troughlands in Quartzite

Surface water systems: The level of stressors in this LTA was relatively low. The macroinvertebrate community, average stream temperature, and fine sediment values were comparable to reference conditions. The percentage of impaired streams was slightly greater than reference conditions and the percentage of impaired waterbodies was much greater than reference conditions. The water quality score was 76 percent and the LTA was considered **within** the NRV.

GDEs: Two GDE assessments had been completed in this LTA: Lee Creek-Big Eightmile and Deer Park-North Fork. Both sites had some peat accumulation but do not otherwise exhibit fen characteristics. The PFC reports indicated that changes in water quality were not affecting the system, but without additional assessments there was **insufficient information** to evaluate the status of GDE water quality in 50Q.

50S—Glacial Troughlands in Sedimentary Bedrock

Surface water systems: The primary stressor in this LTA was grazing; due to the prime forage in valley bottoms, domestic livestock and wildlife tend to concentrate in riparian areas (SCNF 2004). There were no macroinvertebrate community, temperature, or fine sediment data for this LTA. There were no impaired waterbodies, but the percentage of impaired streams was slightly greater than reference conditions. Without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 50S.

50V—Glacial Troughlands in Volcanics

Surface water systems: The level of stressors in this LTA was relatively low. The macroinvertebrate community, average stream temperature, and median substrate size were comparable to reference conditions. The percentage of impaired streams was slightly greater than reference conditions and the percentage of impaired waterbodies was much greater than reference conditions. The water quality score was 76 percent and the LTA was considered **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 50V.

60G—Strongly Glaciated Lands in Granite

Surface water systems: The level of all stressors in this LTA was relatively low. There were no macroinvertebrate community, temperature, or fine sediment data for this LTA. There were no impaired streams, but the percentage of impaired waterbodies was much greater than reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient** information to evaluate the status of GDE water quality in 60G.

60M—Strongly Glaciated Lands in Mixed Geology

Surface water systems: The primary stressor in this LTA was grazing. There were no macroinvertebrate, temperature, or median substrate size data for this LTA. Without additional indicators, there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 60M.

60Q—Strongly Glaciated Lands in Quartzite

Surface water systems: The primary stressor in this LTA was grazing. The macroinvertebrate community, average stream temperature, and median substrate size were comparable to reference conditions. The percentage of impaired streams was slightly greater than reference conditions and the percentage of impaired waterbodies was much greater than reference conditions. The water quality score was 76 percent and the LTA was considered **within** the NRV.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 60Q.

60S—Strongly Glaciated Lands in Sedimentary Rocks

Surface water systems: The primary stressor in this LTA was grazing. There were no macroinvertebrate community, temperature, or median substrate size data for this LTA. The percentage of impaired streams and the percentage of impaired waterbodies were slightly greater than reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 60S.

60V—Strongly Glaciated Lands in Volcanics

Surface water systems: The primary stressor in this LTA was grazing and the level of other stressors were relatively low. There were no macroinvertebrate community, temperature, or median substrate size data for this LTA. The percentage of impaired streams was slightly greater than reference conditions and the percentage of impaired waterbodies was much greater than reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 60V.

70Q—Dissected Foothill Lands in Quartzite

Surface water systems: The stressors in this LTA included mining and grazing. There were no macroinvertebrate community, temperature, or median substrate size data for this LTA. There were no impaired waterbodies, but the percentage of impaired streams was slightly greater than reference conditions. However, without additional indicators, there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: No GDE assessments had been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in 70Q.

70S—Dissected Foothill Lands in Sedimentary Bedrock

Surface water systems: The stressors in this LTA included grazing and roads, particularly those located within the floodplain. There were no macroinvertebrate community or temperature data available in this LTA. There were no impaired water bodies, but the percentage of impaired streams was much greater than reference conditions. Additionally, the median substrate size was moderately altered from reference conditions. However, without additional indicators there was **insufficient information** to evaluate the status of water quality in this LTA.

GDEs: Two GDE assessments had been completed in this LTA: Spring Hill and Sawmill Canyon/Head of Left Fork. The Spring Hill report noted point source pollution from cattle and that changes in water quality, including increased temperature, had affected the GDE. The Sawmill Canyon report also noted impacts from livestock to the GDE, but water quality was sufficient to support riparian-wetland plants. Without additional PFC reports, there was **insufficient information** to evaluate the status of GDE water quality in 70S.

70V—Dissected Foothill Lands in Volcanics

Surface water systems: The stressors in this LTA included grazing, roads, and recreation, particularly camp sites located within the floodplain. The macroinvertebrate community was substantially altered from reference sites. The median substrate size was slightly less than reference sites. The percentage of impaired streams was also slightly greater than reference conditions, but no waterbodies were impaired. The water quality score was 60 percent and the LTA was considered **moderately altered** from the NRV.

GDEs: Forest staff had completed 27 GDE Assessments in this LTA: Leadbelt/Deer Creek Trough, Leadbelt/Deer Creek Pond, Deer Creek Pond Site 3, Deer Creek Pond Site 4, Horsethief Pond Site 5, Horsethief Pond Site 6, Horsethief Pond Site 7, Horsethief Pond Site 8, Horsethief Pond Site 9, Big Buck Spring, Dry Fork Site 1, Dry Fork Unit, Leadbelt Pasture 1, Leadbelt Pasture 2, Leadbelt Pasture 3, Leadbelt Creek Unit, Lee Creek-Walters Unit, Spring Hill Site 1, Spring Hill Site 2, Spring Hill Site 4, Spring Hill Site 5, Spring Hill Site 9, Spring Hill Site 11, Spring Hill Site 12, Spring Hill Site 15a, Spring Hill Site 15b, and Upper Camp Unit. Of these, Lee Creek-Walters Unit, Spring Hill Site 5, and Spring Hill Site 12 exhibited fen characteristics. Nearly all the reports indicated that livestock grazing was negatively impacting the GDE sites and one-third of the assessments noted that changes in water quality were affecting the GDE. We concluded that GDE water quality in this LTA was **moderately altered** from the NRV.

VB—Valley Bottom

Surface water systems: The stressors in this LTA included mining and recreation. Despite these stressors, the macroinvertebrate community, average stream temperature, and median substrate size were comparable to reference conditions. The percentage of impaired streams was slightly greater than reference conditions and the percentage of impaired waterbodies was much greater than reference conditions. The water quality score was 76 percent and this LTA was considered **within** the NRV.

GDEs: No GDE assessments have been completed in this LTA. There was **insufficient information** to evaluate the status of GDE water quality in VB.

Reference

Salmon-Challis National Forest [SCNF]. 2004. Landtype association and landtypes of the Salmon-Challis National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Salmon-Challis National Forest, Salmon, ID.

Appendix E—Channel and Floodplain Dynamics

Methods

We scored nine indicators for channel and floodplain dynamics based on whether they showed evidence of little or no, moderate, or substantial alteration from reference conditions within the Frank Church-River of No Return and Jim McClure-Jerry Peak Wildernesses. If the land type associations (LTA) had little or no alteration, it was given a score of 5; moderate alteration was given a score of 3; substantial alteration was given a score of 1 (table E1). The scores for each LTA were summed and divided by the potential total to give a percentage rating for each association. LTAs were considered within the natural range of variation (NRV) for channel and floodplain dynamics if the index was greater than 75 percent; moderately altered from the NRV if the index was between 60 percent and 75 percent; outside the NRV if the index was less than 60 percent.

Table E1—Scoring for indicators of channel and floodplain dynamics within each LTA.

Indicator	Little or no alteration (5 points)	Moderate alteration (3 points)	High alteration (1 point)
Floodplain acres/stream mile	>9.97	7.76 < x < 9.97	<7.76
Sinuosity	>1.08	0.81 < x < 1.08	<0.81
Bank stability	>95.2	88.1 < x < 95.2	<88.1
Bank angle	<120	120 < x < 148.5	>148.5
Large wood frequency	>173.6	50 < x < 173.6	<50
Large wood volume	>34.6	10 < x < 34.6	<10
Wildfire disturbance	<10%	10% < x < 20%	>20%
Wetland rating	>70	60 < x < 70	<60

Land Type Association Summaries

10G—Steep Canyonlands in Granite

This LTA includes side slopes and a range of valley bottoms that may be narrow with a stream actively cutting its channel through bedrock or wide with a stream meandering across depositional material (SCNF 2004). Debris slides are a common and natural disturbance to stream channels in 10G. Streams in this association tend to be very short with extremely steep gradients (SCNF 2004). There is little forage production in this LTA and the steep slopes tend to limit grazing to the flatter valley bottoms. The steep terrain also limits the development of floodplains and riparian zones, as most valley bottoms are mostly xeric with small mesic sites that tend to produce Engelmann spruce and Douglas-fir (SCNF 2004). Stressors to channel and floodplain dynamics in this LTA included mining, trails within the floodplain, and invasive species. Despite these stressors, floodplain acres/stream mile, sinuosity, bank stability, bank angle, large wood frequency, wildfire disturbance, and wetland rating were all comparable to reference conditions. The volume of large wood in 10G was slightly altered from reference sites. Overall, the channel and floodplain dynamics index was 95 percent and 10G was considered **within** its NRV for channel and floodplain dynamics.

10M—Steep Canyonlands in Mixed Geology

This is a very small LTA with no information available on its features or typical channel structure. The levels of all stressors to channel and floodplain dynamics were relatively low. There was **insufficient information** to evaluate the status of channel and floodplain dynamics in this LTA because there were no monitoring sites.

10Q—Steep Canyonlands in Quartzite

This LTA includes side slopes and a range of valley bottoms that may be narrow with a stream actively cutting through bedrock or wide with a stream meandering across depositional material (SCNF 2004). Debris slides are a somewhat common natural disturbance to stream channels in 10Q. Streams in this association tend to be very short with extremely steep gradients (SCNF 2004). There is little forage production in this LTA and the steep slopes tend to limit grazing outside of flatter valley bottoms. The steep terrain also limits the development of floodplains and riparian zones, as most valley bottoms are mostly xeric (SCNF 2004). Stressors in this LTA included roads, trails, and recreation sites located within the floodplain, mining, and invasive species. Despite these stressors, the floodplain acres/stream mile, sinuosity, bank stability, bank angle, large wood volume, wildfire disturbance, and wetland rating were all comparable to reference conditions. The frequency of large woody debris within the channel was slightly altered from reference channels. Overall, the channel and floodplain dynamics index score was 95 percent and 10Q was considered **within** its NRV.

10S—Steep Canyonlands in Sedimentary Bedrock

This LTA includes side slopes and a range of valley bottoms that may be narrow with a stream actively cutting its channel in bedrock or wide with a stream meandering across depositional material (SCNF 2004). Debris slides are a somewhat common natural disturbance to stream channels in 10S. Streams in this association tend to be very short with extremely steep gradients. There is little forage production in this LTA and the steep slopes tend to limit grazing outside of flatter valley bottoms. The steep terrain also limits the development of floodplains and riparian zones, as most valley bottoms are mostly xeric with small mesic sites composed of poor quality aspen clones (SCNF 2004). Stressors in this LTA included livestock grazing, roads, and recreation sites within the floodplain, and invasive species. These stressors appeared to have impacted some components of channel structure. Floodplain acres/stream mile, sinuosity, and bank stability were all comparable to reference conditions. Bank angle and the frequency of large woody debris were slightly altered from reference channels. The volume of large wood, wildfire disturbance, and the wetland rating were all highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 60 percent and 10S was considered **moderately altered** from the NRV.

10V—Steep Canyonlands in Volcanics

This LTA includes side slopes and a range of valley bottoms that may be narrow with a stream actively cutting through bedrock or wide with a stream meandering across depositional material (SCNF 2004). Debris slides are a common and natural disturbance to stream channels in 10V. Streams in this association tend to be very short with extremely steep gradients. There is little forage production in this LTA and the steep slopes tend to limit grazing outside of the flatter valley bottoms. The steep terrain also limits the development of floodplains and riparian zones, as most valley bottoms are mostly xeric (SCNF 2004). Stressors in this LTA included trails and invasive species within the floodplains. Despite these stressors, floodplain acres/stream mile, sinuosity, bank stability, bank angle, large wood volume, wildfire disturbance, and wetland rating were comparable to reference conditions. The frequency of large woody debris within the channel was slightly altered from reference channels. Overall, the channel and floodplain dynamics score was 95 percent and 10V was considered **within** the NRV.

20G—Mountain Slopelands in Granite

The streams of this LTA exist in v-shaped valleys with steep sided slopes (SCNF 2004). Stream gradients tend to be high and riffles typically dominate the channel. When pools do form, they are generally poor in quality. Unless modified by beaver, channel substrates are dominated by boulder and rubble. In some locations, wider valley bottoms have allowed for agricultural or housing developments (SCNF 2004). The primary stressor in this LTA was invasive species within the floodplain. Despite this stressor, floodplain acres/stream mile, bank stability, bank angle, large wood frequency, large wood volume, and wetland rating were all comparable to reference conditions. Channel sinuosity was slightly altered from reference channels and wildfire disturbance was highly altered from reference sites. Overall, the channel and floodplain dynamics index score was 85 percent and 20G was considered **within** the NRV.

20M—Mountain Slopelands in Mixed Geology

This is a small LTA with no information available on its features or typical channel structure. Relative to other LTAs on the Forest, 20M had higher densities of mines and trails within the floodplain. There was **insufficient information** to evaluate the status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

20Q—Mountain Slopelands in Quartzite

The streams of this LTA exist in v-shaped valleys with steep sided slopes (SCNF 2004). Stream gradients tend to be steep and riffles typically dominate the channel. When pools do form, they are generally poor in quality. Unless modified by beaver, channel substrates are dominated by boulder and rubble. In some locations, wider valley bottoms have allowed for agricultural or housing developments. Lower slopes in this association provide good forage that relieves some grazing pressure from the valley bottoms (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 20Q had been harvested for timber and the percentage of floodplain impacted by invasive species was high. In this LTA, floodplain acres/stream mile, sinuosity, bank stability, bank angle, and wetland rating were all comparable to reference conditions. The frequency of large woody debris within the channel was slightly altered from reference sites. The volume of large wood and wildfire disturbance were highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 75 percent and 20Q was considered **moderately altered** from the NRV.

20S—Mountain Slopelands in Sedimentary Bedrock

The streams of this LTA exist in v-shaped valleys with steep sided slopes (SCNF 2004). Stream gradients tend to be steep and riffles typically dominate the channel. When pools form, they are generally poor in quality. Unless modified by beaver, channel substrates are dominated by boulder and rubble. Most streams are intermittent or ephemeral and limit the size of riparian zones. In some locations, wider valley bottoms have allowed for agricultural use or housing developments. Debris slides occur somewhat frequently and are a natural disturbance to channel structure (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 20S has active grazing allotments and there was a greater density of roads in the floodplain; the percentage of floodplain impacted by invasive species was high. Despite these stressors, floodplain acres/stream mile, sinuosity, bank stability, and bank angle were comparable to reference conditions. The frequency and volume of large woody debris was slightly altered from reference conditions. Wildfire disturbance and wetland rating were both highly altered from reference sites. Overall, the channel and floodplain dynamics index score was 70 percent and 20S was considered **moderately altered** from the NRV.

20V—Mountain Slopelands in Volcanics

The streams of this LTA exist in v-shaped valleys with steep sided slopes (SCNF 2004). Stream gradients tend to be steep and riffles typically dominate the channel. When pools do form, they are generally poor in quality. Unless modified by beaver, channel substrates are dominated by boulder and rubble. Most streams are intermittent or ephemeral and limit the size of riparian zones. In some locations, wider valley bottoms have allowed for agricultural use or housing developments. Debris slides occur somewhat frequently and are a natural disturbance to channel structure (SCNF 2004). Relative to other LTAs on the Forest, a larger percentage of 20V had active grazing allotments. Despite this stressor, floodplain acres/stream mile, sinuosity, bank stability, and bank angle were comparable to reference conditions. The frequency of large woody debris, volume of large woody debris, wildfire disturbance, and wetland rating were highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 60 percent and 20V was considered **moderately altered** from the NRV.

30G—Cryic Uplands in Granite

Stream development in this LTA is limited due to high rates of percolation and the position on the landscape (SCNF 2004). Channels tend to have more moderate gradients than glaciated lands and the substrate is usually dominated by fine sediments. Forage is limited to valley bottoms, commonly concentrating livestock and big game where moisture is available (SCNF 2004). Relative to other LTAs, 30G had a larger percentage of the floodplain affected by recreation. Despite this stressor, floodplain acres/stream mile, sinuosity, bank stability, bank angle, volume of large woody debris, wildfire disturbance, and wetland rating were all comparable to reference conditions. The frequency of large woody debris within the channel was slightly altered from reference channels. Overall, the channel and floodplain dynamics index score was 95 percent and 30G was considered **within** the NRV.

30M—Cryic Uplands in Mixed Geology

This is a small LTA with no information available on its features or typical channel structure. Relative to other LTAs on the Forest, a large percentage of floodplains in 30M were impacted by invasive species. There was **insufficient information** to evaluate the status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

30Q—Cryic Uplands in Quartzite

Stream development in this LTA is limited due to high rates of percolation and the position on the landscape (SCNF 2004). Channels tend to have more moderate gradients than glaciated lands and the substrate is usually dominated by fine sediments. Forage is limited to valley bottoms, commonly concentrating livestock and big game where moisture is available (SCNF 2004). Relative to other LTAs on the Forest, the percentage of 30Q with active grazing and the percentage of floodplain impacted by invasive species were both high. In this LTA, floodplain acres/stream mile, sinuosity, bank stability, bank angle, and wetland rating were comparable to reference conditions. The frequency of large woody debris within the channel was slightly altered from reference channels. The volume of large woody debris and wildfire disturbance were highly altered from reference sites. Overall, the channel and floodplain dynamics index score was 75 percent and 30Q was considered **moderately altered** from the NRV.

30S—Cryic Uplands in Sedimentary Bedrock

Stream development in this LTA is limited due to high rates of percolation and the position on the landscape (SCNF 2004). Channels tend to have more moderate gradients than glaciated lands and the substrate is usually dominated by fine sediments. Forage is limited to valley bottoms, commonly concentrating livestock and big game where moisture is available (SCNF 2004). Relative to other LTAs on the Forest, the percentage of the LTA with active grazing allotments and the floodplain road density were high. There was **insufficient information** to evaluate the NRV status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

30V—Cryic Uplands in Volcanics

Stream development in this LTA is limited due to high rates of percolation and the position on the landscape (SCNF 2004). Channels tend to have less gradient than glaciated lands and the substrate is usually dominated by fine sediments. Forage is limited to valley bottoms, commonly concentrating livestock and big game where moisture is available (SCNF 2004). Relative to other LTAs on the Forest, the percentage of 30V with active grazing allotments was high. In this LTA, floodplain acres/stream mile, sinuosity, bank stability, and large wood volume were comparable to reference conditions. Bank stability was slightly altered from reference sites. The frequency of large woody debris within the channel, wildfire disturbance, and the wetland rating were highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 65 percent and 30V was considered **moderately altered** from the NRV.

40G—Cryic Basinlands in Granite

Wet meadows with a water table at or near the surface are a significant characteristic in this LTA (SCNF 2004). Streams within these meadows typically have low gradient, meandering channels that are fragile and easily altered by disturbance. They are especially prone to headcutting and bank erosion. Stream substrate in this LTA is typically small gravel and fines, with the majority of channels functioning as depositional zones. The valley bottoms typically contain high volumes of sedges and grasses with some willow and these areas provide the principle forage sources for cattle and wildlife. Beavers are often found in the streams that flow through 40G (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of the LTA had active grazing allotments and a large percentage of floodplains was impacted by invasive species. Despite these stressors, floodplain acres/stream mile, sinuosity, bank stability, bank angle, frequency of large woody debris, and the wetland rating were comparable to reference conditions. The volume of large woody debris was slightly altered from reference channels and wildfire disturbance was highly altered. Overall, the channel and floodplain dynamics index was 85 percent and 40G was considered **within** the NRV.

40Q—Cryic Basinlands in Quartzite

Wet meadows with a water table at or near the surface are a significant characteristic in this LTA (SCNF 2004). Streams within these meadows typically have low gradient, meandering channels that are fragile and easily altered by disturbance. They are especially prone to headcutting and bank erosion. Stream substrate in this LTA is typically small gravel and fines, with the majority of channels functioning as depositional zones. The valley bottoms typically contain high volumes of sedges and grasses with some willow, and these areas provide the principle forage sources for cattle and wildlife. Beavers are often found in the streams that flow through 40Q (SCNF 2004). Relative to other LTAs on the Forest, 40Q had a high percentage of land with active grazing allotments and a high density of trails within the floodplain. There was **insufficient information** to evaluate the status of channel and floodplain dynamics because there were no monitoring sites in 40Q.

40V—Cryic Basinlands in Volcanics

Wet meadows with a water table at or near the surface are a significant characteristic in this LTA (SCNF 2004). Streams within these meadows typically have low gradient, meandering channels that are fragile and easily altered by disturbance. They are especially prone to headcutting and bank erosion. Stream substrate in this LTA is typically small gravel and fines, with the majority of channels functioning as depositional zones. The valley bottoms typically contain high volumes of sedges and grasses with some willow and these areas provide the principle forage source for cattle and wildlife. Beavers are often found in the streams that flow through 40V (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 40V had active grazing allotments, a large percentage had experienced timber harvest, and mining density was high. There was **insufficient information** to evaluate the NRV status of channel and floodplain dynamics because there were no monitoring sites in 40V.

50G—Glacial Troughlands in Granite

In this LTA, streams are small, steep, high elevation, and perennial (SCNF 2004). The channels are dominated by boulders and streambanks are generally rated good to excellent under natural conditions. Debris slides are a somewhat common natural disturbance to channel structure in these lands. High quality forage used by wildlife and livestock, including moderate to heavy volumes of forbs and grasses, are limited to moist areas in valley bottoms and wet meadows (SCNF 2004). The level of stressors was relatively low in this LTA and all indicators were comparable to reference conditions. The channel and floodplain dynamics index score was 100 percent and 50G was considered **within** the NRV.

50M—Glacial Troughlands in Mixed Geology

This is a small LTA with no information available on its features or typical channel structure. The level of stressors was relatively low. Nevertheless, there was **insufficient information** to evaluate the status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

50Q—Glacial Troughlands in Quartzite

In this LTA, streams are small, steep, high elevation, and perennial (SCNF 2004). The channels are dominated by boulders and streambanks are generally rated good to excellent under natural conditions. Debris slides are a somewhat common natural disturbance to channel structure in these lands. Valley bottoms are used by elk, deer, and livestock with most high-quality forage limited to moist areas. In these areas, wet meadows have moderate to heavy volumes of forbs and grasses (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of the floodplain was impacted by invasive species. Despite this stressor, floodplain acres/stream mile, sinuosity, bank stability, bank angle, frequency of large woody debris, and the wetland rating were comparable to reference conditions. The volume of large wood was slightly altered from reference sites and wildfire disturbance was highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 85 percent and 50Q was considered **within** the NRV.

50S—Glacial Troughlands in Sedimentary Rocks

In this LTA, streams are small, steep, high elevation, and perennial (SCNF 2004). The channels are dominated by boulders and streambanks are generally rated good to excellent under natural conditions. Valley bottoms are used by elk, deer, and livestock with most high-quality forage limited to moist areas. In these areas, wet meadows have moderate to heavy volumes of forbs and grasses (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 50S had active grazing allotments and a large percentage of floodplains were impacted by invasive species. There was **insufficient information** to evaluate the NRV status because there were no monitoring sites in 50S.

50V—Glacial Troughlands in Volcanics

In this LTA, streams are small, steep, high elevation, and perennial (SCNF 2004). The channels are dominated by boulders and streambanks are generally rated good to excellent under natural conditions. Debris slides are a common natural disturbance to channel structure in these lands. Valley bottoms are used by elk, deer, and livestock with most high-quality forage limited to moist areas. In these areas, wet meadows have moderate to heavy volumes of forbs and grasses. Relative to other LTAs on the Forest, the level of stressors to channel and floodplain dynamics was low. Floodplain acres/stream mile, sinuosity, bank stability, bank angle, frequency of large wood, volume of large wood, and the wetland rating were comparable to reference conditions. Wildfire disturbance was highly altered from reference sites. Overall, the channel and floodplain dynamics index score was 90 percent and 50V was considered **within** the NRV.

60G—Strongly Glaciated Lands in Granite

This is a high elevation LTA composed of cirques, cirque basins, headwalls, and ridges (SCNF 2004). Streams in 60G are very small and shallow. Low quality pools dominate the channels and boulders are the primary substrate, with little rubble or fine sediment. Streambanks are naturally in excellent condition. Talus slopes and rock outcrops are common features in this association and debris slides are a somewhat common natural disturbance to channel structure. Due to short growing seasons and poor soil development, disturbance is generally longer lived in this LTA. Mesic vegetation within the cirque basins provides forage and these areas are used by elk during breeding season (SCNF 2004). Relative to other LTAs on the Forest, the level of stressors to channel and floodplain dynamics was low. However, there was **insufficient information** to evaluate the NRV status because there were no monitoring sites in 60G.

60M—Strongly Glaciated Lands in Mixed Geology

There is no information available on this LTA's features or typical channel structure. Relative to other LTAs on the Forest, the percentage of 60M with active grazing allotments is high. There was **insufficient information** to evaluate the status of channel and floodplain dynamics because there were no monitoring sites in 60M.

60Q—Strongly Glaciated Lands in Quartzite

This is a high elevation LTA composed of cirques, cirque basins, headwalls, and ridges (SCNF 2004). Streams in 60Q are very small and shallow. Low quality pools dominate the channels and boulders are the primary substrate, with little rubble or fine sediment. Streambanks are naturally in excellent condition. Talus slopes and rock outcrops are common features in this association and avalanches are a common natural disturbance to channel structure. Due to short growing seasons and poor soil development, disturbance is generally longer lived in this LTA. Mesic vegetation within the cirque basins provides forage and these areas have high potential for conflict between domestic and wild grazing animals (SCNF 2004). Relative to other LTAs on the Forest, a somewhat large percentage of 60Q had active grazing allotments. Floodplain acres/stream mile, sinuosity, bank stability, and bank angle were comparable to reference conditions. The frequency of large woody debris was slightly altered from reference channels. The volume of large woody debris, wildfire disturbance, and the wetland rating were all highly altered. Overall, the channel and floodplain dynamics index score was 65 percent and 60Q was considered **moderately altered** from the NRV.

60S—Strongly Glaciated Lands in Sedimentary Bedrock

This is a high elevation LTA composed of cirques, cirque basins, headwalls, and ridges (SCNF 2004). Streams in 60S are small and shallow. Low quality pools dominate the channels and boulders are the primary substrate, with little rubble or fine sediment. Streambanks are naturally in excellent condition. Talus slopes and rock outcrops are common features in this association and debris slides are a somewhat common natural disturbance to channel structure. Due to short growing seasons and poor soil development, disturbance is generally longer lived in this LTA. Mesic vegetation within the cirque basins provides forage, but grazing is somewhat limited because of steep slopes and access difficulty. Water and mesic vegetation in the basins attract elk during the summer and breeding season (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of the land in 60S was open to grazing. There was **insufficient information** to evaluate the NRV status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

60V—Strongly Glaciated Lands in Volcanic

This is a high elevation LTA composed of cirques, cirque basins, headwalls, and ridges (SCNF 2004). Streams in 60V are small and shallow. Low quality pools dominate the channels and boulders are the primary substrate, with little rubble or fine sediment. Streambanks are naturally in excellent condition. Talus slopes and rock outcrops are common features in this association and debris slides and avalanches are a common natural disturbance to channel structure. Due to short growing seasons and poor soil development, disturbance is generally longer lived in this LTA. Mesic vegetation within the cirque basins provides forage and these areas are used by elk during breeding season (SCNF 2004). Relative to other LTAs on the Forest, the percentage of 60V open to grazing was high. There was **insufficient information** to evaluate the NRV status of channel and floodplain dynamics because there were no monitoring sites in this LTA.

70Q—Dissected Foothill Lands in Quartzite

The streams in this LTA are located in modified u-shaped valleys (SCNF 2004). The channels typically have moderate gradients with substrates composed of rubble and gravel. The pool-riffle ratio in 70Q is expected to be good with fairly good quality pools. Streams originating in this LTA are generally intermittent or ephemeral, limiting the extent of floodplain development. This LTA is capable of supporting a large amount of grazing by wild or domestic animals and is important winter range for big game (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 70Q was open to grazing; mine density and diversion density were high; and a large percentage of the floodplain was impacted by invasive species. There was **insufficient information** to evaluate the NRV status of channel and floodplain dynamics because there were no monitoring sites 70Q.

70S—Dissected Foothill Lands in Sedimentary Bedrock

The streams in this LTA are located in modified u-shaped valleys (SCNF 2004). The channels typically have moderate gradients with substrates composed of rubble and gravel. The pool-riffle ratio in 70S is expected to be good with fairly good quality pools. Streams originating in this LTA are generally intermittent or ephemeral, limiting the extent of floodplain development. The perennial streams in 70S can support good fish populations with important spawning and nursery areas for anadromous fish. This LTA is capable of supporting a large amount of grazing by wild or domestic animals and is important winter range for big game (SCNF 2004). Relative to other LTAs, a large percentage of 70S was open to grazing and the road density within the floodplain was high. There was **insufficient information** to evaluate the NRV status because there were no monitoring sites in 70S.

70V—Dissected Foothill Lands in Volcanics

The streams in this LTA are located in modified u-shaped valleys (SCNF 2004). The channels typically have moderate gradients with substrates composed of rubble and gravel. The pool-riffle ratio in 70V is expected to be good with fairly good quality pools. Streams originating in 70V are generally intermittent or ephemeral, limiting the extent of floodplain development. This LTA provides suitable forage for domestic sheep, but slopes are generally too steep to support cattle grazing (SCNF 2004). Relative to other LTAs on the Forest, a large percentage of 70V was open to grazing; there was a high density of roads and trails in the floodplain; and a large percentage of floodplains were impacted by recreation sites. In this LTA, floodplain acres/stream mile, sinuosity, bank angle, wildfire disturbance, and the wetland rating were all comparable to reference conditions. Bank stability and the volume of large woody debris were slightly altered from reference conditions. The frequency of large woody debris within the channel was highly altered from reference sites. Overall, the channel and floodplain dynamics index score was 80 percent and 70V was considered **within** the NRV.

VB—Valley Bottom

This LTA includes the valley bottoms of drainages across the Forest. There is no information available on the geology or typical channel features, but it is likely primarily composed of alluvium. Approximately 24 percent of this LTA was floodplain, more than any other LTA on the Forest. Relative to other LTAs on the Forest, there were high densities of roads, mines, diversions, and trails in VB; there was a high percentage of floodplains impacted by recreation sites and invasive species. In this LTA, floodplain acres, sinuosity, bank stability, and bank angle were comparable to reference conditions. The frequency and volume of large woody debris were slightly altered from reference channels. Wildfire disturbance and the wetland rating were highly altered from reference conditions. Overall, the channel and floodplain dynamics index score was 70 percent and VB was considered **moderately altered** from the NRV.

Reference

Salmon-Challis National Forest [SCNF]. 2004. Landtype association and landtypes of the Salmon-Challis National Forest. Unpublished report on file with: U.S. Department of Agriculture, Forest Service, Salmon-Challis National Forest, Salmon, ID.

Appendix F—Condition of Spring Runout Channel

Methods

To evaluate the condition of spring runout channels, we used proper functioning condition (PFC) reports completed by Salmon-Challis National Forest (SCNF) staff. These assessments included information on whether the runout channel was functioning naturally or was entrenched, eroded, or otherwise substantially altered. The reports also included information on the potential stressors to the condition of spring runout channels, including hydrologic alterations, soil alterations, presence of structures, recreation effects, or animal effects. We summarized these reports and used best professional judgment to determine the natural range of variation (NRV) status of water quality at groundwater-dependent ecosystems (GDEs).

Land Type Association (LTA) Summaries

No GDE assessments had been completed and there was therefore **insufficient information** to evaluate the condition of spring runout channels in the following LTAs:

10G—Steep Canyonlands in Granite
10M—Steep Canyonlands in Mixed Geology
10Q—Steep Canyonlands in Quartzite
10S—Steep Canyonlands in Sedimentary Rocks
10V—Steep Canyonlands in Volcanics
20G—Mountain Slopelands in Granite
20M—Mountain Slopelands in Mixed Geology
20S—Mountain Slopelands in Sedimentary Rocks
30G—Cryic Uplands in Granite
30M—Cryic Uplands in Mixed
30Q—Cryic Uplands in Quartzite
30V—Cryic Uplands in Volcanics
40G—Cryic Basinlands in Granite
40Q—Cryic Basinlands in Quartzite
40V—Cryic Basinlands in Volcanics
50M—Glacial Troughlands in Mixed Geology
50S—Glacial Troughlands in Sedimentary Rocks
50V—Glacial Troughlands in Volcanics
60G—Strongly Glaciated Lands in Granite
60M—Strongly Glaciated Lands in Mixed Geology
60Q—Strongly Glaciated Lands in Quartzite
60S—Strongly Glaciated Lands in Sedimentary Rocks
60V—Strongly Glaciated Lands in Volcanic
70Q—Dissected Foothill Lands in Quartzite
VB—Valley Bottom

20Q—Mountain Slopelands in Quartzite

A single GDE assessment (Cove Creek-Cove Creek) was completed at a spring in this LTA in 2015. The report documented that there was water flowing in channels, but that unnatural entrenchment and channelization had occurred, causing the site to go dry. Grazing wild animals and livestock was noted to be causing erosion and ground disturbance that had disturbed the spring runout channel. This site was described as functional-at-risk with a downward trend. This LTA is large with only one GDE assessment available. Therefore, there was **insufficient information** to evaluate the condition of spring runout channels in 20Q.

20V—Mountain Slopelands in Volcanics

Seventeen GDE assessments had been completed for this LTA. Thirteen of these PFC reports indicated the systems were functional-at-risk. The majority of assessments reported negative impacts to spring runout channels from grazing. Trailing, trampling, and bank shearing from hooves had caused erosion and channelization. Additionally, some spring channels in this LTA were affected by diversions, ditches, and roads/trails. Most of the reports did not indicate trends of the GDE systems. Overall, PFC reports suggested that there were significant impacts and the condition of spring runout channel in 20V was considered **outside** the NRV.

30S—Cryic Uplands in Sedimentary Rocks

A single GDE assessment had been completed by Forest staff in this LTA: Timber Creek-Trail Creek. This report noted minor impacts from grazing by wild animals. Nevertheless, the spring runout channel was functioning naturally and was not entrenched, eroded, or otherwise altered. The site was categorized as properly functioning. However, without additional assessments, there was **insufficient information** to evaluate the condition of spring runout channels in this LTA.

50G—Glacial Troughlands in Granite

Three GDE assessments had been completed by Forest staff in this LTA: Smiley Mountain Spring 1, Smiley Mountain Spring 2, and Antelope/Smiley Meadow. All three reports indicated that spring flow paths had been altered by heavy cattle use. However, this is a large LTA and without additional assessments there was **insufficient information** to evaluate the NRV status of spring runout channels.

50Q—Glacial Troughlands in Quartzite

Two GDE assessments had been completed by Forest staff in this LTA: Lee Creek-Big Eightmile and Deer Park-North Fork. The Big Eightmile site exhibited fen characteristics and did not have any spring runout channels present. The runout channel at the Deer Park-North Fork was entrenched, eroded, or otherwise substantially altered as a result of livestock use. The report indicated channel erosion, excavation of the spring source, and a nonfunctional trough as contributing to a functional-at-risk system with a static to downward trend. Without additional assessments there was **insufficient information** to evaluate the NRV status of spring runout channels in this LTA.

70S—Dissected Foothill Lands in Sedimentary Rocks

Two GDE assessments had been completed in this LTA by SCNF staff: Spring Hill Site 3 and Sawmill Canyon/Head of Left Fork. Both reports indicated major impacts to spring runout channels from livestock grazing. The natural flow paths at the Sawmill Canyon site had been altered by hoof action. Historic headcuts were present, but they were revegetated and the seep complex was determined to be trending upward. The spring runout channel at the Spring Hill Site was entrenched, eroded, or otherwise substantially altered. Without additional assessments, there was **insufficient information** to evaluate the NRV status of spring runout channels in this LTA.

70V—Dissected Foothill Lands in Volcanics

Twenty-seven GDE assessments had been completed by SCNF staff in this LTA. Of these, nine reports indicated channel erosion was occurring at the site. Fifteen of the assessments indicated that either the natural flow pattern had been altered by disturbance or that the runout channel was entrenched, eroded, or otherwise substantially altered. Thirteen of the sites showed impacts such as trailing or trampling from livestock and wild animal grazing. One report recorded entrenched channels where water used to dissipate across the associated meadow. Anthropogenic effects were impacting the condition of spring runout channels at more than half of the sites assessed in this LTA. The condition of spring runout channels in 70V was considered to be **outside** the NRV.

Appendix G—Composition and Condition of Riparian Ecosystems

Methods

Because of the inherently complicated nature of riparian composition and condition and the shortage of sampling sites in many land type associations (LTAs), we used a combination of quantitative methods and professional judgment in determining natural range of variation (NRV) status. We calculated indices of composition and condition using spatial and field-sampled datasets, some of which were available for managed and reference (Wilderness) sites.

1. We calculated an index from spatial data by combining estimates of conifer encroachment, upland vegetation encroachment, replacement by introduced vegetation (these three from Riparian Condition Assessment Tool [R-CAT] results) and riparian and wetland condition (from Watershed Condition Framework [WCF]). We gave each of these four indicators a score of 5, 3, or 1 using the criteria in table G1, which were informed by means from reference areas. We summed these scores for each LTA and divided by their potential total to obtain a final index value ranging between 0 and 100 percent.
2. We calculated an index from Pacfish-Infish biological opinion (PIBO) data using native cover, reach alien cover, greenline cover, effective ground cover, and wetland index. Because PIBO variables have been remeasured over several years at most stream sites, we calculated index scores from the first measurement year and from the most recent measurement year. Criteria for scoring were informed by

Table G1—Criteria for assigning riparian distribution and connectivity scores, which were used calculate an index value for each LTA.

Indicator	Data source	Little or no alteration (5 points)	Moderate alteration (3 Points)	High alteration (1 Point)
Percent conifer encroachment	R-CAT	<15	15–20	>20
Percent upland encroachment	R-CAT	<10	10–15	>15
Percent replacement by introduced vegetation	R-CAT	<1	1–2	>2
Riparian condition	WCF	Majority of LTA in good condition	Majority of LTA in fair condition	Majority of LTA in poor condition
Percent reach native cover	PIBO	>75	50–75	<50
Percent reach alien cover	PIBO	<1	1–2	>2
Percent greenline cover	PIBO	>80	70–80	<70
Percent effective ground cover	PIBO	>90	80–90	<80
Cross-section wetland index	PIBO	>50	40–50	<40

means from sampling sites in reference areas. We divided cumulative scores by their potential total to obtain a final index value ranging between 0 and 100 percent.

3. We examined trends in Aquatic Zone Analysis Rating (AZAR) scores and other information to develop a qualitative assessment of the condition of riparian community types present in each LTA.
4. We considered the above results to determine whether riparian composition and condition is within the NRV, outside of the NRV, or moderately altered in each LTA.

Land Type Association Summaries

10G—Steep Canyonlands in Granite

Over 95 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Approximately 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (70 percent) because of moderate levels of upland encroachment and high levels of introduced species. Vegetation data were collected on 14 occasions at six PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were high (92 percent). Most of the LTA (60 percent) was in Wilderness and less than 10 percent was within active grazing allotments. There were nine watershed monitoring sites in the LTA. The most recent mean AZAR score (82.4) was greater than the long-term mean (81.7) and the 5-year mean (79.5), indicating improving riparian conditions at these managed sites. Given the above information, we determined that 10G was **within** its NRV because, though encroachment and invasive species were prevalent, condition indicators were relatively high.

10M—Steep Canyonlands in Mixed Geology

This is a very small LTA with all perennial streams in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. The composition and condition index derived from spatial data was high (90 percent) with moderate levels of conifer encroachment. This LTA was entirely within Wilderness and there were no active grazing allotments. There was **insufficient information** to determine NRV status at 10M because field data are unavailable.

10Q—Steep Canyonlands in Quartzite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fair (60 percent) because of high levels of conifer encroachment, moderate levels of introduced species, and fair riparian and wetland condition. Vegetation data were collected on 10 occasions at four PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fairly high (84 percent). Most of the LTA was in managed areas (82 percent) and active allotments (56 percent). There were 10 watershed monitoring sites in the LTA. The most recent mean AZAR score (68.7) is less than the long-term mean (80.7) and the 5-year mean (78.3), indicating declining riparian conditions in these managed sites.

Given the above information, we determined that 10Q was **within** the NRV because, though AZAR scores were decreasing, there were fairly high composition and condition index values from managed PIBO sites.

10S—Steep Canyonlands in Sedimentary Bedrock

Nearly 90 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 2 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly low (50 percent) as a result of high levels of conifer and upland encroachment and fair riparian and wetland condition. Vegetation data were collected on nine occasions at three PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fairly low and fair, respectively (44 percent and 68 percent). The LTA was entirely in managed areas and active grazing allotments, but riparian areas may be inaccessible to livestock due to steep topography. There were three watershed monitoring sites in the LTA. The most recent mean AZAR score (80.7) was greater than the long-term mean (76.8) and the 5-year mean (79.3), indicating improving riparian conditions.

Given the above information, we determined that composition and condition at 10S was **moderately altered**, but low index values from spatial data and PIBO sites could be addressed through management changes.

10V—Steep Canyonlands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was low (50 percent), because of fair riparian and wetland condition, moderate levels of conifer and upland encroachment, and high levels of introduced species. Vegetation data were collected on 20 occasions at eight PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and fairly high, respectively (68 percent and 76 percent). Most (66 percent) of the LTA was in Wilderness and 35 percent was in active grazing allotments. Riparian areas may be inaccessible to livestock due to steep topography. Composition and condition were influenced by beaver activity at one PIBO site. Another site was burned by wildfires but deciduous trees had recovered via resprouting. There were five watershed monitoring sites in the LTA. The most recent mean AZAR score (82.6) was greater than the long-term mean (81.1) and the 5-year mean (80.3), indicating improving riparian conditions at managed sites. Given the above information, we determined that 10V was **moderately altered** with increasing PIBO index values and AZAR scores.

20G—Mountain Slopelands in Granite

Over 95 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fair (60 percent) as a result of moderate levels of conifer and upland encroachment and high levels of introduced species. Vegetation data were collected on 15 occasions at three PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and high, respectively (68 percent and 100 percent). Most (56 percent) of the LTA was in Wilderness and 21 percent was in active allotments. There were three watershed monitoring sites in the LTA. The most recent mean AZAR score (79.7) was less than the long-term mean (83.1) and the 5-year mean (83.2), indicating declining riparian conditions at managed sites. Given the above information, we determined that 20G was **within** the NRV because of relatively high PIBO index values and AZAR scores.

20M—Mountain Slopelands in Mixed Geology

This is a very small LTA with all perennial stream miles in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. The composition and condition index derived from spatial data was fair (70 percent) with moderate levels of conifer encroachment and high levels of introduced vegetation. This LTA was entirely in Wilderness and outside of active allotments. There was **insufficient information** to determine NRV status at 20M because field data were unavailable.

20Q—Mountain Slopelands in Quartzite

Over 95 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data is fairly high (70 percent) with high levels of conifer encroachment and fair riparian and wetland condition. Vegetation data were collected on 31 occasions at 11 PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were high (92 percent). Most (83 percent) of the LTA was in managed areas and active allotments (57 percent). There were 15 watershed monitoring sites in the LTA. The most recent mean AZAR score (82.5) was similar to the long-term mean (82.3) and the 5-year mean (83.4), indicating stable conditions in managed areas. Given the above information, we determined that 20Q was **within** its NRV because of the high spatial data index, PIBO index values, and AZAR scores.

20S—Mountain Slopelands in Sedimentary Bedrock

Most (70 percent) perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 10 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fair (60 percent) with high levels of upland encroachment, moderate levels of conifer encroachment, and fair riparian and wetland condition. Vegetation data were collected on six occasions at two PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and fairly high, respectively (60 percent and 76 percent). Most of the LTA was in managed areas (98 percent) and active allotments (93 percent). Livestock effects were apparent at a best management practices (BMP) monitoring site at Canyon Creek, but grazing greenline composition and woody plant age class were improving. Given the above information, we determined that 20S was **moderately altered** with fair but improving conditions at PIBO and BMP sites.

20V—Mountain Slopelands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 30 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was low (50 percent) because of fair riparian and wetland condition, moderate levels of conifer encroachment and introduced species, and high levels of upland encroachment. Vegetation data were collected on 90 occasions at 32 PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and fairly high, respectively (60 percent and 76 percent). Most of the LTA was in managed areas (68 percent) and active allotments (75 percent). Composition and condition were influenced by beaver activity at three or more PIBO sites.

There were 24 watershed monitoring sites in the LTA. The most recent mean AZAR score (72.4) was less than the long-term mean (79.9) and the 5-year mean (74.2), indicating declining riparian conditions in managed areas. Livestock effects were apparent at several BMP monitoring sites. Conditions were improving at these sites, but desired conditions had not been met. Given the above information, we determined that 20V was **moderately altered** with improving PIBO index values.

30G—Cryic Uplands in Granite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 10 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (100 percent). Vegetation data were collected on three occasions at one PIBO monitoring site. Composition and condition index values from the first and most recent measurements were fairly high and fair, respectively (76 percent and 68 percent). Most (54 percent) of the LTA was in managed areas and 31 percent was in active allotments. There was **insufficient information** to determine NRV status at 30G because field data were limited to one PIBO site.

30M—Cryic Uplands in Mixed Geology

This is a very small LTA with all perennial stream miles in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. The composition and condition index derived from the spatial data was high (100 percent). Nearly all of the LTA (>99 percent) was in Wilderness and only 2 percent was in active allotments. There was **insufficient information** to determine NRV status at 30M because field data were unavailable.

30Q—Cryic Uplands in Quartzite

Over 90 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Nearly 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was moderate (70 percent) because of fair riparian and wetland condition and high levels of conifer encroachment. Vegetation data were collected on 10 occasions at four PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were high (100 percent and 92 percent). Most of the LTA was in managed areas (95 percent) and active allotments (71 percent). There were six watershed monitoring sites in the LTA. The most recent mean AZAR score (85.7) was greater than the long-term mean (82.1) and the 5-year mean (83.6), indicating improving riparian conditions. Given the above information, we determined that 30Q was **within** the NRV because of high PIBO index scores and AZAR scores.

30S—Cryic Uplands in Sedimentary Bedrock

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 1 mile of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was moderate (60 percent) as a result of fair riparian and wetland condition, high levels of conifer encroachment, and moderate levels of upland encroachment. This LTA was entirely in managed areas almost entirely in active allotments (98 percent). There was **insufficient information** to determine NRV status at 30S because field data were unavailable.

30V—Cryic Uplands in Volcanics

Over 95 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Nearly 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (80 percent), with fair riparian and wetland condition and moderate levels of conifer encroachment. Vegetation data were collected on six occasions at three PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were low (44 percent and 36 percent). Most of the LTA was in managed areas (69 percent) and active allotments (62 percent). There was one watershed monitoring site in the LTA. The most recent AZAR score (77.0) was less than the long-term mean (82.7) and the 5-year mean (84.5), indicating declining riparian conditions at this managed site. Given the above information, we determined that 30V was **moderately altered**, but low PIBO index and AZAR scores can be addressed through management changes.

40G—Cryic Basinlands in Granite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (90 percent) with fair riparian and wetland condition. Vegetation data were collected on three occasions at one PIBO monitoring site. Composition and condition index values from the first and most recent measurements were fair (68 percent). Most of the LTA was in managed areas (76 percent) and active allotments (75 percent). There was **insufficient information** to determine NRV status at 40G because field data were limited to one PIBO site.

40Q—Cryic Basinlands in Quartzite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 1 mile of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (80 percent), with fair riparian and wetland condition and moderate levels of conifer encroachment. This LTA was entirely in managed areas and active allotments. There was **insufficient information** to determine NRV status at 40Q because field data were unavailable.

40V—Cryic Basinlands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 2 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (90 percent) with fair riparian and wetland condition. This LTA was entirely in managed areas and almost entirely in active allotments (98 percent). There was **insufficient information** to determine NRV status at 40V because field data were unavailable.

50G—Glacial Troughlands in Granite

Over 90 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 40 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (90 percent) with fair riparian and wetland condition. Vegetation data were collected on 13 occasions at five PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and high, respectively (68 percent and 100 percent). Most (55 percent) of the LTA was in Wilderness and 47 percent was in active allotments. Given the above information, we determined that 50G was **within** its NRV because of high spatial index and PIBO index scores.

50M—Glacial Troughlands in Mixed Geology

This is a very small LTA with all perennial stream miles in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. The composition and condition index derived from spatial data index was high (100 percent). This LTA was entirely in Wilderness and outside of active allotments. There was **insufficient information** to determine NRV status at 50M because field data were unavailable.

50Q—Glacial Troughlands in Quartzite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Nearly 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (70 percent), with high levels of conifer encroachment and fair riparian and wetland condition. Vegetation data were collected on three occasions at one PIBO monitoring site. Composition and condition index values from the first and most recent measurements were fair (68 percent). Most of the LTA was in managed areas (87 percent) and active allotments (59 percent). There was one watershed monitoring site in the LTA. The most recent AZAR score (81.0) was greater than the long-term mean (69.1) and the 5-year mean (71.3), indicating improving riparian conditions at this managed site.

Given the above information, we determined that 50G was **moderately altered** with fair PIBO index scores and improving AZAR scores.

50S—Glacial Troughlands in Sedimentary Bedrock

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 2 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was moderate (70 percent), with fair riparian and wetland condition and high levels of conifer encroachment. Almost all of the LTA was in managed areas (99 percent) and active allotments (97 percent). There was **insufficient information** to determine NRV status at 50S because field data were unavailable.

50V—Glacial Troughlands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (80 percent), with fair riparian and wetland condition and moderate levels of conifer encroachment. Vegetation data were collected on 13 occasions at two PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair (60 percent and 68 percent). Most (59 percent) of the LTA was in managed areas and 45 percent was in active allotments. There were three watershed monitoring sites in the LTA. The most recent mean AZAR score (75.0) was less than the long-term mean (81.3) and the 5-year mean (79.2), indicating declining riparian conditions in managed areas. Given the above information, we determined that 50V was **moderately altered** with improving PIBO index scores.

60G—Strongly Glaciated Lands in Granite

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 10 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (90 percent) with fair riparian and wetland condition. Most (67 percent) of the LTA was in Wilderness and 26 percent was in active allotments. There was **insufficient information** to determine NRV status at 60G because field data were unavailable.

60M—Strongly Glaciated Lands in Mixed Geology

This is a very small LTA with all perennial stream miles in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. The composition and condition index derived from spatial data was high (90 percent) with fair riparian and wetland condition. Most (74 percent) of the LTA was in managed areas and active allotments (86 percent). There was **insufficient information** to determine NRV status at 60M because field data were unavailable.

60Q—Strongly Glaciated Lands in Quartzite

Most (64 percent) perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Nearly 100 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was moderate (70 percent) with fair riparian and wetland condition and moderate levels of conifer and upland encroachment. Vegetation data were collected on 47 occasions at 15 PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fairly low and fair, respectively (52 percent and 60 percent). Most of the LTA was in managed areas (96 percent) and active allotments (63 percent). Composition and condition were influenced by beaver activity at two or more PIBO sites. Recreation effects were evident at a BMP site on East Fork Big Lost River, but composition and condition otherwise indicated that management objectives have been met. There were 11 watershed monitoring sites in the LTA. The most recent mean AZAR score (68.7) was less than the long-term mean (72.2) and the 5-year mean (70.9), indicating declining riparian conditions. Given the above information, we determined that 60Q was **moderately altered**, but low PIBO index scores and AZAR scores could be addressed through management changes.

60S—Strongly Glaciated Lands in Sedimentary Bedrock

Over 90 percent of perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (80 percent) with fair riparian and wetland and moderate levels of upland encroachment. This LTA was entirely in managed lands and almost entirely in active allotments (99 percent). There was **insufficient information** to determine NRV status at 60S because field data were unavailable.

60V—Strongly Glaciated Lands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was high (90 percent), with fair riparian and wetland condition. Most (73 percent) of the LTA was in managed areas and active allotments (61 percent). There was **insufficient information** to determine NRV status at 60V because field data were unavailable.

70Q—Dissected Foothill Lands in Quartzite

Most (69 percent) perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 2 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was low (50 percent) because of fair riparian and wetland condition scores and high levels of conifer and upland encroachment. This LTA was entirely in managed lands and 84 percent was in active allotments. There was one watershed monitoring site in the LTA. The most recent AZAR score (72.0) was less than the long-term mean (77.5) and the 5-year mean (77.5), indicating declining riparian conditions. There was **insufficient information** to determine NRV status because field data were limited to one WMP site.

70S—Dissected Foothill Lands in Sediments

Nearly 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (70 percent), with fair riparian and wetland condition and high levels of upland encroachment. Vegetation data were collected on three occasions at one PIBO monitoring site. Composition and condition index values from the first and most recent measurements were fairly high (0.84). Most (>99 percent) of the LTA was in managed areas and active allotments (93 percent). There was **insufficient information** to determine NRV status because field data were limited to one PIBO site.

70V—Dissected Foothill Lands in Volcanics

Over 90 percent of perennial stream miles in this LTA were in confined settings with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Less than 5 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (70 percent), with fair riparian and wetland condition and high levels of upland encroachment. Vegetation data were collected on three occasions at one PIBO monitoring site. Composition and condition index values from the first and most recent measurements were fairly low and fairly high, respectively (52 percent and 84 percent). Most of the LTA was in managed areas (99 percent) and active allotments (95 percent). There were four watershed monitoring sites in the LTA. The most recent mean AZAR score (82.3) was greater than the long-term mean (74.8) and the 5-year mean (81.8), indicating improving riparian conditions. Given the above information, we determined that 70V was **moderately altered** with improving PIBO index scores and AZAR scores.

VB—Valley Bottom

Most (73 percent) perennial stream miles in this LTA were in confined settings, with riparian communities typically characterized by conifer and low deciduous tree dominance groups. Over 200 miles of perennial streams occurred in unconfined valley bottoms, which can contain tall deciduous, willow, non-willow shrub, and herbaceous dominance groups.

The composition and condition index derived from spatial data was fairly high (70 percent), with fair riparian and wetland condition and moderate levels of conifer encroachment and introduced species. Vegetation data were collected on 147 occasions at 54 PIBO monitoring sites. Composition and condition index values from the first and most recent measurements were fair and fairly high, respectively (68 percent and 76 percent). Most of the LTA was in managed areas (87 percent) and active allotments (60 percent). Composition and condition were influenced by beaver activity at five or more PIBO sites. Several PIBO sites have been burned by wildfires, but deciduous vegetation had recovered. There were 59 watershed monitoring sites in the LTA. The most recent mean AZAR score (78.9) was similar to the long-term mean (78.1) and the 5-year mean (79.4), indicating stable riparian conditions. Given the above information, we determined that VB was **moderately altered** with fair index scores and improving AZAR scores.

Appendix H—Composition and Condition of Groundwater-Dependent Ecosystems

Methods

We summarized proper functioning condition (PFC) reports for each land type associations (LTA) and used best professional judgment to determine the natural range of variation (NRV) of composition and condition of groundwater-dependent ecosystems (GDEs) in LTAs where at least 10 surveys were conducted.

Land Type Association Summaries

No GDE assessments had been completed and there was therefore insufficient information to evaluate the condition of spring runout channels in the following LTAs:

10G—Steep Canyonlands in Granite
10M—Steep Canyonlands in Mixed Geology
10Q—Steep Canyonlands in Quartzite
10S—Steep Canyonlands in Sedimentary Rocks
10V—Steep Canyonlands in Volcanics
20G—Mountain Slopelands in Granite
20M— Mountain Slopelands in Mixed Geology
20S—Mountain Slopelands in Sedimentary Rocks
30G—Cryic Uplands in Granite
30M—Cryic Uplands in Mixed
30Q—Cryic Uplands in Quartzite
30S—Cryic Uplands in Sedimentary Rocks
30V—Cryic Uplands in Volcanics
40G—Cryic Basinlands in Granite
40Q—Cryic Basinlands in Quartzite
40V—Cryic Basinlands in Volcanics
50M—Glacial Troughlands in Mixed Geology
50S—Glacial Troughlands in Sedimentary Rocks
50V—Glacial Troughlands in Volcanics
60G—Strongly Glaciated Lands in Granite
60M—Strongly Glaciated Lands in Mixed Geology
60Q—Strongly Glaciated Lands in Quartzite
60S—Strongly Glaciated Lands in Sedimentary Rocks
60V—Strongly Glaciated Lands in Volcanic
70Q—Dissected Foothill Lands in Quartzite

20Q—Mountain Slopelands in Quartzite

A GDE survey was conducted at a spring site in the Lemhi Basin in 2015. The spring-fed wetland was characterized by herbaceous dominance groups containing *Poa pratensis* and *Phleum pratense*. Sedges, rushes, and willows were also present, but in patches. This area had become channelized and had lost its wetland character as a result. Willows and aspens were also impacted by herbivory. Soil had been affected by compaction, erosion, and trails. The site was determined to be functional-at-risk with a downward trend. This LTA was large with only one GDE assessment available. Therefore, there was **insufficient information** to evaluate composition and condition of GDEs.

20V—Mountain Slopelands in Volcanics

In the Antelope Creek drainage, springs and wetlands were surveyed for PFC assessments in 2007. These GDEs contained willow, non-willow shrub, and herbaceous dominance groups. Water sedge (*Carex aquatilis*), Nebraska sedge (*Carex nebrascensis*), Baltic rush (*Juncus balticus*), Geyer's willow (*Salix geyeriana*), shrubby cinquefoil (*Potentilla fruticosa*), currants (*Ribes* spp.), and roses (*Rosa* spp.) were present. This vegetation was used as post-fledging habitat by greater sage grouse. Vegetation appeared healthy where water remained flowing during a drought cycle. Where water was absent, dry meadow species were encroaching and willows showed dieback. Some hummocking was noted. Five sites were determined to be functional-at-risk and six were in properly functioning condition.

In the Upper Salmon basin, GDE spring surveys were conducted in the Marco and Spud Creek watersheds in 2011. Tall deciduous tree, willow, non-willow shrub, and herbaceous dominance groups were present. Impacts to wetlands include channelization and downcuting, hummocking, soil compaction, trailing, and headcutting. Shearing and soil instability occurred at crossings or other sections of streams with livestock access. Three wetlands were determined to be functional-at-risk and one was determined to be in properly functioning condition.

In the Lemhi Basin, GDE surveys were conducted at five sites in 2015. These GDEs contained willow, non-willow shrub, and herbaceous dominance groups. Dominant species included Northwest Territory sedge (*Carex utriculata*), water sedge, and Booth's willow (*Salix boothii*). Other plants include tufted hair grass (*Deschampsia cespitosa*), mosses, and willows. Thistles had invaded disturbed areas at one site. Impacts to GDE wetlands included channelization soil compaction, livestock and wildlife use, trails, trampling, lack of willow recruitment, and hummocking. Four sites were determined to be functional-at-risk and one was in properly functioning condition.

Three sites were visited for GDE surveys in the Big Lost River Subbasin in 2016. Two of these sites were in properly functioning condition. These two sites had fen-like characteristics and contained willow and herbaceous-dominated communities. Sedges, rushes, and bryophytes were present. Soil disturbance was limited to hummocking at these sites and some willow browsing and recruitment was noted. The third site was rated as functional-at-risk because of heavy soil disturbance including compaction, erosion, hummocks, and trails, and damage to the runout channel. Grazing and trampling by livestock and wildlife were also noted.

Overall, PFC reports suggested that most GDEs had been heavily altered with significant impacts to vegetation and soil in 20V. We therefore determined that composition and condition were **outside** of the NRV.

50G—Glacial Troughlands in Granite

In the Antelope Creek drainage, springs and wetlands were surveyed for PFC assessments in 2007. At one site, Douglas-fir was encroaching onto wetland vegetation. Herbaceous dominance groups contained water sedge, Nebraska sedge, Kentucky bluegrass (*Poa pratensis*), tufted hair grass, and California false hellebore (*Veratrum californicum*), with Geyer's willow present as well. Hummocking resulted from past heavy use by cattle and elk. Cattle had since been mostly excluded from one of the meadows. At one site, an extensive wet meadow was lined with large willows with dieback. A large area of exposed soil was likely being used as a mineral lick or wallow site. All three wetland sites were determined to be functional-at-risk. This was, however, a large LTA and there was **insufficient information** to evaluate the NRV status composition and condition.

50Q—Glacial Troughlands in Quartzite

In the Lemhi Basin, a GDE survey was conducted in 2015. The hillslope wetland was dominated by graminoids and bryophytes indicative of a fen community. Bebb's willow (*Salix bebbiana*) and Booth's willow were also present. Though no soil disturbances were noted and ground cover by hydric vegetation was adequate, this wetland was judged to be functional-at-risk due to lack of willow regeneration. Overall, there was **insufficient information** to evaluate the NRV status of composition and condition in 50Q.

70S—Dissected Foothill Lands in Sedimentary

In the Antelope Creek drainage, a spring site was surveyed for a PFC assessment in 2007. Low deciduous tree and herbaceous dominance groups were present. These groups included gray alder (*Alnus incana*), Booth's willow, Nebraska sedge, Northwest Territory sedge, Booth's willow, and Baltic rush. The area was hoof-trampled by cattle and elk, old headcuts were revegetating, and extensive wet meadow vegetation was surrounded by small, healthy shrubs. Willow and alder saplings were observed in 2007. The site was determined to be functional-at-risk with an upward trend. Overall, there was **insufficient information** to evaluate the NRV status of composition and condition at 70S.

70V—Dissected Foothill Lands in Volcanics

In the Antelope Creek drainage, springs and wetlands were surveyed for PFC assessments in 2007. Willow, non-willow shrub, and herbaceous dominance groups were present. Woody species included Geyer's willow, Booth's willow, currants, roses, and shrubby cinquefoil.

Herbaceous dominance groups included species associated with wet meadow and fens including water sedge, Nebraska sedge, Northwest Territory sedge, Kentucky bluegrass, tufted hair grass, and water whorlgrass (*Catabrosa aquatica*). Where water was present during this drought cycle, wetland graminoids and riparian shrubs appeared vigorous. Where springs had dried, willows had died back and dry meadow species had encroached. Remnant patches of Nebraska sedge were all that was left of wetland vegetation in these areas. Soil was exposed around ponds created for livestock use. Channelization at one wetland may have decreased water table and stress vegetation. Four sites were determined to be functional-at-risk, nine sites were in properly functioning condition, and one site was nonfunctional.

At GDE survey sites visited in the Pahsimeroi Basin in 2014, willow, non-willow shrub, and herbaceous dominance groups were present. Dominant/indicator plants included willows, *Ribes* spp., *Carex* spp., Baltic rush, tufted hair grass, and Kentucky bluegrass. Impacts included trailing hummocking, and disturbance to wetland graminoids.

In the Lemhi Basin, GDE surveys were conducted at two sites in 2015. Both sites had the potential to be fens based on water, soil, and vegetation conditions. Herbaceous dominance groups included water sedge, Nebraska sedge, mosses, and some willows. Of these potential fens, one was in properly functioning condition. The other was functional-at-risk because of impacts to inlets and channels including soil compaction, erosion, trampling and grazing by livestock, and reduction of willow cover.

One site was visited for a GDE surveys in the Big Lost River Subbasin in 2016. Aspens and upland vegetation were encroaching on willow and herbaceous dominance groups. The site was rated as functional-at-risk because of aspen encroachment. Grazing and browsing by livestock and wildlife were also noted, along with hummocking in areas dominated by sedges and other graminoids.

Overall, PFC reports suggested that impacts to vegetation and soil were minor at several sites in 70V. Composition and condition were therefore considered **moderately altered**.

VB—Valley Bottom

In the Lemhi Basin, a GDE survey was conducted at a site in 2015. A narrow wetland with fen characteristics contained willow and herbaceous dominance groups. Engelmann spruce (*Picea engelmannii*), Booth's willow, Northwest Territory sedge, water horsetail (*Equisetum fluviatile*), graminoids, mosses, and forbs were present. This narrow peatland had been affected by willow browsing and trailing by livestock and wildlife. This was a large LTA without additional assessments, so there was **insufficient information** to evaluate the composition and condition of GDEs.

Appendix I—Maps

Stressor Maps

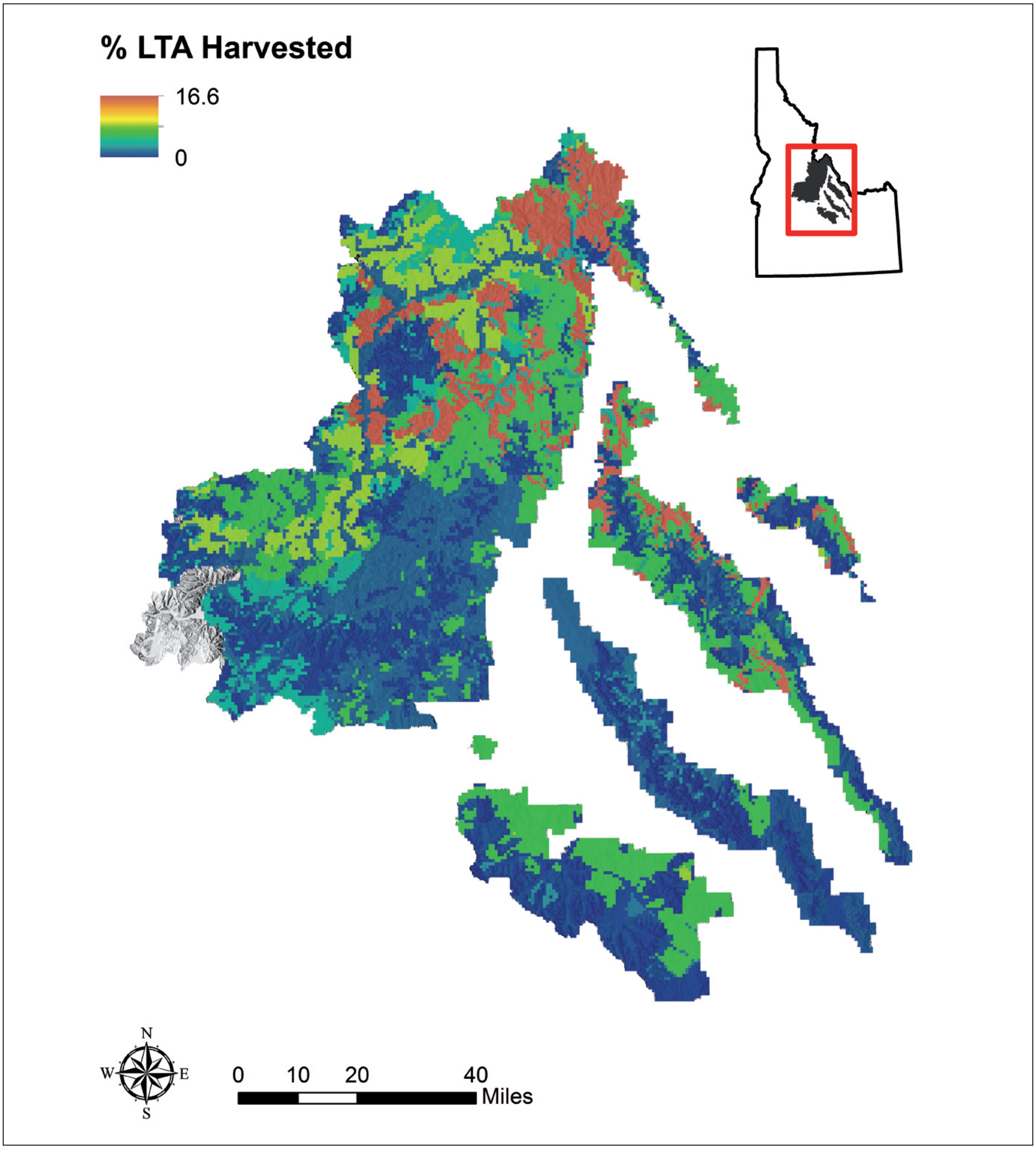

Figure I1—Percentage of land within each LTA affected by timber harvest. The data were derived from the USFS Terrestrial Condition Assessment (Cleland et al. 2017).

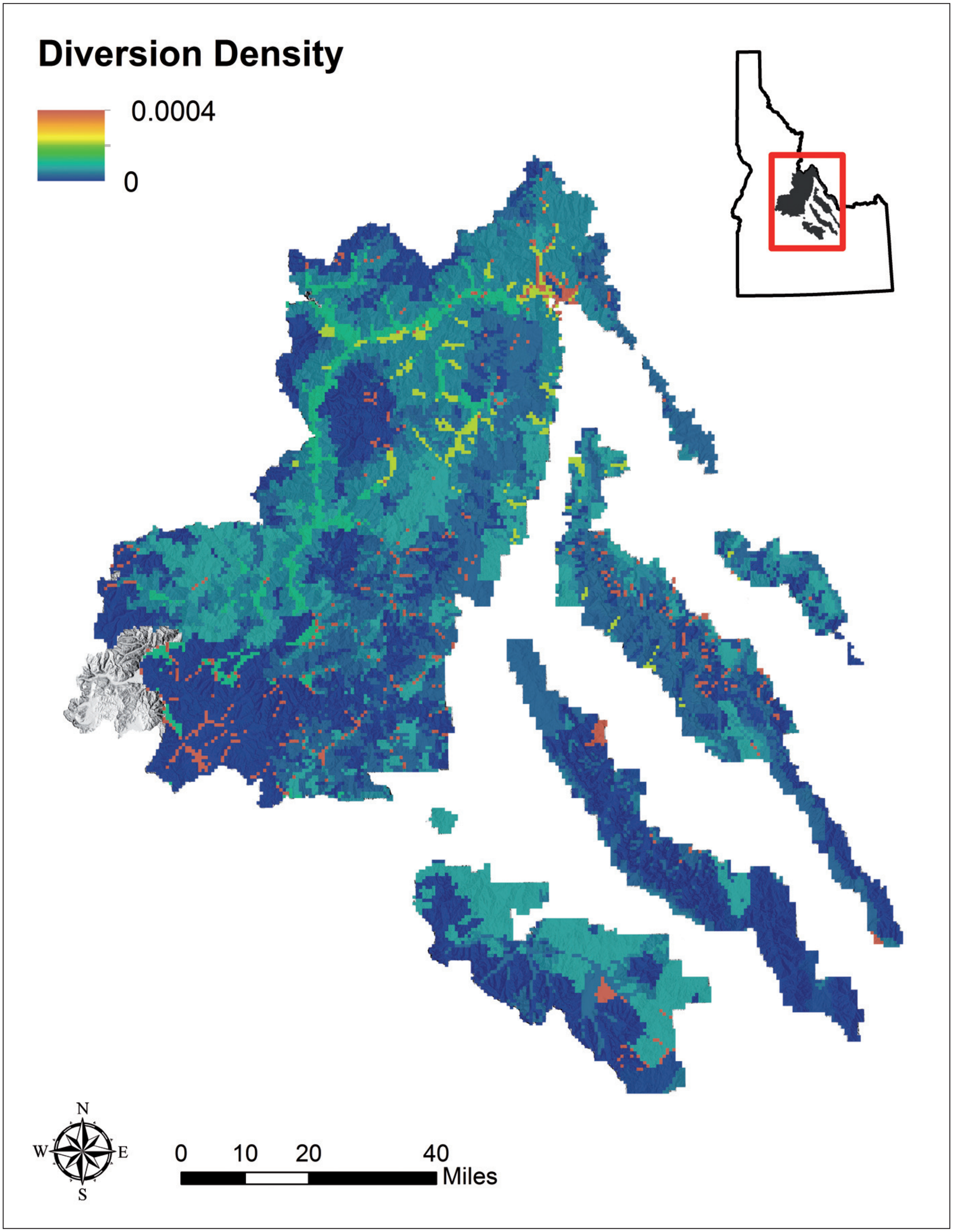

Figure I2—Diversions per acre within each LTA. The data were derived from the Salmon-Challis National Forest diversions layer.

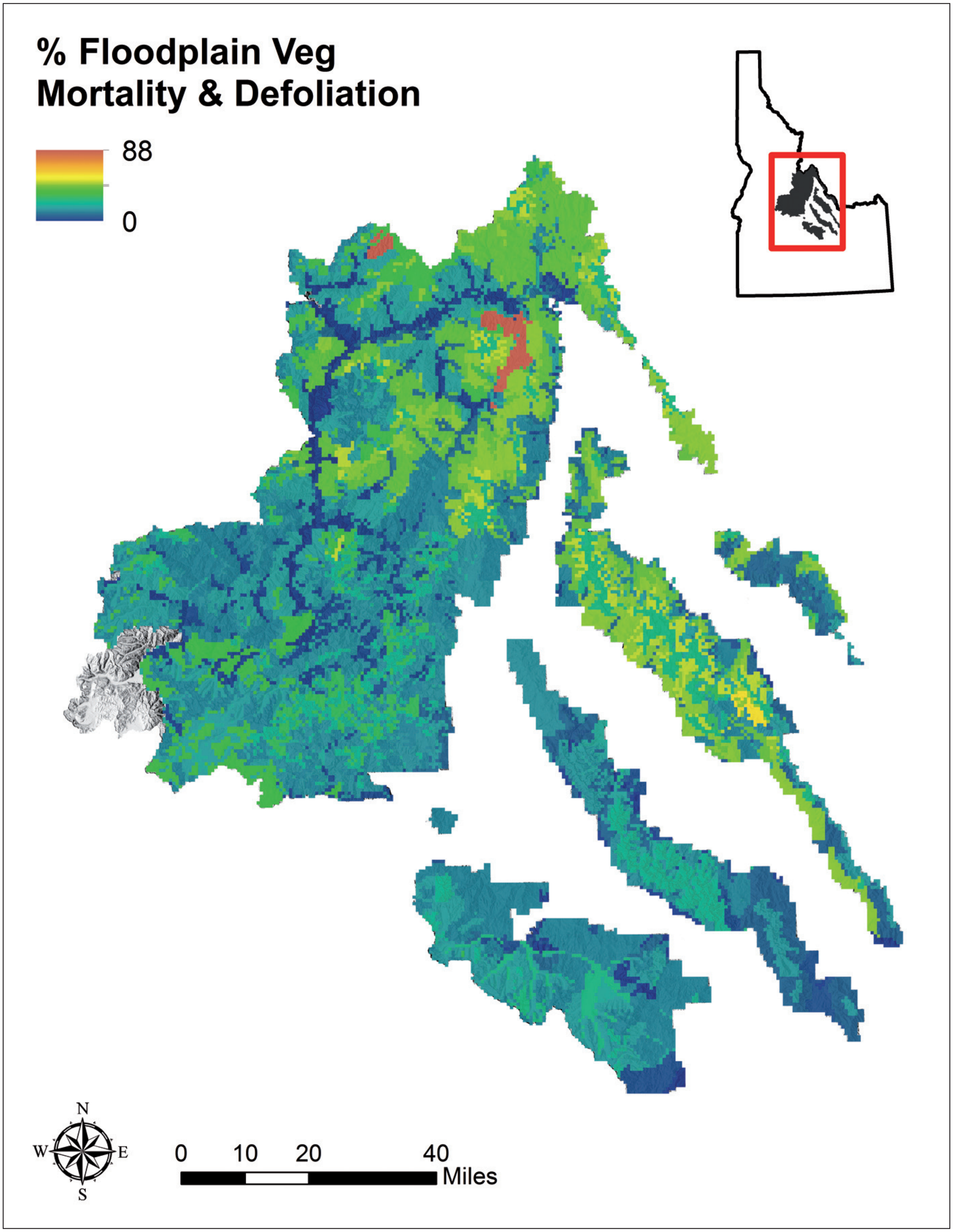

Figure I3—Percentage of floodplain impacted by vegetation mortality by LTA. The data were derived from the USFS Terrestrial Condition Assessment roads layer and the 50-year floodplain map (Abood et al. 2012).

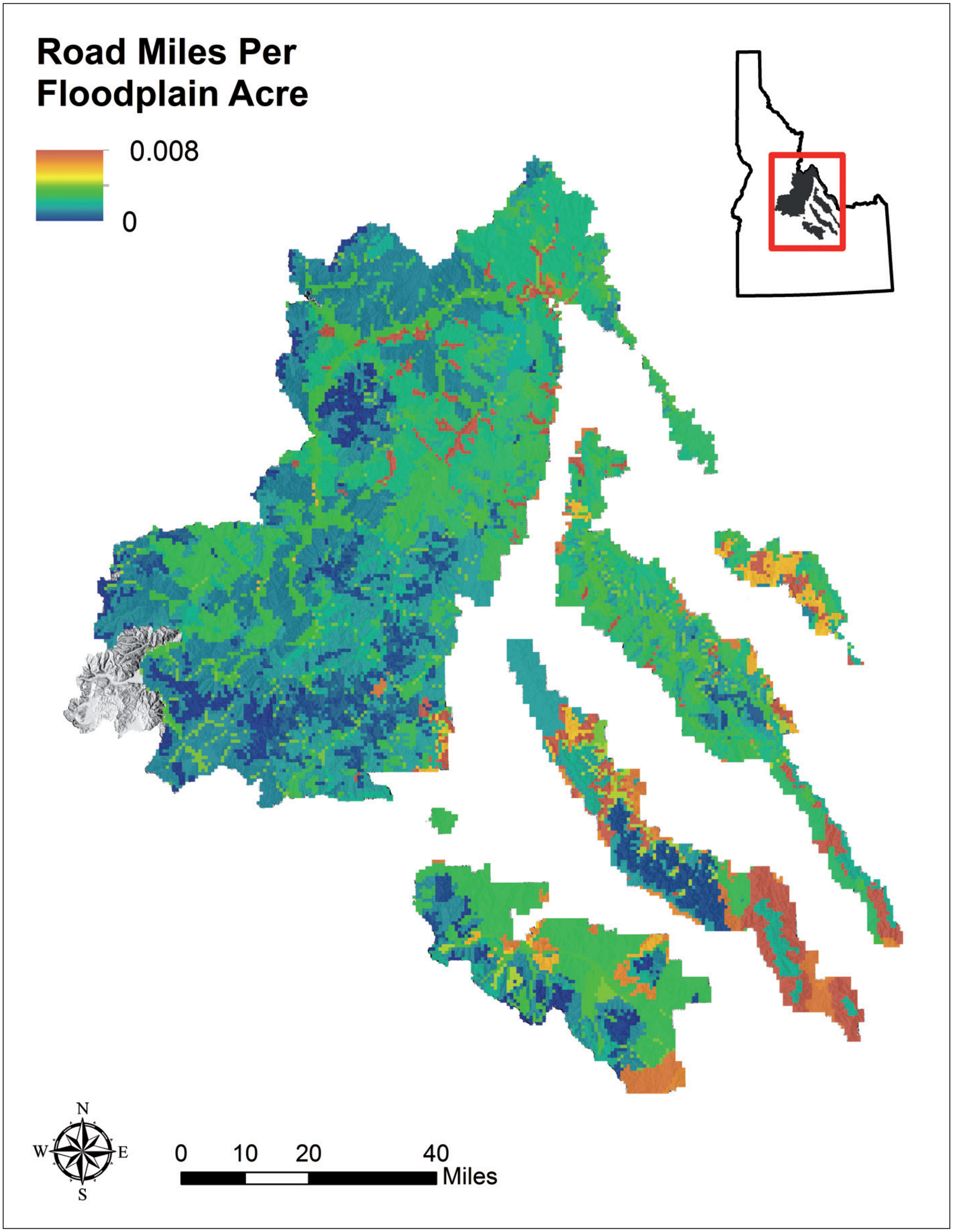

Figure I4—Road miles per floodplain acre by LTA. The data were derived from the USFS Terrestrial Condition Assessment roads layer and the 50-year floodplain map (Abood et al. 2012).

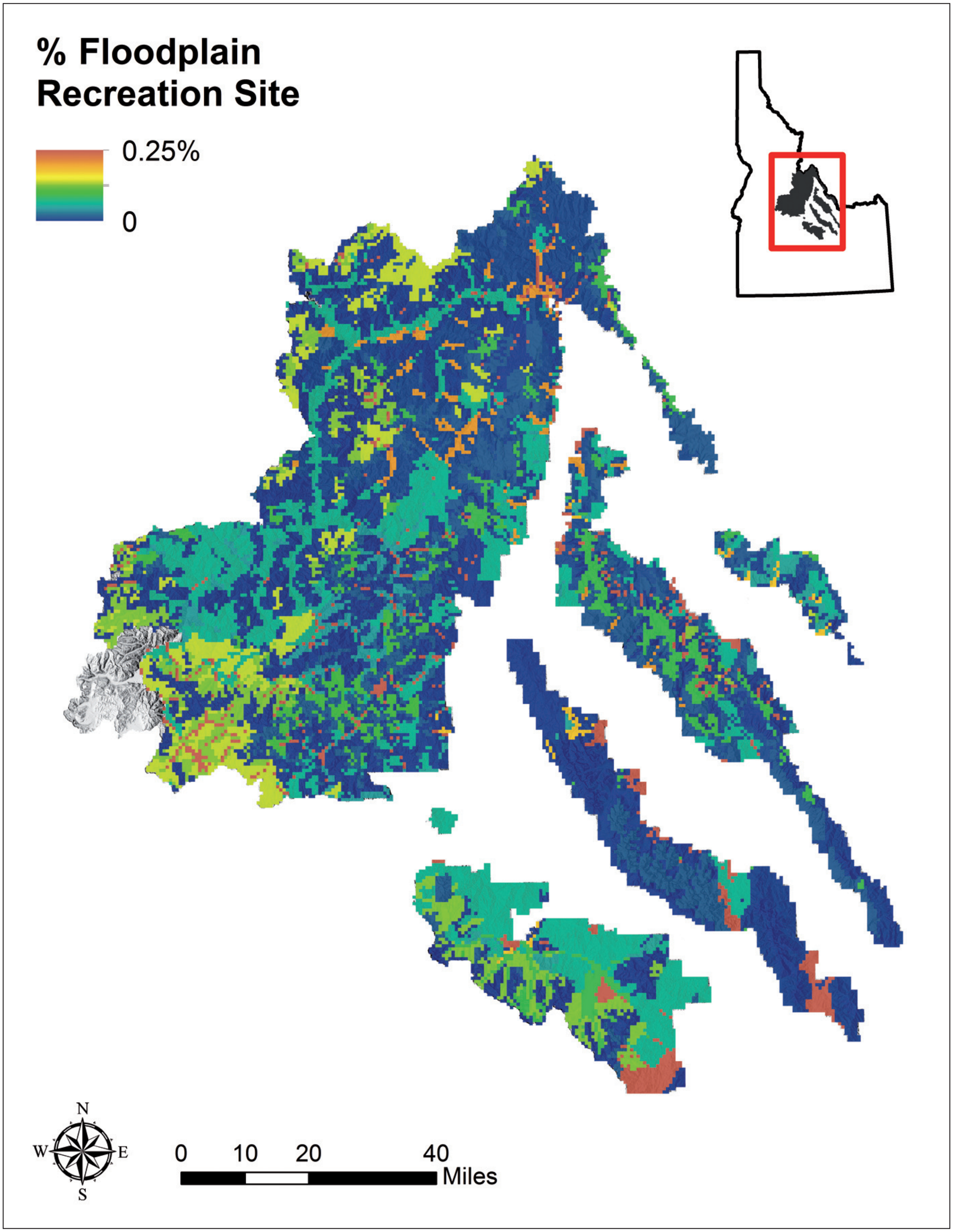

Figure I5—Percentage of floodplains converted into recreation sites by LTA. The data were derived from the Salmon-Challis National Forest recreation site layer and the 50-year floodplain map (Abood et al. 2012).

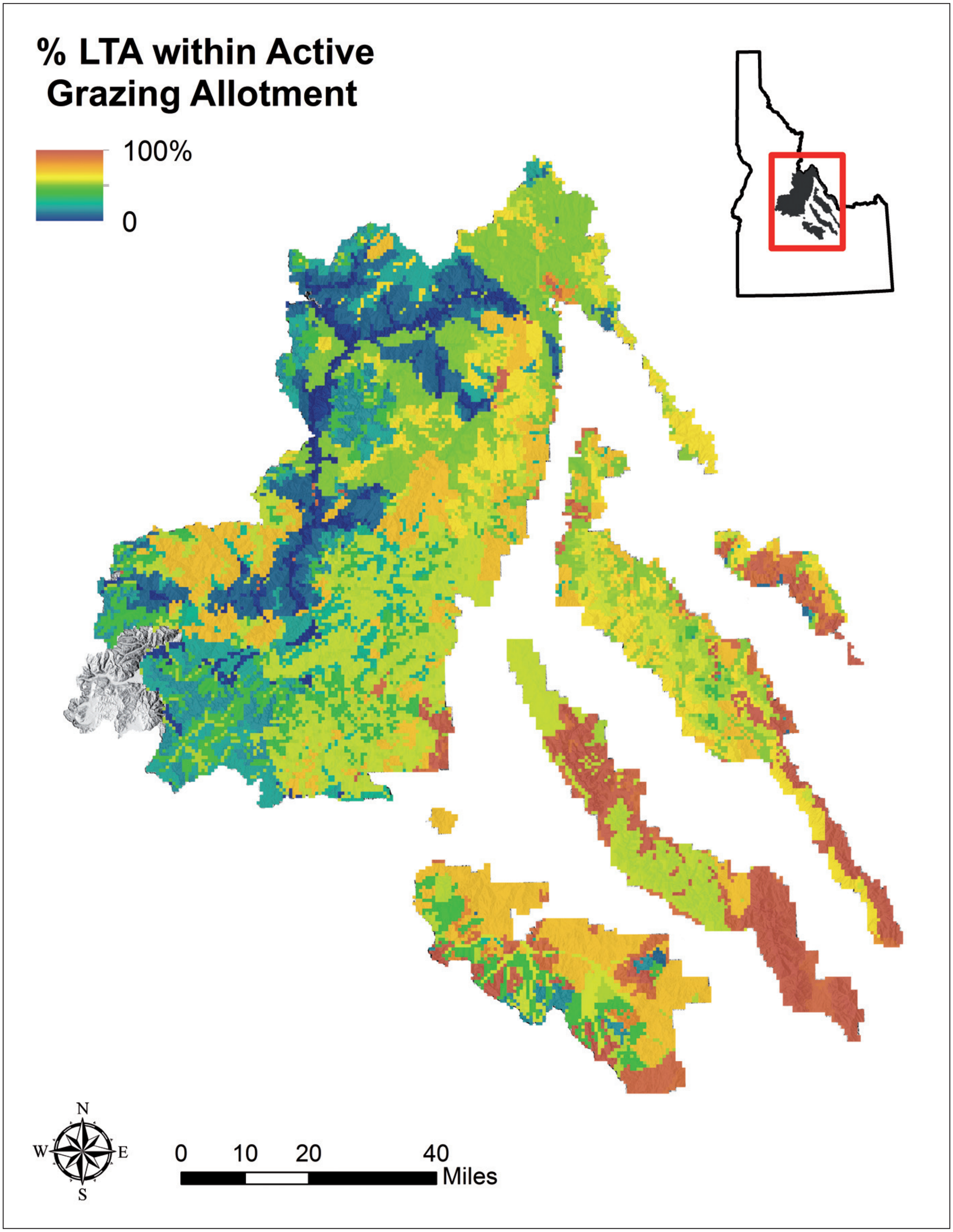

Figure I6—Percent of LTA located within an active grazing allotment. The data were derived from the Salmon-Challis National Forest allotment layer.

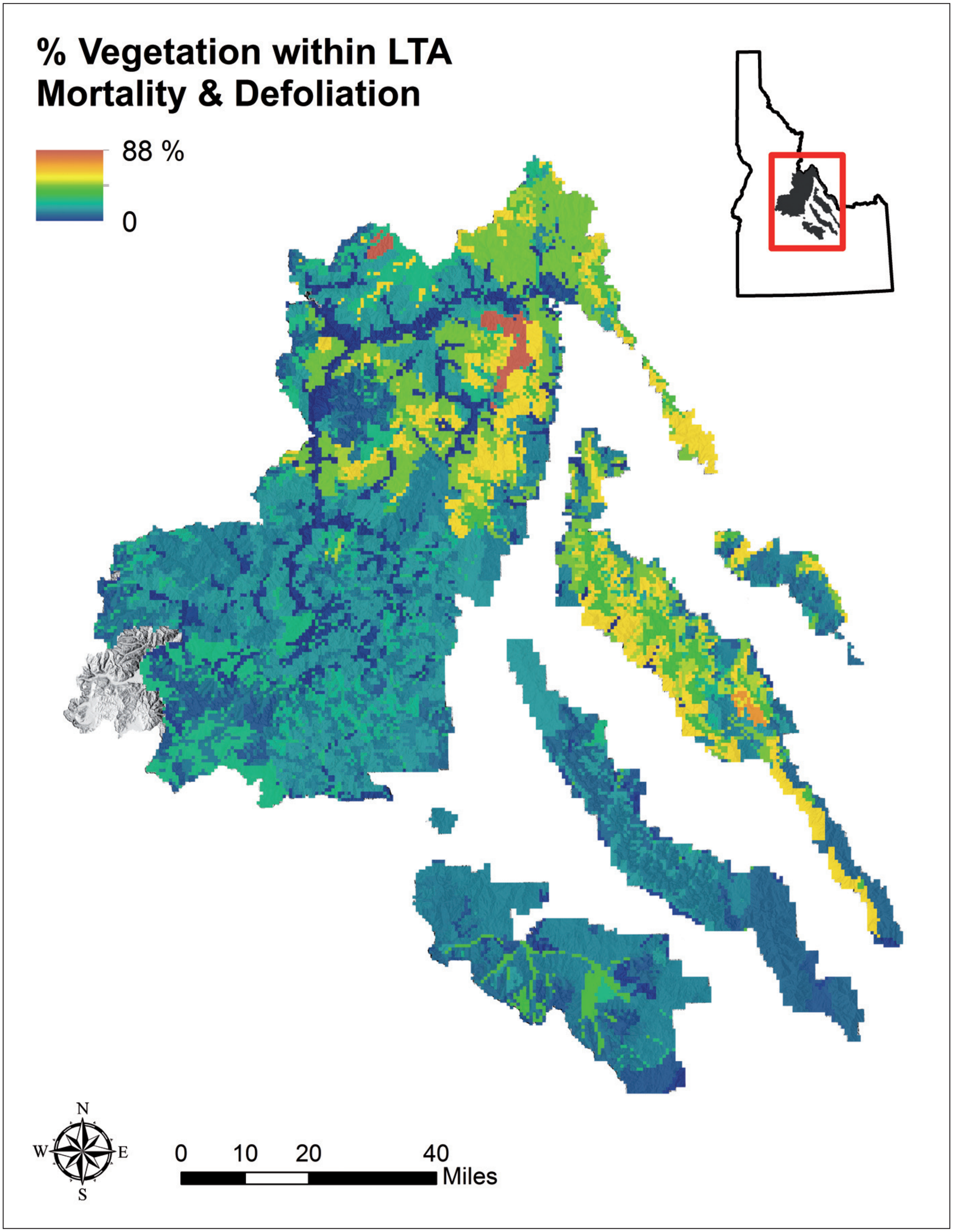

Figure I7—Percentage of vegetation within the LTA that is impacted by mortality and defoliation. The data were derived from the USFS Terrestrial Condition Assessment (Cleland et al. 2017).

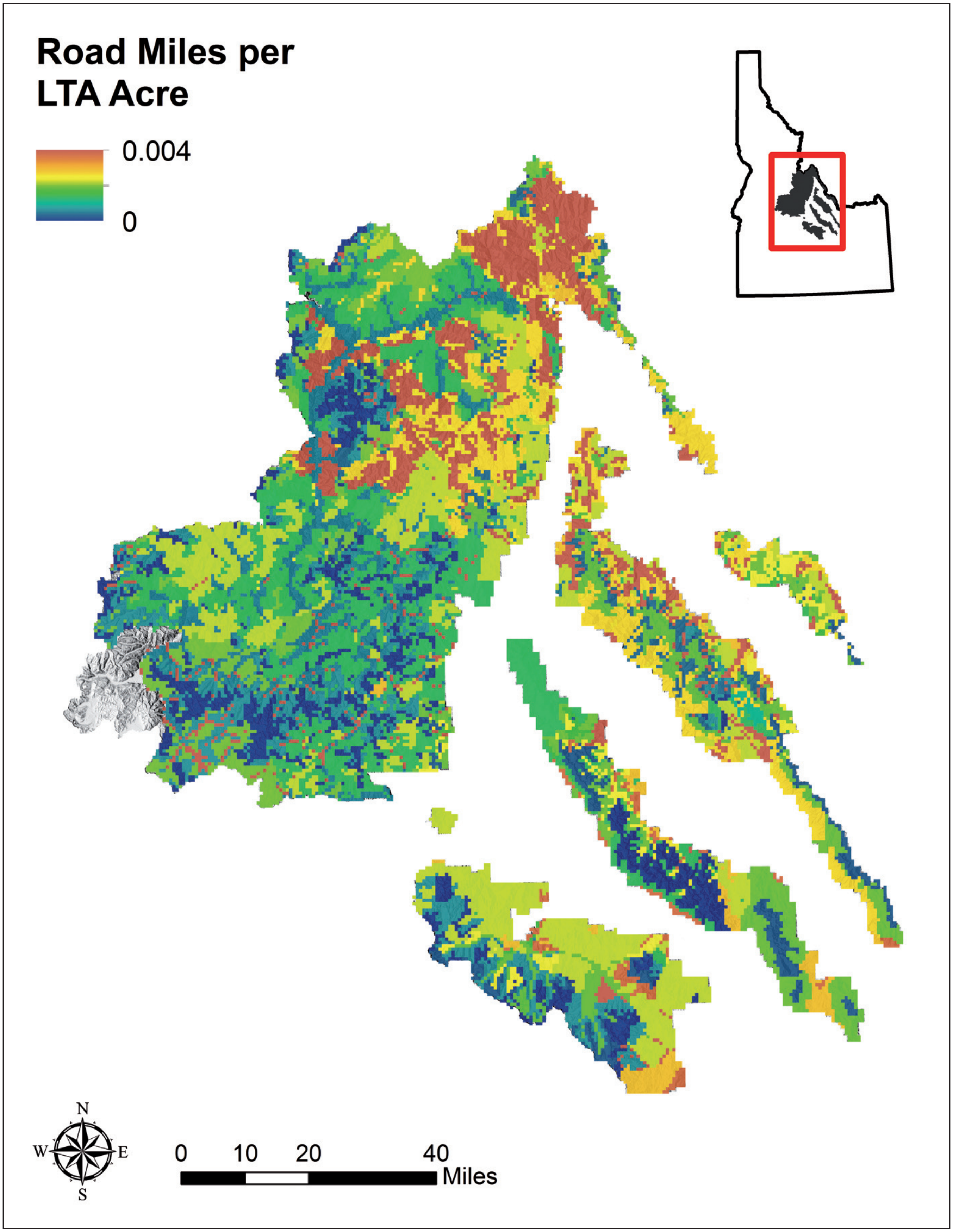

Figure I8—Road miles per acre within the LTA. The data were derived from the USFS Terrestrial Condition Assessment roads layer (Cleland et al. 2017).

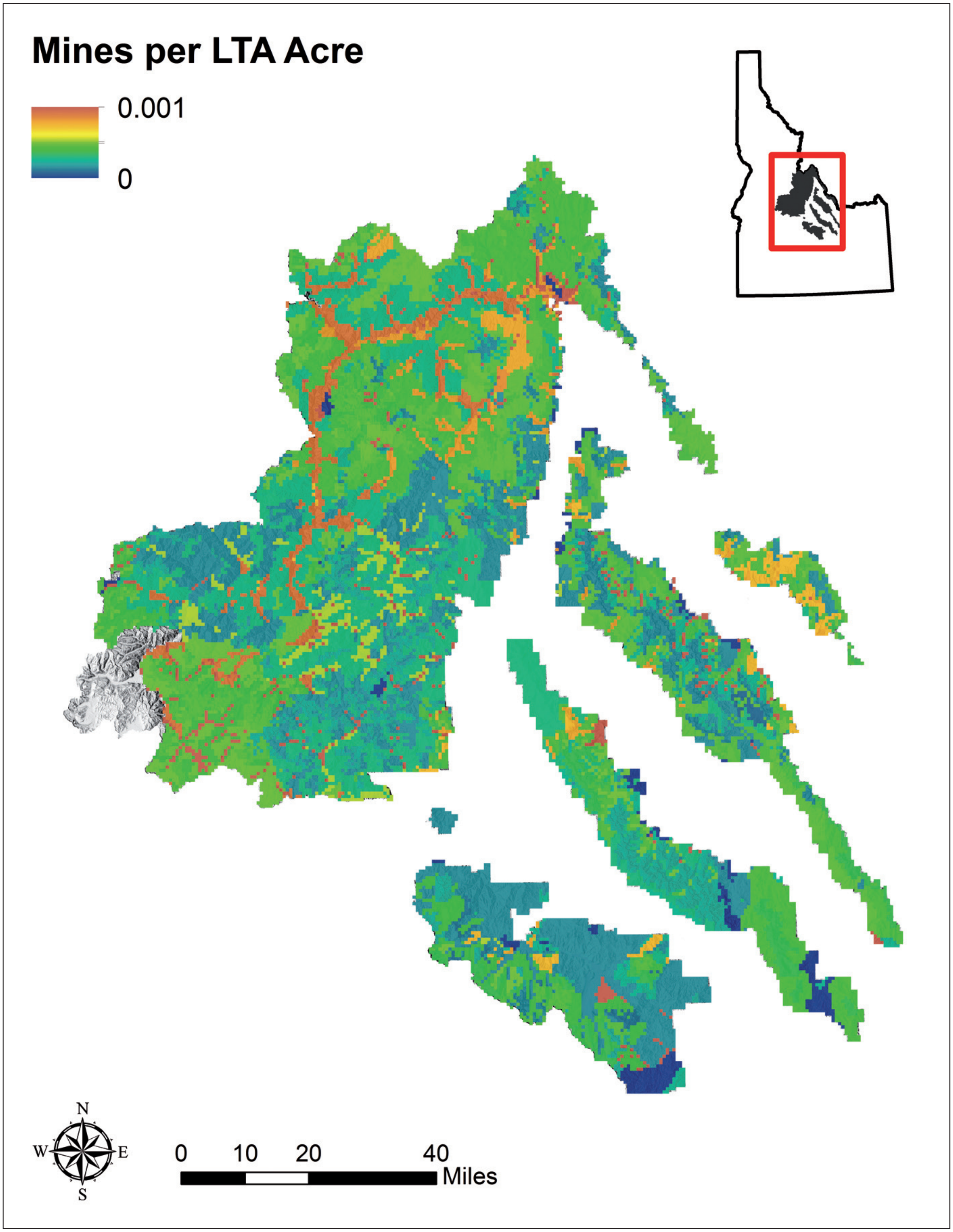

Figure I9—Mines per acre within the LTA. The data were derived from the Salmon-Challis National Forest layer.

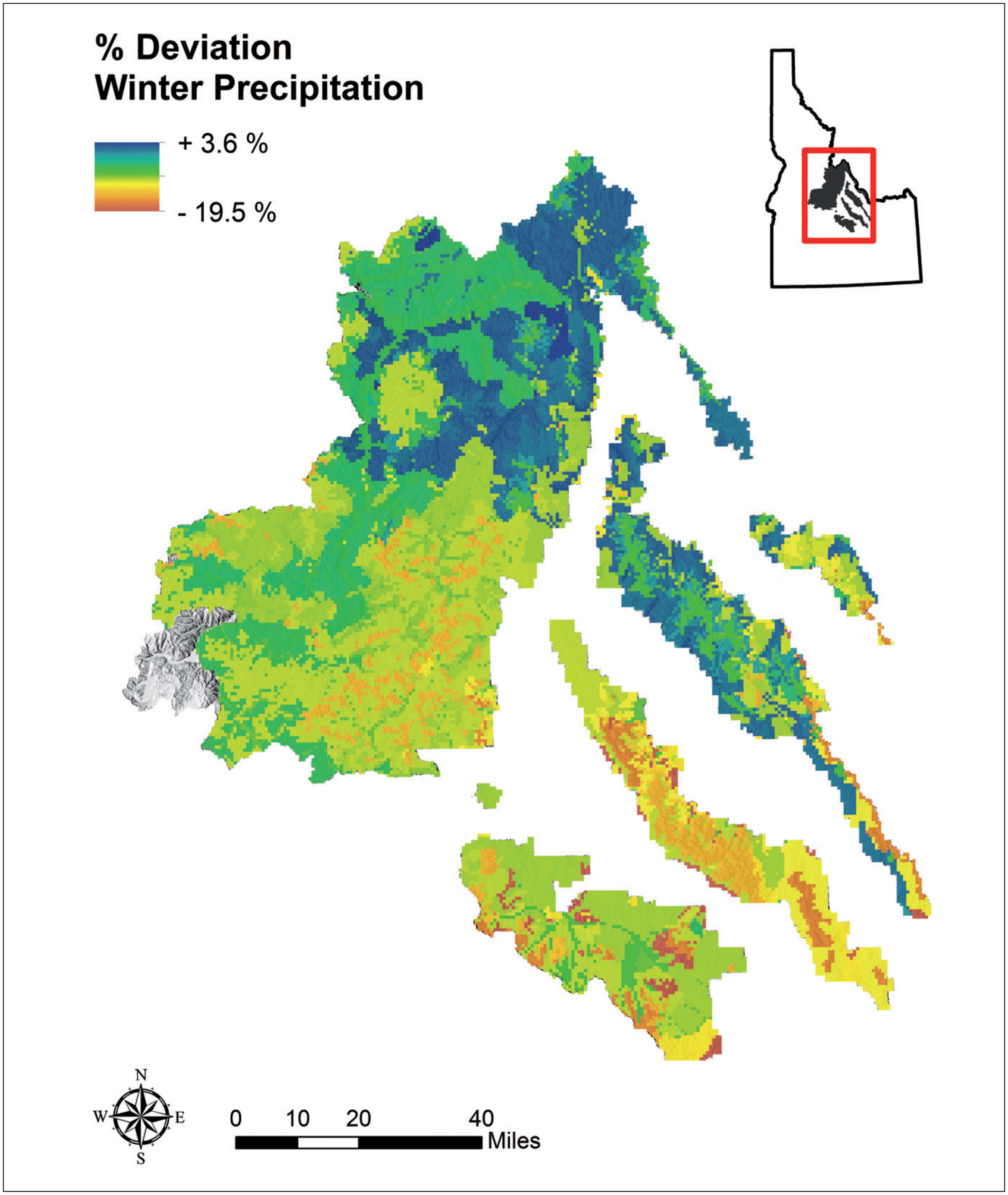

Figure I10—Percentage deviation in winter precipitation from 2010 to 2014 compared to previous century by LTA. The data were derived from the USFS Terrestrial Condition Assessment (Cleland et al. 2017).

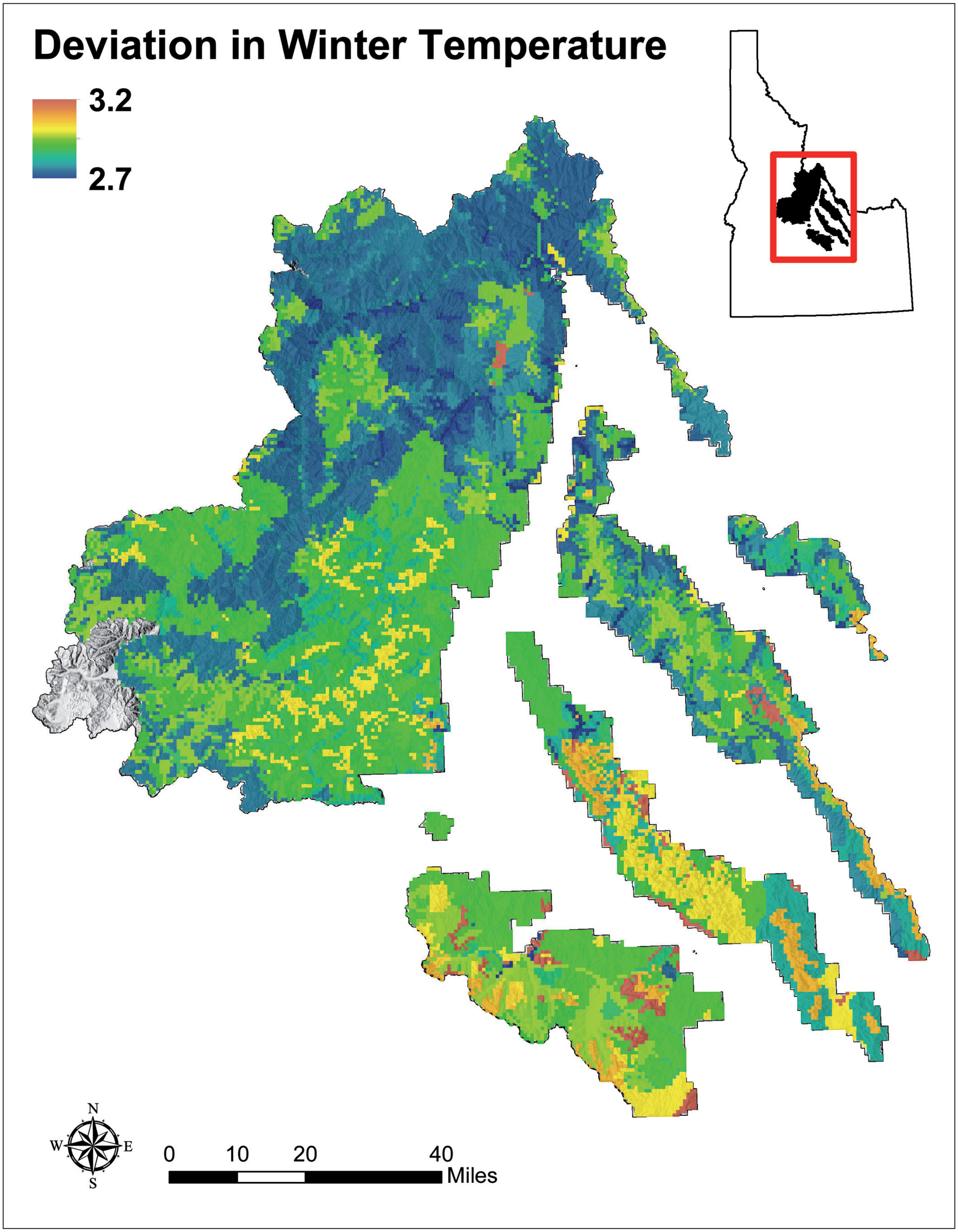

Figure I11—Deviation in winter temperature (°F) from 2010 to 2015 compared to previous century by LTA. The data were derived from the USFS Terrestrial Condition Assessment (Cleland et al. 2017).

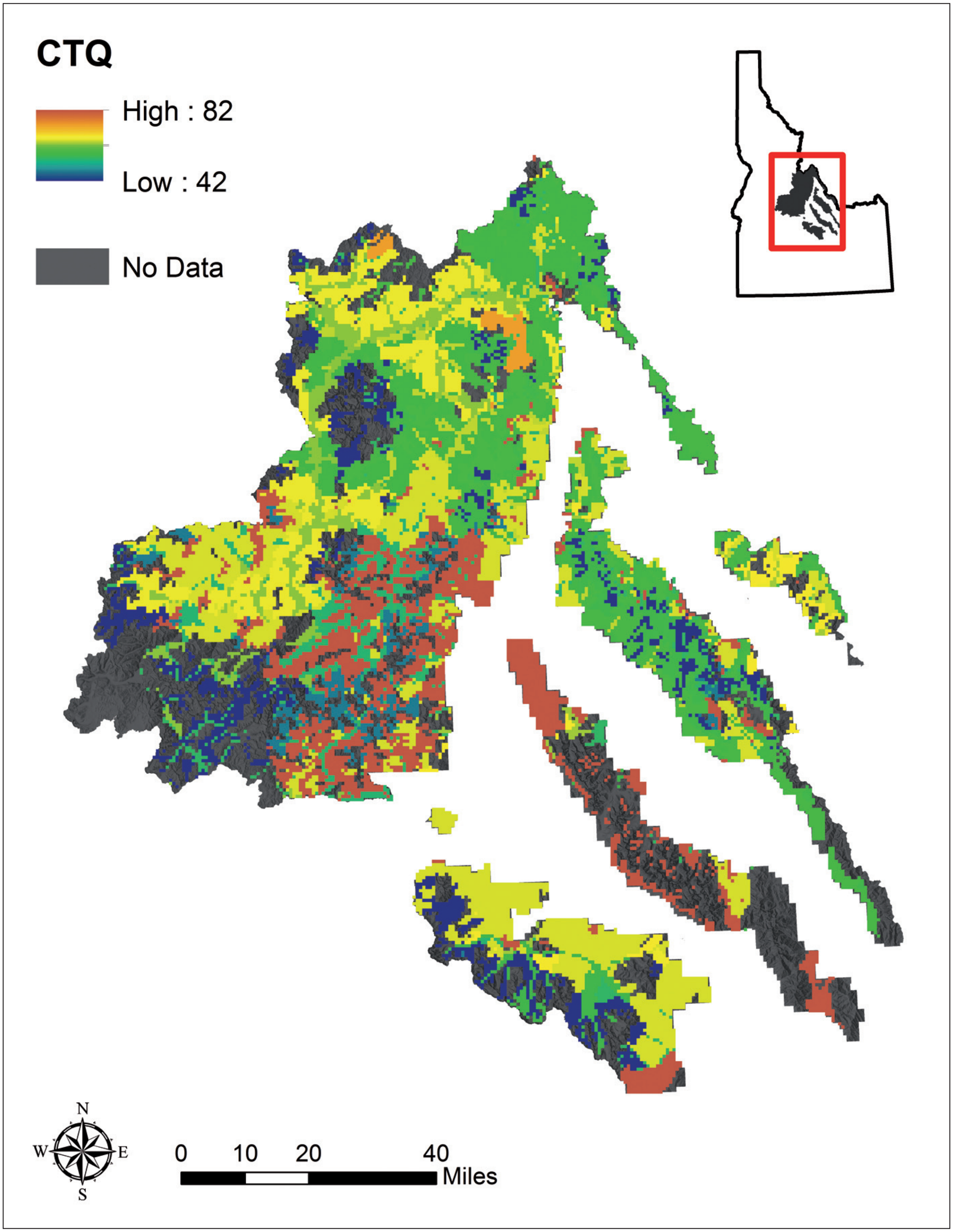

Figure I12—Average Community Tolerance Quotient of macroinvertebrates by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

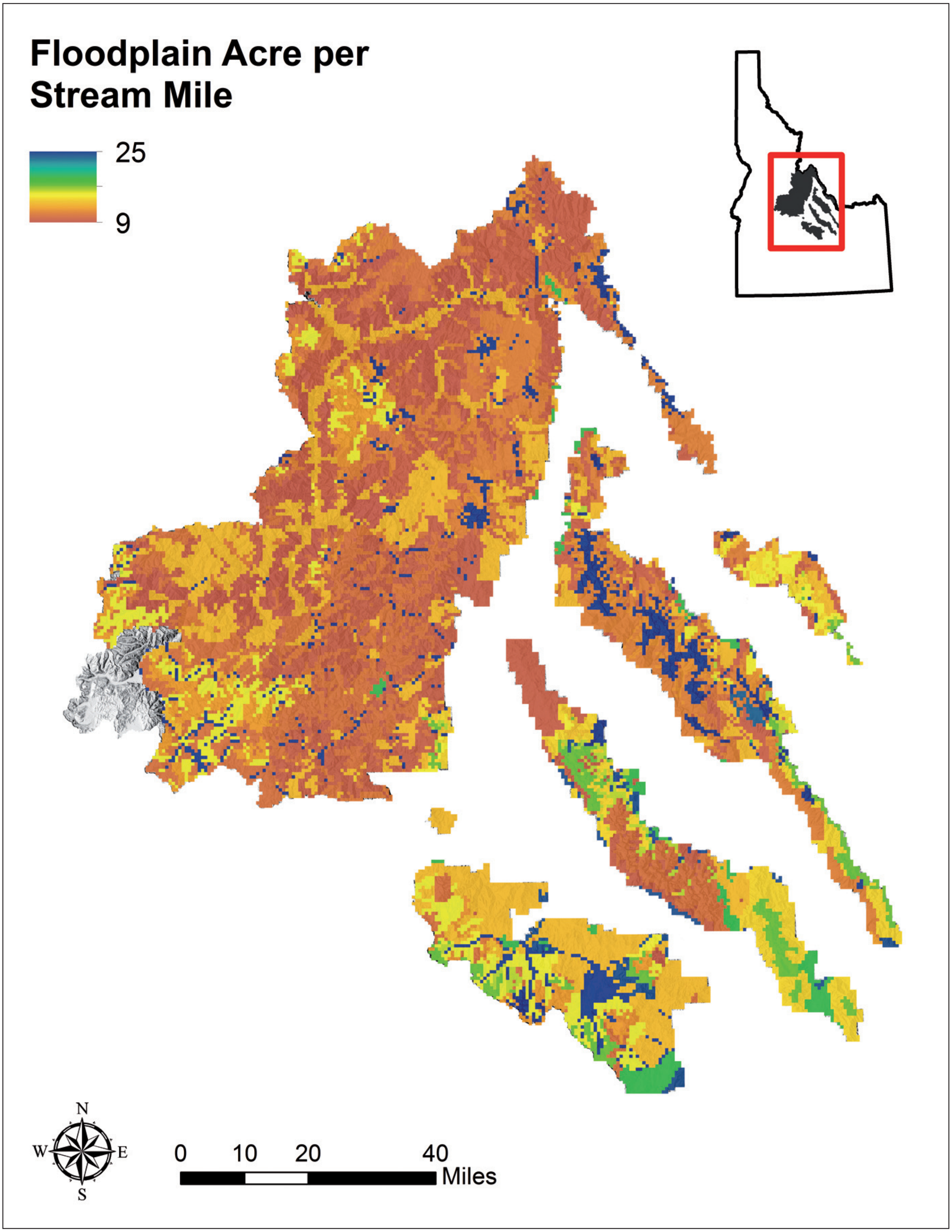

Figure I13—Floodplain acre per stream mile by LTA. The data were derived based on the NHD flowline layer and the 50-year floodplain map (Abood et a. 2012).

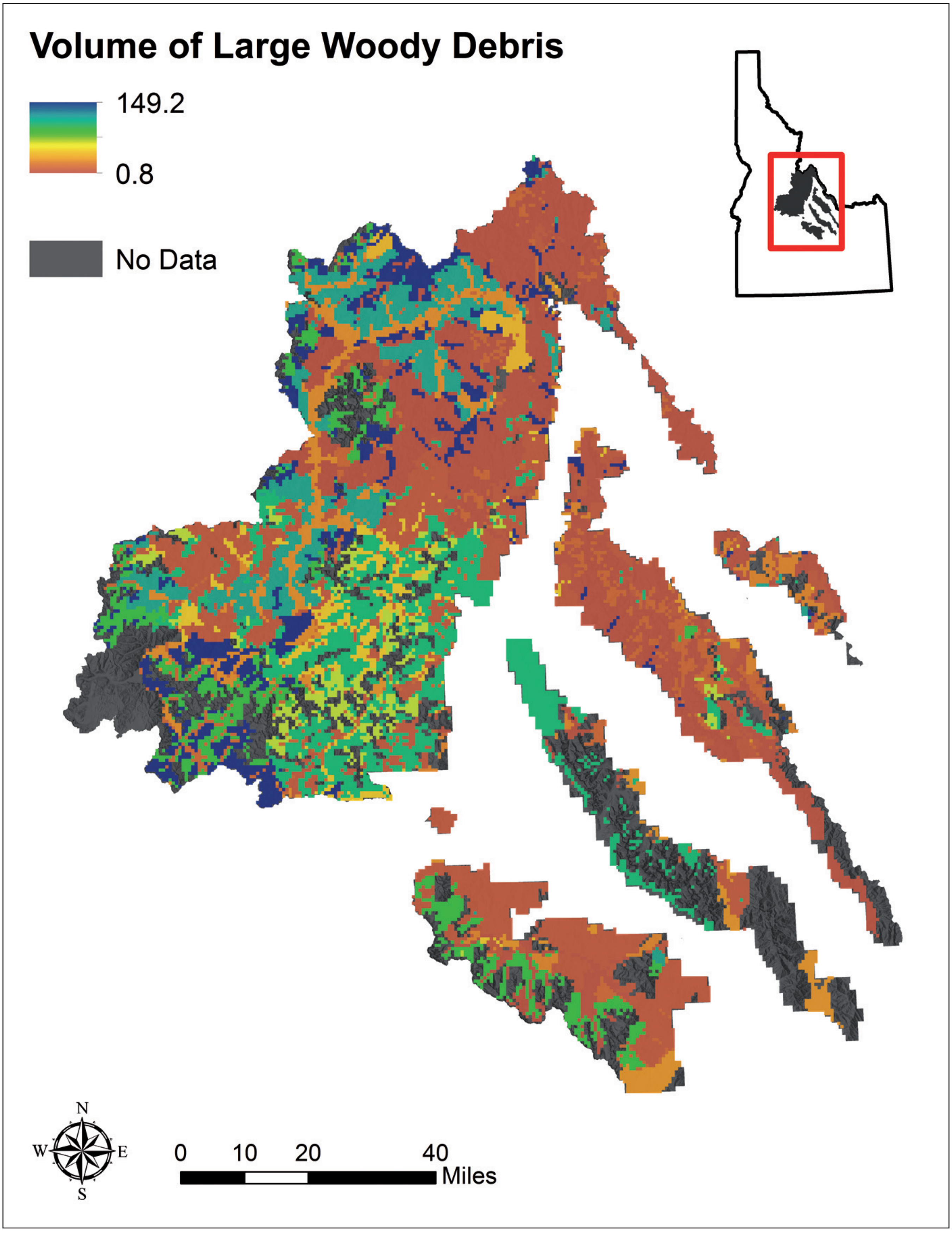

Figure I14—Volume of large woody debris (m^3/km) within the stream channel by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

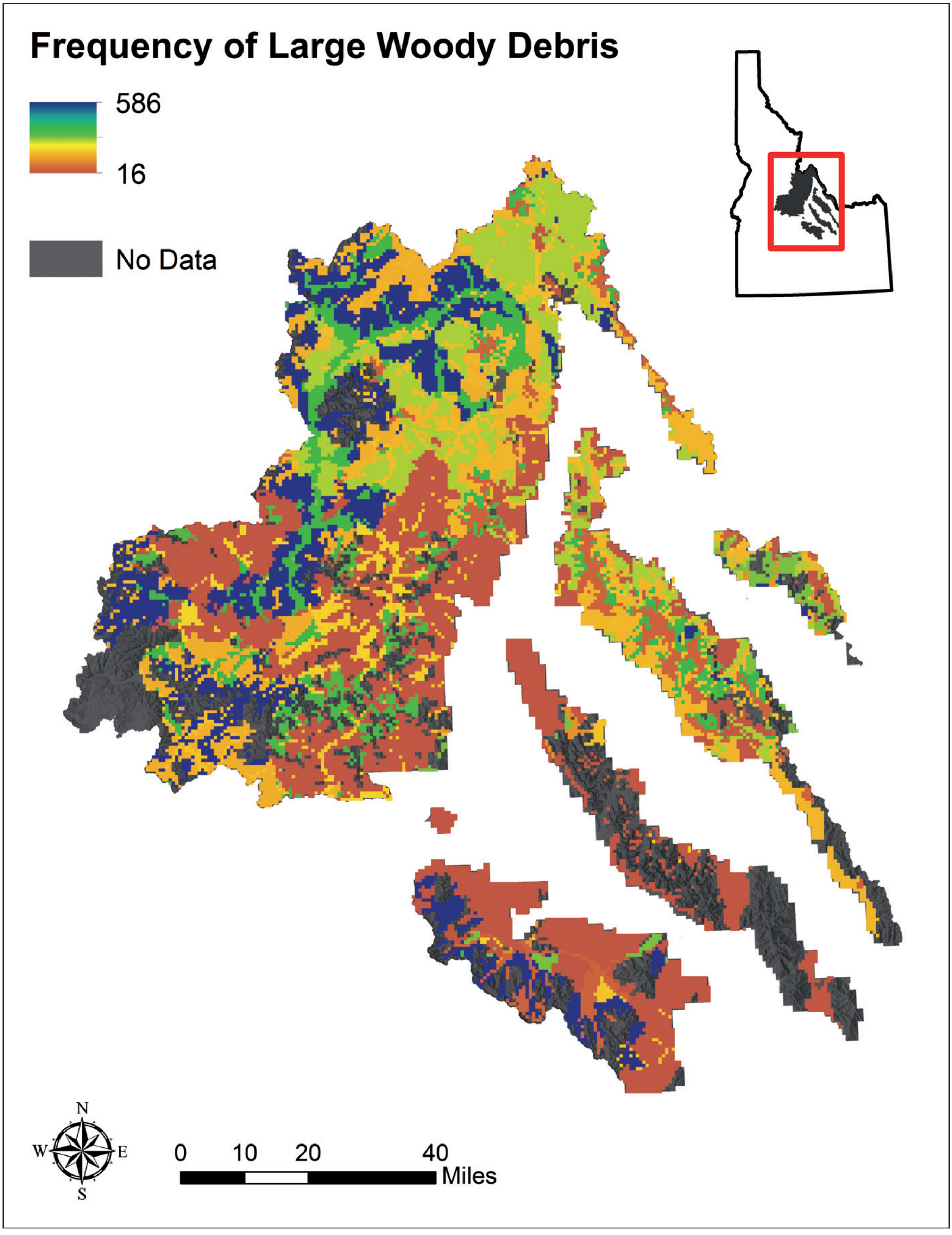

Figure I15—Frequency of large woody debris (pieces/km) within the stream channel by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

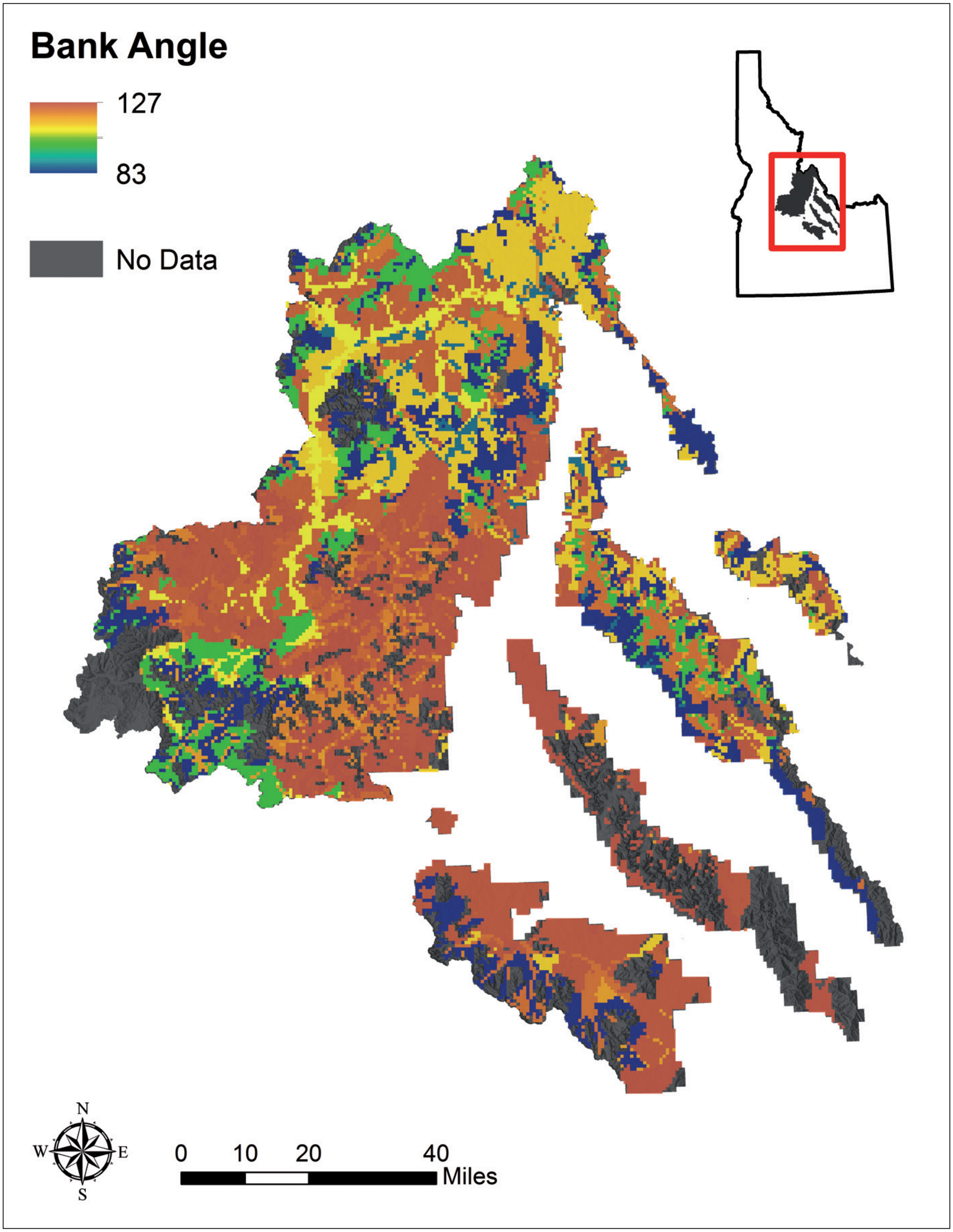

Figure I16—Average streambank angle by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

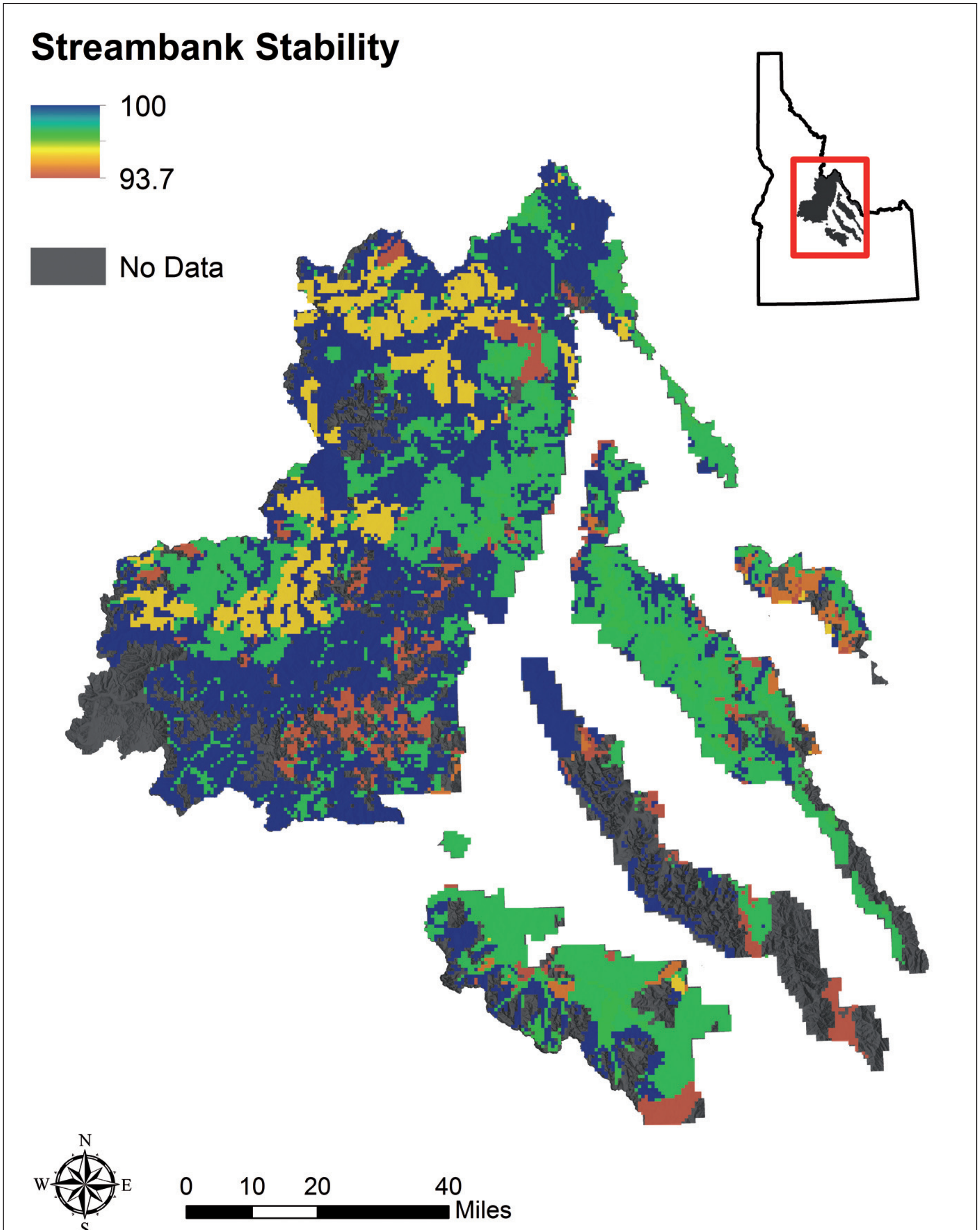

Figure I17—Average streambank stability by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

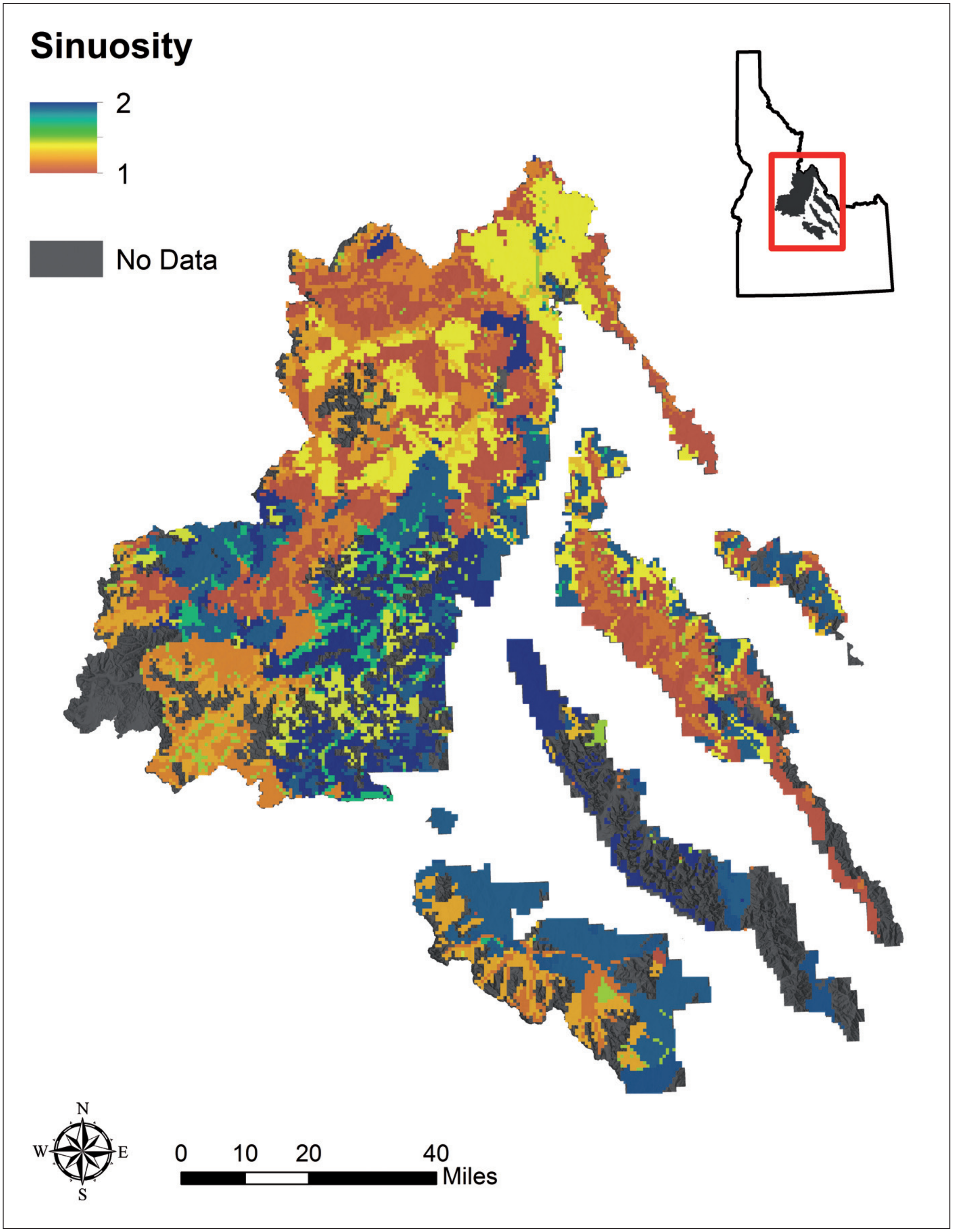

Figure I18—Average stream channel sinuosity by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the Salmon-Challis National Forest between 2001 and 2016.

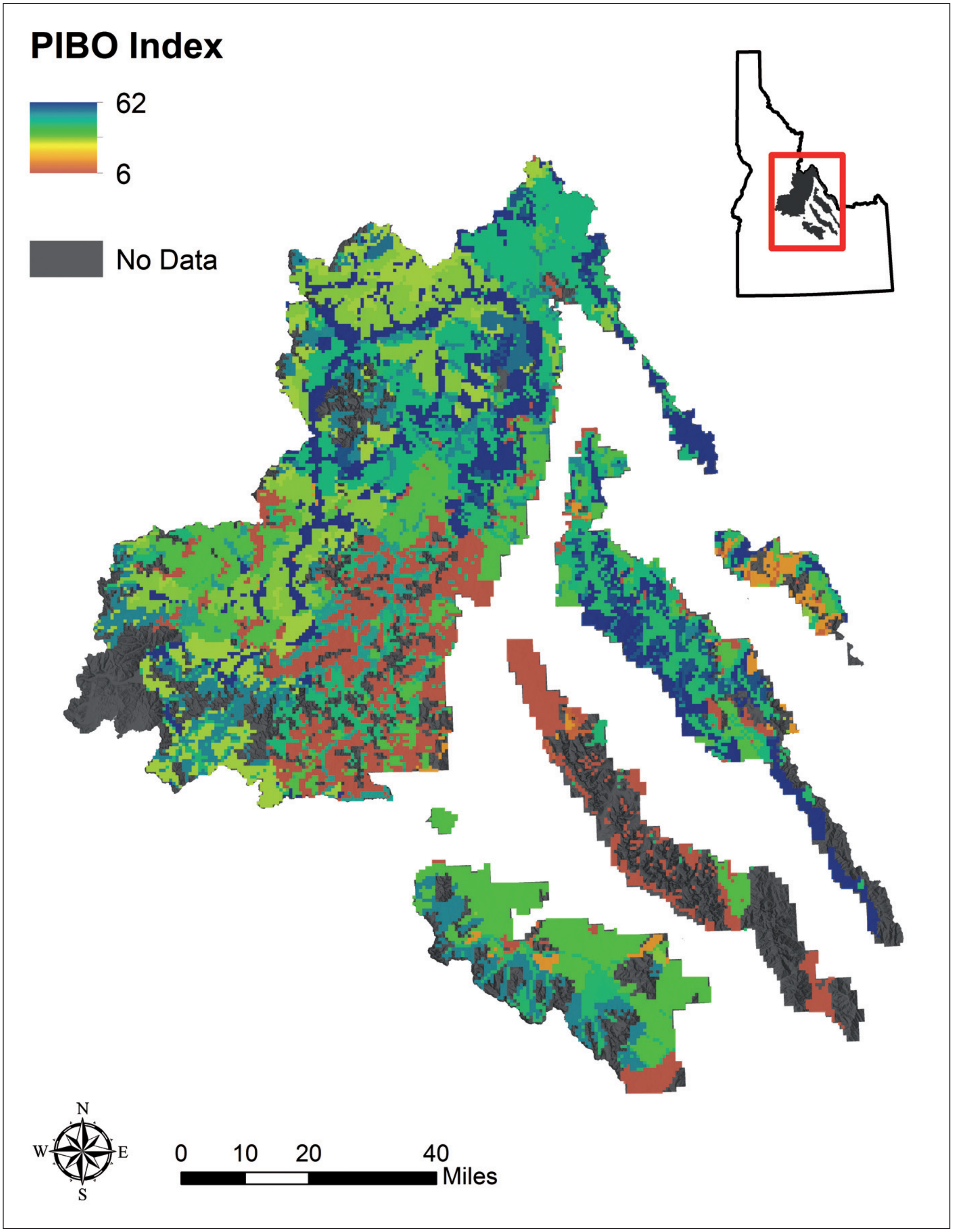

Figure I19—Average PIBO index by LTA. The PIBO index is a numeric score 0 (worst) to 100 (best) that ranks habitat integrity of a reach by considering six metrics (residual pool depth, percent pools, median substrate size, percent pool tail fines <6 mm, large wood frequency, and average bank angle). The data were derived from the PIBO effectiveness monitoring program and include 501 samples collected on the SCNF between 2001 and 2016.

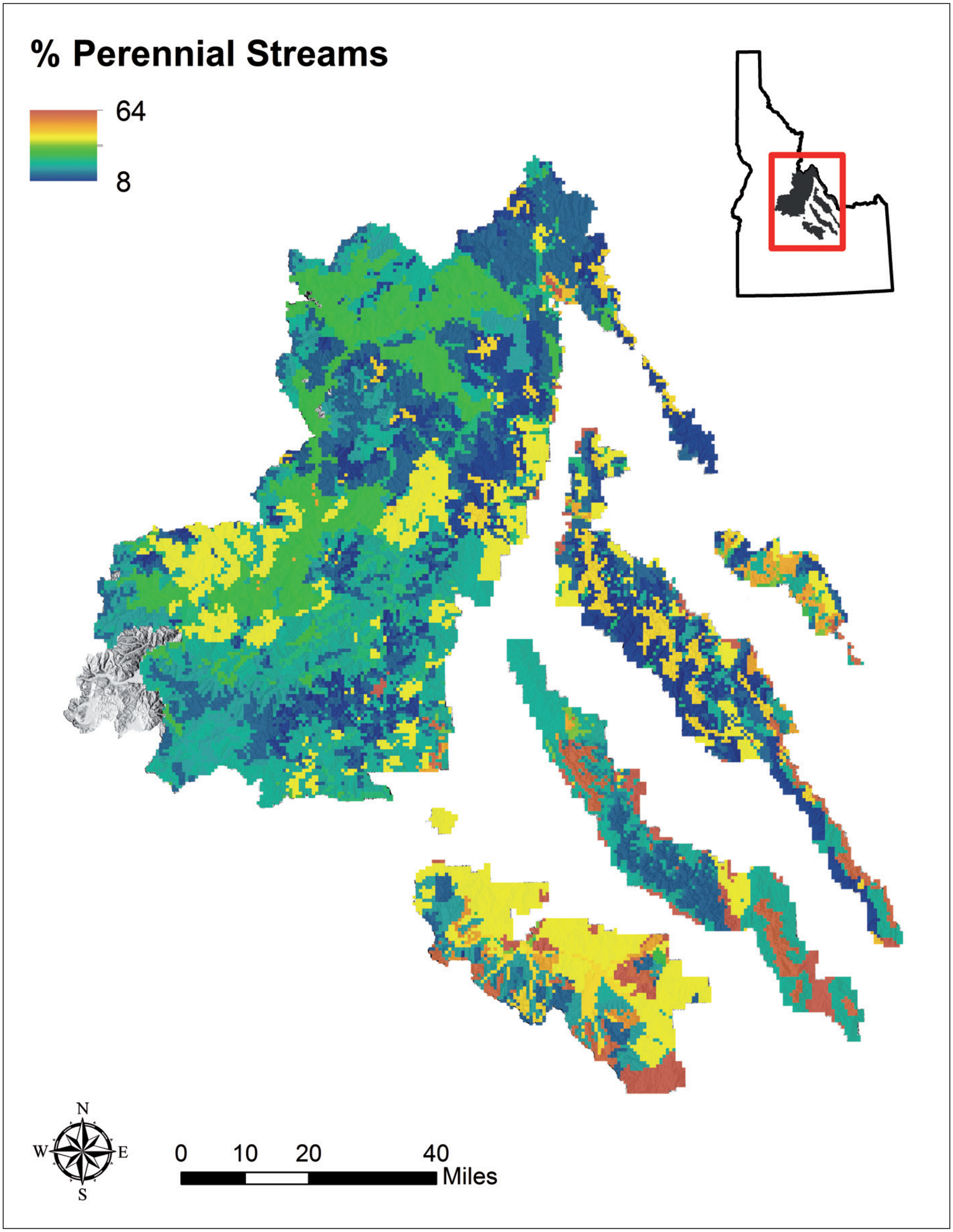

Figure I20—Percentage of perennial stream miles affected by upland encroachment by LTA. The data were derived from the riparian vegetation conversion type classification tool of the R-CAT suite.

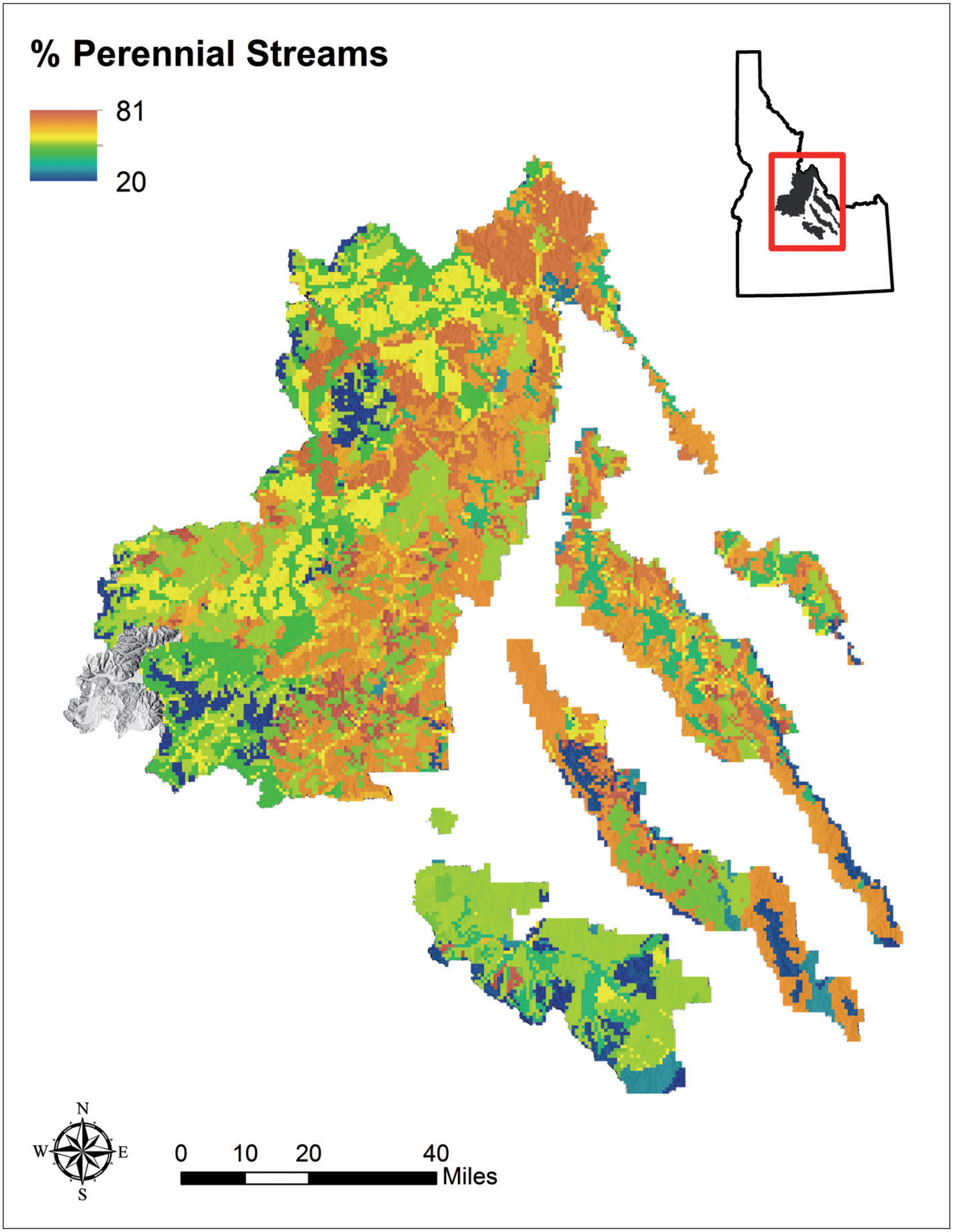

Figure I21—Percentage of perennial stream miles affected by conifer encroachment by LTA. The data were derived from the riparian vegetation conversion type classification tool of the R-CAT suite.

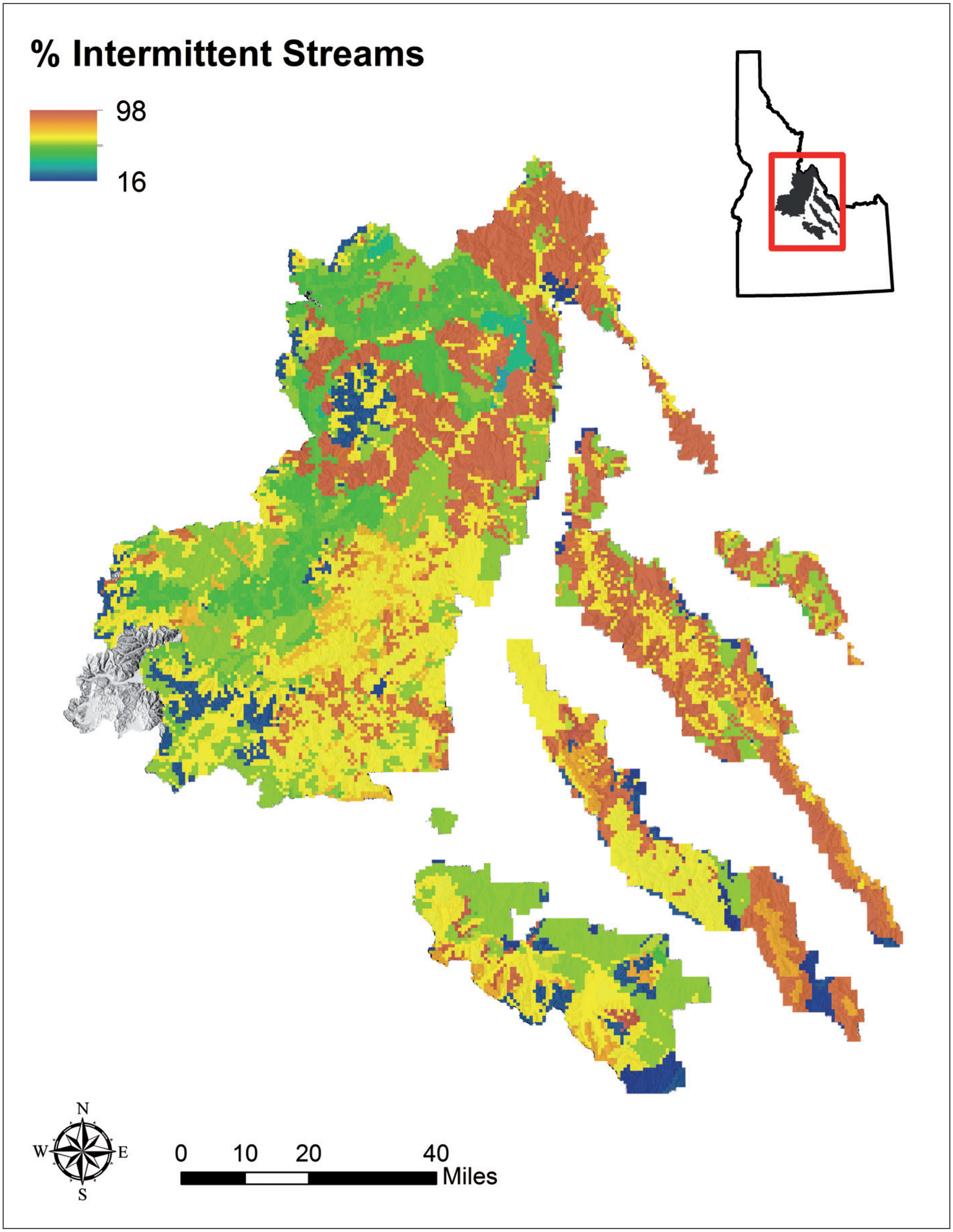

Figure I22—Percentage of intermittent stream miles affected by upland encroachment by LTA. The data were derived from the riparian vegetation conversion type classification tool of the R-CAT suite.

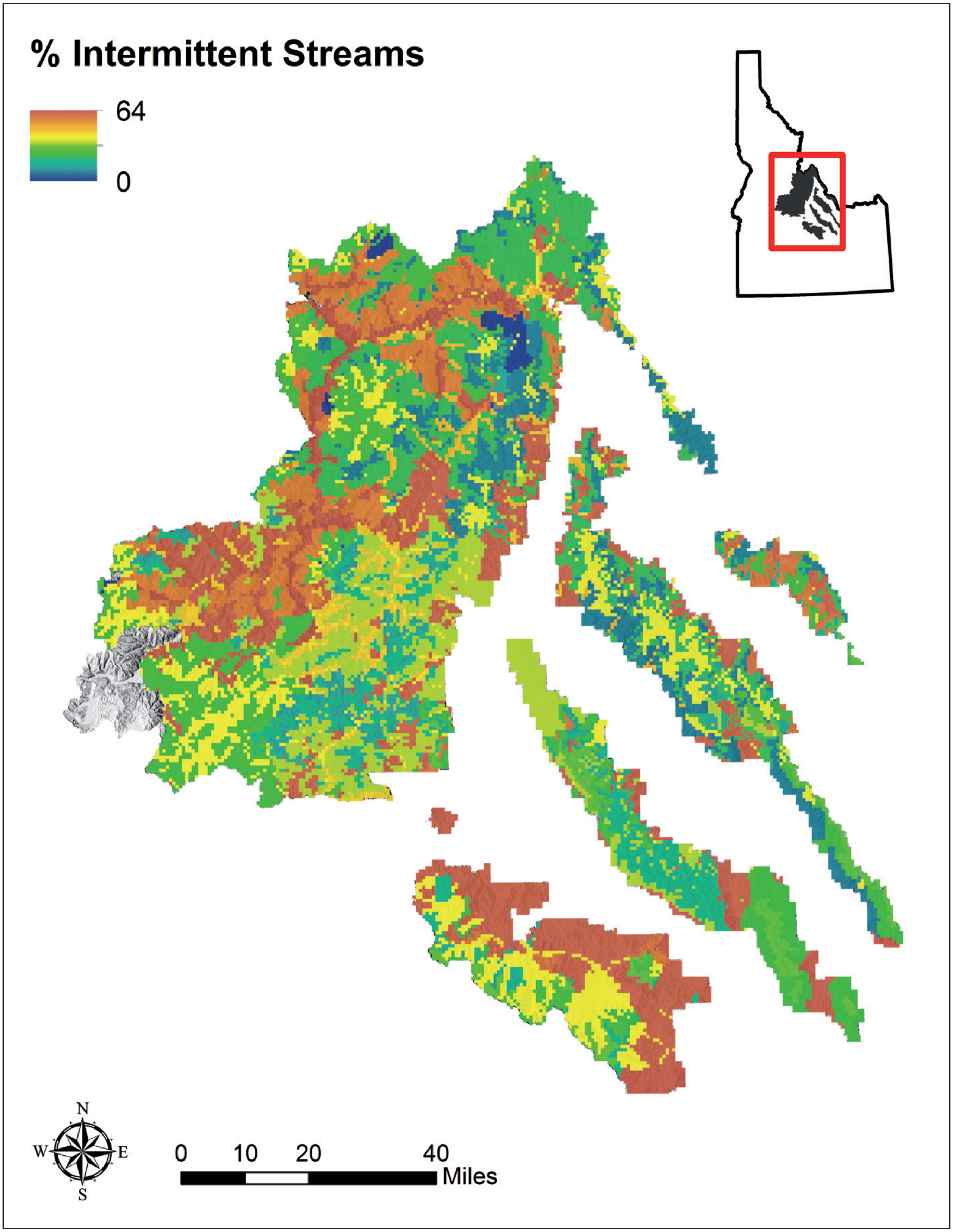

Figure I23—Percentage of intermittent stream miles affected by conifer encroachment by LTA. The data were derived from the riparian vegetation conversion type classification tool of the R-CAT suite.

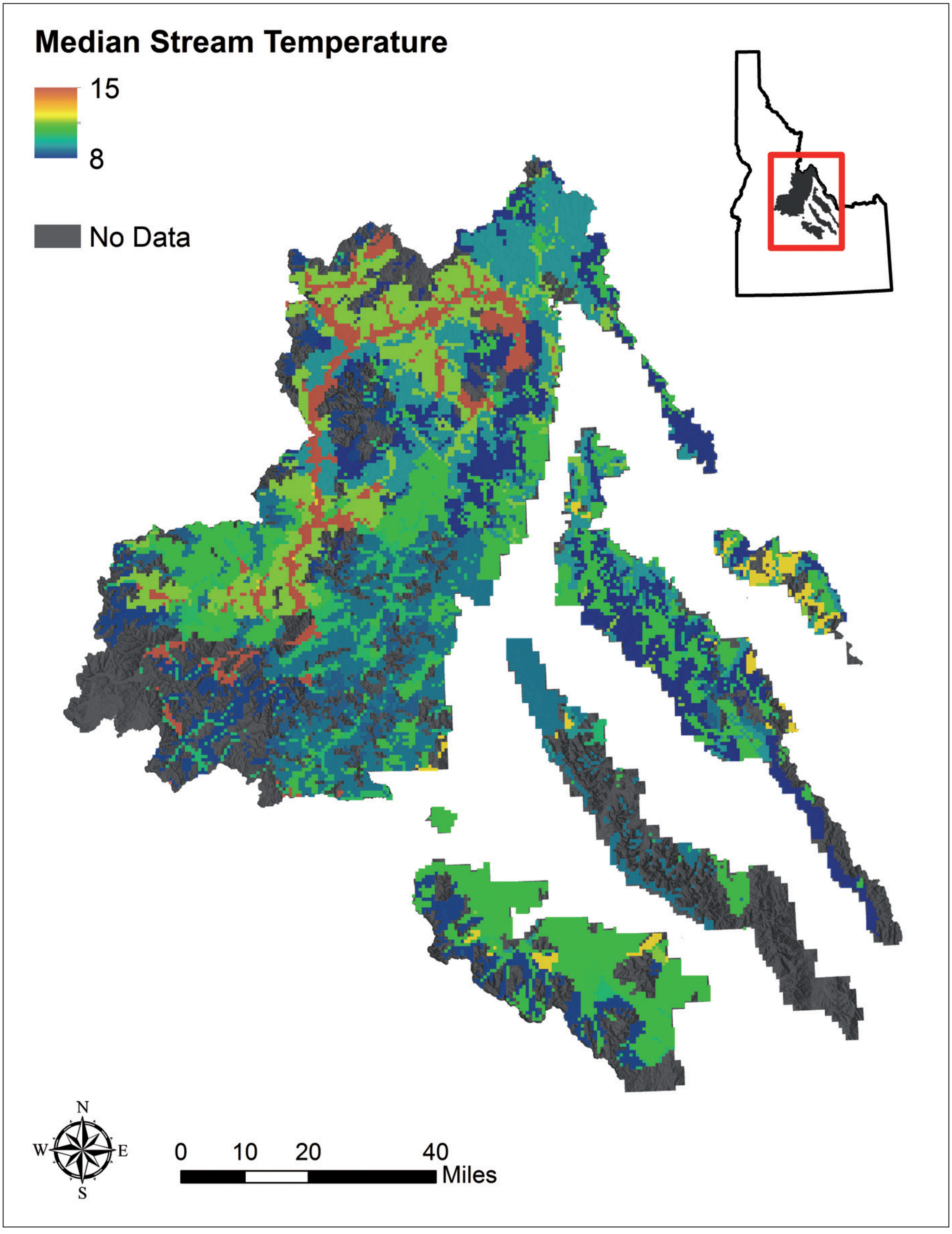

Figure I24—Median summer stream temperature by LTA. The data were derived from the PIBO effectiveness monitoring program and include 293 samples collected on the Salmon-Challis National Forest between 2000 and 2016.

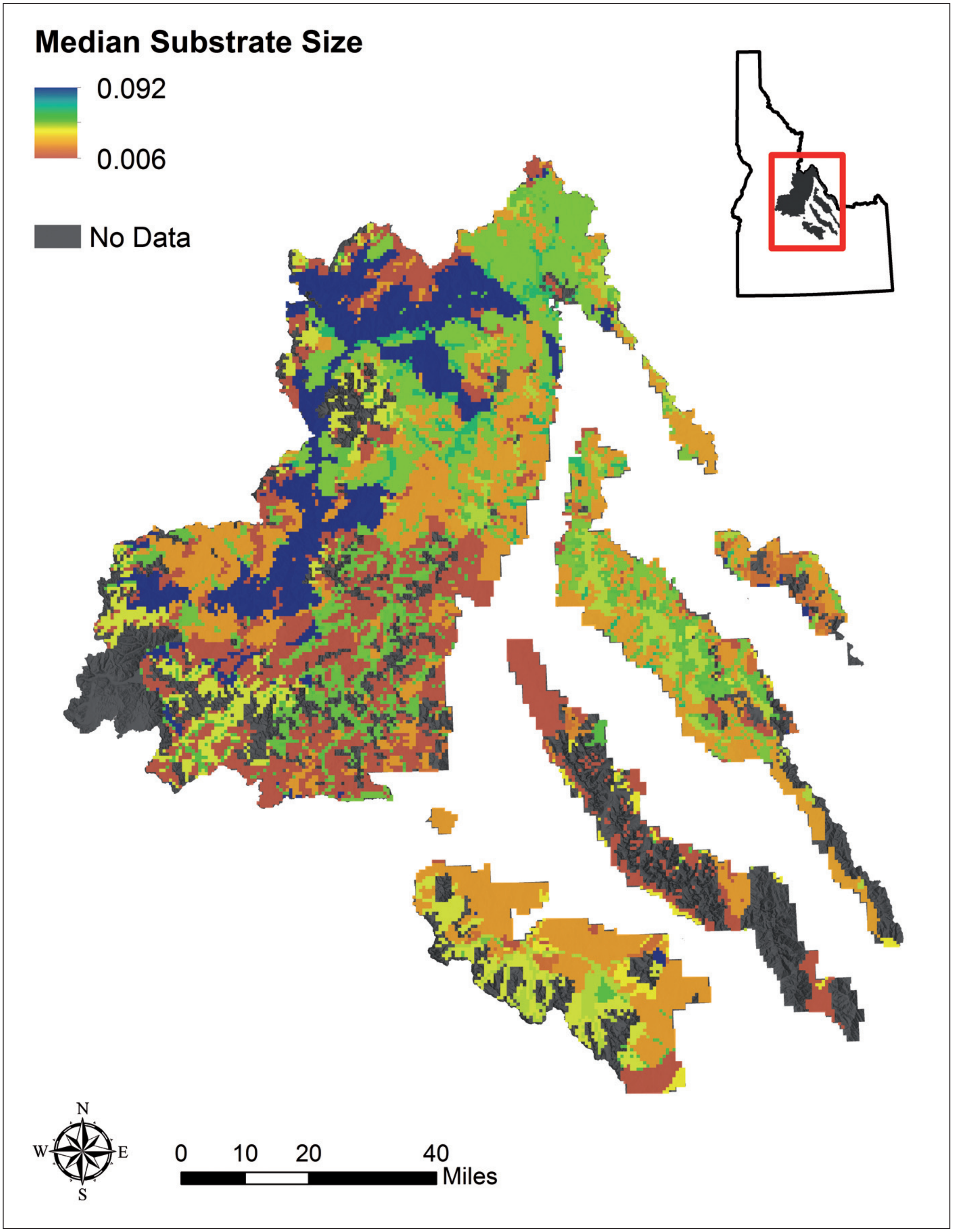

Figure I25—Median substrate size (m) by LTA. The data were derived from the PIBO effectiveness monitoring program and include 501 sample sets collected on the Salmon-Challis National Forest between 2001 and 2016.

Appendix J—Acronyms

AZAR	Aquatic Zone Analysis Rating
BLM	Bureau of Land Management
BMP	Best Management Practices
BPS	Biophysical Setting
CTQ	Community Tolerance Quotient
EVT	Existing Vegetation Type
GDE	Groundwater-Dependent Ecosystems
HGVC	Hydrogeomorphic Valley Classification
IDEQ	Idaho Department of Environmental Quality
KEC	Key Ecosystem Characteristic
LTA	Land Type Association
D50	Median Substrate Size
MIM	Multiple Indicator Monitoring
NHD	National Hydrography Dataset
NRV	Natural Range of Variation
NWI	National Wetlands Inventory
PEMB	Palustrine Emergent Wetlands
PFC	Proper Functioning Condition
PIBO	Pacfish-Infish Biological Opinion
R-CAT	Riparian Condition Assessment Tool
RVD	Riparian Vegetation Departure
SCNF	Salmon-Challis National Forest
USFS	United States Forest Service
USGS	United States Geological Survey
VCA	Valley Confinement Algorithm
WCF	Watershed Condition Framework